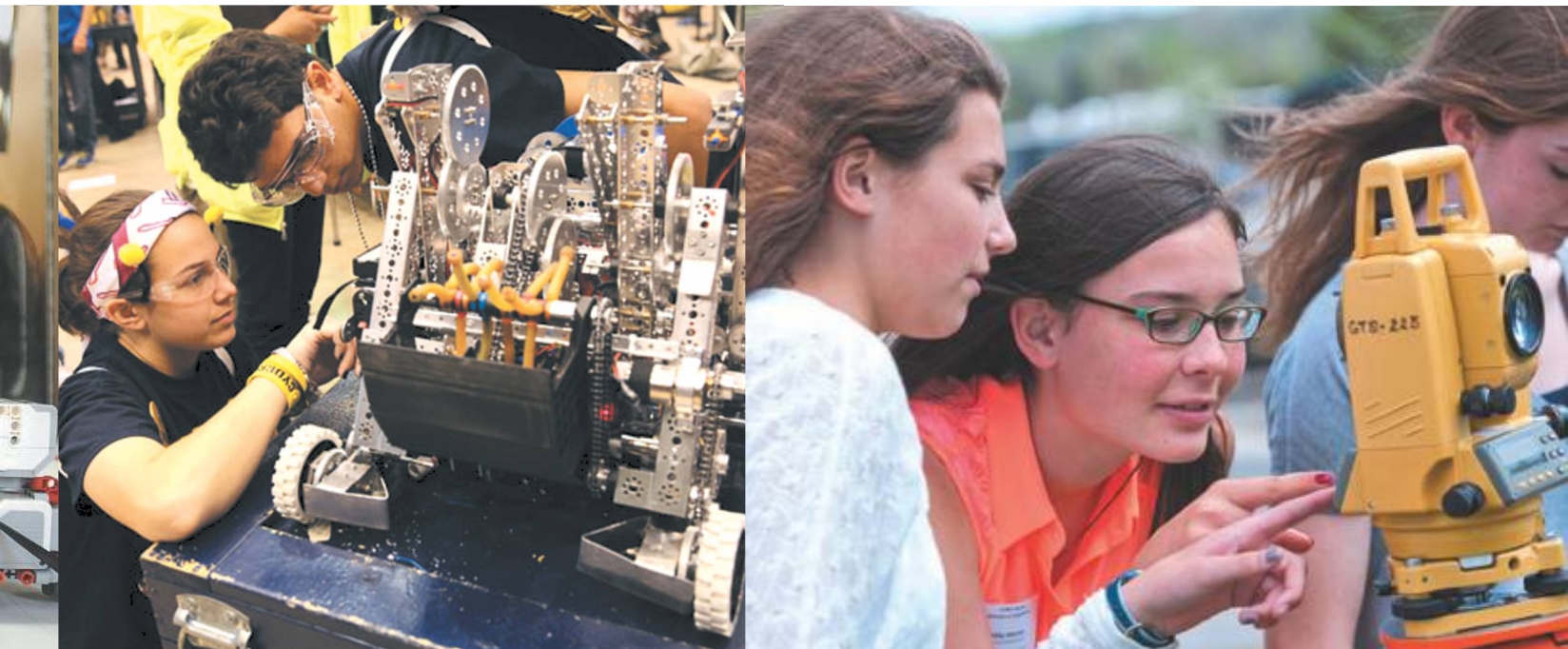


JEET **Journal of Engineering
Education Transformations**



rit + iuc ee
Rajarambapu Institute of Technology & Indo US Collaboration for Engineering Education

Formerly published by Engineering Education Foundation, Pune

Founder Editor : Prof. N. V. Ratnalikar

The Journal of Engineering Education Transformations

Editor in Chief :

Krishna Vedula

Professor and Dean Emeritus, University of Massachusetts Lowell

Founder and Executive Director,

Indo US Collaboration for Engineering Education (IUCEE)

krishna_vedula@uml.edu

Co-Editor in Chief :

Dr. Sohum Sohoni

Professor, Computer Science,

Milwaukee School of Engineering

Editor :

Dr. (Mrs.) Sushma S. Kulkarni

Director

Rajarambapu Institute of Technology, Rajaramnagar

Islampur, Dist. Sangli, Maharashtra - 415 414 (India)

sushma.kulkarni@ritindia.edu.

Review Process Manager :

Dr. Sandeep R. Desai

Associate Professor,

Rajarambapu Institute of Technology.

Published by :

Dr. (Mrs.) Sushma S. Kulkarni

on behalf of Rajarambapu Institute of Technology

Rajaramnagar, Dist. Sangli, Maharashtra - 415414(India).

Printed at :

Deshmane Offset, Kirloskarwadi

Journal Managers

Hemlata V. Gaikwad

Sachin K. Patil

Advisory Board**Hans J. Hoyer**

Secretary General,
International Federation of Engineering Education
Societies (IFEES),
Executive Secretary, Global Engineering Deans
Council (GEDC), USA

Anil Sahasrabudhe

Chairman, All India Council of Technical Education,
New Delhi

Gopalkrishna Joshi

Director, Center for Engineering Education
Research (CEER), BVB College of Engineering
and Technology, India

Bill Oakes

Director, EPICS, Purdue University, USA

Khairiyah Mohd Yusof

Director, Center for Engineering Education,
Universiti Teknologi Malaysia (UTM)

Vinod Lohani

Professor, Virginia Tech University, USA

Principal R. D. Sawant

Secretary of Kasegaon Education Society, Sakharale

Associate Editors**Sangeeta Kulkarni**

K.J.Somaiya College of Engineering,
Vidyavihar Mumbai.

Dr. Satyajit R. Patil

Associate Professor, Automobile Engg. Dept.
Rajarambapu Institute of Technology, Sakharale,
MS, India

Arati Phadke

K J Somaiya College of Engineering,
Vidyavihar, Mumbai.

Dr. Shreeranga Bhat

Professor, Department of Mechanical Engineering
St. Joseph Engineering College,

Dr. Anitha D.

Assistant Professor
Thiagarajar College of Engineering, Madurai,
Tamil Nadu.

Ramaa Ananthamurthy

Associate Professor
RV College of Engineering

Dr. Sivakumar Krishnan

Dean, Vishnu Educational Development and
Innovation Centre (VEDIC)
Professor, Mechanical Engineering,
Sri Vishnu Engineering College for Women
(SVECW)

Dr. Swaroop Joshi

Assistant Professor, Lecturer
School of Computing, University of Utah

Dr. Sandhya Dass

Associate Professor
St. Joseph Engineering College, Mangaluru,
Karnataka, India,

Dr. Medha Dalal

Postdoctoral Scholar,
Ira A. Fulton Schools of Engineering,
Arizona State University

Dr. Teresa Hattingh

Senior Lecturer,
North West University, South Africa

INDEX

Editorial

Dr. Sushma Kulkarni

1. **Dynamic Process for Enhancing Engineering Faculty Competence in India** 07-25
Thanikachalam Vedhathiri
2. **Practical Implementation of Outcome-Based Education Practices in the Indian Engineering Institutes – An Objective Approach Based Investigation** 26-32
Ritesh Bhat, C. Raghavendra Kamath, Kevin Amith Mathias, Prashant Mulimani
3. **Perceiving the Suitability of Adopting Problem Based Learning Pedagogy for Technical Education Entrants** 33-39
Vaishnavi Dabir, Anjali Kulkarni, Kanchan Khare
4. **Project-based Laboratory Assignments to Support Digital Transformation of Education in Turkmenistan** 40-48
Serdar Nazarov, Bayram Jumayev
5. **Effective Teaching of Electric Circuit Analysis through Jigsaw Cooperative Learning Method** 49-59
Reba P., Susithra N., Deepa M., Santhanamari G.
6. **A Study Report on Teaching Skills to Speech and Hearing-Impaired Students in Higher Education Sector** 60-66
S. Thangarasu, K. Karthigadevi
7. **Quality Management System Practices Performed in ISO 9001 Certified Engineering Educational Institutions: A Critical Analysis of Indian Universities** 67-75
Parvesh Kumar, Sandeep Singhal, Jimmy Kansal
8. **Training Faculty for Better Online Teaching – Need & Issues** 76-82
Pai, Chiplunkar

- 9. Integrating IR4.0 Technology in Engineering Education:
Robotic Arm Remote Lab**

*Teoh Jiehan, Tee Chee Yee, Hamna Zadhy, Aminatta Mohamed Diallo,
Merwin Vickraman, Nishata Royan Rajendran Royan*

83-94
- 10. A New Comprehensive Methodology for Evaluation of
Course Outcomes and Programme Outcomes**

*Bimal Kumar Mawandiya, Shashikant Joshi, Bharatkumar Modi,
Kaushikkumar Patel, Vikas Lakhera, Rajesh Patel, Alka Mahajan*

95-103
- 11. LabMIMO: An Open-source Virtual
Laboratory for Process Control**

Alpesh Patel, Dr. Jignesh Patel

104-110
- 12. Experience of Distance Learning Under Emergency
Conditions of the COVID-19 pandemic**

*Veniamin Aleksandrovich Norin, Natalia Vladimirovna Norina,
Yurii Vladimirovich Pukharenko*

111-128
- 13. Opening Students' Creativity and Innovation through CAD
Learning in Collaboration with Small and Medium-sized Enterprises**

Bayu Rahmat Setiadi, Sugiyono, Thomas Sukardi

129-137
- 14. The Influence of Multidisciplinary Factor on the
Technical Universities' Positions in International Rankings**

Leonid Sobolev

138-147
- 15. Factors Influencing Technopreneurial Intention among
Undergraduate Engineering Students in the Philippines**

*Zachariah John Aviles Belmonte, Carl Sebastian C Cruz,
Prince Adriel P De Castro Dexter A Estoesta, Elijah John A. Mitra,
Pamela Eyre Victoria R Lira*

148-157
- 16. Team Teaching: A Blended Learning Tool in Engineering Mathematics**

S. R. Sharma

158-164
- 17. Peer-Observation: An Intensive Study and its Impact
On the Teaching-Learning Process**

Devendra Rawat, Nilima Salankar, Monit Kapoor

165-174

Editorial



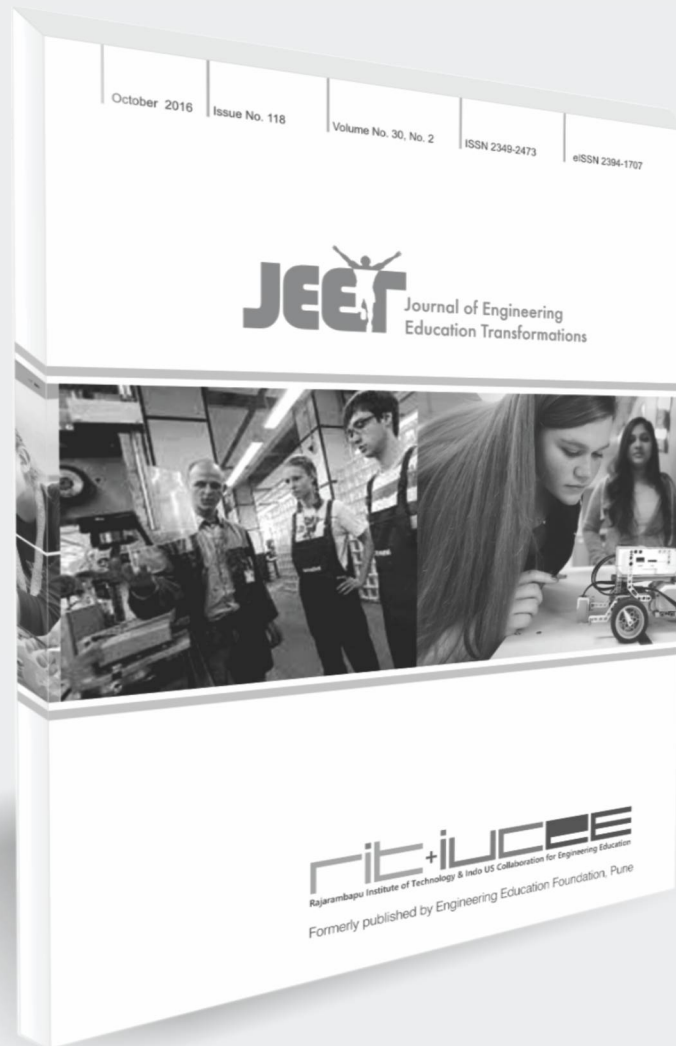
There are established accreditation processes by National Bodies to ensure quality of Higher education. Getting an institution or a program accredited demonstrates that, it meets the standards set by accreditation organizations representing the professional community and other stakeholders. Accreditation systems like NAAC or NBA conduct their comprehensive reviews to assess, evaluate and monitor the progressiveness of the institute towards the dynamic technical and non-technical environment. A regular quality assurance process helps an institute keep the quality of programs in check as well as improves their public accountability.

Preparing for accreditation is a complex, labor-intensive, and a thoughtful undertaking. I feel that preparing for accreditation is more reflective of developing measurable systems and successful implementations. We need to be organized. Simple things like creating a master index table with the needed documents listed along with link to the folder where these materials are saved can save a lot of last minute hassles. It is important to cultivate a habit of routine check on the data maintenance by every department. Just like how a daily five-minute speed-cleaning helps maintain a clean home, organizing files and folders regularly will save you from stress and support you to improve your work to achieve the targets decided on your own self.

One more thing which needs a compulsory mention here is overcoming inertia. Inertia here is the tendency of a department or faculty to continue on its current trajectory due to resource, routine or habitual rigidity. To be specific, I personally feel that accreditation should become a practice and system to be followed and not a special project. To be successful in your accreditation work, I recommend you to use a project management approach, as it is critical to divide the required work into smaller, manageable steps.

The most important thing is find joy in it. The journey should not be a special preparation but a way of life which will spark joy in you and then only you will be able to achieve the desired goal.

Dr. Sushma Kulkarni
Editor



**“JEET Is INDEXED in ELSEVIER LARGEST DATABASE SCOPUS ,
the abstract and citation database of peer-reviewed literature:
scientific journals, books and conference proceedings 2018 onwards.”**

Dynamic Process for Enhancing Engineering Faculty Competence in India

Thanikachalam Vedhathiri,

National Institute of Technical Teachers Training and Research, Chennai
vthani2025@gmail.com

Abstract : Indian engineering colleges need more qualified faculty, since, thousands of engineering colleges have been approved by AICTE with teachers who possess only bachelor's degrees without any experience in curriculum design, instructional design, evaluation, and industrial training. Many of them were not exposed to advanced industrial design and advanced manufacturing practices. This has resulted in the unemployment of about 70% of the graduates. This paper focuses on the systematic planning, and implementing appropriate faculty development programs not only for the fresh graduate teachers but also the senior faculty members through various long-term programs, short-term courses, industrial training, research works, Massive Open Online Courses (MOOCs) under SWAYAM, and training through specialized overseas courses that are implemented by Ministry of Education. National Institutes of Technical Teachers Training are offering MOOCs in various areas of engineering education. Continuous process development has been suggested. The engineering colleges could reimburse faculty

members on the cost of training under MOOCs which are offered by edX, COURSERA, etc. Further, the colleges should organize faculty development programs in collaboration with the well-known global universities and Research & Development Centers of Multinational Companies (MNCs) which are functioning here. Such a dynamic initiative will bring excellence in the knowledge capital. The government can assist professional associations to plan industry-relevant workshops. Considering the difficulties in getting admission for thousands of faculty members in Quality Improvement Programs (QIP), alternate, hybrid and flexible programs are suggested. The significant outcomes of these initiatives are: i) It increased the skills and competencies of the faculty members and students; ii) The graduates have become be industry-ready; iii) Many regions have come industrially competitive, iv) The new initiatives like Pandit Madan Mohan Malavia National Mission on Teachers and Teaching (PMMMNMTT) and MOOCs have improved the faculty competencies in hundreds of colleges; v) Global Initiative for Academic Networks (GIAN) have increased interdisciplinary research capability of the faculty members; vi) The overall outcomes of these initiatives have improved the engineering curriculum, attributes of the graduates and interdisciplinary research. It is suggested to undertake further research on the finetuning of the curricula to meet the challenges of Industry-4.0

Thanikachalam Vedhathiri

National Institute of Technical Teachers Training and Research,
Chennai
vthani2025@gmail.com

Keywords: Faculty Competence, Dynamic Process, QIP, Summer Schools, Webinars, MOOCs.

1. Introduction

According to Asian Development Bank, the Asian countries need to improve the tertiary institutions of world standards, research centers, and model campuses for the knowledge-based economy (KBE).

India's education system, as one of the world's largest, has been studied and reflected on through academic papers, used as a case study, and been the subject of many renowned books (Richard Everitt, Director Education & Society, British Council of India). By 2025, India will have the second-largest graduate talent pipeline globally, following China ahead of the USA.

The government of India has planned to transform this sector since 1992. Every aspect of higher education is being considered and remodelled: funding, leadership and management, quality assurance, accountability, relationships with industry, international collaboration, and the way research and teaching are conducted. If these reforms succeed, the breadth and depth of change will be transformational.

According to Professor Pankaj Chandra, Director of Indian Institute of Management (IIM), Bangalore “Change at the scale, we will see in the next ten years in education in India is unprecedented in human history”.

Considering the need for competent engineers for the fast development of Indian industry after the independence, engineering faculty development has been well planned by the Ministry of Education to improve the inexperienced faculty members of the engineering colleges and polytechnics.

1960s United States Agency for International Development (USAID) offered training programs and advanced courses to engineering professors in India. Many state governments sponsored the faculty members to M.S. and Ph.D. programs in well-known foreign universities in UK and USA and provided a salary to them and met the travel expenditures. Also, the government of India got assistance from Germany, the United Kingdom (UK), the United Nations Development Program (UNDP), the United States of America (USA), and the Union of Soviet Socialist Republics (USSR) for establishing five Indian Institutes of Technology (IIT) in the 1960s. In the 1970s, Summer Schools were organized for training the engineering faculty members through PL480

funds of USA. Now the IITs are offering Master and Ph.D. degree programs to engineering college faculty members under Quality Improvement Programs (QIP) of the All-India Council for Technical Education (AICTE).

1.1 Learning Needs Assessment and Analysis of the Engineering Students

Most of the Boards of Studies rely on the expertise of the members in analyzing the performance needs of the graduates. To meet the fast-changing industrial growth, new technologies, and near-future needs, it is essential to get information from various employers and alumni. The engineering graduates have to be trained in product analysis, design, prototype development, testing the prototype, improving it, estimate the cost, value analysis, manufacturing, marketing, and maintenance. Questionnaires can be prepared and distributed. Analysis of the feedback will provide authentic information of the needed skills, competencies, and attitudes to develop a curriculum.

1.2 Need-based Faculty Development Programs

Since 1992, all the four National Institute of Technical Teachers Training and Research (NITTTR)s at Bhopal, Chandigarh, Chennai, and Kolkata are offering need-based quality improvement programs in engineering education for college teachers. This is based on the recommendation of the Bhattacharya Committee in 1991. The following significant programs are planned based on the expressed needs of the colleges: 1. Instructional Design, 2. Development of Industry-Specific Curricula under TEQIP I and II, 3. Measurement and Evaluation of Students' Achievement, 4. Institutional Development, 5. Bidding for Development Projects, 6. Establishment of Instructional Media Development Centers, 7. Leadership Development, 8. Planning Continuing Education Programs, 9. Curriculum Innovation, 10. Educational Ethics, 11. Globalization of Engineering Education, 12. Planning Tracer Studies under TEQIP I & II, 13. Impact Studies under TEIP I and II, 14. Developing Detailed Project Proposal for Capacity Development and Quality Improvement, and 15. Internal Revenue Generation.

1.3. Other Faculty Development Courses

Indian Society for Technical Education (ISTE) is also offering Summer and Winter Schools for faculty

development. Now various State Technical Universities (STUs), National Institutes of Technology (NITs), and well-grown Autonomous Engineering Colleges also offer Master and Ph.D. programs under Quality Improvement Program (QIP). World Bank assisted projects Technical Education Quality Improvement Program (TEQIP) I and II offered many faculty-development programs from 2004-2016. TEQIP III is being implemented to improve the weaker states.

In the 21st century, the economy of a nation is partly dependent on the available human capital. The Government of India is taking many initiatives to train and develop the faculty members of engineering institutes. However, there is a great gap in faculty development. The concept of pretraining of the university faculty is not there. It is suggested to train the recruits through a four weeks program in curriculum planning, instructional design, developing educational aids, leadership, interdisciplinary research, and consultancy projects. Due to the recruitment of lakhs of untrained faculty who join the engineering colleges, there is a need for bringing the dynamic process of faculty development. However, most of the CEOs of engineering colleges express that faculty development is the biggest challenge. These challenges made us explore appropriate models for faculty development through a research program.

2. Objectives of Research

- To review the training needs of engineering faculty at various levels.
- To plan various modes of offering engineering faculty development programs.
- To plan flexible and hybrid part-time faculty development programs to solve the problems faced by the engineering faculty members.

3. Literature Survey

Centra (1978) described various types of faculty development programs. Wilkerson (1998) developed strategies for improving teaching practices through faculty development.

Ole Vinther and Anette Kolmos (2002) stated that Danish Engineering Institutions have created a national partnership to facilitate staff and faculty development. The National Pedagogical Network for

Engineering Education based in Ballerup, Denmark targets quality pedagogical and curriculum development for all Danish Engineering institutions.

Gillespie, Hilsen, and Wadsworth (2002) developed a guide to faculty development. They added practical advice, examples, and resources. Davis et al. (2003) created a comprehensive faculty development program. Mills and Treagust (2003) analyzed the effectiveness of problem-based learning against project-based learning in engineering education. Cole et al. (2004) developed an intensive longitudinal model for faculty development in teaching skills. Eric Aikens et al. (2005) concluded that faculty development is a continuous improvement plan for inclusive excellence. Froyd et al., (2005) recommend a framework for faculty development as follows: 1. Goal-oriented learning, 2, Active learning, 3. Meaningful learning, 4, Explaining while learning, and 5, Self-monitored Active learning.

Erklenz-Watts, Westbay, and Lynd-Balta (2006) brought out an alternate professional development program. Glowacki- Dudka and Brown (2007) brought out professional development through faculty learning communities.

Johan Malmqvist et al. (2008) described the faculty professional competence include project management, communication, teamwork, and organizational management.

Kavita, Kalpana, and Amarjit Singh (2010) evaluated the criticality of faculty development to enhance teaching effectiveness. According to them careful needs assessment, concepts, and skills are needed in the transformation process. Cook and Kaplan (2011) considered the problem of advancing the culture on teaching campus and suggested the use of a teaching center. Ronald (2011) described a new model of project-based learning (PBL) where the students develop their learning objectives. The projects are offered by the collaborative industries. Patil and Codner (2007) reviewed the accreditation process of engineering education programs and suggested a proposal for global accreditation. Kirk Ingold's (2008) faculty development centers around goal-oriented teachers, social systems, and the learning-centered model. James Jacob, Welyan, and Huiyuan Ye (2015) have stated that higher education professional development trends increasingly focus on areas of quality improvement, quality assurance,

and optimal technology delivery models to achieve academic excellence. World-class universities rely on their faculty professional development centers for an array of professional development programs to support teaching research and student learning.

MOOCs of NITTTRs

All the four NITTTRs at Bhopal, Chandigarh, Chennai, and Kolkata have been approved to offer many faculty development programs in the following areas: Educational Psychology, Curriculum Design, Instructional Materials Development, Instructional Design and Delivery, Educational Evaluation, Higher Education Administration, Leadership, Strategic Planning, Human Resource Development and Management, Creation of Centers of Excellence, Accreditation through NBA, Educational Research, Internal Revenue Generation, Student Personnel Administration, Globalization of Engineering Education, Content Updating, etc. They also offer many postgraduate programs and interdisciplinary doctoral programs. They need a sufficient number of high-performing and motivated faculty with the needed competencies. Since 2018 they offer MOOCs in various areas exclusively for engineering college faculty members. According to Asian Development Bank (2011), professional development programs were established in many higher education institutes to support various initiatives that promote effective teaching and research. In many Asian countries (UNESCO, 2014) faculty qualifications prevent them from being able to keep pace with the rising demands of higher education students. According to European University Association (EUA) (2008), professional development centers in European Universities can move effectively and efficiently reach out, communicate, respond and provide a solution, guidance, and technical assistance. Robert Matross Helms and Alegneta Asfaw stated that many American Universities are developing formalized student learning outcomes that focus on internationalization and global knowledge. According to them, it is primarily the faculty, as the drivers of teaching and learning, who are responsible for helping students achieve these outcomes. They suggested promoting faculty participation in short-term programs abroad. Some of the models are faculty seminars abroad (University of Richmond), and International Faculty Development Seminars. They stated that The Fulbright Specialist Program sends faculty abroad for two to six weeks on curriculum development. As per Dee Fink (2013), faculty

development focuses on organizational change and development. England and five Nordic countries have mandated 175-200 hours of a faculty development program for all newly recruited faculty members. The Ministry of Higher Education in Japan issued a mandate in 2008 that all universities must establish a faculty development program. The College of Engineering of Lund University in Sweden made proficiency in teaching compulsory for all professors.

3.1 Stanford Center for Professional Development (SCPD) Program in China:

At the beginning of each course a faculty member from the Management Science and Engineering Department on the home campus goes to China to teach for a week, then remains involved with students through email and videoconferencing throughout the rest of the course.

Purchase College and State University of New York (SUNY) have established a Center for Collaborative Online International Learning (COIL). This center develops more online courses and conducts workshops and conferences.

3.2 Partnership Delegation Grants of Grand Valley State University (GVSU) of USA: The faculty members receive funds to travel to foreign universities and conduct classes. On return to the home department, they survey the long-term impact of their experiences.

3.3 Faculty Development Program Abroad of Maricopa Community College District of USA:

The faculty receive international travel grants for 30 days and they have to submit the status of the outcome report.

3.4 Purdue University's Center for International Excellence administers the Global Learning Faculty Development Program.

This is designed to assist Purdue instructors to be stewards in optimizing and transforming classroom teaching and learning by integrating global issues, activities and experiences into learning objectives and course content which will facilitate a global experience.

3.5 The Center for Student Engagement and Learning Innovation at Canada's Thomson Rivers University:

This offers a two-part workshop that walks faculty through the process of internationalizing their courses.

3.6 Global Programs and Strategy Alliance of the University of Minnesota:

Organizes a series of lectures and workshops for faculty that focused on internationalizing the curriculum.

Rebecca Brent and Richard Felder (2003) described the NSF-sponsored Southern University and College Coalition for Engineering Education (SUCCEED) and its successful induction of large members of Engineering faculty members to participate in instructional development programs. Their suggestions are as follows:

- Emphasize disciplinary relevance in faculty development programs.
- Keep them practical.
- Include both disciplinary and pedagogical expertise on workshop facilitation teams.
- Cite the research work
- Avoid appearing prescriptive, dogmatic, or evangelical
- Practice what you preach,

3.7 Educating Engineers for the 21st Century

Julia E King, the Chair of the Educating Engineers for the 21st Century Working Party. According to this group, BRIC nations are producing a record number of engineers. According to King, the focus of the industry on the skills and competencies are as follows:

Table-1 (Average of 480 experts views)

Skills	Percentage
Practical Application	29.01
Theoretical Understanding	20.4
Creativity and understanding	18.95
Team Working	15.32
Technical Breadth	13.67
Business Skills	2.65

3.8 The Future of Indian Higher Education and Opportunities for International Cooperation

Leonie Siok Yoong Lee (2011) questioned that whether quality expansion is possible through affiliated colleges in South Asia. According to him, the affiliated colleges are the weakest link in South Asia's Higher Education. India has responded to the demand explosion by fostering the growth of an affiliating college system. Most of the affiliated colleges do not meet the basic requirements of adequate infrastructure and minimum teacher qualification, and they do not have academic autonomy.

The following are quality concerns:

- The loose regulatory system governing the licensing and registration of new colleges.
- Lack of both External and Internal Quality Assurance and Accreditation (QAA) frameworks for existing colleges.
- High graduate unemployment rates corroborate feedback on the college curriculum.
- Lack of qualified teachers; Insufficient permanent teachers.
- Poor and inadequate infrastructure and facilities.
- Complex governance structure: multiple controls with unclear stakeholder relationships.
- Unsustainable organization structures: a large number of colleges affiliated to one university and high average enrollment per college.
- Market forces distorted by lack of information and government policies; weak capacity to monitor and enforce rules
- Role of political economy (The chairmen are from the political parties.).

The faculty development initiatives would improve the quality of the faculty members.

3.8 South Asia Institute (SAI) at Harvard University, USA

The Lakshmi Mittal South Asia Institute, Harvard

University (2012) conducted a “Multidisciplinary Approach to University Leadership Development for university leaders from Maharashtra. Thirty leaders and policymakers, vice-chancellors, directors, principals, and deans attended the program. Harvard faculty challenged the participants to rethink their understanding of university culture, learning approaches, research, liberal arts education, library science, technology, and funding.

3.8.1 Outcomes

The visiting leaders collected the following ideas:

- Increasing communication among university leaders,
- Actively engaging all stakeholders in their institutions in decision-making,
- Incorporating new technologies for learning in the classroom and in the library system, and
- Institutionalizing a fund-raising network.

3.9 Excellence Model of European Foundation for Quality Management

Manuela Brusoni et al. (2014) have presented an Excellence Model developed by the European Foundation for Quality Management (EFQM). The enablers as per this model are:

- Leadership
- Policy and Strategy
- People Management
- Partnership and Resources
- Process Management

Excellent leaders develop and facilitate the achievement of the vision and mission. They develop organizational values and systems required for sustainable success and implement these via their actions and behaviors.

Through appropriate policy and strategy, organizations implement their vision and mission by developing a stakeholder focused strategy.

In this model, people management focuses on the management, development, and release of the full potential of their people at an individual, team-based, and organizational level. They care for, communicate, reward, and recognize in a way that motivates staff and builds commitment to using their skills and knowledge for the benefit of the organization.

Through partnerships and resources, organizations plan and manage external partnerships, suppliers, and internal resources to support policy and strategy and the effective operation of processes.

Process management focuses on the organization's design and improves the processes to fully satisfy and generate increasing value for customers and other stakeholders.

This model will be of great use in planning faculty development in engineering institutes to bring excellence.

3.10 Challenges for Indian Higher Education

Lynne Heslop (2014) identified the following four broad challenges for Indian Higher Education:

- The supply-demand gap is increasing
- Shortages of high-quality faculty members
- The curriculum is not tuned to incorporate modernized industrial practices.
- Absence of interdisciplinary research and innovation
- Absence of industrial linkages

3.11 Harvard Institute for Superintendents and District Leaders

Andres Alonso, Faculty Chair is conducting a four-day program for the superintendents to achieve excellence for all students since 2017. The course is centered around clear expectations for students; rigorous curricula aligned to standards; professional development that improves instructional quality, and assessment as a tool for feedback and accountability. The participants will have an opportunity on their leadership strengths for developing a team with a full range of capacities needed to lead systematic reform.

3.12 1000 Chinese University Leaders to Receive 'Upgrade' Training Abroad

China has stepped up its overseas training program for presidents and vice-presidents of public universities to compete with world-class systems and top international universities. 1000 university presidents and vice presidents have been sent to Australia, Britain, Germany, and the USA for leadership training programs. An amount of US \$12.8 million has been committed. The leadership scheme was funded by Lee Shau Kee Foundation and Pei Hua Foundation. A group of 23 university leaders and administrators have been trained at Oxford's Leadership and Public Policy program. The University of Michigan at Ann Arbor in the USA conducted the training program for 24 university leaders and administrators through the 2012 Michigan China-University Forum. The training has focused on curriculum development and student evaluation.

3.13 Engineering Education in the Rapidly Changing World

Kamp Albert (2016) developed a vision for engineering education in 2030 that encompasses the following eight key aspects:

- The rigor of Engineering Knowledge
- Critical Thinking and Unstructured Problem-Solving
- Imagination, Creativity, Initiative
- Communication and Collaboration
- Interdisciplinary and System Thinking
- Global Mind-Set: Diversity and Mobility
- Ambitious Learning Culture: Student Engagement and Professional Learning Community
- Employability and Lifelong Learning

These largely concur with the categories of the Technical, Professional, Personal, Interpersonal, and Cross-cultural Engineering Criteria of the Accreditation Board for Engineering and Technology (ABET) and the Revised Attributes of a Global Engineer by the American Society for Engineering Education (ASEE).

3.14 Harvard Seminar for New Presidents

Harvard University program focuses on critical issues in the first months and years of the presidency, with intensive sessions that address a range of topics, including board governance, fundraising, academic leadership, strategic planning, and lifestyle decisions. The seminar provides a practical orientation to the presidency, familiarizing new presidents with the opportunities and hazards they will likely face and preparing them to respond to multiple responsibilities.

3.15 New initiatives of Ministry of Education, Government of India

The Ministry of Education developed a scheme of Pandit Madan Mohan Malaviya National Mission on Teachers and Teaching (PMMMNMTTNM) in 2015. This scheme offers teacher development programs for all university faculty members. The following are the components of this mission:

- 30 Schools of Education
- 50 Centers of Excellence for Curriculum and Pedagogy
- 5 Centers of Excellence in Science and Mathematics Education
- 25 Teaching Learning Centers
- 20 Faculty Development Centers
- 2 Inter-University Center for Teachers Education
- Subject Networks for Curriculum Renewal and Reforms
- National Resource Center for Education/Higher Education Academy
- 5 Institutes of Academic Leadership and Education Management
- Teaching-learning Centers have started conducting faculty development programs for various branches of arts, science, and engineering. Many engineering colleges are offering engineering faculty development programs under this scheme.

3.16 Global Initiative for Academic Networks (GIAN)

The government of India started Global Initiative for Academic Networks (GIAN) program in November 2015. In 2018, it is proposed to fund joint research projects between the Indian Higher Educational Institutes and the best of Global Universities. Accordingly, the government of India has sanctioned the Scheme for Promotion of Academic and Research Collaboration (SPARC). This promotes global research collaborations. IIT Kharagpur is coordinating this scheme. The outcome of this scheme is quality research papers, suggestions for industry improvement, enhancing the competencies of the faculty members, and creating active cooperation with world-class researchers.

3.17 Indo-US 21st Century Knowledge Initiatives

This has been established by the US Government for cooperation between the Indian faculty members and US universities for joint research, faculty visits, and faculty training.

The Indus Foundation Inc (2011) convened Indo-Global Education Summit, 2009, 2010, and 2011 in Hyderabad.

The Indus Foundation focused on the following collaborations between Indian and Foreign Universities:

- Research Collaborations
- Organizing Certificate, Joint/Dual Degrees
- Twinning and Transfer Programs
- Distance Education Programs
- Faculty Exchange Programs
- Vocational Education Programs
- Partnership Programs
- Study Abroad India Programs
- Collaboration Methodology

400 foreign universities have been identified for collaboration. A large number of CEOs of the

universities attended the summit and exchanged their planning and collaborations.

3.18.1 Synthesis

Most of the global institutes have studied the problem of faculty development and are looking for alternate methods using various advances in electronic delivery. The advances in ICT would help to cover a large number of faculty and they can be trained at a minimum cost.

A hybrid model is envisaged by combining face-to-face discussion as a follow-up to MOOCs. The programs have been planned to train the faculty without any disturbance to them.

Most of the international institutes focus on the globalization of faculty development, curriculum development, and research studies on the return on investment.

The new initiatives like PMMMNMTT, GIAN, and Indo US 21st Century Knowledge initiative would bring innovative faculty development focused on quality and research through global collaboration.

4. Faculty Development Programs of NITTTRs

The following programs and development activities are offered by NITTTRs:

1. Established Extension Centers in all southern states to work closely with the State Directorates of Technical Education and undertaking the following activities:
2. Short-term Faculty Development Courses are based on the professional needs of the teachers to meet the advances in engineering and technology.
3. Long-term programs in M.Tech. and Ph.D.
4. Research projects, assisting the states in planning many Detailed Project Proposals (DPP) for Capacity Development, Quality Improvement through World Bank Assisted Projects, and Direct Central Assistance.
5. Continuously evaluating the curricula against the needs of the fast-growing industries and improving them.

6. Preparing appropriate instructional packages (textbooks, item banks, learning aids, and teacher support materials).
7. Conducting national and international conferences to exchange innovations.
8. Assisting industries and other higher education institutes to develop the executives.
9. Undertaking diverse global executive faculty development programs under various schemes of Government of India and International Development Agencies like Asian Development Bank, GIZ, SIDA, UNDP, UNESCO, USAID, and World Bank (Thanikachalam. V, 2018, 2019).
10. Incorporating MOOCs with face-to-face programs of NITTTR Chennai.
11. Getting Deemed University Status so that many innovative multidisciplinary postgraduate and doctoral programs could be undertaken easily.
12. Provide solutions to engineering institutes through Design Thinking, IoT, and Artificial Intelligence.

4.1 Training Needs Assessment

The Curriculum Development Center of NITTTR Chennai conducts a training needs assessment every year by sending a questionnaire to all the Polytechnic Colleges in the southern region. The professional training needs of the faculty members are assessed every year and presented to the Program Development Committee which consisted of representatives of the Directorates of Technical Education and the Heads of

Table 1 : Training Needs of Entry-Level Faculty Members

Area	Skills and Competencies
Formative and Summative Evaluation of Engineering Curricula	Exposure to Systems Approach (Input, Process, Output, Feedback) , Context - Input-transformation Process - Product (Skilled graduates (CIPP)) Outcome-based Curriculum, Formative Evaluation, Summative Evaluation, Improving the Learning Resources, etc.

Instructional Design	Programs Educational Objective (PEO), Course Outcomes (COs), Project - based Learning (PjBL), courses based on the needs analysis, Pedagogy, Cognitive Competencies, Motor Skills, Attitude, etc.
Measurement and Evaluation	Preparation of Multiple-Choice Items, Matching Items, Fixed Response Items, Short-Answer Items, Final Question Papers based on the Table of Specification, Open Ended Question, etc.
Content Updating	Advances in various courses, Emerging Technologies, Industrial Methods, Analysis, Product Design, Prototype Development, Testing, Improving, etc.
Interdisciplinary Research and Development	Identification of Research Problems, Educational Research Methods, Research Questions, Research Design, Population, Sample Size, Questionnaire Preparation, Getting Feedback Data Collection, Analysis, Inferences, Conclusions, etc.
Consultancy Works in Testing	Planning Consultancy Projects, Testing, Inference, Report Writing, Costing, etc.

the Departments. Around 200 courses are usually selected for further detailed planning and implementation. A set of selected courses for entry-level faculty members, middle-level faculty members, senior faculty members, and CEOs level are presented in Tables- 1, 2, 3, and 4.

The above needs assessment has been used to train and develop faculty members.

4.2 Implementation of In-house Faculty Development Programs

The above courses have been offered through in-house faculty development. The faculty members

have been given all the course materials, power points, and assignments. They can take up the assignments and complete them and post the output to the course faculty for their review and suggestions for improvements. Online courses were offered and contact classes duration was reduced to two days. This mode has saved time and cost. Also, the course material, power points, and the completed assignments could be made as open access material so that the faculty can take them as and when they need. A set of senior faculty members could also be trained in each institute and they can undertake the courses without travel to outstation faculty development institutes. Further, the power points could be presented through webinars. Such arrangements saved time and cost. For each area, train master trainers were trained in each institute. Later, they can plan faculty development programs as in-house courses. A senior professor could be elevated to “Dean-Faculty Development” and he/she can plan many short-term courses based on the needs of the faculty members.

Table 2 : Middle-Level Faculty Members (Associate Professors)

Curriculum Development and Improvement	Training Needs Analysis, Outcome Based Program, Flexible Curriculum, Reverse System Approach, Industry Relevant Courses, etc.
Instructional Materials Development	Production of Various Instructional Materials, Publication, Monographs, MMLP, etc.
Development of Measuring Instruments and Evaluation of Achievement	Case Studies, Item Banks, Research Works, Term Papers, Capstone Projects, Field Investigations, Take Home Examinations, Open book tests, etc.
Continuing Education Program Development	Research-based training materials, Games, Case Studies, Open problems, Analysis, Prototype Development, Maintenance Manuals, etc.
Advancement in the Technology	Emerging Technology, ICT, Sustainable Development, Advances in IT-based design methods, Clean Development Mechanism.

Educational Research and Development	Interdisciplinary Research, Multidisciplinary Research,
Modernization of Labs and Workshops	Modernization Projects, Maintenance, Testing, Periodical Calibration, etc.
Accreditation of Programs	Self- Evaluation Reports, Academic Auditing under NBA, ABET, Effecting Improvements.

4.3 Planning Weekend Faculty Development Courses

An external faculty development institute could commission to offer a series of courses. A set of colleges can form a consortium and the courses can be planned on Saturdays so that the faculty can attend them.

Table 3 : Senior Level Faculty Members (Professors)

Interdisciplinary and multidisciplinary Curriculum	Global Trends, Networked Curriculum, Dual Programs, etc.
Instructional Resources, Production and Publication	Publication, Marketing, Copyright, Translation, Overseas Publication, Royalty,
Examination Reforms, Evaluation of Program Achievement	Internal evaluation, final evaluation, grading, adjudication of theses,
Development New Labs, Production Units,	Modern Equipment, Digital measuring instruments, online data recorders, etc.
Establishment of Consultancy Centers	Dedicated Consultancy Centers, Innovation Units
Leadership Development	Leadership development, Performance evaluation, Appreciative inquires, etc.
Educational Administration	Strategic Planning, Tactical Planning, Perspective Planning Financial Management, Academic Audit, PPBS, HRM, HRD, etc.

Table 4 : CEO Level (Dean/Director/ Principal)

Institutional Development	Development of Educational Ecosystem, Strategic Planning, Industry-Institute- National Labs-Government- Partnership, Networking with the National and International R&D labs, Corporate Universities, AICTE, Alumni Centers, Continuous Improvement in the Curricula, etc.
Creation of Centers of Excellence	Innovation Center, Sponsored Consultancy Projects under IDAs, Incubation units, Startup units, etc.
Higher Education Administration	Faculty Recruitment, Capacity Building, Quality Improvement, Efficiency Improvement, Development of High Performing Teams, Decentralization, Delegation, Faculty Empowerment, Consortium of Engineering Colleges, Financial Management, etc.
Globalization of Engineering Education and Global Networking	Comparative Education, Faculty Exchange, Student Exchange, Joint Research Projects, Joint Consultancy Projects, Peripatetic Seminars, Diverse Global Faculty Development under IDAs, etc.
Faculty Development	In-house Faculty Development, Industry-based Development Workshops and Programs, Training Manuals, Monographs, Newsletters, MMLPs, Videos, etc.
Patents, IP	Licensing to Transnational Companies, SMEs, etc.
Knowledge Transfer	Licensing to SMEs, Companies, International Development Agencies (IDAs),
Internal Revenue Generation	Through Consultancy, Fees, Royalty, Service Charges, Sales of Books, Rent, University Foundation, Donations from Corporates, Alumni, etc.
Planning National and International Conferences	Collaboration with International Universities, IDAs, Planning International Seminars, Conferences and Workshops, etc.

Bidding for Consultancy Projects under IDAs	Directions to prepare Technical Proposal, Financial Proposal, Negotiation, Contracts, Agreements, etc.
Educational Research, Tracer Studies, and Impact Studies	Research Proposals, Longitudinal Studies, Short-term Impact Studies, Long-term Impact Studies, etc.
Establishment of Campus Placement Cell	Linking with the companies, campus placement, follow-up, etc.

4.4 Other Modes of Implementation

The course coordinators are selected based on their expertise. Then venues and dates are selected to suit the participants of all southern states. The Extension Centers in Bangalore, Hyderabad, Kalamassery, and Vijayawada implemented state-specific courses. Additional faculty members are included from the state technical universities and industries wherever needed. The program duration varies from 3 days to 12 days. Also, new courses are planned based on the emerging needs of the State Directorates of Technical Education.

4.4.1 In-House Programs

The Institute also offers many in-house programs based on the requests to meet the faculty development under the ongoing national or state projects. These in-house programs are very economical.

4.4.2 Outcome Assessment

The participants are given questionnaires using Kirkpatrick's four-scale model to evaluate the course content, method of presentation, case studies, demonstrations, educational media used, guest faculty, transfer exercises, guidance for implementation, etc. The outcome is evaluated and courses are updated for replication. Best programs are retained.

4.4.3 Impact of Faculty Development

Colleen Flaherty (2016) stated that faculty development impacted student learning. The Tracer Study (1998) conducted by the institute after completion of World Bank assisted projects in the

southern region proved the high performance of the engineering students. This is due to intensive training of the faculty of the project institutes, curriculum revision, and improving the learning resources.

4.4.4 Continuous Improvement in Planning and Conducting the Faculty Development Programs

Every year the planning process is updated and needed changes are incorporated. Many All -India Programs are introduced based the emerging needs. The following are additional courses offered on preparing Detailed Project Proposals, Capacity Building, Quality Improvements through Overseas Programs under World Bank/UNDP, research studies on alumni, establishing continuing education centers, and establishing consultancy programs.

4.4.5 The Existing Faculty Development Programs are as follows:

- Quality Improvement Programs to offer Master and Doctoral Degree Programs through IITs, NITs, State Technical Universities, and well-performing Autonomous Engineering Colleges and funded by AICTE.
- Summer Schools and Winter Schools are offered by well- established engineering colleges, IITs, NITs, NITTTRs and funded by AICTE either through the Indian Society for Technical Education.
- National Institutes of Technical Teachers Training and Research since 2001.
- World Bank Project assisted projects like Technical Education Quality Improvement Programs (TEQIP I and II).
- Academic Staff Training Colleges (Human Resource Development Units) are attached to universities and funded through University Grants Commission.
- In-house faculty development programs based on the initiatives of the colleges
- Medium-term and long-term training and development programs through bilateral agreements with various developed countries.

4.4.6 Faculty Members Self-Planned Training and Development Programs

Many faculty members plan their training and development programs based on career plans. The colleges can formalize the planning through an annual plan. Some of them are:

- Joining part-time postgraduate (master and doctoral) programs in the nearby institutions which are recognized
- Resigning and joining full-time postgraduate programs in various State Technical Universities, NITs, IISC, IIITs, and IITs
- Resigning and joining foreign universities in the USA, UK, Canada, Australia, and other developed countries.
- Registering on-line MOOCs offered by Coursera, edX, World Bank Institute, IGNOU, SWAYAM, and DEP of various Indian and Foreign universities
- Undergoing short-term workshops under IUCEE, and other conference organizers

4.4.7 Problems in Getting Full-time Faculty Development Programs to Undergo Postgraduate Programs in the existing QIP Institutes

Most of the faculty members could not get admission to enrol in the quality improvement programs offered by various IITs, NITs, State Technical Universities, and Autonomous institutions. The reasons are as follows:

- The number of seats is limited in the QIP institutes.
- The number of faculty members is more in engineering who have joined the teaching profession with a bachelors' degree.
- Most of the administrators of engineering colleges do not forward the applications for QIP due to a shortage of teachers.
- Most of the self-financing institutes terminate the faculty after forwarding their applications under QIP so that they are not liable to pay the salary.
- The stipends are limited to support the family.

- Sometimes the faculty get admission far off institutions which is very difficult for them to move with the family to those cities.
- Hostel accommodations are limited in some institutions.
- Family quarters are rarely available.
- The house rent is very exuberant in many cities.

4.4.8 Outcomes of the Faculty Development

• The engineering curricula are continuously evaluated and improved to meet the emerging needs of the industries.

- State Directorates can establish many new diploma programs to meet the demands of industries.
- The faculty members can undertake challenging programs.
- The State Universities can establish more graduate and postgraduate programs based on the availability of trained faculty members.
- More skilled and competent engineers are readily available for establishing new industrial corridors and hubs.
- More entrepreneurs can emerge in many specializations.
- Many states can attract new industrial initiatives in higher occupations like design and research.
- Many engineering institutes have been turnaround through well-trained and motivated faculty members (Thanikachalam. V., 2018).
- Many polytechnics and engineering colleges can undertake consultancy projects from the industries,
- They can generate internal revenue.

4.4.9 Development Programs for Industries and Government Engineering Departments

The senior faculty members undertook many executive development programs under various

projects of World Bank, UDAID, GIZ, CIDA, etc. These departments fully utilized the expertise of the Institute. The outcomes of training and development resulted in efficiency and effectiveness (Thanikachalam. V, 2017, 2018).

4.4.10 Problems in Undergoing Part-time Programs in Postgraduate Programs

The significant problems faced by the teachers are as follows:

- Workload increases on the faculty members since there is no provision to get additional faculty who can handle the classes during the faculty training period.
- Many institutes do not provide funds for reimbursing the expenditure incurred by the faculty for undergoing the outstation faculty development programs.
- They find it very difficult to undergo many new courses due to limited time available for assignments, tests and laboratory works.
- Sometimes the participants have to travel about 40 kilometers to reach the institutions.
- The desired specialization may not be available in the desired QIP institute.

4.4.11 Planning Hybrid Faculty Development Programs

- To overcome these difficulties, it is proposed to plan- flexible faculty development programs using various modern facilities as follows:
- Planning sequential summer and winter schools to cover the planned courses.
- Developing needed instructional materials, case studies, assignments, test items, and references, and upload them to the institute web for easy downloading by the faculty members.
- Offer needed MOOCs as a part of the program.
- Offer many lectures through webinars.
- Recorded lectures can be included on YouTube for easy access.

- Conduct additional face-to-face presentations during weekends in various cities and towns to clarify doubts.
- Establishment of study centers so that the teacher trainees can get guidance, counselling, coaching, and mentoring.
- Uploading lectures on YouTube and make them available to the teacher trainees.
- Offering the dissertation work through recognized and qualified local faculty guides in various engineering colleges.
- Recognizing industry-based practicums and evaluating the outcome and calculating the credits and marks in consultation with the industrial engineers and managers.
- Recognizing the work done in the workshops, and other faculty training courses offered by the organizers of the national or state seminars and conferences.
- Allotting guides or supervisors to monitor and evaluate the progress and achievement of the teachers who wished to undertake self-planned courses.
- Improving the library resources for the faculty self-planned courses.

4.4.12 Faculty Performance Requirement as per AICTE Regulations of 2019

1. Participating in International Conferences and Workshops
2. Undertaking Consultancy Works
3. Start-up activities
4. Creation of Entrepreneurship
5. Community Services
6. Working in an Industry for six Months
7. Professional Development
8. Teaching Research Fellowship in a Foreign University

9. Quality Improvement Program in a Foreign University

4.4.13 Impact of the Faculty Development Programs on the National Economy

- Multinational companies (MNCs) have expressed the availability of engineering graduates to undertake design, production, and maintenance.
- Many states have established special economic export zones for manufacturing modern products.
- GDP is increasing due to the availability of trained human resources.

4.4.14 Major Short Comings on the Existing Faculty Development Programs:

- Only the top 100 universities/ colleges can alone participate in the GIAN/ SPARC projects.
- The GIAN programs need an in-depth focus on the globalization of engineering education.
- Most of the PMMNMTT institutes need more trained faculty to plan needed high-end programs
- Only well-performing universities can alone plan global research programs or send their faculty members for undertaking joint research projects.
- The faculty training through MOOCs has to be encouraged for undertaking research works and recruitments for high posts.
- The Interdisciplinary and multidisciplinary programs are not focused on the faculty development programs.
- Till now there is no mandate for undergoing the faculty development for the engineering faculty members.
- There is an urgent need for well- planned programs for training the trainers to plan and implement courses under PMMNMTT.

4.4.15 Needed Focus on the Faculty Development for the next five years

- Establishing separate departments in all state technical universities for the development of

faculty members from various types of engineering colleges.

- Focus on the globalization of the engineering curriculum.
- Planning impact studies on the new initiatives.
- Improving the curricula to absorb the digital technology-based design and manufacturing.
- Creating a center for undertaking interdisciplinary research projects.
- Networking with the R&D Departments of industry and national laboratories.

4.4.16 Transition to Meeting the Needs of Industry-4 through Dynamic Curriculum

Josh Bersin, et al. (2017) suggested that successful organizations must be designed for speed, agility, and adaptability to enable them and win in today's global business environment. The following actions are needed:

- Share values and culture
- Create transparent goals and projects
- Ensure free flow of information
- Reward faculty members for their accomplishments and creation of knowledge capital
- Build accountability
- Facilitate faculty learning, innovation, and student impact
- View the institute as an agile network,
- Empower the faculty by team leaders
- Fuel by collaboration and knowledge-sharing
- Base the departments on work and projects,
- Focus teams on research and developments, publications, consultancy to MSMEs, and services to the society

- Facilitate the advancements through global projects, diverse global faculty development, and multifunctional leadership assignments
- Faculty “create followers” to grow in influence and leadership
- Lead by orchestration
- Create a culture of safety, abundance, and importance of risk-taking and innovation
- Eliminate restriction for innovation but focus on the complex problem solving
- Define clear responsibilities for teams, but roles and job titles would change regularly
- Facilitate self-managing teams (Vanessa and Jane, 2004).

5. Conclusion

Engineering curricula have to be based on the in-depth learning needs analysis and NITTTRs are offering assistance to plan industry-relevant courses since 1992.

The faculty development programs are also to be based on the training needs analysis and NITTTRs are offering around 200 courses exclusively of engineering colleges.

Institutes have to plan for preservice training programs, in-house faculty development programs, permitting them to undergo MOOCs, industrial exposure, curriculum development, formative and summative evaluation, instructional packages development, interdisciplinary research programs. NITTTRs are offering one week to four weeks preservice courses based on the requests of the Directorates of Technical Education. The Ministry of Education is funding for implementing research projects with global universities under GIAN/SPARK Scheme. The colleges could plan developing consultancy projects for industries and internal revenue generation as envisaged by TEQIP I and II.

The faculty development programs under MMMNMTT may accommodate a large number of engineering faculty members.

Hence, innovative hybrid faculty development

programs are suggested with MOOCs which are developed through the SWAYAM scheme of the Ministry Education. It is composed of various successful components and integrated into a new model. This model can be implemented as a pilot program and later refined to suit the faculty members. NITTTRs have become the Associated Center of UNESCO's Asia and Pacific Educational Innovation for Development (APEID). They also conduct around 10 to 15 international faculty development programs which are sponsored by the Ministry of External Affairs and Ministry of Finance since 1982. The faculty members could be included in these programs to get an experience of working with a diverse global faculty member.

Such a radical method would meet the high demands from the engineering faculty members to plan global programs and network with foreign universities. Further research is required to modernize the engineering programs to meet the challenges of Industry-4.0

References

- [1] All India Council for Technical Education. (1st March 2019). Notification: AICTE Regulations on Pay Scales, Service Conditions and Minimum Qualifications for the Appointment of Teachers and other Academic Staff such as Library, Physical Education and Training & Placement Personnel in Technical Institutions and the Maintenance of Standards in Technical Education- (Degree) Regulation, 2019, The Gazette of India: Extraordinary, Part III, Sec: 4
- [2] Altbash P.G and Salmi J (eds). (2011). The Road to Academic Excellence: The Making of World-Class Research Universities, World Bank Publications: Washington DC.
- [3] AICTE. (2018). Scheme for Promotion of Academic and Research Collaboration (SPARC), Retrieved From <https://www.aicte-india>
- [4] Andres Antonio Alonso. (2017). Harvard Institute for Superintendents and District Leaders, Retrieved from <https://www.gse.harvard.edu/ppe/harvard-institute-superintendents-and-district-leaders-interest-form>.
- [5] Asian Development Bank. (2010). Regional Workshop on Higher Education Faculty Development, Asian Development Bank: Manila, Philippines
- [6] Asian Development Bank. (2011). Improving Instructional Quality- Focus on Faculty Development, Manila, Philippines
- [7] Bland CJ, et al. (1990.) Successful Faculty in Academic Medicine: Essential Skills and how to acquire them? New York: Springer Publishing Company.
- [8] Centra J. A. (1978). Types of Faculty Development Programs, Journal of Higher Education, 49: 151-62
- [9] Cole K A, et al. (2004). Faculty development in teaching skills: An intensive longitudinal model, Acad. Med, 79:469-80.
- [10] Colleen Flaherty (2016). New Study suggests that faculty development has a demonstrable impact on student learning, Inside Higher Ed, Retrieved from <https://www.insidehigher.com/news/2016/02/10/new-study-suggests-faculty-development-has-demonstrable-impact-student-learning>.
- [11] Cook C E, and Kaplan. M. (2011). Advancing the Culture of Teaching on Campus: How a Teaching Center Can Make a Difference, Sterling VA: Stylus Publishing.
- [12] Dee Fink. L. (2013). The Current Status of Faculty Development Internationally, IJSoTTL, 7 (2) Art. 4 , Retrieved From : <https://doi.org/10.20429/ijstotL.2013.07024>
- [13] Davis G, Foley B J et al. (2003.) Creating a comprehensive faculty development program. Journal of Faculty Development. 19(1) 19-28
- [14] Department of Higher Education, Ministry of Human Resource Development. (2015). Scheme of Pandit Madan Mohan Malaviya National Mission on Teachers and Teaching (PMMMNTT).
- [15] Eric Aikens, et al. (2005). Faculty Development Continuous Improvement Plan for Inclusive Excellence, Miami University Coordinating

Council, Miami University, Oxford, Ohio, USA.

- [16] European University Association. (2008). Implementing and Using Quality Assurance Strategy and Practice- A Selection of Papers from the 2nd European Quality Assurance Forum. University of Rome, Italy.
- [17] Erkelenz-Watts M, Westbay T, Lynd-Balta. E. (2006). An alternative professional development program: lessons learned. *College Teaching*. 54(3): 275-279.
- [18] Finelli C J, et al. (2008). Utilizing Instructional Consultations to enhance the teaching performance of engineering faculty, *Journal of Engineering Education*. 97(4): 397-411.
- [19] Froyd J., Fowler, D., Layne, J., Simpson, N. (2005). Frameworks for Faculty Development. 35th ASEE/ISEE Frontiers in Education Conference, S3E:23-28.
- [20] Asian Develop Bank. (2013). *Innovative Asia: Advancing the Knowledge-Based Economy*, Manila, Philippines.
- [21] Fulbright Tries Out Short-Term Fellowships, *Chronicle of Higher Education*, October 28, 2012.
- [22] Gillespie K H, Hilsen L R, and Wadaworth E C. (2002). *A Guide to a Faculty Development: Practical Advice, Examples, and Resources*. Boston, MA: Anker Publishing Company Inc.
- [23] Glowacki- Dudka M and Brown, M P. (2007). Professional development through faculty learning communities. 21(1-2): 29-39.
- [24] Guglielmo B J et al. (2011). A Critical appraisal of and recommendations of a faculty development program for pharmacy practice faculty, *Pharmacotherapy*. 29(1) :127 Harvard Seminar for New Presidents. (2018). Retrieved from: <https://www.gse.harvard.edu/ppe/harvard-seminar-new-presidents-interest-form>
- [25] Indo Universal Collaboration on Engineering Education, Retrieved from <http://iuciee.org>
- [26] Indo-U.S. 21st Century Knowledge Initiatives, Retrieved from <http://www.usief.org.in>.
- [27] James Jacob. J., Weiyan Xiong, and Huiyuan Ye. (2015). *Professional Development Programs at World-Class Universities*, Palgrave Communications, 27 July 2015, retrieved from <https://www.nature.com/articles/palcomms20152.pdf>
- [28] Johan Malmqvist, Svante Gunnarsson, and Martin E. Vigild. (2008). *Faculty Professional Competence Development Programs- Comparing Approaches from three universities*, Proceeding of the fourth International CDIO Conference, Hooe School Gent, Belgium, June 16-19, 2008.
- [29] Jason W. Lancaster et al. (2014). *Faculty Development Program Models to Advance Teaching and Learning within Health Science Programs*. *American Journal of Pharmaceutical Education*. 78(5): 99.
- [30] Josh Bersin, Tiffany McDowell, Amir Rahnema, Yves Van Durme. (2017). *Organization of the future: Arriving now 2017 Global Human Capital Trends*, <https://dupress.deloitte.com/dup-us-en/focus/human-capital-trends/2017/the-organization-of-the-future>
- [31] Julia E King. (2007). [Chair Person] *Educating Engineers for the 21st Century*, The Royal Academy of Engineering, London
- [32] Kamf, Aldert. (2016). *Engineering Education in the Rapidly Changing World, Rethinking the Vision for Higher Engineering Education*, Delft University of Technology, The Netherlands
- [33] Kavita Bhatnagar, Kalpana Srivastava, and Amarjit. (2010). Is faculty development critical to enhancing teaching effectiveness? *Industrial Psychiatry Journal*. 19(2): 138-141.
- [34] Kirk Ingold. (2008). *Faculty Development*, Center for Teaching Excellence, United States Military Academy, West Point, NY
- [35] Kirkpatrick DL. (1997). *Evaluating Training Programs: four levels*, San Francisco: Berrett-Koehler Publishers.
- [36] Leonie Siok Yoong Lee, (Ed). (2011). *Affiliated Colleges in South Asia: Is Quality Expansion*

- Possible? South Asia Human Development Sector, Report No. 7, Discussion Paper Series, World Bank, Washington, USA
- [37] Lynne Heshop. (2014). Understanding India: The Future of Higher Education and opportunities for International Cooperation, British Council, United Kingdom
- [38] Mahmoud Abdulwahed. (2017). Technology Innovation and Engineering Education and Entrepreneurship in Engineering Schools: Novel Model for Elevating National Knowledge-Based Economy and Socio-Economic Sustainable Development, Sustainability, 2017, 9, 171; Retrieved from doi:10.3360/su9020171
- [39] Manuela Brusoni, et al. (2014). The Concept of Excellence in Higher Education, European Association for Quality Assurance in Higher Education, Brussels, Belgium. Retrieved from <http://www.enqa.eu/index.php/publications/>
- [40] The effectiveness of a faculty training program: Long-term and Institutional Impact. International Journal of Academic Development. 12(2): 99-109.
- [41] Mills, J.E and Treagust, D.E. (2003). Engineering Education- Is Problem-Based or Project-Based Learning the Answer? Australian Journal of Engineering Education, 3, 205-207.
- [42] National Institute of Technical Teachers Training and Research, Bhopal, Chandigarh, Chennai, and Kolkata www.nitttrbpl.ac.in , www.nitttrchd.ac.in www.nitttrc.ac.in , www.nitttrkol.ac.in,
- [43] Ole Vinther and Anette Kolmos. (2002). National Strategies for Staff and Faculty Development in Engineering Education in Denmark, Global Journal of Engineering Education, Vol. 6., No. 2, p 161-166.
- [44] Patil.A. and Codner. G. (2007). Accreditation of engineering education: Review, observations, and proposal for global accreditation. European Journal of Engineering Education, 32, 639-651.
- [45] Rebecca Brent and Richard M. Felder. (2003). A Model for Engineering Faculty Development, International Journal of Engineering Education, 19(2), 234-240
- [46] Robin Matross Helms and Alegneta Asfaw. (2019). Internationalization in Action: Engaging Faculty in Internationalization, Part 2, American Council on Education. Retrieved from <https://www.acent.edu/news-room/Intlz-in-Action-2013-June.aspx>.
- [47] Ronald R Ulseth. (2011). A New Model of Project-based Learning in Engineering Education, AC2011-1199 American Society for Engineering Education, p 22.78-2011.
- [48] Scheme for Promotion of Academic and Research Collaboration (SPARC), Department of Higher Education, Ministry of Human Resource Development, Government of India, Shastri Bhavan, New Delhi.
- [49] South Asia Institute (SAI), Harvard University. (2017). A Multidisciplinary Approach to University Leader Development Workshop, Retrieved from <http://southasiainstitute-harvard.edu/events/faculty/vish-viswanathan/>
- [50] Thanikachalam. V. (2013). Radical Innovations in the Technical Education, Organization of American States, Washington DC, USA
- [51] Thanikachalam. V. (2017). Research Cluster in Engineering and Human Resource Development, 4th ICTIEE, Manipal University, Jaipur, <http://www.iucee.org/>
- [52] Thanikachalam. V. (2018). Enhancing Interdisciplinary Research in Engineering Education (IRDEE), 5TH ICTIEE, Theyagaraja College of Engineering, Madurai, Retrieved from <http://www.iucee.org/>
- [53] Thanikachalam. V. (2018). Educational Management Ecosystem for Facilitating the Development of Professional Competence of CEOs. In Higher Education Institutes. 5th ICTIEE, Theyagarajar College of Engineering, Madurai, Retrieved from <http://www.iucee.org/>
- [54] Thanikachalam. V. (2018). Academic Excellence through Improved Ecosystem and Faculty Development, 5th ICTIEE, Theyagarajar College of Engineering, Madurai,

Retrieved from <http://www.iucee.org/>

Sloan: Management Review

- [55] Thanikachalam. V. (2018). Performance Management and Turnaround Mechanism of Poorly Performing Institutes, 5th ICTIEE, Theyagarajar College of Engineering, Madurai, Retrieved from <http://www.iucee.org/>
- [56] Thanikachalam. V. (2019). Contribution to Diverse Engineering Faculty and to South Asian Regional Development, 6th ICTIEE, Malla Reddy Engineering College, Hyderabad, Retrieved From <http://www.iucee.org/>
- [57] The Indus Foundation INC. (2011). Collaborations with foreign Universities, New Jersey, the USA, Retrieved from <http://www.indus.org/>
- [58] Tracer Study on Technician Alumni (1998) Research Report based on the World Bank assisted Project, TECHED I and II.
- [59] UNESCO. (2014). Higher Education in Asia: Expanding Out, Expanding Up UNESCO Institute of Statistics, Montreal, Canada.
- [60] Vanessa Urch Druskat and Jane V Wheeler. (2004). How to lead a self-managing team, MIT
- [61] Wilkerson L, Irby D. M. (1998). Strategies for improving practices: A comprehensive approach to faculty development. Acad. Med. 73: 387-96.
- [62] 62.Yojana Sharma. (2012). 1000 Chinese University Leaders Receive ‘Upgrade’ Training abroad in Australia, Britain, Germany, and the USA, University World News, Global Edition Issue 251, Retrieved from <http://www.universityworldnews.com/article.php?story=20121207101739560&mode=print>

Short CV of the Author:

Thanikachalam Vedhathiri B.E. (1968, Civil Engineering, Univ. of Madras), M. Tech. (1970, Soil Mechanics and Foundation Engineering, IIT Madras), Ph.D. (1975, Filter Design for Earth and Rockfill Dams, Univ. of Madras), M.S (1988, Instruction Systems Technology, Indiana University, Bloomington, Indiana State, USA), FIE, FIGS, FFIUCEE and the Senior Researcher under Fulbright Scheme of USA. Guided 18 Ph.D. scholars in the Interdisciplinary Engineering Education and the founder professor of M. Tech. (HRD) program and the founder of Diverse Global Engineering Faculty Development Programs.

Practical Implementation of Outcome-Based Education Practices in the Indian Engineering Institutes – An Objective Approach Based Investigation

Ritesh Bhat¹, C. Raghavendra Kamath², Kevin Amith Mathias³, Prashant Mulimani⁴

^{1,2 & 3}Department of Mechanical and Industrial Manufacturing Engineering, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, India 576104

¹ritesh.bhat@manipal.edu

Abstract: Outcome-based education (OBE) by Washington Accord (WA) promises to improve the technical education system by clarifying expectations for students and focussing assessment on specific learning outcomes for better measurement of student achievements. Numerous publications describe the process and results of OBE implementation in India. This article is a meta-analysis of research articles documenting the OBE efforts made by Indian engineering institutes. The study implements the established objective approached based reviewing technique. A rubric comprising seven distinct measurements was applied to assess critically selected articles. The detailed assessment indicates that there is a lack of empirical validation of the results obtained by the researchers. The papers were also found to lack a consistent understanding of CO-PO mapping. Hence, there is a clear research gap of statistical validation of the results using pre and post-implementation data for a given improvement.

Keywords: Education; Engineering; Outcome-based education; Students; Undergraduates

1. Introduction

Technical education in India contributes a significant share to the overall education system. In addition to the technical knowledge through the courses, it deals with the socio-economic development of our nation. The employability of engineering graduates is a major issue in India. One factor is the incapability of the graduates to apply their knowledge to problems requiring higher-order thinking skills. Additional factors include ineffective academic curriculum, lack of qualified faculties and inefficient conventional teaching-learning techniques (Misra and Khurana, 2017; Sahoo and Das, 2019). Outcome-Based Education (OBE), required for accreditation by the Washington Accord, promises to improve the technical education system by improving the standards of the mentioned critical factors. The Washington Accord was initially established between six countries to recognise equivalencies across the accrediting process and measure the process. Since its formation in 1989, other countries, including India, have joined the accord, summing the total members to be 25 at present (Kootsookos et al., 2017). This major problem of declining employability ratio and the need for improvement in the quality of engineers at the grassroots level necessitates the in-depth exploration and implementation of effective OBE. To date, no systematic review of engineering education research papers on the process and quantitative assessments of OBE.

Ritesh Bhat¹

¹ritesh.bhat@manipal.edu

Department of Mechanical and Industrial Manufacturing Engineering, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, India 576104

The prime focus of this systematic review article is to evaluate and synthesise the best available empirical evidence of implemented OBE approaches on the competencies of Indian engineering students. The review findings aim to add strong empirical evidence of implementing OBE approaches while supporting their adoption to improve the quality of Indian next-generation engineers.

2. Review Methodology

2.1 Search strategy

The systematic review using the objective approach for searching proves a superior search strategy to the most commonly used conceptual approach for reviewing (Hausner et al., 2015). Most popular electronic databases: Science Direct, Springer, Web of Science, Google Scholar and IEEE is used for identifying relevant studies. However, they are limited to articles published from 2009 to 2019. The literature search is accomplished using the search terms “outcome-based education” AND “Engineering curriculum.” The said terms represent the methodology of obtaining the initial development set (Hausner et al., 2015). The comparator set is later searched by breaking down the review questions into concepts of interest. This objective approach of reviewing aims to answer the question: can the proficiency of the Indian Engineering students be improved by replacing the traditional educational approaches with the OBE approaches in the engineering education system? The review question framed follows the PICO clauses: Population (Indian Engineering undergraduates), Intervention (outcome-based education approaches), Comparison (traditional engineering education approaches), Outcome (improved competencies of undergraduate engineering students).

2.2 The inclusive and exclusive part of the review-study

The comprehensive investigation that meets the following criteria is retrieved and evaluated for its methodological quality.

- Peer-reviewed articles related to engineering education/programs/courses and engineering graduate students;
- Outcome-based education and project-based learning approaches;

- Observational or empirical data or observation of the PBL/OBE approach;
- Effects of OBE approach on the competency of the Indian engineering students.

The following are not part of the current study:

- Investigative works that do not assess the effectiveness of the OBE approach in engineering education;
- or a post-graduate and a higher level of technical education because of the difference in the skill sets evaluated;
- or investigations with incomplete documentation.

2.3 Screening and assortment of the reviewed articles

The initial search resulted in $358-68=290$ potential relevant published peer-reviewed articles through the selected database searching. The remaining 290 papers were initially screened by title, and 186 documents were removed.

In the next stage, screening 104 articles for abstract led to the exclusion of 63 articles. The final screening stage comprised a detailed full-text review of the remaining 41 articles concerning all the earlier stated inclusion criteria. This stage resulted in rejecting 29 articles. The elimination of the articles at this stage was the lack of comparative validation, lack of quantitative results, and vague selection of the population.

Certain individual cases of articles were close enough to get included but rejected due to minor concerns. For example, In one of the discarded articles in the final stage, the authors (Padma and Sridhar, 2015) implanted the mini-project based learning component of OBE. They validated the results in the best possible manner. The article faced rejection because the population selected for the studies were the post-graduate students, and the methodology adopted was to improve the skill set of the undergraduate level. Another rejected article focussed on faculty readiness for the implementation of project-based learning. Though the article comprised a structured questionnaire, the authors (Srinivasa, Niranjana and Shrinivasa Rao, 2018) failed to validate the findings. Only two articles were based on empirical research in OBE in engineering education, which was also rejected.

Authors (Mandal and Banerjee, 2012) conducted an empirical analysis based on the OBE system in engineering education to identify the gap between the industrial requirement and educators provision. The article failed to show any implementation of the gap-filler and validation. Authors (Waychal, 2016) presented empirical research in his article that investigates an engineering student's utilisation of available study resources. Though the article provides a conclusion on the highest preferred study resources by the students in the modern era, it fails to show the interrelationship between them and the student learning outcome. The present work is limited to the final nine articles because there is a scarcity in the availability of the relevant studies.

3. An Overview

The nine critically reviewed articles published between 2009 and 2019 include investigations of Indian engineering institutes. Authors (Pulavarthi et al., 2017; Rout, Mishra and Routray, 2018) focused on implementing project-based learning in one of the laboratory courses to improve student learning outcome attainment. The indirect and direct assessment of the courses and program outcomes indicated an excellent level of outcome attainment by the selected student population. Authors (Dhulavvagol et al., 2015; Kanmani, Shreenivas and Prasanna Kumar, 2016; Naragund et al., 2016) aimed to implement the OBE system by introducing open-ended experiments cultivating an inquiry-based learning environment in one laboratory course. The result of the implementation proved to enhance the learning skills, and the same was evident from the improvements in the grades. Author (Indiramma, 2015) implemented the OBE system in the form of project-based learning in one of the theory courses in the program. The improvement in the grades indicated the validation of the implementation. Author (Pushpavathi, 2015), in her study related to the implementation of the OBE system, slightly modified the course learning outcome and added additional elements to one of the courses without affecting its essence. The implementation improved the attainment level of the student learning outcome. Authors (Kumar, Garimella and Nalla, 2015) investigated the method of inculcating higher-order thinking in engineering students. The article provides a good guideline with validated results on implementing OBE in institutes that do not possess the autonomy to change the curriculum. Authors (Misra and Priyadarshini, 2018) applied OBE in their

program by involving the stakeholder's feedback to design the curriculum.

The pre and post-test survey results obtained from students enrolled in the program validated the effect of new implementation on the student's learning acceptable behaviour. The nine articles critically reviewed in this paper have addressed various causes and effects of OBE system implementation. Hence, the results cannot be used for meta-analysis. Author (Pushpavathi, 2015) dealt with the OBE system implementation in the program core course titled "Digital Switching System", handled in the 5th semester of the Telecommunication Engineering Program at BMSCE Bangalore, India. The study population included two cohorts with 60 students in each cohort. In her study, the author (Indiramma, 2015) involved 63 students of Computer Science and Engineering Program at BMSCE, Bangalore, India and evaluated the implementation of the OBE system in the 4th-semester program core course titled "Theoretical Foundation of Computation." Authors (Naragund et al., 2016) considered the laboratory course titled "Scripting Lab" for the 3rd-semester students of Computer Science and Engineering students at BVBCET (now known as KLE Tech SoCSE) for the OBE system implementation. The study population, in this case, was 11 students.

Authors (Rout, Mishra and Routray, 2018) addressed the need for OBE system implementation. Their study involved the selected interested students of the 8th semester of engineering who participated in the final year project. The chosen student population counted ten and belonged to the Department of Electrical Engineering Program at IIIT Bhubaneswar, India. Authors (Pulavarthi et al., 2017) from the Department of Electrical Engineering, RIT, Sangli, India, implemented the OBE system in the laboratory course titled "Automation and Control Lab." The student population selected for the studies were of final year and numbered 60. Authors (Misra and Priyadarshini, 2018) implemented the OBE system in the Information Technology program, CVRCE, Bhubaneswar, India. The study compared four cohorts of undergraduate batches with 180 students in each group. The study was based on the complete change in curriculum structure based on the stakeholder's feedback. Authors (Kumar, Garimella and Nalla, 2015) from NMREC, Hyderabad, India, implemented the OBE system to gauge its effect on employability through in-campus recruitments. The study included a comparison of two consecutive cohorts. It involved

many students as the population from two successive admitting groups from four different programs. Authors (Kanmani, Shreenivas and Prasanna Kumar, 2016) from Telecommunication Engineering, BMSCE, Bangalore, India, investigated the effect of OBE implementation by considering the third-semester students numbering 68. Authors (Dhulavvagol et al., 2015) examined the impact of OBE system implementation by applying the change in curriculum. The study included a large student population from 3 cohorts of the Information Science Engineering Program at BVBCET (now known as KLE TechSoCSE).

Since the selected nine articles employ a quantitative approach, the present study uses the criteria established by authors (Bryman, Becker and Sempik, 2008) for assessing their quality. Validity, reliability, replicability, generalizability, explicitness, transparency in the methodology, congruency to the research question and significance of the findings are the categories for assessing the articles. The maximum point of each element is 10. The total point of assessment sums up to 80. Each article's summarised score equals the ratio of the summation of marks obtained for the eight factors to the maximum point. The article inclusion encompasses the cut-off point decided by all the authors of this article in agreement. A minimum quality score (QS) of 40.0, referring to 50% of the total possible maximum score, is mandatory to include the article for the critical review. The articles with QS ranging between 40.0 to 49.0 are the least significant. The peer-reviewed articles with the QS ranging between 50.0 - 74.9 make it moderate significance. The article with QS greater or equal to 75.0 is termed to have a critical finding incorporating potential study. The form used for evaluating the paper is shown in Table 1.

Table 1: Reviewer form used by authors to review the articles

CRITERIA	P1	P2	P3	P4	P5	P6	P7	P8	P9
Validity (10)									
Reliability (10)									
Replicability (10)									
Generalizability (10)									
Explicitness (10)									
Transparency (10)									
Congruency (10)	Can the proficiency of the Indian Engineering students be improved by replacing the traditional educational system with the OBE system?								
The significance of the study (10)									

4. Results and Discussion

Table 2 gives the consolidated evaluation of all the nine articles regarding the four authors' eight factors. The critical remarks on each of the selected nine articles by each of the authors of the present article are consolidated and given in Table 3.

Table 2 : Evaluation of The Selected Nine Articles

Author #	Article Code								
	P1	P2	P3	P4	P5	P6	P7	P8	P9
Author 1	59	53	70	59	70	59	56	42	72
Author 2	57	55	68	54	66	58	44	40	67
Author 3	55	54	72	56	68	55	48	36	70
Author 4	58	55	66	55	71	60	49	40	69
Average	57	54	69	56	69	58	49	40	70

The systematic review conducted using the objective approach indicates that though several articles exist in the worldwide database, none of them directly and explicitly describe the efficacy of outcome-based education on the proficiencies of Indian engineering students. The nine assorted articles from the lot of 358 articles, when critically reviewed, indicated that none of them qualified to be an article incorporating potential study. Table 2 shows that two of the nine articles chosen are of least significance and the rest are of moderate importance. As shown in Table 3, data mining indicates that none of the articles provides a direct and clear empirical validation of the OBE implementation. The results are mainly subjective, and reliability is questionable in most cases. The authors have failed to give a statistical comparison of the pre and post-implementation of the respectively selected tool of OBE.

In most of the articles, there is no mention of the course and program outcome. The response result considered is the grade and placement ratio, which are also affected by certain external factors like the quality of students and the number of companies coming for placement, etc. Though few authors have attempted to deal with the learning outcome, it is found that the mapping of CO to PO is not direct and explicit and hence the OBE implementation is inappropriate. Another point that could be inferred is that the project-based learning and open-ended laboratory components of OBE have been focused on the majority of the articles. Since it mainly addresses the student's psychomotor and affective components, the dynamic enhancement of the knowledge component remains unaddressed.

Table 3 : Details of The Reviewed Articles

Article Code	Title	Details
P1	“Defining course outcomes for digital switching systems: An Example.”	IEEE conference, (Pushpavathi, 2015) (BMS Bangalore)
	Appreciations: Inclusion of seminar as a part of the assessment and expert talks	Critical Remarks: 1. No empirical validation 2. No direct and explicit mapping of COs and POs. Hence inappropriate implementation of OBE.
P2	“Project-based learning- Theoretical Foundation of computation course.”	IEEE conference, (Indiramma, 2015) (BMS Bangalore)
	Appreciations: PBL study is praiseworthy.	Critical Remarks: 1. No empirical validation 2. The only validation is based on the survey; hence, the results are unreliable. 3. The criteria determining the improvement is subjective.
P3	“Enabling higher order thinking and technical communication – An Indian context for OBE.”	IEEE conference, (Kumar, Garimella and Nalla, 2015) NMR Engg, Hyderabad
	Appreciations: Overall, excellent work is done.	Critical Remarks: 1. The sustainability of the study is questionable. 2. The work shows improvement in placing two out of the five selected programs. The external factors like the requirement of the companies, the number of companies, etc., are not considered. 3. No empirical validation.
P4	“Development of an Internet of Things (IoT) based Introductory Laboratory for Under Graduate Engineering Students.”	IEEE conference, (Rout, Mishra and Routray, 2018) IIIT Bhubaneswar
	Appreciations: An excellent way to measure the outcome of lab-based on a survey	Critical Remarks: 1. No empirical validation 2. The criteria determining the improvement is subjective. 3. No comparison between the pre and post-implementation conditions.
P5	Implementation of Course-Mini Project (CMP) in core laboratory course for the attainment of PO in OBE	JEET 2017, (Pulavarthi <i>et al.</i> , 2017) Sangli, Maharashtra
	Appreciations: Both direct and indirect method is used to assess the OBE implementation.	Critical Remarks: 1. No empirical validation 2. No direct and explicit mapping of COs and POs. Hence inappropriate implementation of OBE. 3. No comparison between the pre and post-implementation conditions.
P6	Experimental Learning in Scripting Languages Laboratory	IEEE 2015, (Naragund <i>et al.</i> , 2016) BVB Hubli
	Appreciations: Good work	Critical Remarks: 1. No empirical validation 2. No comparison between the pre and post-implementation conditions.
P7	“Enquiry-based approach for Enhanced Learning in DBA Laboratory: A Case Study.”	JEET 2015 BVBCET
	Appreciations: Unlike in Paper 6(P6), the comparison is given here.	Critical Remarks: 1. No empirical validation 2. The result graphs are inappropriately represented, and data cannot be interpreted. 3. No clarity between the cohorts compared.

P8	Introducing a ‘Modern Tool’ in Engineering Education: An Example	IEEE 2015. BMS Bangalore
		Critical Remarks: 1. No empirical validation 2. No comparison between the pre and post-implementation conditions. 3. The study cannot be generalised and lacks transparency.
P9	Stakeholder Feedback System for Curriculum Design and Improvement-A Case Study	JEET 2018 CV Raman, Bhubaneswar
	Appreciations: Overall, excellent work is done.	Critical Remarks: 1. No empirical validation 2. The only validation is based on the survey; hence, the results are unreliable.

5. Conclusion

An objective approach based systematic review is conducted to investigate the practical implementation of outcome-based education practices in the Indian engineering institutes. The standard database is searched for the peer-reviewed articles published between 2009 and 2019. The Mendeley reference manager is effectively used to sort and filter the articles. After several phases of rejections, nine relevant articles were selected from the first lot of 358 articles.

This article depicts that there is a lack of empirical validation of the results obtained by the researchers. The review also shows a lack of understanding amongst the researchers about the appropriate CO-PO mapping. The systematic review indicates a clear research gap of statistical validation of the results by using pre and post-implementation data for a given improvement. The study also shows a need for training the faculty to comprehend the student learning outcome mapping. The proposition: can the proficiency of the Indian Engineering students be improved by replacing the traditional educational approaches with the OBE approaches in the engineering education system? remains unanswered due to the lack of empirical validation. Thus it can be considered as a potential explorative investigation.

Declaration:

The authors received no financial support for this article's research, authorship, or publication. The authors also declare that there is no conflict of interest.

References

- [1] Bryman, A., Becker, S. and Sempik, J. (2008) ‘Quality criteria for quantitative, qualitative and mixed methods research: A view from social policy’, *International Journal of Social Research Methodology*, 11(4), pp. 261–276. doi: 10.1080/13645570701401644.
- [2] Dhulavvagol, P. M. et al. (2015) ‘Enquiry Based Approach for Enhanced Learning in DBA Laboratory: A Case Study’, *Journal of Engineering Education Transformations*, 29(2), p. 77. doi: 10.16920/jeet/2015/v29i2/83067.
- [3] Hausner, E. et al. (2015) ‘Development of search strategies for systematic reviews: Validation showed the noninferiority of the objective approach’, *Journal of Clinical Epidemiology*, 68(2), pp. 191–199. doi: 10.1016/j.jclinepi.2014.09.016.
- [4] Indiramma, M. (2015) ‘Project based learning - Theoretical foundation of computation course’, in *Proceedings of 2014 International Conference on Interactive Collaborative Learning, ICL 2014*. IEEE, pp. 841–844. doi: 10.1109/ICL.2014.7017882.
- [5] Kanmani, B., Shreenivas, B. and Prasanna Kumar, M. K. (2016) ‘Introducing a “Modern Tool” in engineering education: An example’, *Proceedings of the 2015 IEEE 3rd International Conference on MOOCs, Innovation and Technology in Education, MITE 2015*, pp. 388–391. doi: 10.1109/MITE.2015.7375350.

- [6] Kootsookos, A. et al. (2017) 'Offshore Engineering Education: Assuring Quality Through Dual Accreditation', *Energy Procedia*, 110, pp. 537–542. doi: 10.1016/j.egypro.2017.03.181.
- [7] Kumar, M. N., Garimella, U. and Nalla, D. (2015) 'Enabling higher order thinking and technical communication - An Indian context for OBE', *Proceedings - Frontiers in Education Conference, FIE, 2015-Febru(February)*. doi: 10.1109/FIE.2014.7044020.
- [8] Mandal, K. and Banerjee, C. K. (2012) 'In Search of Performance Gap of education service providers : An Empirical analysis based on engineering education sector of West Bengal', *ipedr.com*, 32, pp. 26–33.
- [9] Misra, R. K. and Khurana, K. (2017) 'Employability Skills among Information Technology Professionals: A Literature Review', *Procedia Computer Science*, 122, pp. 63–70. doi: 10.1016/j.procs.2017.11.342.
- [10] Misra, R. and Priyadarshini, R. (2018) 'Stakeholder feedback system for curriculum design and improvement – A case study', *Journal of Engineering Education Transformations*, 2018 (Special Issue). doi: 10.16920/jeet/2018/v0i0/120913.
- [11] Naragund, J. G. et al. (2016) 'Experimental learning in Scripting Languages laboratory', *Proceedings of the 2015 IEEE 3rd International Conference on MOOCs, Innovation and Technology in Education, MITE 2015*, pp. 213–218. doi: 10.1109/MITE.2015.7375317.
- [12] Padma, M. C. and Sridhar, V. (2015) 'Integrating Mini Project Based Learning Approach in Teaching-Learning Process', *Journal of Engineering Education Transformations*, 0(0), p. 270. doi: 10.16920/ijerit/2015/v0i0/59739.
- [13] Pulavarthi, V. et al. (2017) 'Implementation of Course-Mini Project (CMP) in Core Laboratory Course for the Attainment of Program Outcomes in Outcome Based Education', *Journal of Engineering Education Transformations*, 2, 30(3).
- [14] Pushpavathi, K. P. (2015) 'Defining course outcomes for digital switching systems: An example', *Proceedings of the 2014 IEEE International Conference on MOOCs, Innovation and Technology in Education, IEEE MITE 2014*, pp. 223–226. doi: 10.1109/MITE.2014.7020276.
- [15] Rout, K. K., Mishra, S. and Routray, A. (2018) 'Development of an Internet of Things (IoT) Based Introductory Laboratory for Under Graduate Engineering Students', in *Proceedings - 2017 International Conference on Information Technology, ICIT 2017. IEEE*, pp. 113–118. doi: 10.1109/ICIT.2017.22.
- [16] Sahoo, P. and Das, S. K. (2019) 'Manufacturing Engineering Education—Indian Perspective', in *Manufacturing Engineering Education*. Elsevier, pp. 31–72. doi: 10.1016/b978-0-08-101247-5.00002-2.
- [17] Srinivasa, P. P., Niranjana, N. C. and Shrinivasa Rao, B. R. (2018) 'Project-based learning (Pbl): Issues faced by faculty for its effective implementation', *Journal of Engineering Education Transformations*, 31(3), pp. 9–16. doi: 10.16920/jeet/2018/v31i3/120743.
- [18] Waychal, P. K. (2016) 'Analysing usage of various study resources by engineering students', *ASEE Annual Conference and Exposition, Conference Proceedings*, 2016-June. doi: 10.18260/p.26248.

Perceiving the Suitability of Adopting Problem Based Learning Pedagogy for Technical Education Entrants

Vaishnavi Dabir¹, Anjali Kulkarni², Kanchan Khare³

^{1,2} Assistant Professor, Department of Civil Engineering, Symbiosis Institute of Technology, Symbiosis International (Deemed University), Lavale Pune, India

³ Professor, Department of Civil Engineering, Symbiosis Institute of Technology, Symbiosis International (Deemed University), Lavale Pune, India

¹ vaishnavi.dabir@sitpune.edu.in

² anjali.kulkarni2812@gmail.com

³ headcivil@sitpune.edu.in

Abstract: During campus Interviews, the student's cognition is the Employers desideratum. They have incertitude regarding the same due to the scholastic system which is exam-oriented. It thus is an obligation on the teacher's part to ascertain that students get more proactive during the classroom sessions. Problem-based learning (PBL) could be an effective alternative tool for boosting their interest and involvement in technical education. As Symbiosis Institute of Technology is an autonomous body, the freedom of adopting a different teaching method was used. In this study, the first week of the academic semester was converted into a week full of PBL activities instead of regular classes on a cohort of students from diverse background. This was done to understand if students could apply pre-requisite knowledge that they gained through regular tutelage. To test the usefulness of the concept of PBL in technical education, few activities were planned to introduce students to new concepts allied with the course structure of that semester. The study showed that students had limitations in the application of prerequisite knowledge and 10% could

solve the problem completely. 62% of students were successful in doing new tasks using the PBL technique. 8% of students were able to reach to correct solution. Thus, student engagement can be boosted by the use of PBL pedagogy in technical education.

Keywords: Problem-based learning, Technical Education, Engineering, Employability.

1. Introduction

India is undergoing a transition in education quality, due to the guidelines provided by All India council of Technical Education (AICTE). The faculty of Engineering are getting exposure to quality research and thereby are able to perform as better facilitators in classroom. However, a general perception of Engineering Faculty regarding the students in class is that they lose interest in classroom discussions frequently. They refrain from taking down notes in class. This could be due to the belief that easy availability of the internet makes them omniscient. Ultimately they have a tendency to cram for final examinations. This leads a student to become exam-oriented rather than being inquisitive. This abates the quintessence of technical education which aims them to have finesse in technical know-how and clear Engineering basics. Problem based learning is a proven pedagogy which engages students in an active learning environment. It is also evident that a teachers would require training which is quintessential for success of the pedagogy in general.

Vaishnavi Dabir

Assistant Professor, Department of Civil Engineering,
Symbiosis Institute of Technology,
Symbiosis International (Deemed University), Lavale Pune, India
vaishnavi.dabir@sitpune.edu.in

2. Literature Review

Many educational initiatives worldwide have emerged in recent years to enhance student learning motivation, facilitate student engagement in the learning process, and produce more competent graduates (De Graaff, E., & Cowdroy, R. 1997, Bowe, Brian 2007, Wang, G., Tai B., & Huang, C. et al. 2008.). Constructive alignment is an approach to design a curriculum that optimizes the conditions for quality learning (Biggs, J 2003). student as one who constructs meaning through relevant learning activities; thus, what the student does is important. 'alignment' refers to what the teacher does is to provide a learning environment that supports the learning activities appropriate for achieving the desired learning outcomes (Lee Hong Sharon Yam and Peter Rossini. 2010). It is a student-centered approach that engages students in exploring important and meaningful questions through a series of investigations and collaborations (Krajcik, JS, Czerniak, CM & Berger, CF. 1999). To what extent teachers should give students learning autonomy is dependent on the context. To build up a student-centered learning approach such as PBL, educational practitioners do not only need to transform teachers' perceptions of their role and student learning autonomy (Huichun Li and Xiangyun Du. 2015). The majority of students who graduate from professional institutions and engineering colleges are not employable. In India, the problem is that employability and not that unemployment (Sunita Vijay Kumar, 2016). PBL also would boost the employability skills of Engineering students (Othman, H, Mat Daud, K. A, Ewon, U, Mohd Salleh, B, Omar, N. H, Abd Baser, J, Ismail, M. E. & Sulaiman, A. 2017). Developing nations face challenges in the process of change. In the absence of necessary infrastructure and support for the adoption of the PBL approach, it is necessary to see student's preparedness for the change.

In regular classroom sessions, it is usually observed that students attempt for home/classroom assignments with acquiescence; however, PBL activities shall make them ardent. Chinese philosopher and reformer Confucius stated in 479 BC – "I hear and I forget. I see and I remember. I do and I understand". This implies perfectly the axiom of the PBL approach. An effort to test the capability of students to undergo the same was done. PBL has now become a buzz word of current time and is being used in traditional and advanced forms based on experience of the facilitator.

But, to assess if the present generation of Engineering entrants, who have studied until highschool with traditional system are ready for the shift in education style, this study gave some important insights. As the study was undertaken in a University-led Institute, the teacher's enthusiasm and capability of undertaking PBL without any formal training were also noted.

3. Design Approach

For the application of PBL in Engineering from initial Engineering years, it is necessary to know student's capability to undergo the same. In this study,

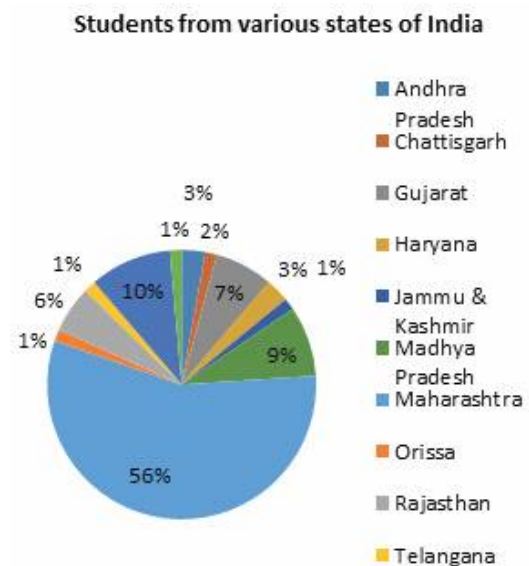


Fig. 1: Student diversity (States of India)

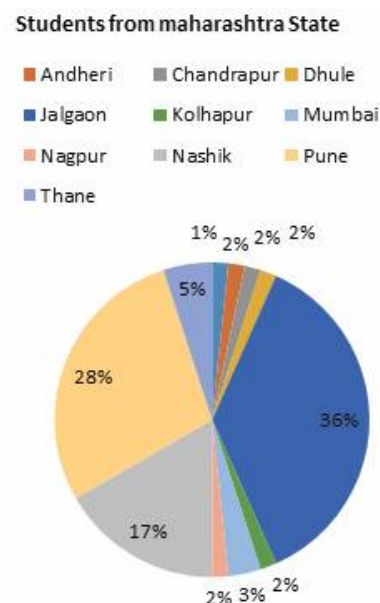


Fig.2: Student diversity (cities of Maharashtra state)

the students which hailed from routine teaching-learning backgrounds were provided with engaging assignments designed in a problem-based learning fashion. The group selected was the class of second-year Civil Engineering. These students had learned interdisciplinary subjects in the first year of their engineering graduate program. A 1-week schedule was devoted to this assignment at the beginning of the semester. The students of the batch were from diverse backgrounds, from across 6 states and 38 cities of India. Figure 1 shows the variations of the batch. India is a culturally diverse country, students from different cities come from a different schooling backgrounds and hence develop a different learning style. The majority of the batch was from the state the University is located in but again, across 11 different cities as shown in Figure 2. Some of the tasks were designed to assess if students could apply the basic knowledge that they had received in early sciences in educational life, given their diverse backgrounds.

Some tasks were designed to introduce them to certain concepts which were part of their curriculum in the second year. The teachers conducted several meetings and brainstorming sessions for constructing the PBL week. The exercises were planned after several rounds of teaming ideas and discussions. Once the type of exercise was abstracted, the discussions were then turned to framing the exercises in a casual/interesting way so that the student takes it up extemporarily. The teacher's group was asked to be focused more on the end solution required from each student group and thus frame the problem statement. This helped them to design the problems effectively. The total number of students in the study was 72. Teachers decided to divide the students into a group of 4, each group designated alphabetically (A to M) refer Table 1.

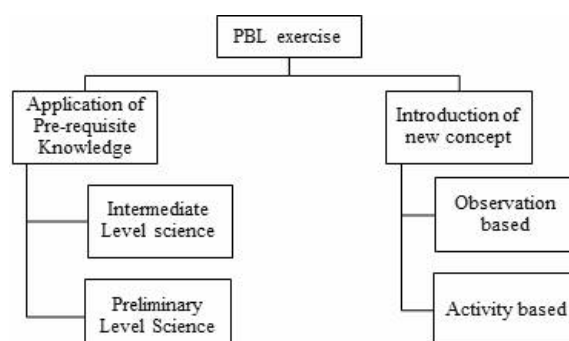
Half of the group were engaged in software training sessions synchronously. This made the

Table 1 : Group swapping along available venues

Timing	Venue Lab 1	Venue Lab 2	Venue Lab 3	Venue Lab 4	Venue Lab 5	Venue Computer Lab
9:45 AM to 10:45 AM	A, B	C, D	E, F	G, H	I	Groups J to M to be engaged in software training
10:45 AM to 11:45 AM	I	A, B	C, D	E, F	G, H	
11:45 AM to 12:45 PM	G, H	I	A, B	C, D	E, F	
Lunch break						
1:30 PM to 2:30 PM	E, F	G, H	I	A, B	C, D	
2:30 PM to 3:30 PM	C, D	E, F	G, H	I	A, B	

faculty supervision less tedious. The exercises were broadly categorized into 2 major parts. The first was to assess the student's ability to apply pre-requisite knowledge to obtain solutions and the second to ascertain if students could grasp a new concept using PBL methodology. All the students were given freedom of resources and a deadline to complete their work. The main aim was to see if students could think about the use of a variety of methods to reach solutions. The final successful outcome in the activities was not expected from the students; however, their thought process and involvement were judged.

Fig.3: Activity chart for PBL for second-year civil engineering students



Problem statements are attached in Annexure A and B. Students had to submit a report of their work after completion of the activity. For enhancing their report writing skills, they were not forced for immediate submission by the provision of an indulgent deadline.

4. Method of evaluation

Teachers evaluated the students on a Likert scale of 5 with 3 evaluation parameters viz. group work, report generation, the content of the report. Orchestrated Supervision with only two rounds by the supervisor teachers was conducted. This helped in understanding how cohesively they were performing as a group. Freedom of choice of resources was given. The scale of 5 indicated excellent as in students who could complete the tasks in right procedure and yielded correct solution of the problem given. 4 number was given to students who could understand the methodology of performance of tasks however did not achieve complete solutions. 3 marks were given to students who could fairly understand the methodology and those who gave a good attempt for it. 2 were assigned to students who attempted the exercise however failed in understanding the gist. Students who failed to attempt the tasks were rated as 1.

5. Results and Discussion:

Using the Likert scale, the first observation shows that the students performed fairly when they had to apply pre-requisite science knowledge to solve problems. 15% of the students could not apply the logic at all and none could excel in the activities.

The supervisors noted that none of the students failed to perform the activity using the PBL approach to the said activities and 10% could solve the problem completely. Figure 5 shows that above 60% of students were successful in doing new tasks using the PBL technique. 8% of students were able to reach to correct solution. It was also observed that students are more successful in activity-based problem. The latter activities involved applying pre-requisite knowledge they gained in early science education, on average 40% of students could perform it efficiently but did not get the correct solution. In these activities, success is considered as good and above as shown in figure no.5.

The student's feedback was taken post submission of the report. They acknowledged overall PBL activity as cogent for understanding the concepts. They appreciated the efforts of the teachers for the same. Overall, they found exuberance in solving activities.

Figure 4 shows result variation for the Likert scale classified based on the degree of activity. It is observed that the students were good in almost all tasks. This may be due to the degree of engagement that the pedagogy provides. A group may have score less in one of the modules but has scored in another one. Thus, the student cohort cannot be directly classified as successful or unsuccessful. This is due to the major advantage of problem-based learning is that all student learning styles get a benefit to be showcased and utilized during the activity course. Thus the marks distribution according to the activity type got a spike in one activity type and low in another.

It was a unique experience for the assistant professors of the department, who had to workgroups for the formulation of the activities. This one-week activity was project-based training for all teachers to get oriented to be able to infuse problem-based learning in routine curriculum and to introduce them to a new role of facilitator. The major issue that they had to tackle was to control the urge of tutelage. The language of the task was framed by finesse to keep up the interest of students. This way the passive student

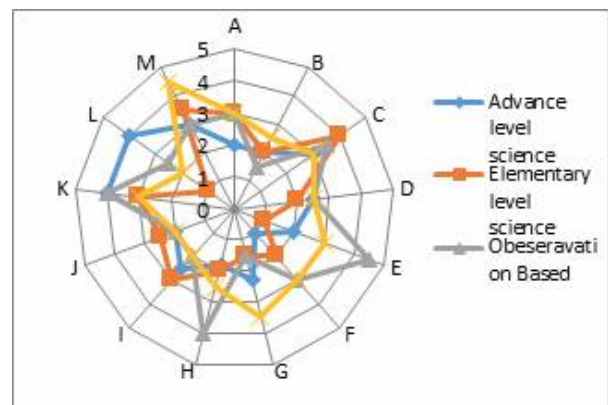


Fig. 4 : Assessment of activity using Likert scale

also found it interesting to give in his share of a task in Group work. The teachers noted by the observation that student's enthusiasm was higher in activity-based assignments. They were performing together as a coterie. It was noted that students needed time to understand the use of simple logic to solve problems.

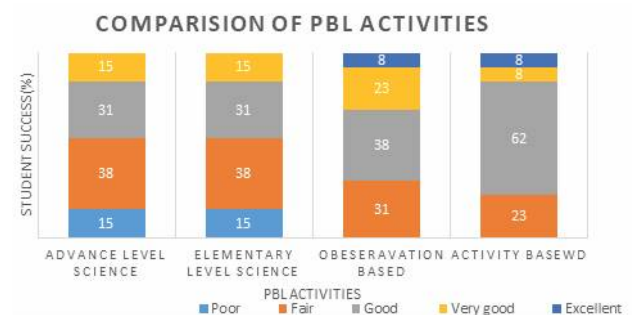


Fig. 5 : Comparison of PBL activities

6. Future Trends

The student group gets well oriented by the PBL activity, and hence, during the induction schedule, every Institute can add the element of PBL for the incoming batch. It is possible to make an alteration of 1 week in a regular teaching-learning system, wherein many hands-on activities can be designed for the students.

7. Conclusion

Embedding PBL in the regular teaching-learning system is not possible completely because of the rules and norms by state universities. However, universities that are private/ state or even government (autonomous) can take advantage of the PBL by implementing it on a very small scale in the form of 1-week PBL activities. The facilitators were zealous in using the PBL approach to introduce the students to a

technical concept. During their supervision rounds, they found it difficult to control the urge of abatement which is essential of PBL. This can be soothed with training. If the construction of a problem statement is lucid then students' interest is coped up. In this activity, the design of the problem statement was made such that students find it intriguing as well as fascinating. Since the concept is new for teachers as well, they had to do contemplate in group discussions to come up with those efficacious problem

statements. The essence of PBL activities requires fresh ideas and thoughtful construction of a problem statement, hence the teachers also had to brush up their basics and upgrade their creative ability. The teachers found the method promising and expressed a desire to cultivate it in regular classroom sessions.

The performance of students was extemporary. The feedback by students states that by the PBL technique they understood that every problem can have a logical thought process for solving it. This exercise proved to be lucrative for boosting student's interest in learning. The students who otherwise were not proactive in classroom teaching sessions were observed to be honchoed in the activities.

Acknowledgment

The Authors thank Symbiosis Institute of Technology and Symbiosis International (Deemed University) to motivate and allow for undertaking this activity amidst the traditional education system.

References

- [1] Biggs, J 2003, "Aligning teaching and assessing to course objectives", in Proceedings of Teaching and Learning in Higher Education: New Trends and Innovations Conference, University of Aveiro. DOI: <http://dx.doi.org/10.7575/aiac.ijalel.v.4n.5p.82>
- [2] Bowe, Brian 2007. Managing the Change from Traditional Teaching to Problem-based Learning in Physics Education. In Kolmos, A., & De Graaff, E. (Eds.). Management of Change, Rotterdam: Sense Publishers (pp. 83-91).
- [3] De Graaff, E., & Cowdroy, R. 1997. Theory and Practice of Educational Innovation Introduction of Problem-based Learning in Architecture: Two Case Studies. International Journal of Engineering Education, 13(3), 166-174. DOI: <https://doi.org/10.1080/17452007.2016.1230535>
- [4] Huichun Li and Xiangyun Du. 2015. Teachers' Perspective of their Role and Student Autonomy in the PBL Context in China, International Journal of Learning, Teaching and Educational Research Vol. 10, No. 2, pp.1831. URL: <https://www.ijlter.org/index.php/ijlter/article/viewFile/259/103>
- [5] Introductory Property Course", 16th Pacific Rim Real Estate Society Conference Wellington, New Zealand. DOI <https://doi.org/10.1080/14445921.2010.11104306>
- [6] Krajcik, JS, Czerniak, CM & Berger, CF. 1999. Teaching science: a project-based approach, McGraw-Hill College, New York.
- [7] Lee Hong Sharon Yam and Peter Rossini. 2010 "Implementing a Project-Based Learning Approach in an Introductory Property Course", 16th Pacific Rim Real Estate Society Conference Wellington, New Zealand, January 2010.
- [8] Othman, H, Mat Daud, K. A, Ewon, U, Mohd Salleh, B, Omar, N. H, Abd Baser, J, Ismail, M. E. & Sulaiman, A. 2017. "Engineering Students: Enhancing Employability Skills through PBL, Mechanical Engineering, Science and Technology International Conference", IOP Conf. Series: Materials Science and Engineering. DOI: 10.1088/1757-899X/203/1/012024
- [9] Sunita Vijay Kumar, "Employability skills for engineering graduates ", The Indian Journal of Technical Education, Vol.39, No.4, October December 2016
- [10] Wang, G., Tai B., & Huang, C. et al. 2008. "Establishing a Multidisciplinary PBL Curriculum in the School of Stomatology at Wuhan University", International Dental Education, 72(5), 610-615. URL <http://www.jdentaled.org/content/72/5/610.full.pdf+html>

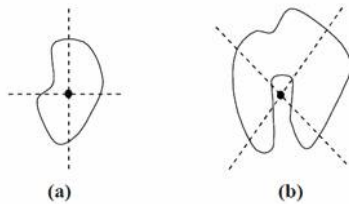
Appendix

Exercise 1 The Modern Sudarshan Chakra (using pre-requisite knowledge)

Prologue - Lord Krishna is a God in Hinduism who is depicted holding a weapon known as the “Sudarshan Chakra”. He keeps rotating it on his forefinger until releasing it for defeating demons.

Lord Krishna thought of rewarding all Symbiosis Civil Dept students. So, he first thought of giving you practice by providing irregular laminas to see whether you can balance it on a fingertip or not.

Can you find out the point at which it can be balanced?



Equipment/ Materials from the almighty

- cardboards/ thermocol sheets of different shapes
- Thread
- Nail/big needle
- pencil
- rule/straight edge
- Balancing pointer
- load (e.g. stone, wood, screws, etc)

Other requirements

Notebook, pencil, pens for recording

What are you thinking? What have you found? *After completion of the activity student's work was checked and then the following sheet was handed over to them.*

.....

1. Explain the center of gravity of an object.
2. List the steps involved in determining the center of gravity of an irregular lamina.
3. If you are given cardboard in a shape of a trapezium, how would you determine its center of gravity?
4. What precautions would you take to ensure good results?
5. Is there any change in the location of the center of gravity if we change the material to have the same shape?

Concept Used: Center of Gravity

Exercise 2: The Forensic expert (using pre-requisite knowledge)

We all have seen the movie Titanic. You are appointed as an expert for redesigning the Titanic ship using various materials for which you have to undergo some lab tests. Find out the factors which affect floating and sinking.

1. Predict whether the following material will sink or float. (Tick mark in the appropriate column)

Sr. No.	Object Name	Float	Sink
1			
2			
3			
4			
5			

2. Apply basic concepts to find out the weight of the immersed object.

3. If there are two blocks of wood having
 - a. 2 kg weight and 3m³ volume
 - b. 8 kg weight and 15m³ volume

In which case more possibility is there for floating and why?

4. If two blocks having the same size (equal volume and weight) kept into two different tanks having
 - a. Freshwater
 - b. Saltier water

In which case more possibility is there for floating and why?

The concept used : Students were expected to apply Archimedes principle

Exercise 3 The Perfect Soil For Garden (New Concept)

Palm Island in Dubai is an engineering marvel. The artificial island is constructed using sand. On a premium villa project in the island, you are appointed as expertise for the landscaping project, wherein you have to decide the type of soil which is best to transport water from ground level to roots.

Take the soil samples provided and find its water retaining capacity using given materials

Hint: Find the amount of water absorbed by the soil

Record your readings by constructing a proper observation table

Questions:

- What property of soil have you found out?
.....
- Calculate the amount of empty space in the sample
.....
- Which particle size had the most amounts of voids?
.....
- The least amount of space? Was there a pattern to your data?
.....
- Does this reveal any relationship between particles size and voids?
.....

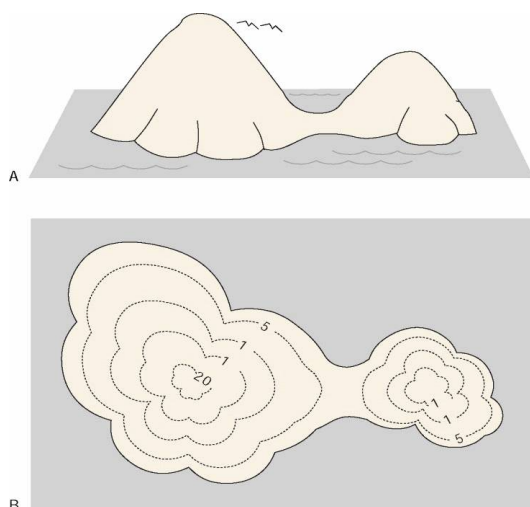
Concept learnt --With this assignment, students were expected to understand water retaining capacity of the soil and thus to lead them to understand “porosity”

Exercise 4: Civil Landscaper

(New Concept)

Only Almighty could create the world! Here is an opportunity for you. Only that you shall play the role of Lord Civil! In this exercise, You will be creating a 2D mini earth on paper in the form of its contour map by using 3D clay models.

What's a contour map? Let's start with the word "contour." A contour is a line that shows the border or outline of an object. A contour map is a 2-dimensional drawing of land. The map includes contour lines to show changes in the elevation of the land. Here is an example



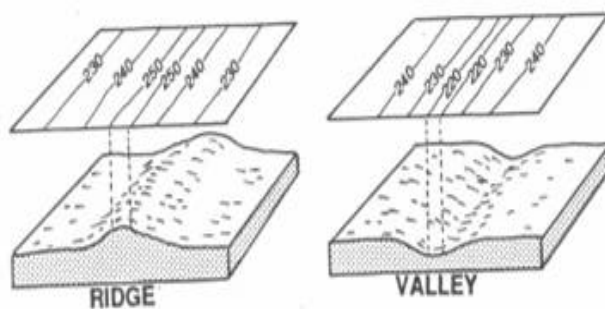
Each contour line shows all connected land that is at the same elevation. Contour lines may be drawn at every 1-meter difference in height, every 10-meter difference in height, or at some other scale, depending on the terrain being mapped. The closer the lines are to each other, the steeper the terrain.

In this project, you will be making a map that is model-sized. That means you are using a scale of 1:1. 1 cm on the map represents one cm of distance on the model. Take a suitable contour interval. You may want to change the interval depending upon its steepness

Make multiple contour map on the same piece of paper showing at least 5 topographical features out of Hill, valley, river, slope, lake, steep rock edge, Ghat, highway, etc

Tip: First make a 11 features using clay and decide their position. Now, Slice the individual feature as shown in the image above. Trace the contour (border) and note down the distance of that slice base from your datum (a piece of paper). Write that number along the contour lines as shown in the figure

Follow this questionnaire once your project is ready



Questionnaire

State True or False - Topographic maps display the three-dimensional characteristics of terrain on a two-dimensional surface.

.....

Tell 1 prominent feature of a contour line

.....

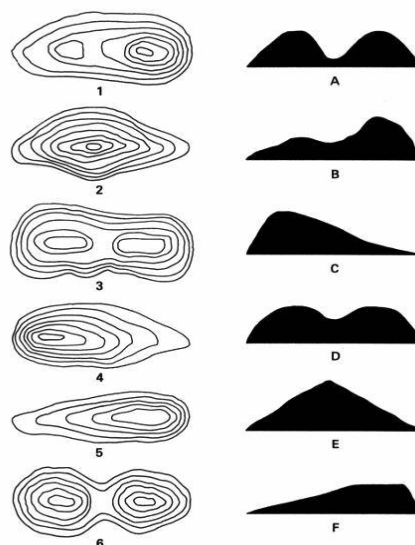
What are your observations regarding the variation of the contour map for various features

.....

Let's say you want to create a map of a real-world feature, like a portion of the China wall. It may be 5000 feet wide. If you want your contour map to fit on a piece of 50 x 120 cm paper, what scale might you use?

.....

Observe the images and match the pairs



Project-based Laboratory Assignments to Support Digital Transformation of Education in Turkmenistan

Serdar Nazarov¹, Bayram Jumayev²

¹Rector, State Energy Institute of Turkmenistan, Bayramhan str. 62, Mary, Turkmenistan

²Head of the department, State Energy Institute of Turkmenistan, Bayramhan str. 62, Mary, Turkmenistan

¹serdar.nazar.tdei@gmail.com

²bajuturkmen@gmail.com

Abstract: On 30th of November, 2018, by the Decree of the Esteemed President of Turkmenistan Gurbanguly Berdimuhamedov, there was accepted a Conception of developing digital economy in Turkmenistan in between 2019-2025. Moreover, on 15th of September, 2017, the Conception of developing digital education in Turkmenistan was approved as well. That is why, new, innovative methodologies and digital solutions are continuously being introduced to the educational system of Turkmenistan. Teaching and training undergraduate students, studying in the field of automation and control engineering, is a tough issue. Because, nowadays, for automation engineer, knowing physics, mathematics, theory of automation and electronics is not enough, moreover, they should also know basics of smart systems, if necessary, programming a microcontroller and methods of using necessary sensors when designing smart systems. In this regards, this paper provides useful information about the steps and key points of integrating digital solutions and microcontroller-based educational methodologies into the undergraduate educational system of Turkmenistan. Moreover, the effect of the proposed method of teaching and appropriateness of the laboratory assignments were also analysed at the end of the course. As a microcontroller board, “Ardunio UNO” was selected as it is easy-to-learn.

Keywords: smart systems, engineering courses, “Arduino UNO” board, methodology of achieving course objectives, Bloom's taxonomy

1. Introduction and literature review

There are several methods or types of undergraduate teaching in terms of the way that students gain intended knowledge, skills or abilities. In general, these techniques can be classified as instructor-centred, student-centred, content focused and interactive methods. Abanador (2014) points out that students, who are studying engineering courses, prefer all the methods of teaching such as teacher-centred, learner-centred and content-focused methods in order to better understand the content of the lecture. Moreover, because embedded systems are widely used in automation, industry and computerized systems, teaching embedded systems could also include various methods such as hardware-oriented, software-oriented, or hardware-software integration (Ibrahim et al., 2015). Therefore, in this paper, learner-centred method was chosen to conduct experiments and reach intended goals.

As it was pointed out in the report, “due to a greater emphasis on science, technology, engineering, and mathematics (STEM) education to prepare students for future economic needs and the challenges of the next generation, the maker movement advocated by a number of governments worldwide is a vital learning trend of innovating educational environments” (Horizon Report, 2016). Because maker education environments make it possible for learners or students

Serdar Nazarov

Rector, State Energy Institute of Turkmenistan,
Bayramhan str. 62, Mary, Turkmenistan
serdar.nazar.tdei@gmail.com

with similar interests and diverse experiences to employ various digital tools to construct, build or make a project by realizing creative ideas of each other (Lee, 2015). That is why, the authors proposed that maker education or project-based learning could help learners to develop skills such as problem-solving and creative thinking, and be educated in different directions of engineering, therefore, they believe that maker education increases or fosters curiosity, tinkering, and iterative learning, which in turn leads to better thinking abilities through better questioning (Kurti et al., 2014). In teaching students of engineering fields, project-based learning may be one of the effective ways (Dym et al., 2005), it could be better experience to direct the students to build goal-oriented projects using a microcontroller, which will result in capacity building and creative thinking skills. In this context, Benitti (2012) offered that future research should take in different educational products of robotics such as Arduino-based educational products for teaching and learning strategies. As Lee (2015) states in his article, variety of available microcontrollers which can be used in education processes, is always changing, but well-known choices nowadays consist of Raspberry Pi, Arduino, BeagleBone, Launchpad and Quark, each of which has different models as well. Among these options, using Arduino platform in the educational process of embedded engineering was proven to be one of the effective platforms (Mohammed, 2017). On the official website of developers, Arduino is defined as “an open-source electronics platform based on easy-to-use hardware and software” (<https://www.arduino.cc/en/guide/introduction>). In general, a microcontroller can be defined as a tiny, programmable computer on a microchip that is able to process input signals from transducers or sensors of physical quantities, switches, internet data, and control various output devices or loads including servo and step motors, light emitting diodes, lamps, and speakers, and can store information in a memory card or web portal (Lee, 2015). Moreover, Mohammed (2017) states that “Arduino became more and more popular among academics, the number of publications involving the Arduino platform has considerably increased over the years”. This indicates the necessity of teaching undergraduates the basics of designing smart or automated systems in a way that they could effectively implement their knowledge in the application.

It is indeed a challenging issue to implement advanced technologies in the higher education and the

key questions in doing so are “where to start?” and “how to test the technology-based skills of students” (Kriti, 2018). Because the pace of learning of any subject is not the same for each student and student diversity is always an issue for instructors, Student Experience Transitions Model (Morgan, 2013) may be implemented in teaching engineering as well.

As with many other attempts to develop innovative educational methods, Son and Sohn (2014) have also worked out an educational method in which they integrated science, art and information technology in teaching programming courses. Moreover, the authors developed an Arduino-based educational program to improve the ability of students to design and implement a creative solutions to the real world problems and to test their skills (Seong et al., 2017). As they point out in the article, “students were interested in and felt a sense of accomplishment in participating in the Arduino-based education program” (Seong et al., 2017). Moreover, in order to promote better Science Technology Engineering and Math (STEM) education, authors developed hands-on laboratory assignments based on Arduino microcontroller (Hoffer, 2012).

Therefore, in this paper, methodology of implementing Arduino-based learning environment in teaching undergraduates of engineering fields is being discussed and possible directions, solutions or proposals are being offered. This will be useful tool or method for the instructors and lecturers of higher educational institutions in Turkmenistan in achieving global objectives of any course such as decision making, brainstorming, project development and rational reasoning, whereas learners will also be satisfied with the technique being used.

2. Content of a course curriculum and its relevancy of Arduino-based learning

In order to inject new methods to the education, matching the educational method with an appropriate course is one of the most important tasks. Therefore, after brainstorming with lecturers, as a course in which Arduino-based learning environment is proposed to be implemented, “Control instrumentation and measuring devices” was selected. This course is taught in undergraduate disciplines such as automation, robotics, and control engineering. The duration of the course is 2 academic semesters, and the division of hours within the course, including lectures, problem-solving and experiments, is being

approved by Deputy Chairman of Cabinet of Ministers of Turkmenistan, while the curriculum of the course is regularly being confirmed by a rector or vice rector of the higher educational institutions each academic year. The “Control instrumentation and measuring devices” course consists of 34 hours of lecture, 18 hours of problem-solving and 34 hours of laboratory works. The main goal of the course is to teach undergraduate students about control systems, types and working principles of sensors and measuring devices, methods or ways of using them, instrumentation of automated systems, basics of smart systems and digital solutions in control engineering. As the main directions of technical higher educational institutions such as State Energy Institute of Turkmenistan are power engineering, energy supply, automation and relay protection, the selected laboratory assignments, as in a Table 1, are closely related to electrical energy issues such as energy saving, energy monitoring, energy metering, effective consumption of electrical energy and implementation of smart solutions in this sector.

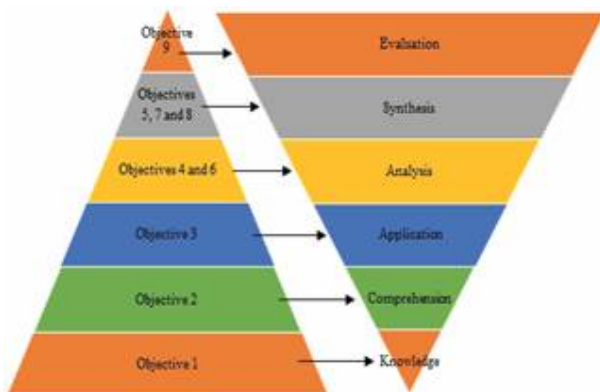


Fig. 1: Objectives of the laboratory assignments in parallel with Bloom's taxonomy

In the lecture section of the course, mainly theoretical part of the subject is delivered to students, while in problem-solving part they solve questions, problems or tasks related to the topics taught in lecture hours. Next comes the laboratory part in which students are fostered to carry out specific experiments such as designing smart or automated mini-systems, measuring devices and thereby understand the working principles of sensors and measuring instruments. Therefore, during realization process of proposed laboratory assignments, implementing the components of “Reorientation and induction” stage of SEPT model (Kriti, 2018) was also taken into account. In fact, by introducing these assignments to the undergraduate course curriculum, demands of

modern job market was also considered and employability of students was fostered.

Usually, for one experiment 4 hours or 2 couple hours are given to complete the tasks, while one couple hour is planning part and other one is designing and implementing part. Therefore, minimum 9 laboratory assignments were required to complete all the experimental hours. As shown in the Table 1, first two hours were spent to get familiarized with the instruments, tools and platforms of microcontroller-based experiments, while remaining 32 hours were covered with 8 laboratory works, one for each 4 hours. The assignments were ordered in a way that the concept in each experiment is getting deeper in terms of its objectives as per Bloom's taxonomy (Anderson and Krathwohl, 2001) which is shown in Fig. 1. In other words, the taxonomy includes the cognitive levels such as Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation, and the key words or verbs that describe each level gets more sophisticated as the level increases.

As Bloom's taxonomy consists of mainly six cognitive levels, each objective was planned in accordance with the taxonomy. In fact, intended objectives gradually require more cognitive skills. Moreover, topics of laboratory assignments were selected among the most focused priorities of both State educational policy and demands of modern education such as digital transformation, smart systems and interactive learning. In this way, laboratory assignments were carried out in accordance with the requirements of pedagogy and priorities of the State educational policy.

Table 1 : Proposed laboratory assignments for the “Control instrumentation & measuring devices” course

No	Name of the assignment	Required tools	Objective of the assignment in regards with the Bloom's taxonomy	Intended laboratory hours
1.	Elements of microcontroller-based automated systems	Arduino UNO board, sensors of physical quantities (motion sensor, voice sensor, temperature sensor, moisture and humidity	To describe basics and logics of smart systems, to identify sensors and actuators	2 hours

		humidity sensor, ultrasonic sensor and etc.), relay modules, several types of loads (motor, lamp, buzzer, LED) to be controlled		
2.	Smart systems based on light intensity	Arduino UNO board, photo-resistor, relay, lamp, potentiometer	To understand working principles of smart systems and to explain logics of designing them	4 hours
3.	Smart systems of saving electrical energy and using electricity effectively	Arduino UNO board, motion sensor, thermo-resistor, relay, bipolar junction transistor, lamp, fan, motor	To implement digital solutions for energy saving and to produce smart systems	4 hours
4.	Smart energy metering and distant energy monitoring device	Arduino UNO board, ACS712 current sensor, ESP8266 WiFi module, SIM900A GSM/GPRS module, SIM card, 16x2 liquid crystal display (LCD)	To compare different kinds of energy meters and to implement IoT (Internet of Things) solutions in energy metering	4 hours
5.	Smart measuring device of water consumption	Arduino UNO board, YF-S201 Hall effect water flow sensor, SIM900A GSM/GPRS module, solenoid valve, relay	To construct water management system and to examine connection diagrams	4 hours
6.	Smart ventilation system for greenhouses	Arduino UNO board, DHT11 temperature and humidity sensors, relay, fan	To compare different values of the same physical quantity, to analyze smart systems	4 hours

7.	Smart alarm system for gas leakages	Arduino UNO board, MQ5 type gas sensor, relay, active buzzer, SIM900A GSM/GPRS module, solenoid valve, LCD	To design smart systems and to create digital solutions to daily-life issues	4 hours
8.	Smart overload protection system for home appliances	Arduino UNO board, ACS712 current sensor, relay protection, potentiometer	To protect electrical devices from over currents and to propose appropriate solutions	4 hours
9.	Smart house prototype and implementation	All above-mentioned tools are required	To evaluate various types of digital solutions in order to combine them and get one smart system	4 hours
Total laboratory hours:				34 hours

As it can be seen from the Table 1, in total 9 laboratory assignments were prepared and after completing each assignment, students were expected to reach the intended objectives. Therefore, below will be explained the implemented methodology of achieving these goals.

3. Implemented methodology of reaching above-mentioned objectives in the laboratory hours

In the spring semester of 2019-2020 academic calendar, the proposed laboratory assignments were carried out with 3rd year undergraduate group studying the “Control instrumentation and measuring devices” course. There was no any budget allocated for the implementation of these laboratory assignments. It was based on the voluntarily initiative of the lecturers and supported by the administration of State Energy Institute of Turkmenistan. In fact, necessary tools were provided by the institute. Required tools for the laboratory assignments were available for the instructors at the Young scholars' council of the institute.

As per the internal regulations of the institute, the laboratory hours were expected not to include students more than 25 students. Therefore, the group with 20 students were selected as a target group for the

realization or implementation of the proposed assignments. Moreover, the amount of tools necessary for the assignments were also limited to this amount of students. The group was divided into 4 subgroups, each consisting of 5 students. Then, each group was informed with intended objectives and goals of the experiments, then students were provided with necessary tools and they were given to the Internet so that students can find out related works or solutions in the Internet as well.

During the project-based assignments, instructors' role was guiding students in using and connecting required tools and assisting them in writing the programming part for the microcontroller. Because students were from technical fields, they had some difficulties in writing the codes for Arduino, therefore, during the laboratory hours, lecturers shortly explained them basics of the C programming and its functions related to the each assignment. Shortly, the instructor served as a mediator who connects students with possible methods of carrying out the experiments. Therefore, the laboratory classes were project-based and student-centred.

A. Objective 1: To describe basics and logics of smart systems, to identify sensors and actuators (2 hours)

This objective was reached in two steps. Firstly, students were shown and explained real-life measuring instruments, implemented smart solutions, sensors, microcontrollers and loads to be controlled. Next, each group was given a name such as "Sensors", "Loads", "Microcontrollers" and "Smart systems". In doing so, in accordance with their group names, students had to explain functions of each device, their working principles and connection diagrams in a written format. For instance, while "Sensors" group described basics and logics of various sensors, "Smart systems" group explained how to construct or create smart systems using required elements. During 2 hours, the name of the groups were shifted to each other so that each group could reach the intended course objectives. After the completion of this step, students had an idea of each part of smart systems individually.

B. Objective 2: To understand working principles of smart systems and to explain logics of designing them (4 hours)

As energy saving is one of the main issues in Turkmenistan (The State Programme, 2018), students

are expected to learn energy saving methods during lecture hours. Therefore, in this experiment, they understood how to do so based on smart systems. In fact, using the microcontroller, light dependent resistor (LDR), 5 V relay, bulb and AC power supply, students completed the given assignment, and they worked out an automated system of street lighting in which electrical bulbs are supplied with electrical energy after Sunset while they are switched off after Sunrise automatically. This objective was reached after completing the experiment and formulating the amount of monthly saved energy. There was observed a side effect of the experiment such as awareness of the electrical energy being consumed and thriftiness. After the second step was completed, students now could explain the elements of smart systems as a whole.

C. Objective 3: To implement digital solutions for energy saving and to produce smart systems (4 hours)

After the 2nd experiment, students had an idea about energy saving methods and the logics of designing them. Therefore, in this laboratory assignment, their duty was to find out innovative or digital solutions to save energy in living houses and buildings as it was also indicated in the implementation plan of The State Programme (2018). In order to achieve the intended goals, students carried out the experiment in which they designed smart systems where loads were controlled by motion sensor and thermo-resistor, which are the sources of input signals. In fact, students worked out small projects of automatic control systems where a motor, opening and closing the door, and indoor light bulbs were run by the help of the motion sensor. Moreover, they also designed smart systems where the speed of fan was automatically controlled by using thermo-resistors. By doing so, students' knowledge about microcontroller-based automated systems deepened, they managed to save or cut electrical energy, used for some electrical devices while the energy was not required, and they comprehended the steps and logics of working out smart systems. In fact, they understood that smart systems should contain the microcontroller, loads and sensors or actuators. One group even proposed an innovative way of calculating the heat energy that is being provided to the living houses.

D. Objective 4: To compare different kinds of energy meters and to implement IoT solutions in energy metering (4 hours)

In Turkmenistan, both digital and analogous energy meters are being used. That's why in this experiment, students got acquainted with various kinds of energy meters and compared their working principles. In fact, they had chance to get familiar with 1-phase and 3-phase energy meters being used in Turkmenistan. Moreover, by using ACS712 current sensor, SIM900A GSM/GPRS module and other additional tools, undergraduates were assigned to construct a simple energy meter which also sends an SMS text and other energy-related information to the Internet portal such as "thingier.io" through ESP8266 WiFi module. At the end, students thoroughly compared different kinds of energy meters and implemented elementary Internet-based solutions. In this way, their knowledge about instrumentation and measuring devices had deepened further. Moreover, they had their own profile or virtual room in the above-mentioned internet platform in which they could monitor energy consumption remotely and control the corresponding relay through the internet.

E. Objective 5: To construct water management system and to examine connection diagrams (4 hours)

In Turkmen Nation, there is a saying like "a drop of water is a grain of gold" which points out the nationwide significance of water management. In this regards, into the syllabus of this course was introduced this experiment which aims to teach students about the mechanisms, connection diagrams and types of water meters. To do this, students of the same group were assigned to construct water management system using YF-S201 water flow meter which operates due to the Hall Effect, a topic which was explained in the theoretical part of the course, i.e., in lecture hours. Students surveyed and found out connection diagrams of the flow meter and necessary programming part from the Internet. In this fashion, objectives of the experiment were met, moreover, the students comprehended the theoretical part of the course and examined various connection diagrams of water meters. Moreover, they came up with the idea that the energy being consumed in order to heat up the living houses can also be monitored and automatically calculated by the help of Arduino-based project. In fact, they proposed that by using double DS18B20 sensors, both water (Twater) and (Toutside) outside temperatures can be measured while the mass of the circulated hot water can be computed by YF-S201 water flow meter. Therefore, the total amount of the consumed heat energy ($Q = m \cdot c \cdot \Delta T$) can easily be calculated.

F. Objective 6: To compare different values of the same physical quantity, to analyse smart systems (4 hours)

As instrumentation plays important role in industry and agriculture as well, the goal of this experiment was to teach students the basics of differential measuring devices which can be implemented in greenhouses. The "humidity of the air" was the physical quantity which would be measured and altered by the help of fans. Therefore, the fundamentals of smart ventilation systems based on differentiation of the physical quantity were explored. To do so, DHT11 temperature and humidity sensors were used together with microcontroller and other required tools. In this way, students learned how to compare the humidity of the greenhouse with the humidity of the air outside the greenhouse. Moreover, after the course, field visit was also organized to show students the instruments already installed in one of the greenhouses. This experience helped them to analyse and compare the different kinds of a device that measure the same physical quantities.

G. Objective 7: To design smart systems and to create digital solutions for daily-life issues (4 hours)

As it was shown and explained in the paper of the authors (Nazarov and Jumayev, 2020), smart alarm system for gas leakages were worked out as a result of the experiments. This device was favourite tool for the students, because there were too many demands to implement this device in daily life in order to prevent any fire disaster that may occur because of gas leakages. The fact that this device is able to send short messages in case of emergency and close the solenoid valve in order to cease the gas supply were sources of motivation for students to further work on the smart systems and create digital solutions that may be used in daily-life problems or issues.

H. Objective 8: To protect electrical devices from over currents and to propose appropriate solutions (4 hours)

The automation engineers should gain skills to overcome any faults or shortcuts which may damage any electrical device or home appliance. In this regards, this experiment aimed to teach them relay protection principles in case of over currents and motivate them to propose appropriate solutions. As they already knew the working principle of ACS712 current sensor and 5 V relay, and their connection

diagrams to Arduino UNO microcontroller (Objective 4), in this experiment undergraduates were expected to solve the overcurrent faults in order to protect electrical devices. To do so, they analysed intended maximum electrical currents for each electrical device and prepared the software of the microcontroller. At the end, each group proposed their own solution and they compared them with each other. Some of them used additional tools other than necessary ones. This showed the eagerness and willingness of students to overcome faults that may negatively affect operation of electrical device.

I. Objective 9: To evaluate various types of digital solutions in order to combine them and get one smart system (4 hours)

As one of the main purposes of education is to teach students how to learn the unknown throughout their life, they should be addressed to real-life contexts within the lectures being taught. Gaining any skill is a tough issue. When it comes to the highest cognitive levels of Bloom's taxonomy such as assembling, combining, evaluating, formulating and concluding (Anderson and Krathwohl, 2001), the issue becomes more complicated. Therefore, in this final experiment, undergraduates were directed to the systems which are unions of subsystems. Here, smart house was a good choice where students could evaluate various subsystems and combine them to get the only one complete system. In this way, they would learn how to solve difficult or complex problems by dividing them into smaller parts and then assembling them to find a final solution. To do so, groups were assigned to design a prototype of a smart house where they had to include at least 7 sensors and mini-mechanisms. This assignment yielded fruitful results as students came up with relatively different and quite new ideas.

4. Analysis

At the end of the laboratory assignments, in other words, at the end of the second semester of the course, ideas of students were elaborated with a questionnaire, in which they were asked about the effect and appropriateness of the implemented method. Questions were related to the intended course objectives. Followings are the main Yes/No kind questions that were included in the questionnaire:

Q1: Do you think that the aims of the laboratory assignments were clearly explained?

Q2: Did you reach your expectations during the laboratory assignments?

Q3: Did you find the method effective and beneficial?

Q4: Do you think that laboratory assignments were feasible with the course objectives?

Q5: Do you think that the laboratory assignments will be beneficial in your future career?

Q6: Did you enjoy the way course was conducted?

Q7: Do you think that the student-centred learning can be applied to other fields as well?

Q8: Do you think that the teaching methodology has enlightened you in a way that you can make an input in realizing state programmes on digital transformation of economy and education?

Moreover, essay-type questions were also directed to students in order to reveal their ideas and get feedbacks related to the proposed method. From the results or answers of above-listed Yes/No type and essay-type questions, it can be concluded up that for undergraduate students, especially studying in the engineering fields such as automation and control, project-based laboratory assignments are one of best choices as students reach the course objectives on their own pace and the project results make them feel more confident. Undergraduate students stated that throughout the laboratory assignments, they had chance to get familiar with various kinds of sensor, actuators and other additional modules. Moreover, questionnaire results revealed that students stayed more interested in the realization of state programmes related to the digital transformation. However, students also pointed out that such kind of teaching may be suitable only for applied sciences or engineering fields, only if the strategy of carrying out the experiments and their topics are selected appropriately.

In the analysis or evaluation stage, students were also directed written questions in which their opinion on integration of theoretical part with the experimental part of the course was evaluated. They replied that by Arduino-based laboratory assignments, not all theoretical parts of the course were thoroughly explained through experiments, however, they understood that some relevant attributions were made within the laboratory manual.

According to their idea, such laboratory assignments were just an exciting introduction to the automation and control engineering.

5. Conclusions

As mentioned before, educating undergraduates of engineering fields is indeed tough and challenging issue. This task demands more attention and in this regards instructors should be addressed appropriate educational methods. In this regards, students, studying in automation and engineering fields, were treated from a different perspective and they were taught using learner-based method integrated with real-life context based approach. Objectives of laboratory hours of “Control instrumentation and measuring devices” course were structured in a way that suits into Bloom's taxonomy going from a simple level to more complex and challenging levels. On first sight, 3rd year undergraduate students found it a little bit difficult to adapt to the new method, however, later they experienced more exciting and learner-friendly environment in carrying out their experiments.

At the end of each laboratory assignment, in order to grade students, it was compulsory for them to write a report about the steps they had followed and laboratory results they had achieved. Moreover, in order to increase reliability and validity of the grading, there were conducted quizzes which included both multiple choice and essay type questions. The quizzes, with one-time-access restrictions, were conducted using Moodle platform which was installed in the local network of the institute. As a result, it was found out that 87% of intended objectives were achieved and students were motivated to further carry out research about smart systems and digital solutions. Moreover, some significant points of State programmes and conceptions were integrated into the lectures so that undergraduate students had idea about the priorities of the topics in national level. Students could deal with or tackle the problems they encountered during laboratory hours due to the fact that working with Arduino UNO was easy and user-friendly, as they had access to the Internet in case of any complexity.

While implementing these laboratory assignments, there were some difficulties as well. Therefore, as suggested in SEPT model, extra supports or needs of students were identified. Among them, one of the most significant challenge was that

each student had different pace of learning as the concepts of the assignments were new for them. Therefore, in order to foster students to work as a team, encourage self-learning and eliminate gaps between the subgroups, the group was divided into subgroups so that each subgroup contained students with various backgrounds. This also helped to develop their team work capabilities. Secondly, it was difficult to grade the reports submitted after each assignment and measure the level of achievement of the intended objectives. Therefore, students were given concrete instructions in writing reports which were related to course objectives.

It can be summed up that the research or implementation of the new methodology yielded fruitful results. In fact, after these laboratory hours, demand for the participation in Young scholars' council of State Energy Institute of Turkmenistan has increased. By the way, Young scholars' council of the institute is a place where enthusiastic students, with their brilliant ideas, meet and realize their projects under the supervision of instructors. Young members of this council deal with innovative ideas and carry out projects related to smart systems. After the completion of the course, new attendees from these classes came up with new project ideas. Therefore, the study will be deepened further in order to find out appropriate or suitable way of implementing the methodology in different disciplines as well.

6. Recommendations

In order to support digital transformation process in Turkmenistan, educational strategies and methodologies should be revised so that undergraduate students can gain digital skills during classes. This can be achieved by using the above-proposed methodology in laboratory assignments. In fact, course objectives should be prepared in parallel with the Bloom's taxonomy of educational objectives and laboratory assignments should be based on the projects through which students can learn basics of digital solutions, automation systems and logics of microcontroller-based devices. As a result of fruitful laboratory classes, it is strongly recommended that “Control instrumentation and measuring devices” course should be provided with appropriate laboratory assignments in which working principles of sensors, actuators and transducers will be studied by students.

7. Limitations

The methodology which is proposed in this article is limited to the technical or engineering courses. Corresponding strategies could be worked out for social or linguistic courses where digital skills are aimed to deliver.

References

- [1] Abanador, J.R. (2014). Teaching Methods and Learning Preferences in the Engineering Department of an Asian University. *International Journal of Academic Research in Progressive Education and Development*, 3(1), 13. <http://dx.doi.org/10.6007/IJARPED/v3-i1/499>.
- [2] Anderson, L.W. & Krathwohl, D.R. (Eds.) (2001). *A taxonomy for Learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Addison Wesley Longman.
- [3] Benitti, F.B. (2012). Exploring the educational potential of robotics in schools: A systematic review. *Computers & Education*, 58, 978-988.
- [4] Dym, C.L., Agogino, A.M., Frey, D.D., & Leifer, L.J. (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education*, 94, 103–120.
- [5] Hoffer, B.M. (2012). Satisfying STEM Education Using the Arduino Microprocessor in C Programming. *Electronic Theses and Dissertations*. Paper 1472.
- [6] Ibrahim, I., Ali, R., Zulkefli, M., & Elfadil, N. (2015). Embedded Systems Pedagogical Issue: Teaching Approaches, Students Readiness, and Design Challenges. *American Journal of Embedded Systems and Applications*, 3(1), 1-10.
- [7] Kriti, K., Brian, S., & Anshuman, K. (2018). Artificial Intelligence and the Student Experience: An Institutional Perspective. *IAFOR Journal of Education*, 6(3), 63-78.
- [8] Kurti, R. S., Kurti, D. L., & Fleming, L. (2014). The philosophy of educational makerspaces. *Teacher Librarian*, 41(5), 8-11.
- [9] Lee, M. (2015). The promise of the maker movement for education. *Journal of Pre-College Engineering Education Research*, 5(1), 30-39. <https://doi.org/10.7771/2157-9288.1099>.
- [10] Mohammed, A.A. (2017). *International Journal of Engineering Pedagogy (iJEP)*, 7(2), 8. <https://doi.org/10.3991/ijep.v7i2.6845>.
- [11] Morgan, M. (2013). *The Student Experience Practitioner Model. Improving the student experience: A practical guide for universities and colleges*, 69–88. Routledge: London and New York.
- [12] Nazarov, S., Jumayev, B. (2020). Smart alarm system for gas leakages. *International Journal of Engineering Research & Technology (IJERT)*, 9(5), 973-976. <http://dx.doi.org/10.17577/IJERTV9IS050508>.
- [13] Son, K., Sohn, W. (2014). The Development and Application to Computer Programming Education using Arduino. *The Journal of Education*, 34(30), 159-179.
- [14] Seong, W.K., & Youngjun, L. (2017). Development and application of Arduino-based education program for high school students. *Journal of Theoretical and Applied Information Technology*, 95(18), 4367-4375.
- [15] The Horizon Report (2016). K–12 edition. Available at <https://www.nmc.org/publication/nmc-cosn-horizon-report-2016-k-12-edition/> (accessed June 21, 2020).
- [16] The State Programme of energy saving in between 2018-2024. – Ashgabat, 2018.

Effective Teaching of Electric Circuit Analysis through Jigsaw Cooperative Learning Method

Reba P.¹, Susithra N.², Deepa M.³, Santhanamari G.⁴

PSG Institute of Technology and Applied Research

¹rebasatheesh@gmail.com

²nsusithra90@gmail.com

³deepa.mohanram@gmail.com

⁴santhanam88guru59@gmail.com

Abstract : In recent times, in addition to the conventional teaching methods, new pedagogical initiatives are indispensable to elongate the attention span of the present students from generation Z and generation alpha. Jigsaw is one of the Collaborative teaching practices which involves facilitators working in tandem with the students, instructing and mentoring them to solve problems. This paper presents the implementation of an enhanced Jigsaw learning method for teaching Circuit Analysis course for first-year students. Instead of randomly assigning students to groups, the proposed enhancement in the Jigsaw learning method presents diverse teams based on student personalities (Triguna levels – Sattva, Rajas, and Tamas). Such diverse groups become effective learning units and ensure team coherence. Minute feedback was obtained at the end of the session to analyze the effectiveness of the proposed enhanced jigsaw method. The feedback analysis indicates a paradigm shift in the students' level of understanding, and the assessment scores of Tamas students had a significant improvement of 20%. Also, the post-session data shows a boost in the confidence level of the students in solving different Direct

Current (DC) and Alternating Current (AC) based electric circuits. A comparison between the conventional teaching method and the enhanced Jigsaw teaching-learning process is also presented. The results indicate that this method proves to be effective both from the students' learning and the faculty's teaching perspective. In addition to improving the desired learning outcome, the enhanced Jigsaw method also makes the learning process enjoyable.

Keywords : Teaching-learning process, Jigsaw method, Triguna levels, Electric circuits, circuit analysis, active learning.

I. Introduction

CIRCUIT Analysis is one of the professional core courses offered to the Electronics and Communication Engineering stream and Electrical and Electronics Engineering stream students. Since it is one of the main courses introduced in the core domain, it has received significant attention among the students and the faculty engaging in the course. Also, facilitating effective learning and increasing students' classroom engagement makes them focus better and explore more in the field of Electronics. Thus, designing an optimal instructional method to foster conceptual understanding of the topics among the students and increasing the desire to learn serves as a major challenge to the course handling faculty (Bernhard & Carstensen, 2002; Carstensen &

Reba P.

PSG Institute of Technology and
Applied Research
rebasatheesh@gmail.com

Bernhard, 2009; Ogunfunmi & Rahman, 2010; Trajković, 2011).

The Circuit Analysis course provides a fundamental understanding of the behavior of different circuit elements and sources (independent and dependent). It introduces different theorems and laws about the analysis of DC and AC circuits. Firstly, it involves the analysis of resistive circuits with independent sources to determine the current passing through the elements and the voltage across the elements in the circuit. Then, the analysis is extended to circuits with dependent sources and other circuit elements. This course also covers the transient analysis of first-order RL, RC circuits, second-order series, and parallel RLC circuits. All these concepts are taught through extensive problem-solving activities.

While teaching circuit analysis course through the traditional approach (teacher-centric), the authors found that students experienced several difficulties grasping the concepts. While analyzing complex circuits, many students could not exactly determine whether the circuit components are connected in parallel or in series. Also, they were uncertain in identifying the nodes and loops in the circuit, thereby writing incorrect nodal and mesh equations. Students were confused while assigning polarities for voltage across an element or determining the direction of current flowing through the elements in the loop. They experienced difficulty correlating the circuit diagrams with the mathematical equations, hindering the application of relevant circuit laws in appropriate circumstances (de Coulon et al, 1993). This daunted the students resulting in loss of interest and became a major challenge. Also, the faculty is expected to shoulder the responsibility of uplifting the teaching-learning process effectively, helping students rectify their misconceptions and thereby increasing the learning interest towards the course (Ortega-Alvarez et al, 2018). Traditional lecturing alone does not seem to facilitate conceptual understanding in applying circuit laws to analyze the circuits. Previous studies suggest that students' conceptual learning is improved when they actively participate in the learning process (Becker et al, 2013)

Students also develop various skills, such as problem-solving, written and oral communication, self-directed independent learning, and teamwork, while they involve themselves in active learning strategies (Gleason et al, 2011). So, there is a dire need

to couple the conventional chalk and talk teaching method with active learning strategies and Information and Communication Technology (ICT) tools. The upshot is the deployment of blended learning methods with a mixture of synchronous online/physical classes, Audio-visual resources, engaging activities, and open source tools (Deepa et al, 2021).

Collaborative learning is one such student-centric active learning approach. The students learn together and help each other in the learning process by forming groups, where the teachers act as facilitators. The collaborative learning process aims to improve individual accountability and fosters the communication and interpersonal skills of the students (Mourtos, 1994). However, if the collaborative learning process is not planned well or if there is a lack of positive involvement among the group, it will not provide fruitful results (Dillenbourg, 2009). Hence, sessions must be well-organized and structured with classroom instructions to increase the likelihood of effective learning.

Many structured pedagogical methodologies like Think Pair Share, Co-Op, Pyramid, Brainstorming, and Jigsaw have been adopted from time to time to enhance the teaching-learning process (Hertz-Lazarowitz et al, 2013). Jigsaw is a structured, cooperative active learning method that fosters cognitive collaboration and provides different perspectives to the same problem when students solve it as a group. It serves as an effective method to handle analytical subjects. It also helps both the facilitators and the students to move towards their goals in unison. This paper presents the process and outcome of deploying an enhanced version of Jigsaw to teach the concepts of mesh and nodal analysis of circuits.

About Jigsaw: Jigsaw is a collaborative active learning strategy that categorizes students into the home and expert groups. The students are assigned learning tasks after forming the expert group; on completion of the task, they return to their home group to teach their learnings to the other members in the homegroup. Aronson et al. introduced it in 1979 (Aronson & Bridgeman, 1979). Topics to be taught are broken into chunks and assigned to student expert groups. Later, Robert Slavin (1986) developed 'Jigsaw II Students', in which it is suggested that students will receive an individual grade and a team grade determined by adding the test scores of all members of each Jigsaw team (Slavin, 1991). This

method improves students' self-esteem, student-student interpersonal relationship, academic performance and also promotes quality teaching.

Benefits of Jigsaw Method

The Jigsaw method of teaching has the following benefits: (Johnson & Johnson, 1985, 1992)

Tangible benefits

- All students work together to complete the task.
- Improves critical thinking.
- Improvement in assessment scores.

Intangible benefits

- Promotes independent learning and enhances individual accountability.
- Provides a platform for team work.
- Students of any learning style get actively involved with a positive attitude
- Students develop the ability to resolve their doubts by themselves. Sometimes even the teacher might not be able to comprehend the difficulties of the students, while the peers can resolve it in an effective manner.
- Creates interest in learning and this, in turn, reduces the dropout in undergraduate courses.
- Increases students' learning satisfaction.
- Facilitates the development of communication skills.
- Aids face to face interaction.

2. Related Articles

Previous studies point out the effectiveness of practicing the Jigsaw method of cooperative learning technique for students in different academic domains such as medical sciences, nursing, and other science courses (Kritpracha et al, 2018; Kumar et al, 2017; Márquez et al, 2017; Orcos et al, 2016). Aydin & Biyikli (2017) and Yoruk (2016) presents the usefulness of the Jigsaw method for teaching physics

and chemistry laboratory courses. In most of these research works, the authors compare the traditional teaching practices with the Jigsaw method. The analysis reveals that the Jigsaw method helps students excel in learning, motivates the students towards academic achievement, promotes a self-directed learning approach, and helps in simultaneous knowledge sharing among the students. Susanti (2019) discusses the effectiveness of Jigsaw teaching methods to enhance the student's critical thinking and problem-solving skills. The authors claim that this method helps develop cognitive skills and promotes team skills among the students. Costouros (2020) analyzed the improvement in students' grades due to the application of jigsaw cooperative learning strategy for the course Insurance Principles and Practices. The analytical study of incorporating jigsaw cooperative learning strategy also reveals that the students acquire a greater sense of autonomy, deeper-level processing and experience a greater social relatedness.

In Dhage et al (2016), the authors studied the merits of the Jigsaw process for teaching courses in the engineering discipline. They concluded that being a student-centric method, Jigsaw facilitates a life-long learning capability, one of the engineers' graduate attributes. The optimum class size required for implementing Jigsaw is explained in Balestrini et al (2013).

Different pedagogical strategies followed for teaching electric circuits courses were found in the literature Kang et al (2019); Johnson et al (2018) and Yoshikawa et al (1992). A student-centered approach for electric circuits is presented in Becker et al (2013) and Yoshikawa et al (1992). The teachers facilitate deeper understanding by introducing specific applications related to the concepts under study. This type of active learning provides a meaningful experience to students while learning this course. Johnson et al (2018) highlights the benefits for both the teacher and the students while having a flexible physical classroom to practice active learning. In Yoshikawa et al (1992), the authors introduced an intelligent tool that assists the students in exercising many problems related to electric circuits. However, the application of Jigsaw as cooperative learning method for the course circuit analysis was not found in the literature. Suganya et al (2020) discusses the implementation of the Jigsaw learning method for the course Microcontrollers for undergraduate electrical engineering students. The authors used the continuous assessment marks scored by the students and feedback

responses to analyze the performance of the Jigsaw activity. However, the jigsaw team formation was not explored. The team-Based Learning (TBL) approach for teaching Electric Circuits is explained in O'Connell (2014). The students were provided instructional materials for the upcoming topics to be taught in classrooms. It is a flipped type of pedagogical strategy, and the students prepare before the actual session, and once they enter the classrooms, they work in groups to solve problems or applications related to the study material provided. O'Connell (2014) also analyzed the size of the team for TBL activity. The authors claim that if the team size is large, some students may be disinterested and remain unnoticed without contributing much. As TBL does not guarantee individual upliftment, the team size is reduced to as low as four members. The same problem may also happen while implementing Jigsaw activity for teaching circuit analysis courses and the literature does not suggest any solution.

Hence, this paper addresses the necessity for a modified version of Jigsaw activity to ensure its effective implementation in terms of quality team formation and individual upliftment.

Objective:

The purpose of this paper is to compare and analyze the outcomes of an enhanced Jigsaw method of teaching with the traditional method for the course 'Circuit Analysis' offered during the first year of the Engineering Programme.

3. Methodology

This section explains the methodology followed for deploying conventional teaching methods and the enhanced Jigsaw method for the students. Sixty students pursuing undergraduate 'Electronics and Communication Engineering' program under Anna University, were divided into two batches for this study; A batch of 28 students who participated in the traditional style of teaching were identified as the control batch, and the remaining 32 students who participated in the Jigsaw method of teaching were identified as the experimental batch. The objective was to make the students solve electric circuits using mesh and nodal analysis methods in different teaching-learning environments (traditional vs collaborative). The course outcome for the chosen topic is "Analysing DC and AC circuits using the

Table 1 : Questionnaire For Minute Feedback

Minute Feedback						
Please respond to the statements in a 5 point scale		1	2	3	4	5
1.	The session enabled in -depth understanding of the topic.					
2.	The session helped in enhancing the communication skills.					
3.	The session helped in overcoming inhibition and hesitation in the class.					
4.	It was interesting and enjoyable to solve the problems.					
5.	The level of confidence in taking up a new problem and solving it on your own has increased.					

Mesh and Nodal Analysis". Initially, all the students were collectively given an elaborate explanation of the underlying concepts required for deriving and solving the mesh and nodal equations in the introductory session. The subsequent tutorial sessions were handled separately for the control batch and the experimental batch of students.

A. Conventional Method

The conventional method of teaching was adopted for the control batch of 28 students. After an introductory session on the topic, the faculty solved a few sample problems in the class for mesh and nodal analysis. During the subsequent tutorial sessions, the students were provided tutorial sheets, in which the difficulty levels of the problems ranged from simple to complex. The circuits with independent sources are quite easy, whereas circuits with dependent sources need critical thinking. This traditional way of teaching, alongside the practice sessions, required about 4 to 5 lecture hours for the teacher to complete the topic. This type of teaching was more teacher-centric, where the teacher shared their knowledge/expertise with the students. The students were also assigned homework problems in mesh and nodal analysis. Some students approached the teacher and clarified their doubts while solving the homework problems. They experienced some difficulties in applying the concepts to solve new problems with different meshes and nodes.

Through this teaching method helped the students

Table 2 :Average Response For The One-minute Feedback- Traditional Method

Response Statements		Average Response (Max. 5)
1.	In-depth understanding of the topic after the session.	3.2
2.	Enhancement in Communication skills	2.0
3.	Overcoming inhibition and hesitation in the class	1.8
4.	Interesting and enjoyable nature of the session to solve problems and understand	2.1
5.	Level of confidence in taking up a new problem and solving it independently.	2.5

grasp the concepts and expertise from the teachers, it lacked the important aspects of the learning process, namely, individual upliftment and the ability to apply the learned concepts to new scenarios. The learning process is also expected to trigger other professional attributes such as interpersonal skills and teamwork in addition to technical knowledge.

After completing the topic, minute feedback was obtained from the students. Table I shows a questionnaire for the minute feedback. The feedback provided by the students was not satisfactory, as detailed in Table II. From the feedback analysis, it can be seen that students had a less in-depth understanding of the topic. Also, the confidence level of the students to take up a new problem and solve independently on the topic was low.

Furthermore, the traditional method does not create much interest among all the students in learning the topic. It does not significantly enhance communication skills, neither does it help them to overcome hesitation in interaction. Table 2 shows the average response score for the feedback statements obtained from the traditional method (on a scale of 1 to 5).

According, to the graduate attributes defined by National Board of Accreditation (NBA) (NBA SAR-format, n.d.), apart from problem solving skills, it is essential to help students develop other graduate attributes such as social interactions, societal understandings, professionalism, team work, communication, ability to function effectively as an individual, or as a member or leader in a team and ability to comprehend, give and receive clear instructions while working as a team. It is inferred from the feedback analysis that the traditional method

does not help in building the above mentioned graduate attributes.

B. Enhanced Jigsaw Method

Need for Enhanced Jigsaw method: The Jigsaw methodology was adopted for teaching the same topic for the experimental batch of 32 students. Even though the Jigsaw method aided the various dimensionalities of learning in the collaborative learning environment, it could not cater to students' individual needs. Certain students tend to stay within their boundaries when injected into team-based learning environments. The construction of the team formed a vital part in reaping the maximum benefits of the collaborative activity. So, the enhanced Jigsaw method proposed in this paper incorporated the grouping of the students based on the Triguna model, a personality prediction model rooted in Indian Vedic literature (Sharma et al, 2016). This methodology also averts the risk of grouping all the proficient students into a single group.

Triguna Model-based Enhanced Jigsaw method: In this proposed method, the students were categorized based on their gunas, such as Sattva, Rajas, and Tamas, with the help of the Personality Assessment test - Triguna model Sharma et al (2016). The grouping of the students for the enhanced Jigsaw method was done so that each group had a mix of all the three predominant guna levels. Students with a predominant Sattva guna are naturally capable of adapting to different situations and can convert any challenging scenario into a growth-promoting opportunity, whereas a student with more inclination to Tamas guna inherently possesses inertia or laziness and procrastination. Even though the students with Rajas guna are known to possess compulsive qualities

Mesh Group	Group 1	1	2	3	4
	Group 2	5	6	7	8
	Group 3	9	10	11	12
	Group 4	13	14	15	16
Nodal Group	Group 5	17	18	19	20
	Group 6	21	22	23	24
	Group 7	25	26	27	28
	Group 8	29	30	31	32

Fig. 1 : Expert grouping of students

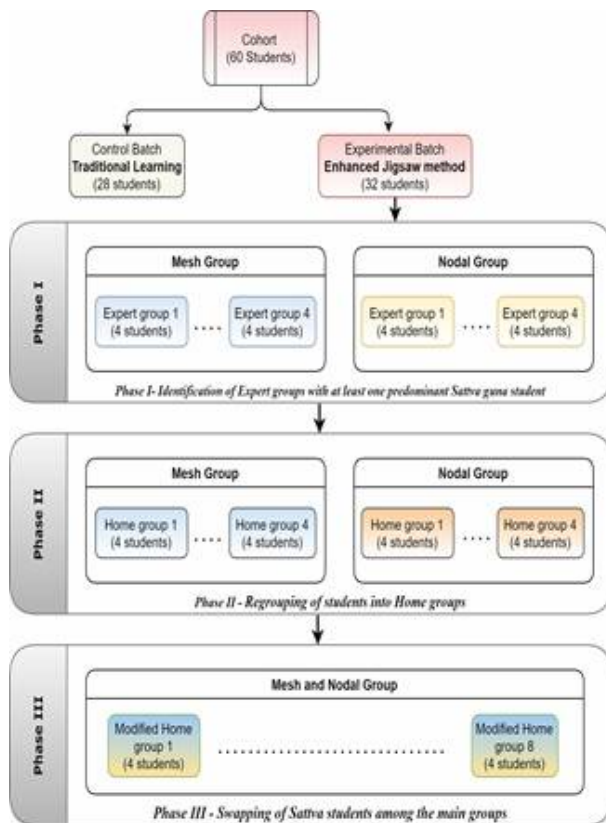


Fig. 2 : Different phases of enhanced Jigsaw method

Mesh Group	Group 1	1	5	9	13
	Group 2	2	6	10	14
	Group 3	3	7	11	15
	Group 4	4	8	12	16
Nodal Group	Group 5	17	21	25	29
	Group 6	18	22	26	30
	Group 7	19	23	27	31
	Group 8	20	24	28	32

Fig. 3 : Regrouping of students into Home groups with the Sattva students indicated by encircled.

Mesh and Nodal Analysis	Group 1	1	5	9	21
	Group 2	2	26	10	14
	Group 3	31	7	11	15
	Group 4	4	8	20	16
	Group 5	17	13	25	29
	Group 6	18	22	6	30
	Group 7	19	23	27	3
	Group 8	11	24	28	32

Fig. 4 : Swapped groups to complete the other half of the problem set

of energy, passion, and action, they also exhibit self-centredness. They are not conducive to promoting positive and harmonious group interactions. So, students with predominant Sattva guna were identified and added to each of the expert groups to facilitate effective collaboration and positive interdependence among the students.

Execution of Enhanced Jigsaw method: The experimental batch of 32 students were divided into two main groups: Mesh analysis Group (1 to 16) and Nodal analysis Group (17 to 32). Each of these groups was then subdivided into four sub-groups with four students each. Thus, Fig. 1 shows all the eight sub-groups, which were identified as the expert groups. Each expert group had at least one predominant Sattva guna student, as illustrated with encircled numbers.

The problems to be solved were divided into three categories based on the level of complexity:

- Category A - easy to solve
- Category B - medium complexity
- Category C - a higher level of complexity

Jigsaw activity implemented to solve mesh and nodal analysis problems were divided into three phases, as depicted in Fig. 2.

1) Phase I- Identification of Expert groups with at least one predominant Sattva guna student

Firstly, each expert group solved a distinct set of three problems, one problem from each category starting from a low level of complexity (Category A) to higher complexity (Category C). The students collaboratively solved the problems; they discussed each other and came up with solutions. This enhanced the ability to work as a team and kindled the critical thinking capability of the students. The faculty acted as a facilitator of the activity while the Sattva guna students played a major role in helping others to solve the problems. Such students became task specialized and were prepared to disseminate the knowledge to other groups in the next phase.

2) Phase II- Regrouping of students into Homegroups

Once each group solved the three problems assigned to them, the students were regrouped, as shown in Fig.3. This group formation was identified

as the base group or the homegroup. In this home group, each student is an expert in 3 distinct problems.

Each student in the homegroup shared the knowledge gained in solving the problems with their home group members. This sharing of knowledge enhanced their group interaction and communication skills. This way, the entire Mesh group (16 students) finished solving all 12 (4 sets of 3 each) mesh analysis problems and the nodal group (16 students) solved all the 12 (4 sets of 3 each) nodal analysis problems under different levels of complexity. Every student, who was accustomed to different learning styles was cooperatively involved in the Jigsaw method. The successful completion of the learning activity promoted a more positive attitude towards the course.

3) Phase III- Regrouping Swapping of Sattva students among the main groups

In order to make the whole class solve all 24 problems under the mesh and nodal analysis, a Sattva student from the mesh analysis homegroup was swapped with the one in the nodal analysis home group, as shown in Fig. 4. For example, the Sattva student (number 13 in Fig. 4) helped the other students of home Group 5 to solve the problems based on mesh analysis, in addition to learning the nodal analysis problems from their peers. Similarly, all the migrated Sattva students ensured sharing of knowledge through peer learning in their respective sub-groups. This served as a win-win situation in boosting the confidence level of the Tamas students and instilling a feeling of responsibility for the Rajas students to impart skills to their peers. Thus, all the students were interested in the activity and finally solved the complete set of problems with a thorough understanding.

Even though the enhanced Jigsaw method produces better results compared to the traditional methods, the success of this method lies in the fact that the faculty must plan and prepare the Jigsaw activity well in advance. A good rapport with the students will also help the faculty in the formation of student groups. Moreover, the faculty must prepare the questions with care. In the present case study, the problems were arranged under three categories, from easy to difficult. Therefore, beginning with simple problems and then slowly increasing the complexity level builds students' interest in solving the problems.



Fig. 5 : Peer learning hall ambiance

Table 3 : Average Response For the One-minute Feedback- Jigsaw Method

Response Statements		Average Response (Max. 5)
1.	In-depth understanding of the topic after the session.	4.05
2.	Enhancement in Communication skills	3.81
3.	Overcoming inhibition and hesitation in the class	4.20
4.	Interesting and enjoyable nature of the session to solve problems and understand	4.28
5.	Level of confidence in taking up a new problem and solving it independently.	4.32

Furthermore, the faculty were present throughout the activity and facilitated the learning process by clarifying whenever a student approached. Thus, the role of the facilitator was indispensable for the smooth conduct of the enhanced Jigsaw activity. The facilitator also made sure that the discussions were in the right direction according to the scripted instructional design for the enhanced Jigsaw learning activity.

The enhanced Jigsaw learning activity was conducted at the peer learning hall allotted for active and collaborative learning activities. It is a well-ventilated space with a size of 30' x 40' sq. ft. (Fig. 5). The hall has a total seating capacity of 75 students, has a good ambiance and infrastructure to accommodate students as groups of 5 in 15 round tables. The classroom setup helped the teacher to move around and hop from one team to another while monitoring their progress. The students also had a comfortable discussion experience while being seated at a round table facing each other. The peer learning hall is also equipped with a green board of size 20' x 4' sq. ft, two hand microphones, one collar microphone, and a Smart TV with a wide 72" screen with internet connectivity.

Table 4 : Comparison of Assessment Marks in Percentage 'part A'

Mode	Min	Median	Mean	Max
Conventional method of Teaching (Control Batch)	43	77	71.87	100
Enhanced Jigsaw Method (Experimental Batch)	64	84	83.07	100

*Part A weightage: 10 marks

Table 5 : Comparison of Assessment Marks in Percentage 'part B'

Mode	Min	Median	Mean	Max
Conventional method of Teaching (Control Batch)	35	65	63.40	95
Enhanced Jigsaw Method (Experimental Batch)	60	79	78.73	99

*Part B weightage: 20 marks

At the end of this enhanced Jigsaw activity, the students were asked to provide minute feedback on the learning activity conducted. The same questionnaire, which was given to the control batch, was provided to the experimental batch to compare the learning outcome attainment and its effectiveness.

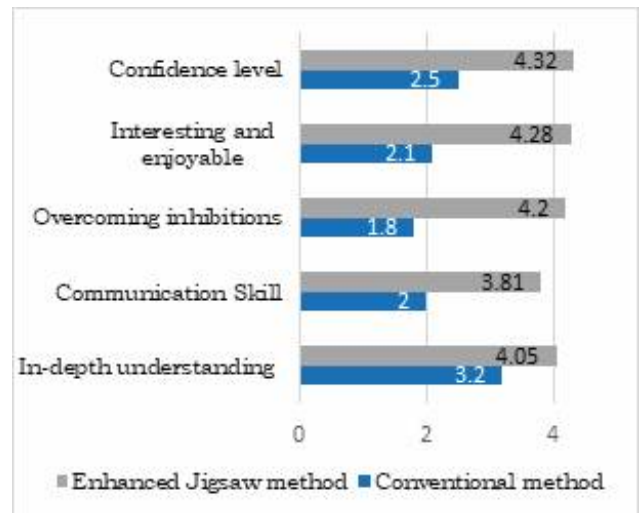
Table III shows the average response of the students from the experimental batch. The feedback obtained suggests that the Jigsaw activity made the session more exciting and enjoyable. From the rating for in-depth understanding, it was inferred that around 81% of students felt more comfortable communicating actively with their peers during the activity compared to their communication with the course instructor. The confidence level of the students also increased to over 86%.

4. Results And Discussion

The effectiveness of implementing the enhanced Jigsaw method can be gauged in terms of the following factors, namely: students' performance, observation by the faculty, and effectiveness of guna classification for grouping the students.

A. Student's Performance

After the completion of the learning process, a one-hour assessment was conducted to gauge the learning effectiveness of both the traditional and Jigsaw

**Fig. 5 : Bar graph comparing the average feedback scores in both the teaching methods**

students. The assessment questions were divided into two sections, 'Part A' and 'Part B'. In Part A medium complexity questions were framed to test their conceptual understanding. The other section included complex problems, which require higher-order thinking skills in applying appropriate theorems to arrive at a proper solution. Table IV and Table V shown below, compare the scores converted to a percentage for the control and experimental batches.

Table IV and Table V compare the students' assessment scores of the control and experimental batches. It was observed that the students performed well in both Part A and Part B while adopting the enhanced Jigsaw methodology. Both the groups of students were able to perform well in Part A. But the experimental batch adopting the Jigsaw methodology showed increased performance in Part B compared to the control batch.

The graph in Fig. 8 compares the average feedback scores obtained by the students using the two different methodologies in Table II and Table III. It was observed from the students' feedback (Fig. 6) that the in-depth understanding, communication skills, confidence levels and interest towards learning was higher for the experimental batch who learnt by the enhanced Jigsaw method compared to the control batch - conventional teaching learning experience.

B. Observations by the faculty

While elaborating the concept using conventional

teaching, the faculty felt that the lectures were monotonous, and the students experienced difficulty understanding the concepts. The faculty had to spend additional time teaching the students who could not grasp the concept in the classroom sessions. The faculty was also unable to address the needs of the reluctant students in the class. When the students were provided with home assignments, they experienced difficulty getting along with their peers in solving the problems.

The faculty felt that the interaction between the students improved substantially, and the students' engagement was maximized while adopting the Jigsaw methodology. When the students were grouped into small teams, every student got the opportunity to help and learn from their peer group environment. It was also observed that the experimental batch was enthused with positive energy, and the students built a constructive competition among and outside their group. The faculty were also highly motivated to provide additional problems of higher-order thinking to cater to the learning interests of students.

Table VI compares the traditional teaching method and enhanced Jigsaw method of learning in terms of

Table 6 : Comparison Of Traditional Teaching Practice And Jigsaw Method Of Learning

	Traditional Teaching Practice	Enhanced Jigsaw method of learning
No of lecture hours required to introduce the concepts of mesh and nodal analysis and solve basic problems :	1 lecture hour + 3 tutorial hours	1 lecture hour + 3 tutorial hours Phase 1: 1 tutorial hr Phase 2: 1 tutorial hr Phase 3: 1 tutorial hr
No of problems solved	Nine problems as in-class activity and ten problems as homework (easy to medium complexity)	24 Problems (easy, medium, and high complexity problems)

Table 7 : Average Assessment Scores (in Percentage) For Guna Based Classification Of Students

Classification of students based on Predominant Guna	Average assessment score	
	Conventional teaching method	Enhanced Jigsaw method
Sattva	75.21	87.94
Rajas	86.08	90.33
Tamas	47.99	67.06

the utilization of time resources and the number of problems solved. The table inferred that the Jigsaw method helped in utilizing the time resources efficiently and the students meticulously solved more problems under different categories.

C. Effectiveness of Guna Classification

When the students were grouped in a team of five or more, predominant Tamas Guna (unprepared or unwilling students) tend to contribute very little in group work, being unnoticed throughout the sessions; in other words, they may "hide" easily. However, a team size of four with guna classification was found to provide sufficient intellectual resources to solve the problems at different levels and prevented students from "hiding" and motivated them to contribute in at least small means.

From Table VI, it was found that the enhanced Jigsaw activity improved the interpersonal skills of the students when they were asked to interact among their groups, facilitated by the faculty. Also, the Sattva students made sure that the discussions were fruitful and in the intended direction establishing a harmonious environment. The faculty encouraged the Sattva students to promote a win-win situation among the group consisting of Rajas and Tamas students. Rajas dominant students were quite hyperactive and did not easily help their peers, but the Jigsaw created an atmosphere for compulsive interaction. The students clarified their doubts by interacting with their peer groups. This activity also enabled the Tamas students to come forward and get involved in the group activities rather than being conservative, thereby scoring better than the same cadre of students in the control batch. Also, it was observed that this activity served as an opportunity to kindle the Sattva guna characteristics among the Rajas and Tamas guna students.

5. Conclusion

The enhanced Jigsaw learning activity was conducted for the first-year students of Electronics and Communication Engineering. The learnings in terms of the impact of the adopted methodology on the teaching-learning process were presented. The students, categorized using the Triguna levels, were divided into an expert and home groups to solve Mesh and Nodal analysis problems. Initially, the students were reluctant to participate in the collaborative activity. Later, it was observed that the student's

interest in the activity and completion of tasks improved significantly. The post-session feedback, students' assessment scores, and the comparison between the conventional and enhanced Jigsaw activity served in inferring the effectiveness of the adopted active learning strategy. This activity ensured to improve every student's learning curve, problem-solving, and critical thinking ability and promote collaborative interdependence among the students. This group activity kindled the positive attributes of the students with different Guna levels and helped them in establishing a coherent environment for their learning activity. This methodology also to deliver the course contents at a faster pace within the stipulated duration, without compensating for the students' academic performance and conceptual.

References

- [1] Aronson, E., & Bridgeman, D. (1979). Jigsaw groups and the desegregated classroom: In pursuit of common goals. *Personality and social psychology bulletin*, 5(4), 438-446.
- [2] Aydin, A., & Biyikli, F. (2017). The Effect of Jigsaw Technique on the Students' Laboratory Material Recognition and Usage Skills in General Physics Laboratory-I Course. *Universal Journal of Educational Research*, 5(7), 1073-1082.
- [3] Balestrini, M., Hernandez-Leo, D., Nieves, R., & Blat, J. (2013). Technology-supported orchestration matters: Outperforming paper-based scripting in a jigsaw classroom. *IEEE Transactions on Learning Technologies*, 7(1), 17-30.
- [4] Becker, J. P., Plumb, C., & Revia, R. A. (2013). Project circuits in a basic electric circuits course. *IEEE Transactions on Education*, 57(2), 75-82.
- [5] Bernhard, J., and Carstensen, A. K. (2002) Learning and teaching electrical circuit theory. *PTEE 2002: physics teaching in engineering education*, 163-178.
- [6] Carstensen, A. K., & Bernhard, J. (2009). Student learning in an electric circuit theory course: Critical aspects and task design. *European Journal of Engineering Education*, 34(4), 393-408.
- [7] Costouros, T. (2020). Jigsaw learning versus traditional lectures: impact on student grades and learning experience. *Teaching & Learning Inquiry*, 8(1), 154-172.
- [8] de Coulon, F., Forte, E., & Rivera, J. M. (1993). KIRCHHOFF: An educational software for learning the basic principles and methodology in electrical circuits modeling. *IEEE Transactions on Education*, 36(1), 19-22.
- [9] Deepa, M., Reba, P., Santhanamari, G., & Susithra, N. (2021). Enriched Blended Learning through Virtual Experience in Microprocessors and Microcontrollers Course. *Journal of Engineering Education Transformations*, 34, 642-650.
- [10] Dhage, J. R., Pawar, A. B., & Patil, M. S. (2016). Effect of the jigsaw-based cooperative learning method on engineering students. *Journal of Engineering Education Transformations*.
- [11] Dillenbourg, P., Järvelä, S., & Fischer, F. (2009). The evolution of research on computer-supported collaborative learning. In *Technology-enhanced learning* (pp. 3-19). Springer, Dordrecht.
- [12] Gleason, B. L., Peeters, M. J., Resman-Targoff, B. H., Karr, S., McBane, S., Kelley, K., ... & Denetclaw, T. H. (2011). An active-learning strategies primer for achieving ability-based educational outcomes. *American journal of pharmaceutical education*, 75(9).
- [13] Hertz-Lazarowitz, R., Kagan, S., Sharan, S., Slavin, R., & Webb, C. (Eds.). (2013). *Learning to cooperate, cooperating to learn*. Springer Science & Business Media.
- [14] Johnson, A. W., Blackburn, M. W., Su, M. P., & Finelli, C. J. (2018). How a flexible classroom affords active learning in electrical engineering. *IEEE Transactions on Education*, 62(2), 91-98.
- [15] Johnson, D. W., & Johnson, R. T. (1992). Positive interdependence: Key to effective cooperation. *Interaction in cooperative groups: The theoretical anatomy of group learning*, 174-199.

- [16] Johnson, R. T., & Johnson, D. W. (1985). Student-student interaction: Ignored but powerful. *Journal of teacher education*, 36(4), 22-26.
- [17] Kang, R., Lin, Y., Wang, Y., Wu, H., Wu, M., & Teng, B. (2019). A pedagogical case on active learning regarding to Kirchhoff's circuit laws. *The International Journal of Electrical Engineering & Education*, 56(2), 179-190.
- [18] Kritpracha, C., Sae-Sia, W., Nukaew, O., Jittanoon, P., Chunuan, S., & Kaosaiyaporn, O. (2018). The Development of Cooperative Learning Using Jigsaw Activities for Learning Achievement and Self-directed Learning Behaviors of Nursing Students. *International Journal of Information and Education Technology*, 8(12), 913-917.
- [19] Kumar, V. C. S., Kalasuramath, S., Patil, S., Kumar, R. K. G., Taj, S. K. R., Jayasimha, V. L., ... & Chacko, T. (2017). Effect of jigsaw cooperative learning method in improving cognitive skills among medical students. *Int J Curr Microbiol*, 6(3), 164-173.
- [20] Márquez, L. M. T., Llinás, J. G., & Macías, F. S. (2017). Collaborative learning: use of the jigsaw technique in mapping concepts of physics. *Problems of Education in the 21st Century*, 75(1), 92.
- [21] Mourtos, N. J. (1994, November). The nuts and bolts of cooperative learning in engineering. In *Proceedings of 1994 IEEE Frontiers in Education Conference-FIE'94* (pp. 624-627). IEEE.
- [22] N B A S A R - format(<https://www.nbaind.org/Files/sar-ug-t-ii-final-ver-06.pdf>), pp. 48.
- [23] O'Connell, R. M. (2014). Adapting team-based learning for application in the basic electric circuit theory sequence. *IEEE transactions on education*, 58(2), 90-97.
- [24] Ogunfunmi, T., & Rahman, M. (2010, May). A concept inventory for an electric circuits course: Rationale and fundamental topics. In *Proceedings of 2010 IEEE International Symposium on Circuits and Systems* (pp. 2804-2807). IEEE.
- [25] Orcos, L., Arias, R., Aris, N., & Magreñán, Á. A. (2016, October). Collaborative learning: implementation of Jigsaw technique in Google. In *2nd. International conference on higher education advances (HEAD'16)* (pp. 373-380). Editorial Universitat Politècnica de València.
- [26] Ortega-Alvarez, J. D., Sanchez, W., & Magana, A. J. (2018). Exploring undergraduate students' computational modeling abilities and conceptual understanding of electric circuits. *IEEE Transactions on Education*, 61(3), 204-213.
- [27] Sharma, S., Singh, A., & Mehrotra, S. (2016). Sattva Guna as a Predictor of Wisdom and PWB. *International Journal of Indian Psychology*, 4(1), 158-167.
- [28] Slavin, R. E. (1991). *Student team learning: A practical guide to cooperative learning*. National Education Association Professional Library, PO Box 509, West Haven, CT 06516 (Stock No. 1845-1-00, \$18.95).
- [29] Suganya, R., Kavitha, D., & Helen, R. (2020). An effective way of improving the course outcomes by using jigsaw technique in core courses of engineering. *Journal of Engineering Education Transformations*, 33, 397-401.
- [30] Susanti, R. D. (2019). Application Of Jigsaw Method With Metacognitive Approach In Social Statistics Learning To See Students' Problem-Solving Abilities. *International Journal of Scientific & Technology Research*, 8(11), 212-215.
- [31] Trajković, L. (2011, May). Teaching circuits to new generations of engineers. In *2011 IEEE International Symposium of Circuits and Systems (ISCAS)* (pp. 1187-1190). IEEE.

A Study Report on Teaching Skills to Speech and Hearing-Impaired Students in Higher Education Sector

S. Thangarasu¹, K. Karthigadevi²

¹Department of Physics, Kalasalingam Academy of Research and Education, Krishnankoil-626 126

²Department of Computer Applications, Kalasalingam Academy of Research and Education, Krishnankoil-626 126

¹ritesh.bhat@manipal.edu

Abstract : It is vital to offer appropriate education and guidance to speech and hearing-impaired (SHIP) students. It is necessary for their successful life. The usage of modern technology will give a better solution for the speech and hearing-impaired students. The main goal of this research study is to apply the updated technologies to the SHIP students in higher education. In this paper, we have summarized the teaching approaches for speech and hearing-impaired students. Establishing a good communication channel between teachers and special students is essential for effective teaching and learning method. Here, Expectation for more findings and submissions has been produced to attain their goal.

Keywords : Speech and hearing-impaired persons (SHIP), Teaching and learning, Technology effectiveness, Education.

1. Introduction

Speech and hearing-impaired (SHIP) students are placed under the group of people who need individual caring and special education [1]. There are many standards for categorizing the speech and hearing-

impaired people. The classification is done in accordance with many factors like, time of loss acquired, the degree of hearing loss, reason, form, place and longevity. The hearing loss degree is measured by audiogram, and they are divided into four categories, medium loss, slight loss, very late loss, and further loss [2]. The training process begins after the students have cleared the diagnostic and instrumentation process. Speech and hearing are the capabilities of a distinct to functionally use oral language in everyday life [3]. The verbal communication is blocked in course, due to hearing problem [4]. As the result, the speech and hearing-impaired students could not obtain the talking and learning measurement of their own language like mother tongue completely. It is proved that the qualities of the students who require special education and their requirements are somewhat different [5]. SHIP students are facing many important problems in school life and social life [6].

Isolate classrooms, proper hearing aids, Loop induction class room, audiogram equipment and educational chart activities are important for this SHIP students. When the SHIP student got fail mark in the classroom, they feel embarrassed and hesitated. In this situation, computer-aided materials can be used to deliver the chance to recurrence their lessons and to create a distinct education setting. This procedure will improve the students' self-confidence and influence [7] in the learning process positively [8]. The teachers got stressed that the preparation of teaching materials [9] like animations are fun based, visual play,

S. Thangarasu¹

Department of Physics,
Kalasalingam Academy of Research and Education,
Krishnankoil-626 126
sthangarasu@gmail.com

paintings and chart work for speech and hearing-impaired individuals [10]. This study focused on the effective techniques and procedures used in teaching of SHIP students. The SHIP students and regular students were examined in this situation for the study and the usage of technology in their education. This study will focus on the vast usage of technologies followed in teaching of SHIP students and the raise of skills and knowledges in using current technologies.

2. Centre for SHIP

Many universities have specialized centre for special students. Similarly, Kalasalingam Academy of Research and Education (KARE), Krishnankoil, Tamil Nadu has organized a good environment for SHIP students with their specific needs for their higher education. Kalasalingam Academy of Research and Education (KARE) in Tamil Nadu has a rich experience about the SHIP students in Engineering and Commerce domain. This centre provides them a discrete education strategy with help of trained special faculties, sign language translators and lab supporters. This organization delivers courses to enhance the student's logical awareness abilities. This centre is dedicated not only to the students but also it trains the professors and delivers them complete instruction about the way of communication with the Speech and hearing-impaired students.

3. Teaching methods for SHIP students

At KARE, all the basic information about the special students were collected. Then various teaching methods will be implemented by teachers of Centre for SHIP at KARE. After through study with the students, it is easy to describe the key tools to help the SHIP student to take part in standard progressions. In this paper we try to focus on outcomes of teaching education and learning development for the students with speech and hearing impairment which was verified by real-world practice from the teaching at the Centre for SHIP at KARE.

3.1 General ground

The speech is the most commonly used medium in the conventional education system, but the research shows, that the information received visually plays the vital role [11].

The Human's sense perception strongly depends on individual so as the information retrieval layout. It

is always very difficult to device an individual teaching method. There are differences in the level of hearing impairment. Based on their hearing loss students can be divided into two different groups:

Pre-lingual hearing loss – Hearing loss before the language is developed.

Post-lingual hearing loss – People who got deaf, but already had learned to speak.

Pre-lingual hearing loss – This type of hearing loss is identified from birth itself. These people have known only sign language as their mother language. Written language was considered as a second language since they don't know the language.

Post-lingual hearing loss – This type of deafness [12] has been identified after any injury in ear. These people know the language how to speak and write. [13].

The students with pre-lingual hearing loss face many problems in understanding of the subject matter because of the dissimilar language.

The sign languages and spoken have a different syntax. Many times, the students interpret the teacher's statements using the watching, reading and lip-reading the notes written at the board. The professor or a sign language translator are helping these SHIP students to understand the subject [14].

At KARE people with hearing impaired can select from two different forms of education: B. Tech or B. Com based on the higher secondary specialization.

This study focusses on the teaching procedures to SHIP students. In general, many of my teachers thought hard to taught SHIP students. It is important that the message has to spread out to all the SHIP students and it is necessary to make adjustments in the classroom to reach out to all of our SHIP students. These adjustments meant for small changes in the teaching methodology.

3.2 Classroom

Teachers in the classroom need to see all of the students. It may require a minor rearrangement or moving the student to a different seat of the classroom. It is advisable to arrange desks in a semicircle if the class is small but it isn't possible then the students can

be placed to the side and in front, a place that provide clear visualization. It is not advisable to stand side and in front of windows. The glare may hurdle the visibility to anyone especially for the SHIP students who focus on lips.

It is necessary to remember not to speak when the SHIP people can't get your face expression for instance when walk around or you write on the board. While making reference to the objects on the sheet in board it is necessary to be precise about the phrase or word pointing directly to it. If the reading an assignment are done during the class hours avoid talking at the same time [15]. It is advisable to have the assistance of a normal student. To grab the attention of SHIP student just tap on the shoulder or wave by the hand in front of their face – or with the help of student nearby. The body language, facial expressions and gestures are important for nonverbal communications. It is good advice to use visual aids whenever possible – since visual reinforcement enhances all communication.

3.3 Communication Issues

Although many assistive listening devices and also some speech reading skills are there to help SHIP students in the teaching space, approximately some people rely on interpreters to communicate. The interpreter is the mediator between the teacher and the SHIP students to communicate. The interpreter cannot be a teacher so it is always important to maintain the direct communication with the student. The subject clarification comes from the end of the teacher not from the interpreter as he does not explain or give advice about subject [16]. It should be maintained that the direct speech with a SHIP student not as the indirect speech. For example, enquire “Do you have your assignment” nor “Does she have her assignment?”. Let the translator stand or sit near by the teachers' that will help the SHIP student to keep interaction with teacher and the translator. The translator should not face any problem to hear the teacher because of close sounds such as air ventilators or projector.

3.4 Interpreters

In the time of class discussion, it is necessary to give sufficient time for the SHIP students to participate [17] and to interact over the interpreter and for the interpreter revert to the teacher. While reading necessary pause to be taken to the SHIP students and

the interpreter should keep up with teacher and the remaining class.

The aim is all the students must have the knowledge to access the greatest education, thus it is necessary that the interpreter should be knowledgeable and qualified.

The interpreters must possess proper training, and must hold a state and/or national certification.

The interpreters should be trained through institutional level interpreter training sessions or state rehabilitation services.

While taking classes the teacher should face the SHIP students not the interpreter when the teacher talking to the SHIP students. The students should have a clear view of vision to the teacher and the interpreter. The interpreter should avoid standing or sitting in front of lights or shadows or windows.

The interpreter should not sit close to the noise sources. The teacher must avoid private discussions or chats with others in front of SHIP students because the interpreter may translate all said.

The basic, simple, and clear speaking style must be followed to help the interpreters to understand easily. In case of long lectures have minimal breaks since the interpreter requires a lot more energy since he makes signing and watching than simply listening.

3.5 Assistive Listening Devices

It is not necessary for all students to use translators. Some SHIP students will trust on assistive learning devices. The ALDs use wireless microphones to convey sound to the student's headset.

So that the talker must be near the microphone.

The ALD working condition should be ensured, the mike or the microphones should be passed to who is speaking or multiple microphones to be arranged. Have the conformation from SHIP student with an ALD that the sound is conveying easily.

Most listening devices depend on battery power for operation hence backup batteries should be kept always. Each evening the rechargeable batteries should be charged. Make sure that the receiver and transmitter are switched off each day to preserve

power. The most important thing is to off the mike when it is not in use.

3.6 Teaching Strategies

Give the benefit of your prior planning to the students with hearing loss [18] and the teaching strategies were presented in Table 1. A brief course outline to be given to the students early in the term. The new vocabulary or specific terms should be listed on the blackboard before each class, or a copy those things should be handed over before that both the translator and the students if necessary.

Some faculties provide a copy of their subject notes to the students. Since the focus of the student on an interpreter and maybe you, support the SHIP student find a fellow student to deliver a copy of subject notes. The SHIP students may find it difficult to take notes since their attention is on you. Hence offer them with the printed copy directions or notices or test schedules and changes any. While teaching anything it is necessary for the students to focus on you, and also referring to the content on the board, it is important to allow sufficient period for the translator to transfer the data to the students and also the SHIP students to understand the concept clearly.

Table 1: Comparison Result of teaching strategies and outcome

S.No	Teaching strategies	Outcome achieved
1.	New vocabulary or specific terms should be listed on the blackboard before each class	Students knowledge improved and got information about new terms and it is easily understandable among SHIP students
2	Teachers circulate a copy of their subject notes to the students before taking class	Providing subject notes early is necessary for these students to focus and concentrate on studies while teachers taking class and also referring the content on the board
3.	Use the meeting apps (online class) with captions and when video lessons are played	With the help of captions or subtitles students came to know about the information in the content clearly
4.	To inform the students we use bulletin board or notice board	With the help of bulletin board or notice board in the noticeboard SHIP students received all the announcements and important information related to their needs.

It is always necessary to use the programs with captions when videos lessons screened and also try to have the decoders if required. If the video programs move too fast, allow enough time for communication even if the student is using an interpreter. It is necessary to ensure that the SHIP student gets all school announcements properly.

3.7 Visual resources

The exploitation of visual resources greatly improves the learning of SHIP students, especially if images, videos or animations are accompanied by explanatory captions. An equation or function properly presented with the legend of its variables is decisive for the understanding.

3.8 Laboratory experiments

Without doubt the realization of experiments from science or engineering subject is determinant in the learning of the physical, because it allows the visualization of the phenomenon. In the case of SHIP students, it is necessary to add very explanatory to the step-by-step of the experiments and what the student should observe while he or she execute it. The teacher should also be careful in cases where the sound is fundamental in the realization of the experiment.

In case of acoustic experiments using tuning forks, the resonance phenomenon is usually observed only by sound observation. For the experiment to be observed by SHIP students in Physics laboratory, it will be necessary to use some accessories, such as microphone and oscilloscope. The microphone to pick up the sound and the oscilloscope to read the sound waves in a display, allowing visual observation of the phenomenon.

3.9 Tips That Have Helped the Faculty

While doing evaluation it is necessary to follow that the loss of hearing can source for difficulties with syntax, expression or grammar of statements. Some SHIP students are capable of communicating through ASL (American Sign Language) can do reading and writing in English as a foreign language. Some instances that have helped other teachers about reading and writing assignments are presented.

First it is necessary to appreciate the exclusive tasks of SHIP students in English writing. Before writing an assignment, a meeting has to be scheduled

with the students in due. Provide a rewriting chance before submission.

Permit SHIP students have enough time to read in-class assignments. SHIP students may struggle to understand fluent terms, so required period of time duration for clarification to be given to SHIP students. They have to understand new phrases and words. They must be educated to use a dictionary effectively. Explanations must be given to understand difficult or unusual passages.

Before the semester meet the SHIP students must be informed as early as possible to recognize and summary the plans. Educate them plainly about the dos and don'ts. For instance, a rewrite of assignments is allowed before the time bound but late submission is not accepted.

Arrange for a meeting with teacher and SHIP student to recognize plans and needs required in a language or verbal subject, or any class. Address the students for his or her responsibilities. Be flexible when modifications and adjustments necessary.

Math teachers have few more responsibilities when communicating with SHIP students. Never assume the SHIP students are good in calculation or mathematics since it is visual. The teacher has to write every step when writing examples on the board, if any steps explained verbally the SHIP student could miss. If the exam needs more reading and writing the SHIP students may require extra time. Sometime an interpreter may be in need to sign test questions.

We the teachers are facing many challenges from our students daily. The SHIP students offer us unique opportunities daily. These are all few guidelines which are the experiences of our fellow teachers. Not only these guidelines but our positive attitude can also help us to get a valuable experience from all of your students.

4. Results and Discussions

4.1 Data collection

This study report analytically collected data via documenting a teachers' work and comprehension questionnaire coded into five different types: General aspects, classroom performance, communications, laboratory performance and visual resources. This study report was collected over a 6-month period.

The main goal of this study is to observe how the speech and hearing loss students differed from the regular students. In this work we took two different kinds of students one is for speech and hearing-impaired students and another type is regular students. We have collected the questionnaire data from 105 speech and hearing-impaired students and regular students.

4.2 Data analysis

The data was analysed based on the collection of questionnaires. The data analysed was taken from current activities, how the students will perform in the classroom, laboratory, visual aspects, and communications and revealed the results of this study.

4.3 Findings

An analysis of the observations the following details we found. In general aspects the 77% SHIP students but 86% of the regular students were given the correct answer. In classroom performance there is no big deviation between SHIP students and regular students, 92% of SHIP students and 94% of regular students give the correct answer. In communications

Table 2: Comparison Result for SHIP and Regular Students

S. No	Methods	SHIP Students	Regular Students
1.	General Aspects	77%	86%
2.	Classroom Performance	92%	94%
3.	Communications	72%	89%
4.	Laboratory performance	94%	92%
5.	Visual resources	95%	86%



Fig. 1 : Comparison of general aspects of SHIP and regular students

there are 72% of SHIP students and 89% regular students give the correct answer. In laboratory performance 94% of SHIP students and 92% regular students were give the correct answer. In visual resources 95% of SHIP students and 86% of regular students were give the correct answer. The above results were presented in Table 2.

The above fig. 1 represents the average test results in general aspects of both speech and hearing impaired as well as regular students.

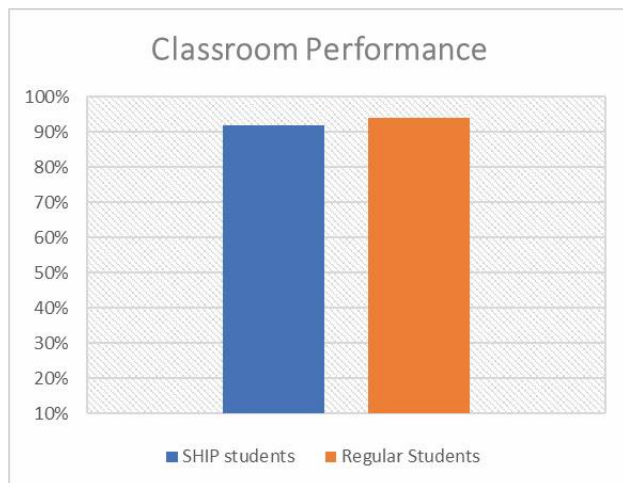


Fig. 2 : Comparison of classroom performance of SHIP and regular students

The above fig. 2 represents the average test results in classroom performance of both speech and hearing impaired as well as regular students.

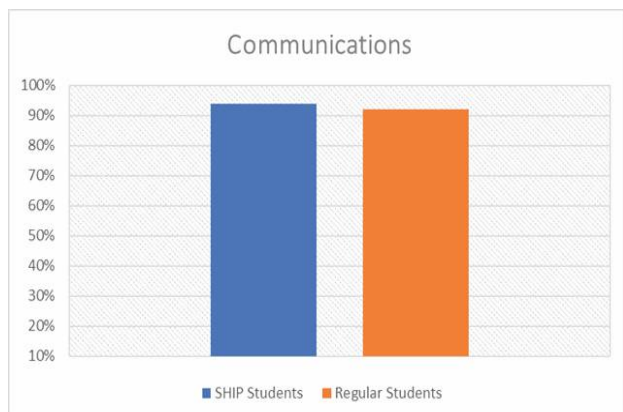


Fig. 3 : Comparison of communications result of SHIP and regular students

The above fig. 3 represents the average test results in communications of both speech and hearing impaired as well as regular students.

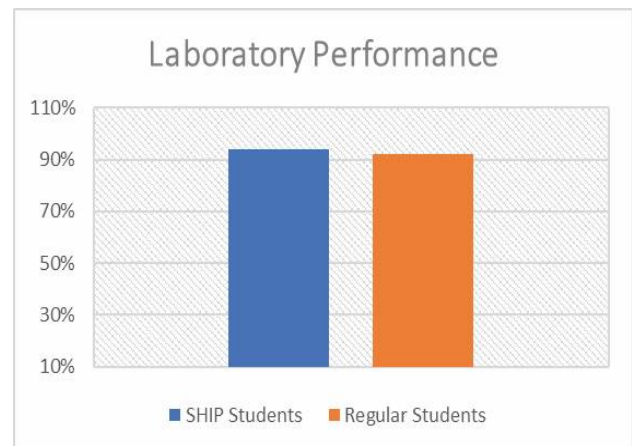


Fig. 4 : Comparison of laboratory performance of SHIP and regular students

The above fig. 4 represents the average test results in laboratory performance of both speech and hearing impaired as well as regular students.

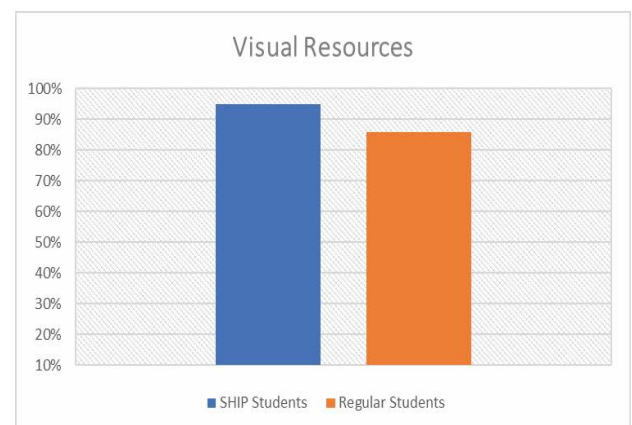


Fig. 5 : Comparison of visual resources usage of SHIP and regular students

The above fig. 5 represents of visual resources usage both speech and hearing impaired as well as regular students.

5. Conclusions

Obviously, it is not easy to educate SHIP students. In this paper we have summarized the teaching approaches for speech and hearing-impaired students. It is vital to establish the communication channel between teacher and special student is essential for the effective teaching and learning process. It is suggested that teachers' skills and knowledge towards using technology-supported applications to teach speech and hearing-impaired students should be increased by conducting regular in-service training and seminars.

References

- [1] Girgin, M. C. (2003). Introduction to the education of hearing-impaired children. Eskisehir: TC Anadolu Universitesi.
- [2] Tufekcioglu, U. (2002), Hearing impairments. Eskisehir: Anadolu Universitesi Yayinlari.
- [3] Timur, S., Ege, E. & Bakis, E. (2006). Reproductive health problems of disabled women and factors affecting them. *Journal of CU Nursing High School*, 10(1), 52-58.
- [4] Ndlovu, S., & Walton, E. (2016). Preparation of students with disabilities to graduate into professions in the South African context of higher learning: Obstacles and opportunities. *African Journal of Disability*, 5(1).
- [5] Cavkaytar, A. (2008). Activities to improve school-family cooperation. *School, Family and Environment Cooperation*, 1, 77-95.
- [6] Akcamete, G. & Gurgur, H. (2009). Education of children with hearing impairment. Ankara: Kok Publishing.
- [7] Alshutwi, S.M., Ahmad, A. C., & Lee, L.W. (2020). The Impact of Inclusion Setting on the Academic Performance, Social Interaction and Self-Esteem of Deaf and Hard of Hearing Students: Systematic Review and Meta-Analysis. *International Journal of Learning, Teaching and Educational Research*, 19 (10), 248–264
- [8] Dogru, S. S. Y. & Arslan, E. (2008). A comparison of the state anxiety levels of mothers with a disabled child. *Selcuk University Journal of Social Sciences Institute*, 1(19), 543-553.
- [9] Downs, S., Owen, C., & Vammen, A. (2000). Tips for teaching students who are deaf or hard of hearing. Webapps.ou.edu. The Postsecondary Education Consortium at The University of Tennessee.
- [10] Karal, H. & Çiftçi, E. (2008). "Making use of computer-aided animations in the education process of hearing-impaired individuals. In 8th International Educational Technology Conference Online papers (Vol. 30, No. 08, p.2013).
- [11] Petty, G. (2009). Teaching today. Nelson Thornes Ltd (United Kingdom).
- [12] World Health Organization. (2018). Deafness and hearing loss. World Health Organization.
- [13] TEIRESIAS, (2010). Course of communication with the hearing impaired. Masaryk University Brno.
- [14] K.Karthigadevi, S. Thangarasu, (2021). "Projecting the Learning Attainment of Speech and Hearing Impairment Students from Domestic, Discrete, Communication and Educational Aspects", *Journal of Engineering Education Transformations*, Volume 34, 337-343.
- [15] AlAsim, K. (2018). Participation and Interaction of Deaf and Hard-of-Hearing Students in Inclusion Classroom. *International Journal of Special Education*, 33 (2), 493–23.
- [16] Stinson, M. S., Elliot, L. B., & Kelly, R. R. (2017). Deaf and hard-of-hearing high school and college students' perceptions of speech-to-text and interpreting/note taking services and motivation. *Journal of Developmental and Physical Disabilities*, 29(1), 131–152.
- [17] Lesar, I., & Vitulić, H. Self-esteem of deaf and hard of hearing students in regular and special schools. (2014). *European Journal of Special Needs Education*, 29(1), 59–73.
- [18] McKee, M., Schlehofer, D., & Thew, D. Ethical issues in conducting research with deaf populations. (2013). *American Journal of Public Health*, 103(12), 2174–2178.

Quality Management System Practices Performed in ISO 9001 Certified Engineering Educational Institutions: A Critical Analysis of Indian Universities

Parvesh Kumar¹, Sandeep Singhal², Jimmy Kansal³

^{1,2}Department of Mechanical Engineering, National Institute of Technology, Kurukshetra, Haryana, India.

³Snow & Avalanche Study Establishment, Defence Research and Development Organization, Chandigarh, India.

¹parveshkamboj14@gmail.com

²sandeep_singhal_reck@rediffmail.com

³jimmy.kansal@gmail.com

Abstract: This study aims to analyse the quality management system (QMS) practices performed in ISO 9001 certified engineering educational institutes of India. The literature divulged that QMS in engineering education mainly engrossed on teaching, learning, examinations, student results and infrastructure. Very few studies mentioned QMS in terms of organizational effectiveness. Thus the author has conducted the QMS analysis in forty-five engineering educational institutions (EEIs) of Delhi NCR area in India and selected two groups of institutions based on years of existence. Group-a consists of twenty institutions less than fifteen years old, and group-b consists of twenty-five institutions over fifteen years old. Data were collected using a questionnaire from forty-five engineering educational institutions. The questionnaire was prepared using QMS constructs (ten factors) followed by the institutions and the quality measures followed by the national board of accreditation-NBA in India. Data analysis was done using SPSS 26.0 software to conclude the student t-test and p-value. The author found that the group-b institutions received substantially higher scores in variables that had top

management commitment, systemic management approach, customer satisfaction, employee involvement, training, teamwork, continuous improvement, corporate social responsibility, academic culture and knowledge audit compared to group-a institutions. The study also revealed the strong and weak points of the institutional QMS, and there is a strong need to incorporate ISO 9001:2015-based QMS practices for the continuous improvement of institutions.

Keywords: National Board of Accreditation, Quality Management, Customer Satisfaction, ISO 9001:2015 QMS

1. Introduction

Technology and globalization have turned nations into societies powered by knowledge. They are radically speeding up the world's rate of transition and rising long-term risks. Performance in the knowledge-driven and innovation-driven world order relies primarily on people's capabilities, and the key to building those necessary capabilities is higher education, especially engineering education (Africano, Rodrigues, & Santos, 2019). India has done phenomenally well in building extensive nationwide infrastructure to disseminate year after year engineering education to lakhs of aspirants in every province. However, we need to promote quality and certified technical education on a scale to be able to fulfil the next wave of standards for engineering skills (Kansal & Singhal, 2018).

Parvesh Kumar

Department of Mechanical Engineering,
National Institute of Technology, Kurukshetra, Haryana, India.
parveshkamboj14@gmail.com

Despite some attractive empirical studies in the field of engineering education (EE), the critical dimensions of quality have not been fully described. To enhance the quality of education, professional and educational institutions should adopt a course of action that accredited institutions around the world can follow (Pandi, Sethupathi, & Jeyathilagar, 2016). The syllabus propounds in most of the engineering institutions in India does not meet a global criterion. Hence, the difficulty arises from the absence of comprehensive and existing QM models in engineering institutions (Papic & Garcia, 2017). However, the rapid growth of technical institutions in India has led to a decrease in the quality of the technical workforce supplied by these private institutions.

Today, the implementation and certification of the Quality Management Systems (QMS) are essential for any organization since it is seen as a distinguishing flag for the educational sector's institutions. Quality is still addressed, but because of bottlenecks in funding, curricula, and faculty and student bodies, management inefficiency is acknowledged (Kansal & Singhal, 2017). In India, to accredit engineering institutions, the All India Council for Technical Education (AICTE) and the National Board of Accreditation (NBA) were established. The All India Council for Technical Education (AICTE) was formed as a national apex advisory body in November 1945 to conduct a survey on facilities available for technical education and to promote the country's growth in a coordinated and integrated manner (Farm, 2005). Focused on the QMS practices advocated by the accreditation body, this research study aimed to investigate the QMS practices carried out and their impact on the organizational effectiveness of engineering institutions.

Theoretical Framework

Quality Management System-QMS in Engineering Institutions

The Quality Management System (QMS) has been one of the world's most popular and omnipresent management systems over the last three decades. The continuous development of QM in organizations was, therefore, motivated, on the one hand, by competition and on the other hand, by increasing customer requirements (Kansal, Singhal, & Kumar, 2014). Mass production shifted to a more and more pull strategy with a higher customer and company

orientation with a pure push strategy. Yet better business performance is required for businesses to compete successfully in the global business world. Hence, it is not possible to disregard the value of using QM criteria such as ISO 9001 (Bravi et al., 2019). Thus, when properly applied, recognized and embraced by all, the Quality Management System (QMS) offers very significant benefits for organizations where clients are continually demanding to enhance the quality of life.

Each company competes in a market economy with others who offer the same product (Suryan, Radhakrishnan, Ramachandran, Abdul Rahman, & Isaac, 2021). This concept applies irrespective of the form of bid, including actual products and intangible services, or their combination thereof. While quality management since the early 1980s has become a notorious problem, it is not an innovation (Vijaya Kumar, Petkar, H. K., & Jangali Satish, 2021). In many ways, we can tell the tale of efficiency. A significant number of scholars accept that the principle or theory of quality has existed for a long time, disagreeing only with others that for hundreds of years the concept of quality has existed, and others talk for thousands of years. As a management discipline, Quality Management is rich in research on various aspects and hypotheses, empirical field evidence and theoretical elaborations (Mohammadian, Babaei, Jarrahi, & Anjomrouz, 2019). Some of its fundamental elements are well identified and developed by international management standards such as ISO 9001 quality management system and ISO 14001 environment management system that are well recognized and commonly used (Kumar, Singhal, & Kansal, 2020). Organizations of consistency don't thrive nowadays. Many organizations, therefore, incorporate QMS with other management systems, such as the Environmental Management System (EMS) and the Occupational Health and Safety Management System (OH&SMS), which seek to utilize, among other things human, material and financial capital. Therefore, in various forms of organizations around the world, ISO 9001 is used (Aniskina & Lunina, 2018).

To evaluate the challenges posed by the Sustainable Development Goals (SDGs) of quality education, understanding the plan of education reform is crucial (Richert et al., 2016). Nowadays, the goal of all educational programs is to provide quality education. In several countries, the introduction of

quality management systems in educational organizations is a reality. In the most varied areas of science, including education, the word "quality" has been used, but there are significant variations in its conceptualization, i.e. there is no standardized meaning. Recognizing consistency, both in goods and services, as a deciding factor for organizational development in an increasingly competitive environment, is universal (Sunitha & Avanija, 2021). In the educational context, the definitions of 'quality' focus on different aspects such as customer satisfaction, the management and administration of educational institutions, the availability of human, financial and infrastructural resources, as they relate to the successful performance of IES functions (Yang, 2018).

Based on ISO 9001:2015, the introduction of the QMS in engineering education in India is intended to make management more effective, with an impact on academic training, financial resources management and human resources (Kumar et al., 2020). Through this introduction, the quality of both the offer of movement and the services offered to the academic community will be enhanced continuously. In addition to being a differentiating factor and affecting the attractiveness and notoriety of engineering educational institutions for teaching of recognized standard, it can also be an essential help for Institutional Marketing, for the external attention that certification can offer (Sá, Amaral, Barreto, Carvalho, & Santos, 2019). In this context, the study is designed and conducted to determine the standard of the randomly selected forty-five engineering institutions located in Delhi, India, using a questionnaire based on the quality standards of National Board of Accreditation (NBA).

2. Methods

The current study is based on a questionnaire survey of 365 faculty members from various ISO 9001 certified engineering institutes in Delhi-NCR, India. The purpose of this study was to look at QMS practises, analyse interrelationships, and compare the QMS procedures used by various groups of engineering training institutions.

In order to collect the data, the analysis used the qualitative approach, the conceptual structure helps to clarify the relationship between the variables, and a questionnaire-based survey was conducted.

1) Conceptual Framework

This study used a questionnaire survey and a structured interview to examine QMS practises and their impact on the organisational performance of engineering institutions. Forty-five ISO 9001 certified engineering institutes in India's Delhi NCR area, namely Gurugram, Palwal, Faridabad, Rewari, Sonapat, Noida, Greater Noida, and Ghaziabad, were chosen at random for pre-audit and structured interviews. The chosen institutions are separated into two groups, with the first group consisting of twenty institutions that are less than fifteen years old (group-a) and the second group consisting of twenty-five institutions that are more than fifteen years old (group-b).

Based on the quality assessment carried out by the All India Council for Technical Education (AICTE) and the National Board of Accreditation (NBA), the author has prepared a questionnaire on ten criteria, such as Top management commitment, systematic approach to management, customer satisfaction, employee engagement, training, teamwork, continuous enhancement (Fakhrzad, Talebzadeh, & Goodarzian, 2018), corporate social responsibility, academic culture, information audit. For the ten factors listed above, group-a institutions were compared statistically with group-b institutions. In which the mean ratings obtained were compared using a t-test of students to conclude. In the test, a P value of less than 0.05 reveals a substantial difference between the two averages achieved. In order to understand their position in terms of the overall quality mandate, all the organizations under study were also evaluated according to the quality model for their strong and weak points.

Hypotheses formulated on the basis of literature.

H1: There is a significant difference in QMS practices performed between Group-A and Group-B respondents.

Table I shows, an independent sample t-test was conducted to compare the QMS practices (TMC, SAM, CS, EI, TG, TW, CI, CSR, AC, and KA) for Group-A and Group-B respondents. There were significant differences ($t(335.711) = 4.971, p < .001$) in the score with the mean score for Group-B ($M=3.9822, SD= 0.73903$) was higher than Group-A ($M=3.5852, SD= 0.86389$) respondents. The magnitude of differences in the means (mean

Table 1: T- Test for equality of means :

		Mean	SD	Levene's test for equality of variances		t-test for equality of means						
				F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% confidence interval of the difference	
											Lower	Upper
	Group B	3.9822	0.73903	6.651	0.010	4.971	335.711	.000	.39703	.07986	.23994	.55413
QMS Practices	Group A	3.5852	0.86389									

difference= 0.39703, 95% CI: 0.23994 to 0.55413). Hence, the above formulated hypothesis is accepted. QMS practices directly and positively influence the institutional performance identified by results domain shown in the table I.

3. Results

The quality evaluation report was used to provide points/scores to the 10 factors examined. Table II and Figure 1 illustrate the maximum points that the institutions may have earned, as well as the average factor-wise scores attained by group-A and group-B institutions.

Table 2 :
Score/points secured by the Institutions (MEAN* $\pm$ SE)

QMS PRACTICES	MAXIMUM OUTCOME POINTS	POINTS SECURED GROUP-A	POINTS SECURED GROUP-B	t-TEST VALUE
Top management commitment	50	34 ^a $\pm$ 1.0	39 ^b $\pm$ 2.2	0.001
Systematic approach to management	100	52 ^a $\pm$ 0.9	65 ^b $\pm$ 1.9	0.33
Customer satisfaction	175	75 ^a $\pm$ 2.6	90 ^b $\pm$ 6.4	0.01
Employee involvement	200	110 ^a $\pm$ 2.7	125 ^b $\pm$ 5.9	0.04
Training	80	34 ^a $\pm$ 1.5	42 ^b $\pm$ 2.7	0.001
Teamwork	50	29 ^a $\pm$ 0.7	35 ^b $\pm$ 2.9	0.06
Continuous Improvement	75	37 ^a $\pm$ 0.8	45 ^b $\pm$ 2.6	0.002
Corporate social responsibility	120	62 ^a $\pm$ 2.4	70 ^b $\pm$ 3.0	0.04
Academic Culture	50	27 ^a $\pm$ 1.1	32 ^b $\pm$ 2.2	0.001
Knowledge Audit	100	32 ^a $\pm$ 0.8	37 ^b $\pm$ 2.4	0.03
TOTAL	1000	492	580	

*The mean values of various superscripts differ considerably between columns.

The accreditation commission requires a minimum score of 650 for three years of certification and a minimum score of 750 for five years of certification for institutions to be certified, although the average scores of both group-a and group-b institutions fall short of this standard. Compared to group-a institutions, which fall short of the three-year award by a score of 158 (24.31 %), institutions in group-b fall short by a score of 70 (10.77 %).

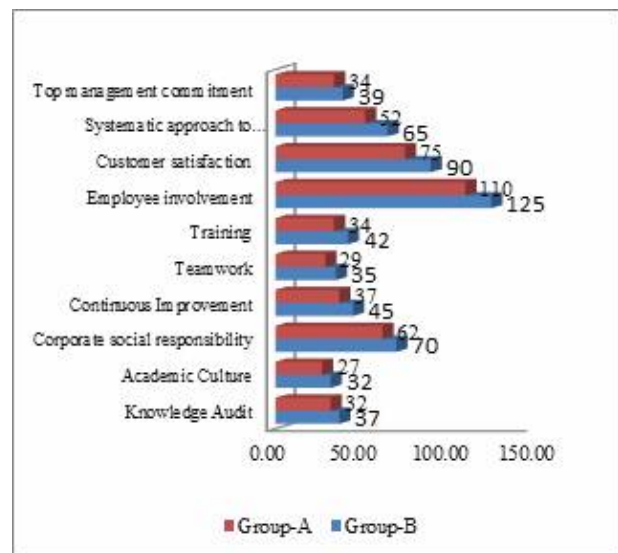


Fig. 1 : Bar chart showing the results obtained by both groups

Comparing group-a and group-b institutions, it was obvious that group B schools had a significantly higher score on the following parameters. Commitment from the top management Customer satisfaction, employee engagement and teamwork are all part of a methodical management approach.

Group-b institutions may have a higher score since they have been around longer. Financial resources are insufficiently utilised by group-a institutions, which lack a well-defined systemic management strategy Training and human resources, such as professors and

employees, are also lacking in quality. Group-a organisations have also failed to implement organisational structures, employee involvement, training, and academic culture. Group-b institutions performed better than group-a institutions, but their overall efficiency remained unsatisfactory, as evidenced by their cumulative scores. In both sorts of institutions, professors and students are underperforming. As a result, both types of institutions do not have the ability to conduct knowledge audits or implement corporate social responsibility in a systematic manner. Group-A and Group-B organisations are evaluated in terms of the following factors:

1) Top Management Commitment

Strong points:

- a) Top-management takes an attempt to maintain customer attention and consistent performance metrics for all in the organization.

Weak points:

- a) The efforts of employees or superiors regarding the production, enhancement and maintenance of quality have not been acknowledged by top management.
- b) Quality circles or services for employee participation are not explicitly enforced in departments.
- c) Lack of an appropriate human resources strategy relating to the institution's reward & recognition.
- d) The organization does not have a systematic goal-setting mechanism for quality.
- e) Workers shall not be permitted, by regular transfer, to make use of work experience in all areas of the organization.

2) Systematic Approach to Management

Strong points

- a) To ensure consistency in the educational process, institutions have an academic performance analysis cell (APAC).
- b) There is a separate coordinator set up to take care of the method of quality assurance.

Weak points:

- a) Regular meetings were not conducted in the institutions to discuss the standard of education.
- b) The allocation of funding for specific faculty development activities does not exist.
- 3) Customer satisfaction

Strong points:

- a) Institutions promote the participation of parents in educating students.
- b) Awards honouring the successful performance of both faculty and students are awarded.

Weak points:

- a) Industry-institution engagement activities are not carried out periodically.
- b) Better student placement programs are not given by campus recruitment.
- c) In organizations, benchmarking procedures are not pursued.

4) Employee Involvement

Strong points:

- a) The workers have the correct attitude towards improving the efficiency of the organization.
- b) The institution frequently holds seminars/workshops/conferences.
- c) Academic decisions are taken by consulting senior members of the faculty.

Weak points:

- a) Through the consistency circle scheme, problems are not solved.
- b) The workers are not driven by non-financial incentives.
- c) There is no high and adequate wage and compensation.

5) Training

Strong points

- a) Management offers effective leadership to improve the expertise of the members of the community and to delegate tasks for the smooth realization of quality targets.
- b) Cooperation between departments is formed concerning the creation and enhancement of the standard of students.

Weak point

- a) Educational programs are not performed at the principal and faculty level using sophisticated mathematical techniques.
- b) The ISO 9001 /Six-Sigma / TQM implementation training are not provided at the institutions.
- c) There is no internal audit of the ISO 9001:2015 program in the institutions with a trained faculty.

6) Team Work

Strong points:

- a) Management makes reasonable efforts to take advantage of faculty expertise to enhance the institution's efficiency.

Weak points:

- a) The ISO coordinator does not work successfully in addressing quality-related problems or issues.
- b) Experts are not used in the resolution of the quality-related problems within the organization.
- c) Individuals do not make their best contribution to achieving success within the organization.

7) Continuous Improvement:

Strong points:

- a) The organization has a cell for an academic performance review or a quality assurance cell for institutional enhancement.
- b) Management promotes workers to develop their

talents and innovation.

- c) Continuous methods of change are implemented within the organization.

Weak points:

- a) Suggestions are not accepted based on feedback/audits on academic affairs for the institution's elevation.
- b) Helpful recommendations made by stakeholders are not generally made within the organization.

8) Corporate Social Responsibility:

Strong points

- a) Protection and safety services are available for individuals concerning emergency exits and fire extinguishers in schools, labs, libraries, etc.
- b) An agency used to solve social issues such as AIDS, seasonal illnesses, infanticide among women and child labour.

- c) The institution coordinates annual general medical check-up services in the surrounding villages.

Weak points:

- a) Social activists should not have special sessions and instruction to mould socially conscious students and faculty.
- b) Agencies are not used for such social programs to receive the support of non-governmental organizations (NGOs).
- c) In nearby villages, social health awareness activities are not carried out by organizations.

9) Academic Culture

Strong points:

- a) A deep dedication to the preservation of discipline and a friendly learning atmosphere exists.
- b) The institution's academic improvement team functions to improve student success.
- c) Management facilitates the involvement of faculty

and students in the process of decision-making related to academics.

Weak points:

- a) Workers are not provided with input on all aspects of their results.
- b) Relevant instruction is not given to all personnel within the institution to preserve the academic culture.
- c) The faculty members do not have an exact academic work schedule and work distribution.

10) Knowledge Audit

Strong points:

- a) After completing faculty learning programs/refresher courses/seminars/workshops, evaluation of faculty members is performed annually.
- b) Faculty members are assessed and reported on an annual basis; benefits are offered based on overall academic results.

Weak points:

- a) Academic performance review cells do not efficiently assess the production performance of both faculty and students in terms of research papers, academic performance, etc.
- b) Policy architects should not register all academic processes.
- c) Information Mapping is not designed to optimize the use of people's resources.
- d) The process of diffusion of information is not carried out by inter/intra-college activities conducted periodically within the university.

Therefore it is of crucial importance that QMS practices are introduced in all institutions to enhance the quality of not only the commitment of top management but also the empowerment and engagement of employees to ultimately increase the quality of engineers generated by these institutions. National accreditation boards can signal quality in the labour market, thus reducing quality uncertainty in the education market and mitigating the prevalence of

low-quality education in engineering.

4. Discussion & Conclusion

One thing is clear: The leadership and commitment of top management are driving forces in the QMS culture at the institute. In terms of the total effect, leadership has a considerable impact on all of the other enablers. found similar results, while found similar results in another field. Leadership, policy and strategy, and people and process management all have a good impact on education, according to " .

When it comes to creating staff policy and managing resources and processes, it is imperative that top management's commitment is a reference point. Among the five enablers, shows that policy and strategy play a significant role. According to — and , management of people and resources is closely linked to the implementation of policy and strategy. "Top management commitment" has been found to have a considerable impact on the management of people, infrastructure, and administrative services in this empirical investigation.

Employee participation in continuous improvement initiatives is critical to the success of a Quality Management System (QMS). For greater performance at work, stress the importance of motivation and training. Educators and non-educators alike must be kept up-to-date on the latest methods, tools, and technology in order to teach pupils the information they need. Faculty training needs are identified and addressed by management by assigning them to suitable workshops and industries through ISO implementation. Teaching and learning become more efficient as a result of this element.

The authors of this study hope to draw the conclusion that high-quality institutions should pay attention to community improvement and well-being as part of their integrated social and environmental management plans. QMS is crucial for both local and global employment, training both students and teachers in the field of technology. Engineering businesses must undergo a paradigm shift and embrace QMS methods to ensure long-term sustainability and quality improvement, according to this study. For the National Accreditation Board, the QMS processes will help ensure that formal training is recognised in India. Quality Management Systems (QMS) can also be used to reduce the number of low-quality engineering institutes.

Acknowledgment

The authors would like to express their gratitude to the heads of engineering colleges and universities in Delhi/NCR for their outstanding support and encouragement in developing this recreational project.

References

- [1] Africano, N., Rodrigues, A. S., & Santos, G. (2019). The main benefits of the implementation of the quality management system in higher education institutions in angola. *Quality Innovation Prosperity*, 23(3), 122–136. <https://doi.org/10.12776/QIP.V23I3.1292>
- [2] Aniskina, N. N., & Lunina, E. V. (2018). Piloting of the Integrated Model for Quality Assurance in Education QMCQAF in Russia. *Proceedings of the 2018 International Conference “Quality Management, Transport and Information Security, Information Technologies”*, IT and Q M a n d I S 2 0 1 8 , 2 2 – 2 6 . <https://doi.org/10.1109/ITMQIS.2018.8524918>
- [3] Bravi, L., Murmura, F., & Santos, G. (2019). The ISO 9001:2015 quality management system standard: Companies’ drivers, benefits and barriers to its implementation. *Quality Innovation Prosperity*, 23(2), 64–82. <https://doi.org/10.12776/QIP.V23I2.1277>
- [4] Fakhrzad, M. B., Talebzadeh, P., & Goodarzian, F. (2018). Mathematical Formulation and Solving of Green Closed-loop Supply Chain Planning Problem with Production, Distribution and Transportation Reliability. *International Journal of Engineering*, 31(12), 2059–2067. <https://doi.org/10.5829/ije.2018.31.12c.10>
- [5] Farm, E. W. (2005). & Approval Process. 1–6.
- [6] Iqbal, A., Latif, F., Marimon, F., Sahibzada, U. F., & Hussain, S. (2019). From knowledge management to organizational performance: Modelling the mediating role of innovation and intellectual capital in higher education. *Journal of Enterprise Information Management*, 32(1), 36–59. <https://doi.org/10.1108/JEIM-04-2018-0083>
- [7] Kansal, J., & Singhal, S. (2017). Application and validation of DMAIC six sigma tool for enhancing customer satisfaction in a government R & D organization. *International Journal for Quality Research*, 11(4), 931–944. <https://doi.org/10.18421/IJQR11.04-13>
- [8] Kansal, J., & Singhal, S. (2018). Development of a competency model for enhancing the organisational effectiveness in a knowledge-based organisation. *International Journal of Indian Culture and Business Management*, 16(3), 287. <https://doi.org/10.1504/ijicbm.2018.090909>
- [9] Kansal, J., Singhal, S., & Kumar, P. (2014). Integration of Quality and Knowledge Management in Indian R & D Organizations. (Som), 889–893.
- [10] Kumar, P., Singhal, S., & Kansal, J. (2020). A Critical Model for Achieving the Global Quality in ISO 9001 Certified Engineering Educational Institutions. 79(September), 810–813.
- [11] Mohammadian, M., Babaei, M., Jarrahi, M. A., & Anjomrouz, E. (2019). Scheduling nurse shifts using goal programming based on nurse preferences: A case study in an emergency department. *International Journal of Engineering, Transactions A: Basics*, 32(7), 954 – 963. <https://doi.org/10.5829/ije.2019.32.07a.08>
- [12] Pal Pandi, A., Rajendra Sethupathi, P. V., & Jeyathilagar, D. (2016). The IEQMS model for augmenting quality in engineering institutions – an interpretive structural modelling approach. *Total Quality Management and Business Excellence*, 27(3–4), 292–308. <https://doi.org/10.1080/14783363.2014.978647>
- [13] Pandi, A. P., Sethupathi, P. V. R., & Jeyathilagar, D. (2016). Quality sustainability in engineering educational institutions - A theoretical model. *International Journal of Productivity and Quality Management*. <https://doi.org/10.1504/IJPQM.2016.076715>
- [14] Papic, L., & Garcia, A. C. (2017). Significant Factors of the Successful Lean Six-Sigma Implementation. 2(2), 85–109.

- [15] Psomas, E., & Antony, J. (2015). The effectiveness of the ISO 9001 quality management system and its influential critical factors in Greek manufacturing companies. *International Journal of Production Research*, 53 (7) , 2089 – 2099 . <https://doi.org/10.1080/00207543.2014.965353>
- [16] Richert, A., Shehadeh, M., Plumanns, L., Gros, K., Schuster, K., & Jeschke, S. (2016). Educating engineers for industry 4.0: Virtual worlds and human-robot-teams. *Proc. of IEEE Global Engineering Education Conference (EDUCON)*, (April), 142–149. <https://doi.org/10.1109/EDUCON.2016.7474545>
- [17] Sá, J. C., Amaral, A., Barreto, L., Carvalho, F., & Santos, G. (2019). Perception of the importance to implement ISO 9001 in organizations related to people linked to quality-an empirical study. *International Journal for Quality Research*, 13 (4) , 1055 – 1070 . <https://doi.org/10.24874/ijqr13.04-20>
- [18] Sunitha, G., & Avanija, J. (2021). Program assessment and evaluation for continuous quality improvement. *Journal of Engineering Education Transformations*, 34(3), 42–55. <https://doi.org/10.16920/jeet/2021/v34i3/150016>
- [19] Suryan, A., Radhakrishnan, V., Ramachandran, G., Abdul Rahman, M., & Isaac, K. P. (2021). Revision of Undergraduate Engineering Curriculum with Emphasis on Project-Based Teaching Learning Approach - Case Study of KTU. *Journal of Engineering Education Transformations*, 34(3), 7. <https://doi.org/10.16920/jeet/2021/v34i3/128523>
- [20] Vijaya Kumar, N., Petkar, P. K., H. K., M., & Jangali Satish, G. (2021). Integrated Learning Experience Through Activity Based Learning in UG Course. *Journal of Engineering Education Transformations*, 34 (3) , 16 . <https://doi.org/10.16920/jeet/2021/v34i3/142465>
- [21] Yang, C. C. (2018). The effectiveness analysis of the practices in five quality management stages for SMEs. *Total Quality Management and Business Excellence*, 1–23. <https://doi.org/10.1080/14783363.2018.1456010>

Training Faculty for Better Online Teaching – Need & Issues

Pai, Chiplunkar

principal_nmamit@nitte.edu.in

Abstract: Online teaching and learning is a necessity rather than a choice in all forms of education today. Faculty are one of the important element in this online teaching / learning process. There are several issues pertaining to faculty and one important issue is the training of the faculty and their orientation towards online teaching. There are several platforms, services and MOOCs available, which provide training to faculty regarding different aspects related to teaching better online. This paper explores the need for training the faculty to do better online teaching. The author has conducted a 4-hour short course on “online learning – theory and practice” for 23 faculty in his institution. Feedback collected from the faculty through a questionnaire survey support the need for such training by emphasizing the need to understand both theoretical and practical aspects, but expect freedom in selection of the platform to be used, consider student satisfaction and delivery as more important, support online assessment and consider regular student feedback important for online teaching. The findings of this study have some implications for development and implementation of training and support programs to help faculty to teach online.

Keywords: online teaching, pandemic, faculty training, feedback

1. Introduction

Excellent teaching transcends environment (Nilson, 2018). Online teaching is a requirement in the pandemic situation for all forms of education. The pandemic forced schools, colleges and universities to close temporarily. Now things are slowly returning to normal. However, in the Indian context, no decisions have been taken regarding reopening of schools and colleges by the authorities. At this point in time, online teaching is the only option. There are several factors which favor the adoption of online teaching and include accessibility, affordability, flexibility, learning pedagogy and lifelong learning. Online learning involves the use of technology and learning processes and include computer-based learning, web-based learning, virtual class rooms and digital collaborations (Urdan and Weggen, 2008). Efforts are also being made in various Universities all over the world to adopt blended or flipped classroom arrangements, which is a combination of physical class room lectures with online teaching. Online learning can help in making the teaching-learning process more student-centric, innovative and flexible (Dhawan, 2020). Online learning can happen in a synchronous or an asynchronous environment. Synchronous learning environment is structured, as the students attend live lectures and there is real-time interaction between the students and teachers and there are instances of instant feedback being provided. Whereas in an asynchronous environment, there is no proper structure and there is no live interaction between the students and teachers and immediate response and feedback is not possible. This mode does not provide avenue for social interaction as in case of

Pai, Chiplunkar

principal_nmamit@nitte.edu.in

synchronous mode (Dhawan, 2020).

Due to the pandemic, online teaching is no longer a choice, it is a necessity. Institutions and individuals are working out strategies to use the available technology in the best possible way to reach the students. The use of either open technologies, which are free and readily available and easy to use are being tried by the teachers or institutions are selecting technology / platform which are commercial in nature, as they need to be purchased. But they have several features, which make them acceptable like user friendly, secure, no issues of data security breach and necessary technical and other support. It is not the question of whether online methods can provide quality education, but how best the institutions and individuals can use and adopt the available technologies on a large scale (Dhawan, 2020).

There are several problems associated with online teaching and learning. The major problems are technical in nature in terms of internet availability, bandwidth issues, device availability, accessibility and problems like login, audio, video etc. Students find online classes unengaging and boring. It is not possible to provide personal attention to students and two-way interactions are not always possible. Students need to effectively balance their personal and professional life. Teachers have their own set of problems, which include additional preparation for classes, work out strategies for providing effective online instructions, learn to use technology / platform for delivery of lectures, interactions, participation in all forms of communication through chat, social media, email, discussion forums etc., perform online assessment, provide feedback etc.

Online learning is going to stay for some more time in the future. In this context, there is a need to orient the faculty, who are the most important component in the online teaching-learning system. Even if situation returns to normal, may be a few of the courses may need to be offered online. According to Clay (1999), some of the barriers identified by faculty for online teaching include increased workload, changed role of the teacher, lack of technical and administrative support, reduced course quality and negative attitudes of other faculty. Barker (2003) feels that training faculty to teach online is a challenge. There are both educational and technological issues. There is a need to understand the educational theory and principles for proper course delivery and development for better quality student understanding. According to Worley &

Tesdell (2009), the involvement of the faculty for preparing and presenting the content online increases by 20 %. Some of the factors identified includes class size, course content, student's involvement, faculty time constraints and faculty's familiarity with technology. Many of the faculty lack the necessary technical and pedagogical skills in delivering the content online. Faculty role change in an online environment, as they need to assume the roles of facilitator, teacher, organizer, assessor, mentor, counselor, problem solver, coach etc., (Liu et al., 2005). There is a need for the faculty to first orient themselves to online teaching, become familiar with digital learning environment, understand pedagogy and technology, before they convert their course format to online. As per Keengewe et al. (2009), the faculty need to engage their students in activities that can maximize learning and learning should be the most important outcome. Zisow (2000) mentions that teachers need to consider technology only as a tool and its use depends on the motivation of the teacher and also desire to learn and use new tools.

In this context, in the changed scenario due to the pandemic, in the author's institution, the transition to online teaching happened in the 'emergency mode' and later faculty started getting adapted to it. Now they use institutional supported platform for online teaching and assessment. Based on the review of the literature, the author felt the need to understand and explore the views of the faculty regarding the need for faculty training regarding the knowledge of theoretical concepts of online learning. Accordingly, the author conducted a 4-hour short course on "online learning – theory and practice" for 27 faculty in his institution. Feedback was collected from the faculty, who participated in the course through a questionnaire survey regarding the need for such training by emphasizing on understanding both theoretical and practical aspects.

2. Need For The Study

The current pandemic has forced academic institutions to adopt online teaching and few institutions have adopted blended learning. The requirement for online teaching is going to stay for some more time. Many academic institutions / faculty are reluctant to change their teaching method and adapt themselves to this new pedagogy. There has been no specific literature, which describes the research conducted regarding assessing the need for online teaching in this pandemic situation or any

natural disaster situation. However, to get necessary perspective, this section reviews a few studies regarding the online teaching-learning situations in institutions/universities.

Dhawan (2020) studied the importance of online learning in this pandemic situation and conducted a strengths-weaknesses-opportunities-challenges (SWOC) analysis of e-learning modes. The author looks lessons learnt in adopting online learning in situations disaster and suggests measures to overcome the barriers. There is a need for teachers to have pedagogical and technical competency, when doing online teaching. Quality and continuous improvement is critical for online teaching success and training can play a major role. Keengwe & Kid (2010) reviewed the literature pertaining to online learning and teaching. They provided a brief historical perspective on online education. The barriers for its implementation, the role of the faculty in such a changed scenario and some implications for the same are presented. The paper stimulates the need to look at strategies required for higher faculty success in online teaching. Keengwe & Georgina (2012) discussed about the need for systematic faculty development programs to help faculty for undergoing a smooth transition from traditional teaching to online. The Digital Course Training Workshop (DCTW) approach was used. The authors feel there is a need to balance between technology and pedagogy to facilitate smooth transition. The training provided the necessary confidence to the faculty to design online courses. There is a need to understand that effective technology integration requires the need to consider existing social environments. Barker (2003) describe the process of creating a faculty development program for online teaching. There are several concerns of faculty regarding online courses and mainly related to quality and student learning. The training provided should help in developing courses which are based on sound educational theory and principles. Hook & Pitkethly () discussed about the need for proper design, while developing online courses for the arts faculty. According to them the factors that need to be considered include – learning design, encouraging student interaction, building personal and group rapport, fostering student motivation, integrating assessment tasks and feedback and finally optimizing the online experience. Kinney (2015) in the doctoral thesis suggest the need for research in understanding the gap in implementing online program and courses in engineering education. A mixed methods approach was used to identify factors, which the faculty felt are

important for implementation of online courses. The gaps are mainly due to difference in perceptions and the reality with regard to offering online engineering courses. The three major factors identified that influence the offering are online teaching experience, course development issues and implementation of technical aspects particularly to engineering courses in online mode. Brinkley (2016) in her PhD thesis studied the relationship of a particular approach for training faculty for online teaching and how it influenced the teaching effectiveness and attitude of the faculty towards online teaching. The theoretical framework guiding the study was the Technological Pedagogical Content Knowledge (TPCK) model developed by Mishra and Koehler (2005). The study established the need for more research regarding how best technology and pedagogy can be integrated and how this integration is related to the design and execution of faculty development program that have significant impact on online teaching effectiveness. Lackey (2011) discussed about the preparations required for faculty to teach online. The types of preparation activities required and the faculty perception regarding the effectiveness of these activities and discussions on these activities were found to be beneficial. Both experienced and non-experienced faculty were involved. From the study the important strategy identified was technical and pedagogical training. The study emphasizes the need for formal and informal training programs which should emphasize both these aspects for effective online instructions. Schmidt, Tschida & Hodge (2016) studied the best practices required for the professional development of instructors to teach online. The authors feel that there is a need for informal and requirement based training programs, in addition to networking among the teachers and self-directed learning. The administrators need to understand the specific ways in which teachers learn to teach online, so that they can take proper decisions for devising and providing necessary training programs to those teachers. Blankson (2009) used mixed method design to find out the resources available to teachers as they teach or prepare to teach online in a mid western university in USA. The study looked at the peer interactions among teachers who taught or were planning to teach online. The faculty felt that peer support, collaboration and interactions are essential for creating a successful teaching experience online.

3. Method

An email from the Head of the Institution,

publicizing about this 4-hour short course on “online learning – theory and practice” along with an introductory video providing details about the content of the workshop was sent to all the faculty of the institution. A total of 41 faculty members registered for the course. The reasons for registering for the short course was collated through a Google form used for registration. Most of the participants felt the need to know more about online learning and teaching, its need in the pandemic situation, its merits and demerits, different tools and techniques used, different forms like blended learning etc. The form also wanted the participant's expectation from the short course and it included – to gain knowledge about online learning theory and practice, best practices, relevance of theory to practice, how to make online classes more interesting, virtual hands on session, discussion on scientific findings of online learning and practices and modern tools for online learning and teaching.

The course was offered on three consecutive days from 3 to 4.30 PM (IST) in virtual mode using a suitable platform. The mode of presentation by the author was using power point. After each session, an assignment was given to the participants concerning the topics covered in that session and they were supposed to submit in the next day before the start of the session. Feedback orally was obtained after each session to know the comfort level of the participants and how to go about the next session. After the last session of the short course, all the participants, who attended all the sessions (27 in number) were asked to fill a questionnaire survey regarding the need for training in online teaching. The questionnaire had a total of 15 questions, of which the first five questions were close ended and included name, department, designation, gender and number of years of teaching experience. The close ended questions were concerning responses to previous online teaching experience, need for formal training, need for understanding the theoretical and practical concepts, freedom in selection of technology, online assessment and student feedback. 23 out of 27 participants responded and gave their feedback.

4. Result And Discussions

Out of the 23 participants – 11 were male and 12 female. The department distribution of the participants is as follows-

The designation of the faculty followed a

distribution as shown in fig. 1

Most of the faculty are at the assistant professor level. Senior faculty with an experience of 36 years and junior faculty with an experience of 2 years, with

biotechnology	1
mechanical	4
electrical	1
computer science	6
information science	7
chemistry	1

an average experience of 13.5 years have participated in this short course. This represents a spectrum of

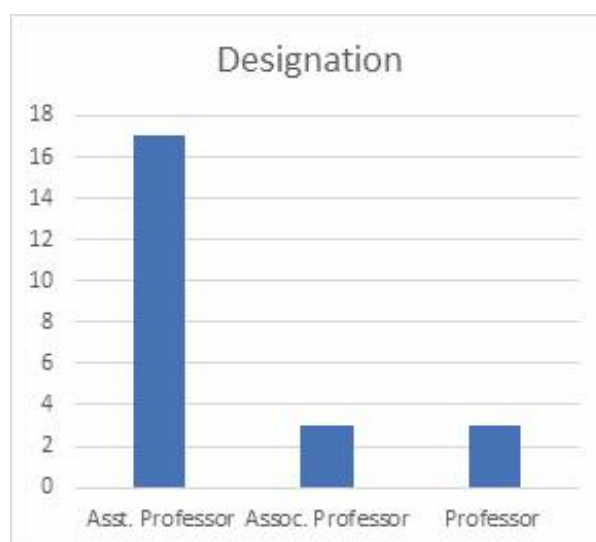


Fig.1 : Faculty distribution (Designation wise)

experience, with faculty irrespective of number of years of teaching experience showing interest in online learning and teaching.

The majority of the participants showed interest towards online learning and teaching. The results regarding the individual questions pertaining to different aspects of online teaching are as follows:

The faculty were asked about whether they have done online lectures earlier and 10 said yes and 13 said no. When asked about the need for formal training in online teaching / learning, 19 felt the need for training and 4 felt that it was not necessary.

With regard to identifying the factors that were important for online teaching, fig. 2 shows the factors and the results. It is clear that 17 faculty felt the need to know both the theoretical and practical aspects, 5 felt the need to know only the practical / implementation aspects and 1 felt the need for only theoretical aspects. When the faculty were asked as to whether understanding the theoretical and practical aspects of online class help in better use of educational technology to teach effectively, 20 faculty felt the need and remaining 3 said no. Some of the reasons given by the faculty for the need include – enhance knowledge of online teaching, improves quality, effectiveness in delivery of contents, better understanding of target audience behavior etc.

These days a wide variety of platforms are available for engaging online classes / assessment. In the author's institution, it started with ZOOM, then Google Meet and other platforms like SKYPE, YouTube etc. and now a commercial platform for only engaging online classes, which is linked to Moodle, the LMS of the institution. When the faculty were asked as to whether there should be freedom in the selection and use of educational platforms for engaging online classes, 21 faculty said yes and only 2 said no. Some of the reason given include – gives flexibility and authority, helps in choosing features in a platform, which can be effectively used for online teaching, provides alternatives in case of emergencies, each teacher has his / her own teaching style and will be comfortable in some of the platforms, familiarity, based on the course taught etc.

Based on the literature review, four factors were identified as important, while engaging online classes, namely content, delivery, technology and student satisfaction. The results obtained is as shown in fig. 3.

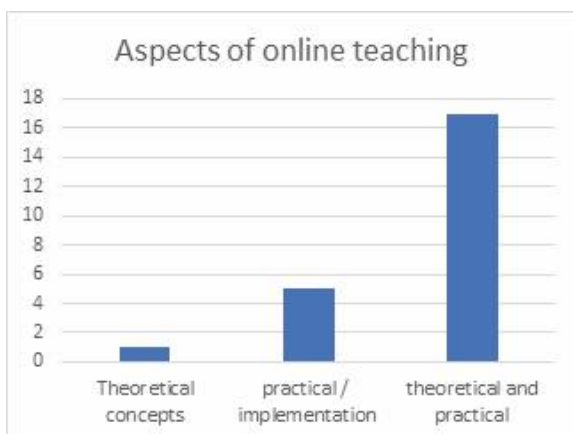


Fig. 2 : Aspects of online teaching

From the figure it is clear that faculty give significant importance to student satisfaction (11), followed by delivery (9), content and technology were found to be not very important.

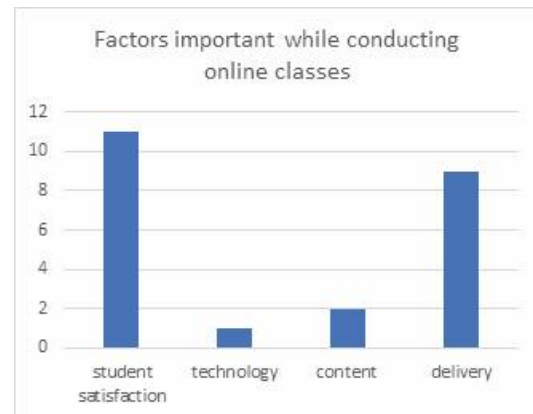


Fig. 3 : Factors important while conducting online classes.

When the faculty were asked their opinion regarding whether online assessment can be done effectively, 14 said yes and 9 said no. Many faculty had apprehensions regarding technical issues, possibility of cheating, assessment may not be effective, lesser possibilities of monitoring the student and need to use proper mechanism to strictly monitor the conduction of the online assessment. Further, when they were asked, which mode of assessment they would prefer to use from among MCQ, assignment, open book assignment and project work, the results are obtained are as shown in fig. 4. 11 faculty preferred to use MCQ, 5 preferred to use open book assignment, 4 preferred using project work and 3 preferred to use assignment.

Finally, when the faculty were asked about the need for regular student during online teaching, 22 felt it is necessary and only one faculty felt it as not necessary.

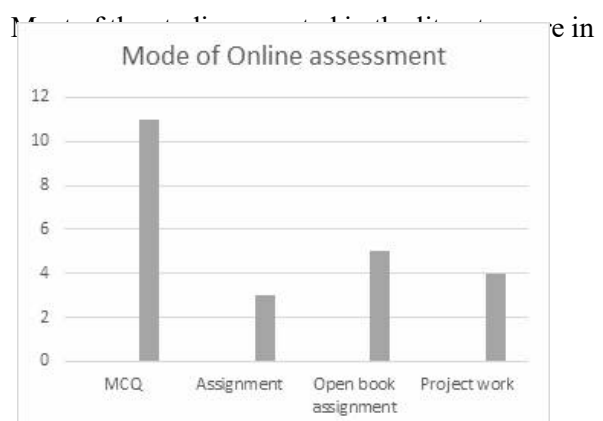


Fig.4 : Mode of Online assessment

the context of the need for training faculty to develop course content for online classes. For eg., Julie Ray (2009) conducted a study regarding perceptions of faculty teaching online in 2008. Out of 300 instructors, 111 responded and they had taught at least one online course. Faculty felt difficult in transition from face-to-face teaching to online mode, most of the faculty felt the need for training in both technology and pedagogy, large percentage of faculty were not trained to teach online either in technology or pedagogy and there was a lack of policy in institutions regarding the same, about 86.5 % felt that faculty new to online teaching need to participate in technical training before teaching and 84.5 % believed that faculty new to teaching online need to participate in training. It was reported that irrespective of the format in which training is provided, training received prior to online teaching both in technology and pedagogy had a positive effect. In 2016, Glenn Klesser, prepared a report on developing a framework for virtual class room training. The survey was administered through Online Learning Consortium (OLC). There were 733 respondents, out of which 241 respondents received training regarding the use of virtual classroom technology, which was around 66 %, 27 % received a month or more of training, 34 % received less than one day of training and on an average 55 % of the teachers received training before handling online classes for the first time. It was a comprehensive study covering aspects like perceived effectiveness of training, amount of training, training provider, institutional policy and use of synchronous and asynchronous components

In the context of the results obtained from this study, which is concerning the emergency transition to online teaching and the need for a formal training program, the results obtained are very similar to that obtained in the studies conducted regarding transition to online mode from face to face mode. Faculty wanted to learn the theoretical and practical aspects of online teaching, wanted freedom in the selection of platform for engaging online classes, gave more importance to student satisfaction and delivery of content had apprehensions regarding online assessment and were ready to adopt different modes of assessment. The need for a formal training is clearly evident in the study conducted for successful online teaching experience among the faculty. Further as highlighted in the report developed by Glenn Klesser (2016), there is a need to adopt the following critical points for effective training for online teaching and

include:

Need to understand the online learning experience from the standpoint of student,

Collaborate with peers and instructional designers during training,

Learn from successes and failures, by reviewing the performance during training,

Develop skills through an experienced mentor and

The important focus should be on adapting content and pedagogy to an online context rather than focusing only on technology.

5. Conclusions

The need for online learning and teaching cannot be overemphasized in today's context due to the pandemic. There are bodies of literature available, where studies have been carried out to understand the need for training faculty for transition from physical class room to virtual classroom. In the Indian context, such studies are rarely found in the literature as in a formal teaching-learning environment adopted in institutions and Universities, there were no online courses taught earlier. Also in the changed scenario such formal studies have not been reported. In this regard, this study assumes significance. The study establishes that training faculty in different aspects of online teaching /learning is essential. Institutions / Universities need to take steps to organize such training programs either inhouse through available expertise or through external professionals to the faculty of their institutions. This will help faculty to understand all issues related to pedagogy and technology, while offering online courses. If there are no initiatives taken till date, it is time that it is taken as online teaching is going to stay for some more time and there will be issues both for the faculty and students. Govt. bodies, Universities, funding agencies etc. need to take note of this major issue and formalize plans and mechanisms to help in this effort to make both students and faculty more comfortable.

References

- [1] Nilson, L. B., & Goodson, L. A. (2021). Online teaching at its best: Merging instructional design with teaching and learning research. John Wiley

& Sons.

- [2] Urdan, T. A., & Weggen, C. C. (2000). Corporate elearning: Exploring a new frontier.
- [3] Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems*, 49(1), 5-22.
- [4] Clay, M. (1999). Development of training and support programs for distance education instructors. *Online Journal of Distance Learning Administration*, 2(3).
- [5] Barker, A. (2003). Faculty development for teaching online: Educational and technological issues.
- [6] Worley, W. L., & Tesdell, L. S. (2009). Instructor time and effort in online and face-to-face teaching: Lessons learned. *IEEE Transactions on Professional Communication*, 52(2), 138-151.
- [7] Liu, X., Bonk, C. J., Magjuka, R. J., Lee, S. H., & Su, B. (2005). Exploring four dimensions of online instructor roles: A program level case study. *Journal of Asynchronous Learning Networks*, 9(4), 29-48.
- [8] Keengwe, J., Kidd, T., & Kyei-Blankson, L. (2009). Faculty and technology: Implications for faculty training and technology leadership. *Journal of Science Education and Technology*, 18(1), 23-28.
- [9] Zisow, M. A. (2000). Teaching style and technology. *TechTrends*, 44(4), 36-38.
- [10] Keengwe, J., & Kidd, T. T. (2010). Towards best practices in online learning and teaching in higher education. *MERLOT Journal of Online Learning and Teaching*, 6(2), 533-541.
- [11] Keengwe, J., & Georgina, D. (2012). The digital course training workshop for online learning and teaching. *Education and Information Technologies*, 17(4), 365-379.
- [12] Hook, J., & Pitkethly, C. Key considerations for designing online learning in the Arts Faculty.
- [13] Kinney, L. S. (2015). Faculty perceptions of online learning in engineering education (Doctoral dissertation).
- [14] Brinkley, K. E. (2016). Learning to teach online: An investigation of the impacts of faculty development training on teaching effectiveness and attitudes toward online instruction.
- [15] Lackey, K. (2011). Faculty development: An analysis of current and effective training strategies for preparing faculty to teach online. *Online Journal of Distance Learning Administration*, 14(4), 8.
- [16] Schmidt, S. W., Tschida, C. M., & Hodge, E. M. (2016). How faculty learn to teach online: What administrators need to know. *Online Journal of Distance Learning Administration*, 19(1), 1-10.
- [17] Kyei-Blankson, L. (2009, March). Learning to teach and teaching online: Faculty-faculty interactions in online environments. In *Society for Information Technology & Teacher Education International Conference* (pp. 947-952). Association for the Advancement of Computing in Education (AACE).
- [18] Ray, J. (2009). Faculty perspective: Training and course development for the online classroom. *Journal of Online Learning and Teaching*, 5(2), 263-276.
- [19] Kessler, G. (2016). What Can We Learn from Our Colleagues? A Framework for Virtual Classroom Training. *Online Learning Consortium*.

Integrating IR4.0 Technology in Engineering Education: Robotic Arm Remote Lab

Teoh Jiehan¹, Tee Chee Yee², Hamna Zadh³, Aminatta Mohamed Diallo⁴,
Merwin Vickraman⁵, Nishata Royan Rajendran Royan⁶

¹School of Engineering, UOW Malaysia KDU University College

Jalan Kontraktor U1/14, Seksyen U1, Glenpark U1 40150 Shah Alam, Selangor, Malaysia

⁶nishata.r@kdu.edu.my

Abstract : The education sector, in general, is constantly trying to integrate the current fourth industrial revolution known as Industry Revolution 4.0 (IR4.0) into its curriculum. In efforts to do that, this capstone project was assigned to a group of students doing their Bachelor's in Engineering to effectively create and design a virtual or remote lab that would further help students everywhere to be more engaged and involved in the learning process. In this regard, this paper introduces the initiative being carried out by the UOW Malaysia KDU University College (UOWMKDU) to implement IR 4.0 in various modules being taught, in terms of projects or assignments. Therefore, a remote lab was created based on the learning outcomes of a subject available in the module. The lab includes a robotic arm manipulated through an established interface developer Blynk, being simultaneously observed through a website built by a student in the School of Engineering, UOWMKDU. The movement of the

robotic arm is viewed through the website by incorporating an inexpensive camera chip into the design. Also, this paper discusses the advantages of using those components, in-depth information regarding the components and their usage, and a detailed methodology that could be used as a guideline for future students interested in creating their robotic arm. It highlights the objectives of the lab, procedures, and challenges that were faced during the period of assembling the prototype and how those challenges were overcome to produce a well-functioning robotic arm.

Keywords : education sector; IR4.0; remote lab; robotic arm; virtual lab

1. Introduction

The problem which currently dominates intellectual debate is Industrial Revolution 4.0 (IR4.0). This fourth industrial revolution began at the World Economic Forum in 2016, where an announcement was made that the world had reached the inception of the fourth revolution in the industry. To describe the current revolution, these have used many different terms, including 'Fourth Revolution', 'Industry 4.0', 'Revolution 4.0', and 'Fourth Industry'. The Fourth Technological Revolution can be described as the latest and evolving alteration of human function, resulting from disturbing inventions and phenomena such as digital technology, the

Teoh Jiehan¹

School of Engineering, UOW Malaysia KDU University College
Jalan Kontraktor U1/14, Seksyen U1, Glenpark U1 40150
Shah Alam, Selangor, Malaysia
nishata.r@kdu.edu.my

Internet of Things (IoT), augmented reality, and artificial intelligence (AI) .

The development of IR4.0 is a recent trend that directly affects many industries, including higher education institutions (IHL). Higher education is a significant sector that needs due attention because it is closely linked to the economic sector of the country. If the education system is not aligned or equipped to meet current trends, our country will stay behind and this will have lasting consequences for the country and the community. The Public Institute of Higher Education as one of the most relevant institutions has a strong duty to produce good human capital to meet the demands of people today more inclined to achieve the highly qualified human resources of the country.

Based on improvements in the country's education system as a result of its growth and success, universities have begun focusing in particular on the industrial requirements that will consume university education products. The change in IR4.0 implicitly complicated human life and characterized the competition aspect. Otherwise, graduates will not be able to meet the demands of modern times. Graduates will be unable to meet the requirements of the modern era without this preparation. Consequently, apart from the growing usage of intelligent computers, the use of digital technologies, information access, and the introduction of modern media has become a fact that cannot be disregarded. Therefore, IHL must be well prepared to leave the comfort zone and routine to meet the obstacles presented by IR4.0 .

In this modern period, formal education is becoming a benchmark for employing workers. As such, career possibilities are the standards for the worth of any education sector in the world of education. Education is also considered to be a long-term investment to meet the demand for trained workers in society . Any formal education loopholes might compromise a nation's education and human capital. Thus, education must be meticulously planned. IR4.0 is rapidly changing the globe, as well as the labor requirements. As a result, public universities have begun to customize their curricula to meet the demands of the firm.

For all the above-mentioned, Robotic Arm Remote Lab is introduced in this paper to improve the education system by implementing IR4.0 into the curriculum. This lab aims to provide an alternative solution to performing labs when the lab is

unreachable due to distance. With that, it will help enhance the practical skills of students in adjusting a robotic arm to perform a particular task remotely. With the help of technology, distance will no longer be a problem in education. The details of the core work done by the group are presented in the following chapters.

2. Literature Review

A. Industrial Revolution

The first industrial revolution began in the 18th century with the use of steam power and the mechanization of production . The mechanized edition, which had generated threads on basic spinning wheels before, accomplished eight times the volume at the same time. The biggest advance in rising human productivity was its use for manufacturing purposes. The Second Industrial Revolution began with the invention of electricity and assembly line manufacturing in the 19th century . The notion of mass processing from a slaughterhouse in Chicago was picked up by Henry Ford between the years 1863 and 1947. The pigs were hanged from conveyor belts and each butcher undertook only a part of the process of butchering them. In the '70s, by partial automation using memory-programmable controllers and computers, the Third Technological Revolution started in the 20th century for the most part. The whole manufacturing chain is simplified with the advent of these innovations without human help. Robots that execute programmed sequences without human interference are known examples of this.

Industrial Revolution 4.0 (IR4.0) is currently being implemented in this day, where information and communication technologies are applied to the industry. Production systems that use computers are advanced with the use of network connection which will allow them to have a digital twin on the internet to speak to. This will allow interconnection between facilities that can assess each other's outputs. This intends to produce smart factories where everything is connected through a network making it almost autonomous. IR4.0 changed the manufacturing industry by digitizing it. IR4.0 involves 9 pillars which are The Internet of Things, Augmented Reality, Simulation, Additive Manufacturing, System Integration, Cloud Computing, Autonomous Systems, Cybersecurity, and Big Data Analytics.

B. Remote & Virtual Labs

Virtual laboratories can be considered as replicas or imitations of real-life experiments which are carried out using simulation on a computer. Accessibility, availability, safety, and observability are some of the general benefits of virtual and remote laboratories. Remote laboratories are of great use when it comes to distance-learning courses which mainly develop professional skills, conceptual knowledge, and understanding in students. According to one of the papers, most educational institutions prefer virtual laboratories used in the first stages of learning to build confidence in students, then make use of remote laboratories in later stages of learning to achieve learning outcomes of module courses .

Previous research has shown that virtual and remote laboratories produce higher achievement in learning outcomes and higher transfer of learning compared to hands-on laboratories . It is of great importance to focus on the mental activities of students when using these laboratories, some of which may include their motivation, collaboration, and feedback. The students were more enthusiastic to learn about the current technologies available for the automation of manufacturing systems. Interest increased amongst students due to the ability for them to visualize the behavior of productive systems when using the virtual lab and remote lab.

Although remote laboratories are deemed less efficient than hands-on laboratories, they provide a greater experience of working geographically with students and allow for better compensation of any problems that may arise from equipment failures. Authenticity, inquiry, collaboration, and technology are all considered to be important features when operating laboratories . Through the synthesis, planning, making of decisions, and transforming of data, students develop a greater cognitive engagement and higher-level learning strategies. Motivational challenges because the complexity and difficulty of the experimental course must also be exploited .

Students can learn new modules without having to worry about experimental setup, while researchers can try out new ideas on testbeds previously used by other researchers/focus groups hence producing fast, reliable comparisons of a variety of solutions. In most cases, remote laboratories prove to be a sufficient and effective trade-off between needs for real experiments and the shortage of time and resources. With minimal

effort, several different experiments can be carried out thus reducing expenses and reducing the time taken to complete the experiments .

C. Robotics and Automation

Industrial Networks is a program that allows students the opportunity to develop methodical solutions related to the installation and design of industrial networks surrounded by process automation. It requires an analysis of the representative models, devices, protocols, topologies, and planning systems included in industrial communication networks to gain a further understanding of what occurs between these networks. It is largely rooted in the architecture and automation of the plants and industrial procedures from a distance, their Programmable Logic Controllers (PLC), and their transmission methods . Integrated Manufacturing Systems enables students to identify different technologies that are found in an integrated manufacturing system. Some important technologies used in process automation include Human Machine Interface (HMI), industrial communication buses, and PLC .

The first implementation of a virtual lab (VL) was done through the design and construction of a PLC simulator. More its environment rather than the PLC itself. Of this implementation, various problems arose but were subsequently solved. Some of these included the availability of equipment for each student to use, low training, and accessibility for students to practice and learn through trial and error as the errors in programming did not impact the physical devices. Lastly, the evaluation of results needed to be done efficiently as the feedback times of the system were instantaneous. Several Virtual Reality Machines (VRM) were developed to facilitate this .

The main constituents found in a remote lab (RL) are prototypes of the process, a PLC, video cameras, and a PC server. In this application, features such as process dynamics will take a primary role in the overall performance of the control system. It will validate that the control actions are carried out successfully and adequately within the automatic system including feedback meaning closed-loop systems, but especially without feedback which is open-loop systems. A remote laboratory with this kind of equipment has a reduced cost of implementation and operation .

3. Methodology

In this chapter, the details of developing the remote lab are shown where the main task of the robotic arm is to pick and place an object from one place to another. The user can manipulate the robotic arm by giving specific commands to control the motion. The robotic arm contains servo motors that allow the arm to move in the desired direction. A microcontroller is used to give commands to the motors of the robotic arm where the commands will be given through the user interface on the app, Blynk. The robotic arm control is done through the Internet to the wifi module connected to the robotic arm. The signal provided to the robotic arm can simply be transmitted over the Internet and the user can then access the robot anywhere and anytime as long as there is an Internet connection. In addition, this project provides a webpage to monitor the robotic arm. This webpage allows the user to observe how the robot is moving while controlling the robot's operation through the app. For security purposes, access can be restricted from the webpage for specific students only while the controller is given to students performing the lab to ensure only one student controls a robotic arm every time. By doing so, the admin would be able to track the user easily too.

A. Software Application

Arduino Integrated Development Environment (IDE) provides a text editor for writing code and messages. It contains a set of toolbars and menus with the basic feature icons. It is connected with the hardware to import and interface the programs into it. The sketch is the term for a program used by Arduino. It is the unit of code on which an Arduino Board is run.

B. Hardware Integration

In this section, the hardware design and the reason behind each decision made for the project will be discussed. This involves the design concepts, material and component selection as well as the software chosen for the completion of the project.

1) Robotic Arm

In this project, acrylic plastic was chosen as the material to build the robotic arm. Acrylic plastic is light and strong; therefore, the SGR 90 servo motor can rotate the robotic arm. As the prototype has electrical components as well, acrylic plastic acted as an insulator material to avoid current shock. The robot

arm contains 5 servo motors which indicate that the robot has five degrees of freedom. There are three wires in the servo motors that act as power and signal control of the servo motors. The servo motor acts as the motor for rotating and shifting the robot arm. The five servo motors are linked to the NodeMCU ESP8266. It is used to transmit the signal to control the rotation of the servo motor. The signals are sent to the robotic arm via the internet and thus can be accessed from anywhere as long as there is an internet connection. The action of the robot is visible through the website. Hence, by combining the website and robotic arm controller, the user can monitor the robot and control the robot's motion.

The connection of five servo motors and the NodeMCU ESP8266 was verified through Fritzing before being implemented to the robotic arm as shown in Fig. 1. By doing so, the risk of servo motors and NodeMCU ESP8266 being burnt out can be reduced. These motors will not consume more power therefore the 5V DC supply is enough to drive them. The actual connection is shown in Fig. 2.

The MB102 Solderless Breadboard Power Supply Module was used as a power supply in this robot arm to provide a separate power supply to the servo motor. Two output voltages can be used simultaneously for

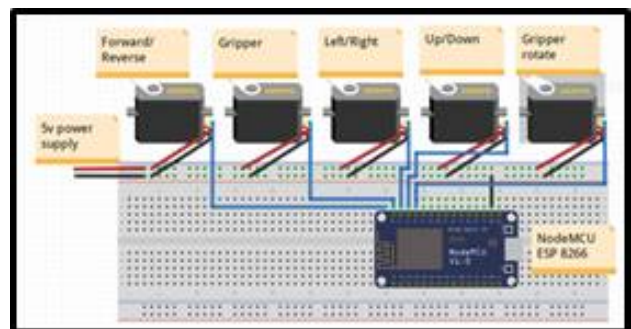


Fig. 1 : Connection of the servo motors and NodeMCU ESP8266 in Fritzing

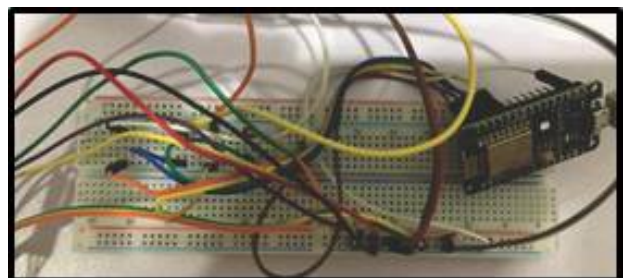


Fig. 2 : Connection of the servo motors and NodeMCU ESP8266

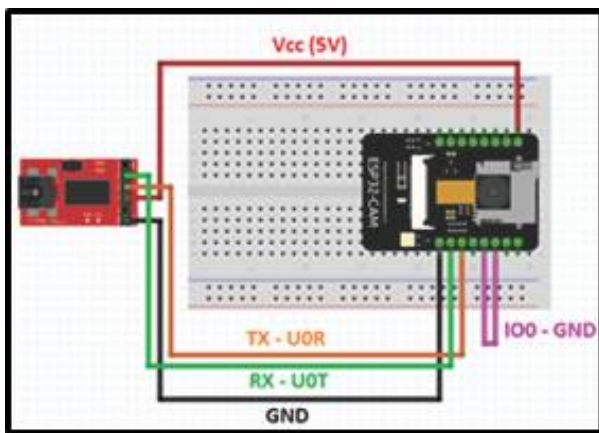


Fig. 3 : The connection of ESP-32 Cam to FTDI in Fritzing

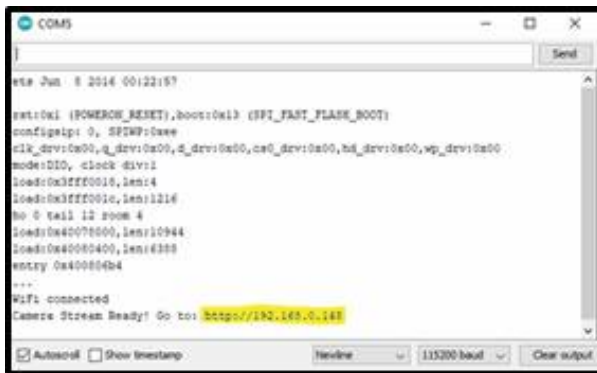


Fig. 4 : Example of IP address from the Serial Monitor of Arduino IDE

the project. This MB102 module can be plugged into the breadboard directly without any soldering needed. With a separate power supply, the robot arm will operate more smoothly, and the power supply would not be affected by the NODEMCU ESP8266. The power supply is controlled so that it does not exceed the requirements of 5V of Arduino.

2) ESP-32 cam

The ESP-32 Cam is used as the camera for the project because it is one of the cheapest IoT cameras available in the market. The ESP-32 Cam will contribute to one of the main purposes of the website, which is viewing the robotic arm. To upload the code into the camera, FTDI is needed because it can be used as a medium connecting the camera to the laptop. Fig. 3. shows the connection of the ESP-32 cam with the FTDI. After uploading the codes, the IP address of the camera will be created after running the codes where it can be obtained from the Serial Monitor as shown in Fig. 4.

C.Control system development

1) Block diagram

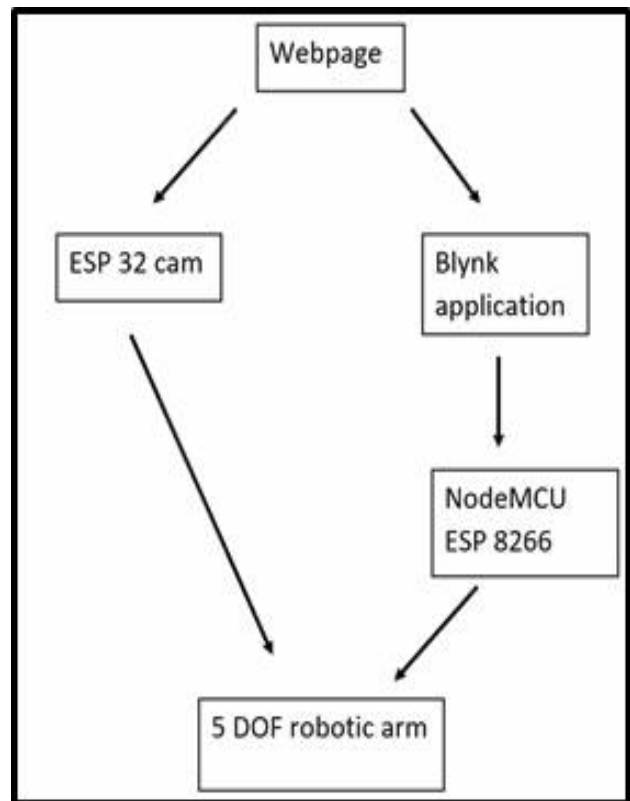


Fig. 5 : Block Diagram of IoT Robot Arm

The block diagram above describes the overall concept of the project, in which a webpage would provide lab details and be used to monitor the 5 DOF robotic arm, while the Blynk application is used to control the arm's movement. Therefore, to perform the lab, the user must have access to internet connection while having a smartphone for the Blynk application and a desktop/laptop is recommended to access the webpage.

2) Blynk controller

The project used the Blynk application as a platform to control the robotic arm. The reason for using the Blynk application in this project is because Blynk application is a well-established interface developer. It allows users to create an interface quickly for controlling hardware projects from Android and IOS devices. To upload the code, the NodeMCU library needs to be installed in the Arduino IDE. The NodeMCU can be installed using the built-in library manager available in Arduino IDE.

```

#include <BlynkSimpleEsp8266.h>
#include <Servo.h>

char auth[] = "aMjv08caijv49bknVyrw2BAc6nAvEx"; //Paste Auth Token Here

// Your Wifi credentials.
// Set password to "" for open networks.

char ssid[] = "iPhone"; //Enter Wifi User Name
char pass[] = "issac59515753"; //Enter Wifi Password

Servo servo;
Servo servo1;
Servo servo2;
Servo servo3;
Servo servo4;

BLYNK_WRITE(V3)
{
  servo.write(param.asInt());
}

BLYNK_WRITE(V0)
{
  servo1.write(param.asInt());
}

BLYNK_WRITE(V1)
{
  servo2.write(param.asInt());
}

BLYNK_WRITE(V2)
{
  servo3.write(param.asInt());
}

BLYNK_WRITE(V4)
{
  servo4.write(param.asInt());
}

void setup()
{
  // Debug console
  Serial.begin(9600);

  Blynk.begin(auth, ssid, pass);

  servo.attach(D0);
  servo1.attach(D1);
  servo2.attach(D2);
  servo3.attach(D3);
  servo4.attach(D4);
}

void loop()
{
  Blynk.run();
}

```

Fig. 6 : Coding for the NodeMCU ESP8266

The Blynk application is required to be set up to control the robotic arm. First of all, an authorization code (auth token) will be sent through email after signing up for the application. The token can then be directly copied into the codes as shown in Fig. 6. After logging in to the Blynk app, a new project was created and it is named as robot arm. In the “New Project” setting, the NodeMCU was selected as a device and the connection type is WIFI.

Besides that, an application is needed to be created in Blynk which will allow it to act as a controller for the robotic arm. Since the robotic arm is controlled by 5 servo motors, it is required to add 5 sliders in the controller. The slider settings are shown in the table below. The slider value is fine-tuned to achieve the desired angle and movement for the robotic arm.

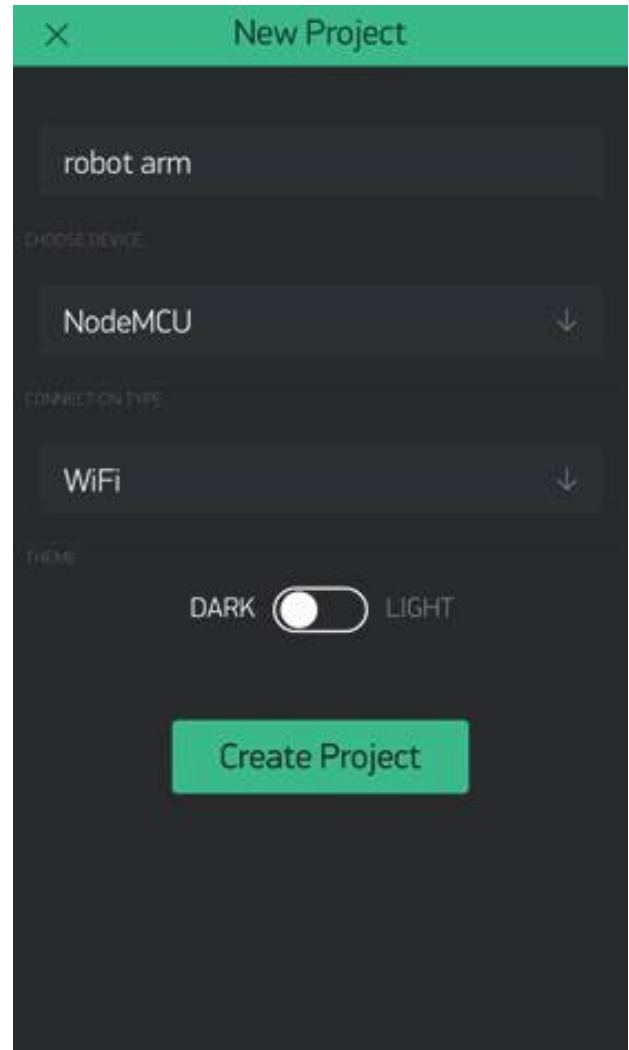


Fig. 7 : New project setting in Blynk application

Table 1 : The setting of the slider in Blynk

Slider name	Output	Slider value (angle)
Gripper	V0	0-180
Left/right	V1	0-180
Up/down	V2	30-150
Forward/reverse	V3	10-90
Gripper rotate	V4	0-180

The controls were then shared with other users using a QR code. The app provides 2000 Energy for new users which were used to “buy” the sliders for designing the controller and the sharing of the

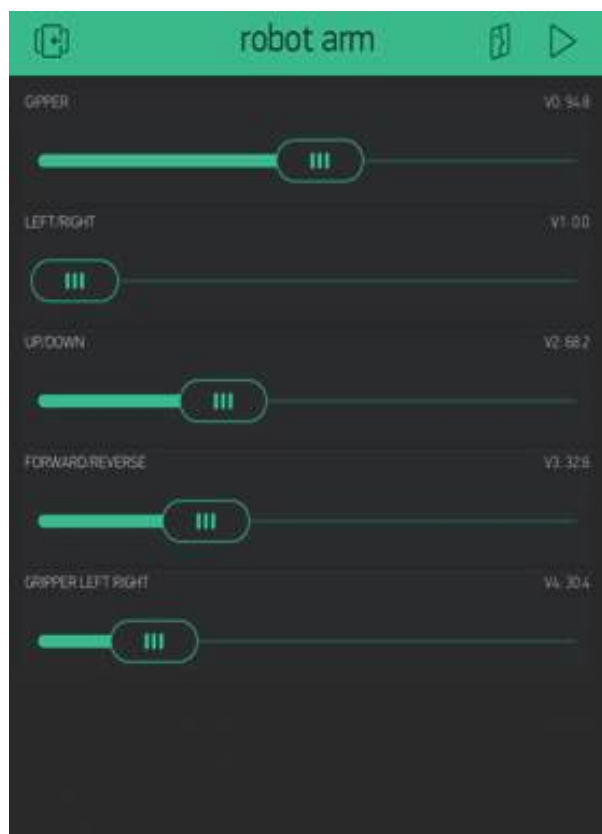


Fig. 8 : Robot arm control in Blynk

controller. Therefore, if extra Energy is needed to add more features, such as an emergency stop button, the user has to spend money to buy the Energy. This application was used since mobile phones are used in the IoT in the industry to access and control devices such as CCTV, August smart lock, SCADA apps which will give the students a better experience of how things run in the industry.

1) Webpage

In this project, the main purpose of the webpage is to monitor the robotic arm as well as provide a platform that consists of all the necessary information of the lab. This webpage allows the user to observe how the robot is moving and controlling the robot's operation through Blynk. The google site was chosen to be used as the website builder because:

- Easy to design and manipulate
- Able to achieve the requirements where the website will be used as the lab cover as well as the monitor while controlling the robot arm

- Able to restrict the users accessing the website based on the student email (no Log-in feature required)
- Admin can manage and analyze the website easily

The website developed has 3 main pages which include the Home page, the Labs page, and the Schedule page as shown in Fig. 9. The Home page is used to provide a brief idea for the user about the project therefore, it includes a simple introduction of the team, the topic given and the lab decided to be done. On top of that, the project objectives are also included on this page to give more details to the user regarding the project.



Fig. 9: Home page of the website

The lab page was used to list the available virtual and remote labs which in this case was Robotic Arm Remote Lab. Students would be able to check the availability using the Schedule page and they would have to make a booking with their respective lecturers or admin depending on the system of the school. After a student has booked a slot, the admin of the webpage would have to update the availability of the labs. It does not require much technical knowledge to change, manage and manipulate the content of the website. Thus, using Google Site significantly reduces the maintenance cost of the website and it is sustainable.

The most important page on the website is the subpage in the Labs page - Robotic Arm Remote Lab. Details of the labs such as the overview, user guide, and lab procedures are included on this page. After the student successfully books a slot, access will be given to the student. On top of that, the host of the controller needs to be online for the shared controller to be used. This also helps to make sure that the student can only access the controller during the given time slot and not any other period.

4) Animation

On the website, a demonstration of how the robotic remote lab should turn out was included when carrying out the lab experiment provided in the lab cover. The demonstration of the lab is an animation of the robot arm's movements when picking and placing the weights on a platform.

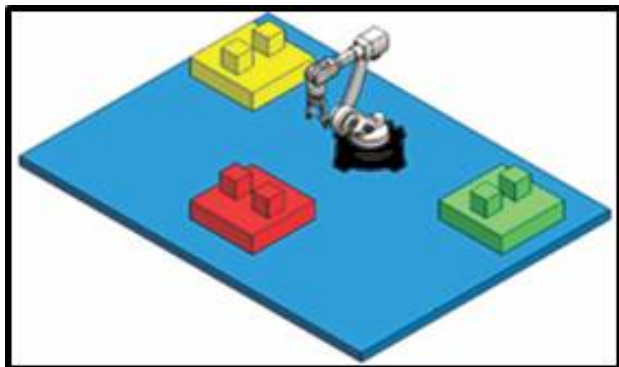
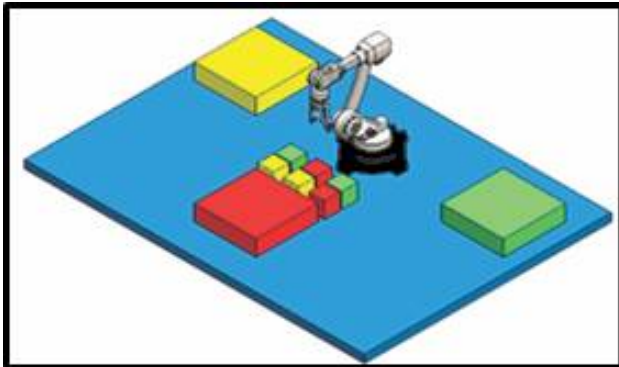


Fig. 10: Screenshot of the demo for lab (Exercise) at the beginning (top) and end (bottom)

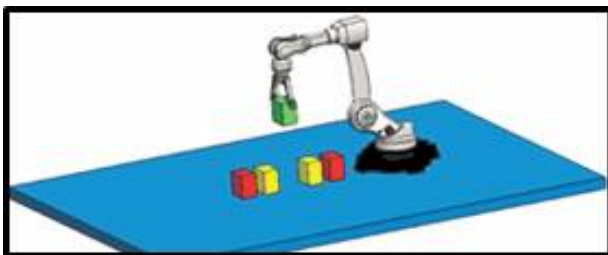
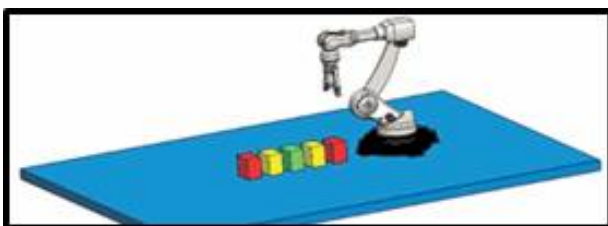


Fig. 11. Screenshot of a demo for lab (Part A) setup and picking up one of the weights

SOLIDWORKS is used to design and create the animation as it would be more conducive for the task to be completed. Each component was designed separately and then assembled accordingly to form the final design of the robot arm model. Once the full 3D drawing is completed, SOLIDWORKS is used to create the animation of the robotic arm showing its functionality in the virtual remote lab.

D. Overall Prototype

In this section, the presentations of the complete model and embodiments of the prototype will be shown including the assemblies and parts. The parts of the robotic arm are shown in Fig.12 which includes the acrylic parts, motors as well as bolts and nuts.



Fig. 12. Parts of the robotic arm

The parts of the robotic arm can be separated into three main sections which include the base of the robotic arm, the arm itself, and the gripper. Each part is assembled accordingly to the servo motors using the bolts and nuts. The overall final prototype of the robotic arm is shown in Fig.13.

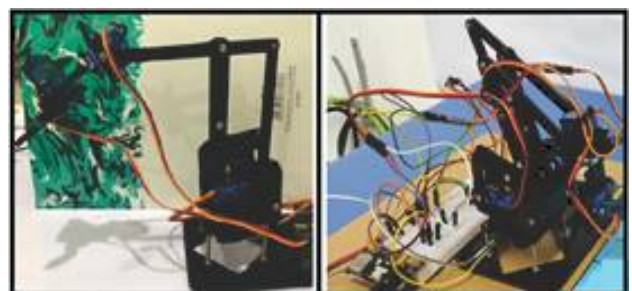


Fig. 13. The assembled robot body with the base (left) and the full assembly 5 DOF robotic arm along with the circuit (right)

4. Finding and Analysis

A. Robotic Arm

The initial plan was to use a 4DOF robotic arm but there were issues regarding the gripper and servo

motors. This was solved by replacing the gripper and using a 5DOF robotic arm for the gripper.

During the testing process, there were times when a signal was given from Blynk, but the servo motor did not respond to it. This might be due to the internet connection causing the controller to be in an offline status, thus the signal provided to the microcontroller is unstable. The internet connection also affected the speed of the signal transfer. This means that when the latency was high, the lab was not performed smoothly.

The robotic arm seemed to vibrate even when no signals were being sent through Blynk. This vibration occurred due to the peak current of the power supply being unable to handle the large torque. Therefore, the power supply needed to be increased until it was sufficient to drive five servo motors.

Two capacitors with values of $2200\mu\text{F}$ and $220\mu\text{F}$ are inserted into the servo motors' connection. The capacitors were connected parallel with the power supply to servo motors. This is to solve the problem where the power is insufficient to support all five servo motors which result in the shaking of the robotic arm at certain angles. After inserting the capacitors, the current capacity is sufficient to supply five servo motors. The second improvement done to the robotic arm is using two gears to control the angle of the gripper to open and close. With gear control, the gripper can grip an object more efficiently since it can provide more angles.

Building a platform for the robotic arm allowed the user to perform their lab activity in a safer environment. The platform ensures that the user is controlling the robotic arm under the safety region while protecting the robotic arm because it avoids the robotic arm from going over to its maximum operation. It is similar to the safety line marking in the industry.

B. Camera

The initial setting for the camera shows lots of latency at the image which is quite normal for a low-cost IoT camera and if the internet connection is bad. From the reference found (ESP32-CAM Troubleshooting Guide: Most Common Problems Fixed, n.d.), some improvements have been made to reduce the latency of the image. The frame size of the image can be reduced to reduce file size. Using a standalone power supply can also improve the

problem. Another method found which is quite useful is to upload the sketch (codes) into the camera again before using it. Overall, the setting of the camera can be changed to suit the condition.

C. Previous papers

Since there were no calculations and simulations involved while developing the prototype, the comparison with a pre-existing project which was similar to the prototype would be discussed and analyzed in this section.

Based on the previous paper found, the robotic arm was controlled using a Raspberry Pi microcontroller, and the programming language used is Python 2.7, JavaScript, and Node-RED (Ishak et al., 2018). The robotic arm is a 4 DOF robot and the joints that enable the movement of the robotic arm are represented by RC servo motors. The frame of the robot is made from lightweight aluminum. The 4 MG996R servo motors were used for the movement of the robotic arm as shown in the figure below.

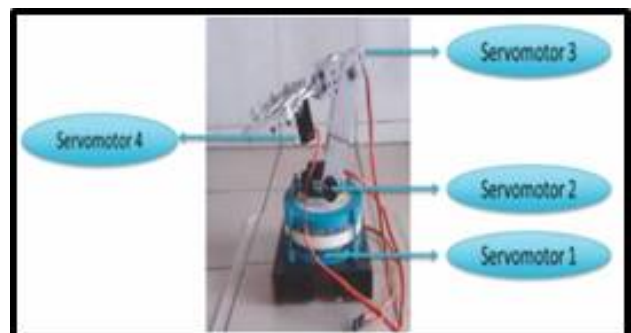


Fig. 14 : The robotic arm of the previous paper

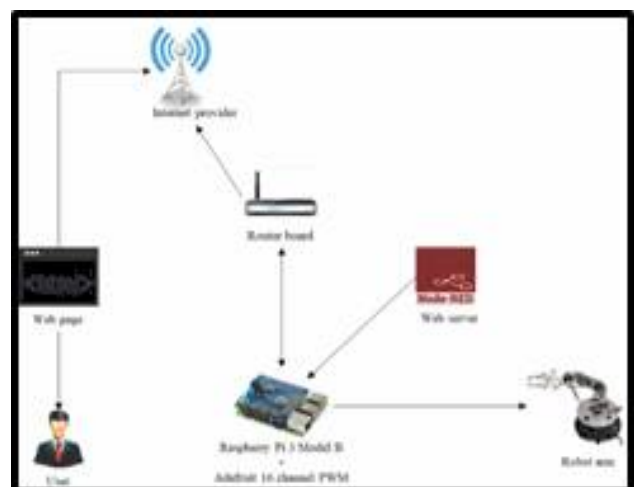


Fig. 15 : Block diagram of the robotic arm system design from a previous paper

The robotic arm system design requires the user to use an internet-connected computer to access the webserver using a Node-Red platform. The web server interacts with Raspberry Pi which is followed by a PWM servo motor drive to manipulate the robotic arm.

As a comparison, this robotic arm system from the previous paper is more expensive and has less degree of freedom compared to the existing prototype for Robotic Arm Remote Lab. Although the Robotic Arm Remote Lab was not able to pick up heavyweights, the objective of the lab was achieved. In addition, the Robotic Arm Remote Lab allows users to monitor the robotic arm from the web page and control the robotic arm from the Blynk application which is user-friendly and more interesting for the users.

To compare the pick and place operation, the model from the previous paper allows users to operate only by clicking on the button "Pick and Place" available on the websites as shown in the figure below. On the other hand, the system fixes the pick and place operation as shown hence not much can be manipulated. While the Robotic Arm Remote Lab requires the user to download the Blynk application and scan the QR code from the confirmation email then only he/she can control the robotic arm.



Fig. 16 : The web page from a previous paper

There is one similar problem that both projects faced which is the time delay through a network. The time delay problem that occurs in the Robotic Arm Remote Lab is when the camera displays the movement of the robotic arm on the web page where there is some latency shown. The previous paper faced the time delay issue on the angle of each joint display on the web page. Both projects use Internet Protocol (IP) to access the web page and camera therefore, the time delay issue can be due to the internet connection problem. With the introduction of 5G in more and more places, said the problem should not arise soon. A summary of the comparison can be seen in the table below.

Table 2 : Comparison of the prototype with pre-existing model

Factor	Robotic Arm Remote Lab	Previous Paper
Material	Acrylic plastic	Aluminum
DOF	5	4
Micro-processor	NodeMCU ESP8266 + ESP 32 cam	Raspberry Pi
Programming language	C programming	Python 2.7, JavaScript and Node-Red
Actuator	SG 90 servo motor	MG996R servo motor
Controller	Web page + <i>Blynk</i>	Web page
Angle rotate	0-180 degree	0-180 degree
Display	Camera display + Angle from <i>Blynk</i>	The angle of each joint display
Demo	Yes (Animation)	No
Problem	Time delay	Time delay

Overall, the current prototype is a low-cost prototype done for illustration purposes. Some of the possible future works are as below if there were no time and budget limit.

(a) Webpage

(b) Camera

(c) Robotic Arm

As mentioned earlier, the google site was chosen to be used due to its conveniences and ability to achieve all minimum requirements of the lab. However, if there were more time and budget given, a better webpage could be done to enhance the performance and provide better service for the users of the lab. For example, the current webpage does not have a login page since it is under the user can only access the webpage using the same domain as the school. However, if the webpage has a login page, it can then

be used not only for the students from the same school but also for outsiders for research purposes.

On the other hand, the camera used for the current prototype is a low-cost camera with lesser complexity where the quality of the image is not very ideal where its highest resolution is 1600 x 1200 pixels. Some other common camera module such as the Raspberry Pi camera module has a resolution of up to 2592 x 1944 pixels but the price is also much higher as compared to the current camera module. Therefore, the appropriate module can be chosen based on the requirements and the budget given.

As for the robotic arm, a pre-existing model is used and modified due to the time frame given. For a better prototype, a robotic arm can be done from scratch to suit the requirements more. The angle of rotation, for example, can be increased as well as the DOF of the robotic arm. With that, the robotic arm would be able to perform the movement with higher complexity hence improving the overall performance of the lab.

5. Conclusion

The objective of this project was to design a virtual lab based on the title 'Robotic Automation Virtual Lab' and to achieve this, a Robotic Arm Remote Lab was created which focused on the learning outcomes of a subject available in the module, ECTE471 - Robotics and Flexible Automation.

After careful consideration, it was decided that the Blynk app meets the requirements and Google Sites was used to design the website. The website allows students to check the availability of the lab and provides the link to get video streams of the robot along with a demonstration of what is expected of them. Whereas the Blynk application is used to move the robotic arm according to the instructions provided in the lab while observing the change in the degree of movement. The website and the robotic arm are connected by a camera chip which was used to provide a live feed of the robotic arm, students can then perform their labs based on the tasks assigned to them.

As expected, certain issues were encountered during the assembly of the robot. The initial plan was to use a 4DOF robot instead of a 5DOF robot. However, the prototype did not respond to the various commands and the gripper was not reading any of the commands. Therefore, a servo motor was added and the gripper was replaced which solved the problem.

There were issues regarding the camera module as well, mostly concerning the connections and these issues were resolved well ahead of time.

After putting together the camera chip and the robot it was observed that the robot sometimes does not read the inputs sent from the Blynk app. Upon inspection of the prototype, it was discovered that there were some connection issues. This issue could have occurred due to the slow internet connection leading to a slower rate at which data is transmitted. After which the prototype was able to pick and place objects and move freely as per the instructions provided to it, the students can see how a robotic arm is manipulated and they can do it themselves remotely which was the goal of the project. In addition, there were certain problems with regards to the ESP32 cam and its connection to the Arduino but they were all settled in due time. The robotic arm was able to maneuver according to the path decided by the user and this was observed from the website.

With that, this remote lab can align with IR 4.0 because it provides an option to transform the conventional way of experimenting from carrying out physical labs to allowing students to conduct experimental procedures online. This is done so by integrating some of the pillars of IR4.0 into the lab such as IoT, System Integration, and Autonomous Systems. Through remote access, students will have the opportunity to perform labs that used to be physically unreachable to them. Hence, engineering education can be improved as the distance is no longer a barrier.

Therefore, it is safe to assume that the project was successful as the aims and objectives of the project and lab were achieved. This is said so because the education system can be improved by implementing IR4.0 into the curriculum where this lab enhances the practical skills of students in adjusting a robotic arm to perform a particular task that can be done remotely. Although the best way of performing a lab is still through physical experimenting, remote labs provide an alternative solution to bring labs closer to students with the help of technology.

Acknowledgment

The authors would like to acknowledge the financial support from UOW Malaysia KDU University College, Utropolis Glenmarie, Malaysia

References

- [1] Bakar, N. R. H. A. (2017). Educational and Employment Trend among Females in Malaysia and the Need for Vocational Guidance in Job Selection. *E - B a n g i*, 3 (1) . <https://ejournal.ukm.my/ebangi/article/view/22061/6871>
- [2] Casini, M., Garulli, A., Giannitrapani, A., & Vicino, A. (2014). A remote lab for experiments with a team of mobile robots. *Sensors (Switzerland)*, 14(9), 16486–16507. <https://doi.org/10.3390/s140916486>
- [3] Devi, M., Annamalai, M. A. R., & Veeramuthu, S. P. (2020). Literature education and industrial revolution 4.0. *Universal Journal of Educational Research*, 8 (3) , 1027 – 1036 . <https://doi.org/10.13189/ujer.2020.080337>
- [4] ESP32-CAM Troubleshooting Guide: Most Common Problems Fixed. (n.d.). Retrieved March 10, 2021, from <https://randomnerdtutorials.com/esp32-cam-troubleshooting-guide/>
- [5] Industrial Revolution - From Industry 1.0 to Industry 4.0. (n.d.). Desouttertools. Retrieved February 3, 2021, from <https://www.desouttertools.com/industry-4-0/news/503/industrial-revolution-from-industry-1-0-to-industry-4-0>
- [6] Ishak, M. K., Roslan, M. I., & Ishak, K. A. (2018). Design of robotic arm controller based on Internet of Things (IoT). *Journal of Telecommunication, Electronic and Computer Engineering*, 10(2–3), 5–8.
- [7] Kehdinga, D., & Fomunyan, G. (2019). Education and the Fourth Industrial Revolution: Challenges and Possibilities for Engineering Education. *IJMET_10_08_022 International Journal of Mechanical Engineering and Technology*, 10 (8) , 271 – 284 . <http://www.iaeme.com/IJMET/index.asp271http://www.iaeme.com/ijmet/issues.asp?JType=IJMET&VType=10&ITYPE=8http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=10&ITYPE=8>
- [8] Ma, J., & Nickerson, J. V. (2006). Hands-on, simulated, and remote laboratories: A comparative literature review. *ACM Computing Surveys*, 38(3), 1. <https://doi.org/10.1145/1132960.1132961>
- [9] Morales-Menendez, R., Ramírez-Mendoza, R. A., & Guevara, A. J. V. (2019). Virtual/Remote Labs for Automation Teaching: A Cost Effective Approach. *IFAC-PapersOnLine*, 52(9), 306–311. <https://doi.org/10.1016/j.ifacol.2019.08.219>

A New Comprehensive Methodology for Evaluation of Course Outcomes and Programme Outcomes

**Bimal Kumar Mawandiya¹, Shashikant Joshi², Bharatkumar Modi³,
Kaushikkumar Patel⁴, Vikas Lakhera⁵, Rajesh Patel⁶, Alka Mahajan⁷**

^{1,2,3,4,5}Department of Mechanical Engineering,

School of Engineering, Institute of Technology, Nirma University, Ahmedabad, Gujarat, India

⁶Additional Director, School of Engineering, Institute of Technology, Nirma University, Ahmedabad, Gujarat, India

⁷Dean at SVKM's NMIMS Mukesh Patel School of Technology Management & Engineering, Mumbai, Maharashtra, India

¹bimal.mawandiya@nirmauni.ac.in

²s.j.joshi@nirmauni.ac.in

Abstract : Course Outcomes (CO) and Programme Outcomes (PO) are the backbone of Outcome Based Education (OBE) and their evaluation using a definite established methodology is necessary to track the progress and effective implementation of OBE. The CO, Course and PO attainment levels determine the extent to which the skill/abilities as envisaged vide POs are imbibed by the students. The CO, Course and PO attainment also provide an insight for corrective actions.

A new method for determination of CO, Course and PO attainment level is presented in this paper. The method is comprehensive and unique as it takes into consideration the varying weightage of each course component such as Continuous Evaluation (CE), Semester End Examination (SEE), and Laboratory and Practical Work (LPW). This not only ensures that all assessment components are covered but it also has a provision to take into account the effect of multiple

mapping. This allows a teacher the flexibility to frame questions which can map with multiple COs. The proposed method gives individual as well as class attainment levels of the Course and the COs, thus allowing a more focused root cause analysis and corrective actions. The method also allows for calculation of the PO attainment level based on the CO and Course attainment level and the Program Articulation Matrix. The criteria for deciding the actions based on the PO and CO assessment levels are also presented.

Keywords: Accreditation; Course outcome; Direct attainment; Outcome based education; Program outcome

I. Introduction

Accreditation of the academic programmes serves a very important purpose of assuring stake holders about maintenance of quality in education. It is a validation of the quality initiatives taken and the teaching-learning process followed by an institute. It promotes a healthy competition amongst educational institutes, motivating them to strive for excellence in education. Implementation of OBE offers numerous advantages. It clearly defines the output expected from the teaching-learning process and systematically helps planning and implementation of curriculum delivery. The students are the largest beneficiary of OBE implementation as the focus changes from

Shashikant Joshi

Department of Mechanical Engineering,
School of Engineering, Institute of Technology,
Nirma University, Ahmedabad, Gujarat, India
s.j.joshi@nirmauni.ac.in

conventional approach of mere accumulating course credits to higher order learning and acquisition of cognitive thinking skills. Normally, a course comprises assessment components such as continuous evaluation, semester end examination and laboratory & practical work. Depending on the nature of the course, these components may have different weightage. Table I shows the typical weightage of various components for two courses of undergraduate (B.Tech.) programme. It is important to note here that the weightage of various course components is normally being decided by the course coordinator based on the nature of the course and course execution methodology planned.

Table 1 : Weightage Of Various Course Components

Course Component? Course ?	Continuous Evaluation (CE)	Semester End Examination (SEE)	Laboratory & Practical work (LPW)
ME301 Kinematics	0.6	0.4	-
ME601 Production Technology	0.4	0.4	0.2

Continuous evaluation refers to evaluation of students using various assessment tools on a continuous basis throughout the semester. The various assessment tools for continuous evaluation may be class test, course seminars, assignments, term paper, presentation, classroom interaction etc. The semester end examination is normally held at the end of the semester to assess the overall learning of the student. Laboratory and Practical Work refers to the continuous evaluation of exercises/activities carried out by the students in the laboratory for enhanced practical understanding of the course. The traditional methods of evaluating the CO based on the marks scored by students in SEE is highly myopic. First, it fails to highlight the extent of learning by the student throughout the semester as it is based only on examination normally held at the end of semester. Secondly, it does not take into consideration the nature of various courses.

The framework developed till this date by academic community has definitely reached a specific decisive state. It offers the advantages that it addresses both qualitative and quantitative methods. Another advantage is that the methods can be easily adopted by all teachers and are quick. The limitation being the qualitative and quantitative assessment is not being combined. Another limitation being, methods are rigid and offer no flexibility to the teacher in the

execution considering variation in the course structure and nature of the course.

In the framework of OBE, all the courses have course outcome (COs). The COs are framed to fulfil the Program Outcomes (POs). In turn, POs are framed based on Program Educational Objectives (PEOs) and Mission & Vision of the institute. POs indicate the attributes that the graduates must possess in the broader sense whereas Program Specific Outcomes (PSO) indicate the graduate attributes specific to discipline of program. A great deal of coherency between the Mission & Vision, PEOs, POs, PSOs and COs is vital for effective implementation of OBE. COs and in turn courses are mapped with POs/PSOs. The Course Outcomes of a sample course (Kinematics), POs/PSOs, Course Articulation Matrix (mapping of POs/PSOs with COs and course) are shown in Table II, Table III and Table IV, respectively. The mapping of COs and courses with POs/PSOs is essential for evaluation of PO/PSO attainment level.

Table 2 : Course Outcomes of Subject Me301 – Kinematics

CO	Statement
	After successful completion of the course, student will be able to
ME301.1	understand the concept of machines, mechanisms and related terminologies.
ME301.2	analyse a planar mechanism for displacement, velocity and acceleration graphically.
ME301.3	analyse various motion transmission elements like gears, gear trains, cams, belt drive and rope drive
ME301.4	synthesise the planar mechanism for function generation and path generation.

Table 3 : Program Outcomes and Program Specific Outcomes

Program Outcomes	
1.	Engineering knowledge
2.	Problem analysis
3.	Design/development of solutions
4.	Conduct investigations of complex problems
5.	Modern tool usage
6.	The engineer and society
7.	Environment and sustainability
8.	Ethics
9.	Individual and team work
10.	Communication
11.	Project management and finance
12.	Life-long learning
Program Specific Outcomes	
1.	Ability to apply the concepts of material science and engineering, computer aided engineering, thermal engineering and manufacturing technologies for design, development, analysis and maintenance of mechanical systems and processes.
2.	Ability to work as a professional and/or as an entrepreneur by applying mechanical engineering principles and management practices.

Table 4 : Course Articulation Matrix (mapping Of Cos, Course With Pos/psos)

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
ME301.1	Understand the concept of machines, mechanisms and related terminologies.	3													
ME301.2	Analyse a planar mechanism for displacement, velocity and acceleration graphically.		2											3	
ME301.3	Analyse various motion transmission elements like gears, gear trains, cams, belt drive and rope drive									1				3	
ME301.4	Synthesise the planar mechanism for function generation and path generation.				3									3	
ME301	Kinematics	3	2	-	3	-	-	-	-	1	-	-	-	3	-

*3,2 and 1 represent strong, moderate and marginal relationship respectively.

The PO/PSO attainment level is a direct measure of the extent of attainment of PEOs, and the accomplishment of Mission and Vision of the institute.

The Program Outcomes are predefined by the accreditation bodies like Accreditation Board for Engineering and Technology (ABET 2018), National Board of Accreditation, India (NBA 2018). Killan (2000) have outlined two kinds of outcomes of OBE. The first one is qualitative requiring learners to express their learnings and capabilities as an outcome of study of the program. The second type of outcome is quantitative comprising percentage course completion, employment, results of examination. The limitation of first approach is that it is based on the perception of the individual. The second approach is not dependent on the perception of evaluator but is not exhaustive and does not reflect the realistic attainment. Thus, both approaches do not represent the true picture of attainment. According to Brandt (1994) OBE consists of four principles viz. design down, expanded opportunities, focus and high expectations. A case study of assessment of PEO for an engineering programme is presented by Tshai et. al. (2014) wherein the level of attainment of PEOs is evaluated using surveys. The methodology of assessment based on exit surveys and exit test is proposed by Afida Ayub et.al. (2011)

Direct measurement of student learning and quantifying the same is a major challenge for institutions undergoing the process of accreditation. A simple method for CO attainment based on the marks obtained by students in various components such as final exam, test, quiz, assignment is developed by

Izham ZindAbidin et.al. (2009). The same is extended by Hamimi Fadziati A Wahhab et.al (2011) for PO assessment.

The result of CO and PO attainment is a very important quality parameter of the study program. It reflects the immediate actions to be taken so as to ensure that all the necessary skills/qualities as promised by various COs are attained. Immediate actions may be organizing expert lectures, industrial visits, and specific assignments etc. Evaluation of the POs may result in long term actions to be taken such as changes in the curriculum, teaching methodologies, evaluation methodologies etc.

A new methodology for CO and PO evaluation is proposed in the work presented which is based on direct assessment and is comprehensive. The proposed methodology is based on following assumptions (i) The course comprises of one of many components such as Continuous Evaluation (CE), Semester End Examination (SEE), Laboratory and Project Work (LPW) and each component may have different weightage. (ii) The program coordinator conducts various surveys from various stake holders to decide the indirect attainment of POs. (iii) A courses and its COs map onto at least one PO. Similarly, at least one course / teaching exercise exists to address a PO. (iv) The course coordinator has specific plan to decide the corrective of actions based on results of CO attainment. The new method takes into consideration the fact that a question / assignment of an assessment tool may be mapped with multiple number of COs. Also the weightage of various components such as CE, SEE, LPW is taken into account while calculating the attainment level.

2. Methodology For Evaluation Of Co Attainment

The activities of teaching learning process are planned and executed in such a manner that all COs are being addressed. The faculty members should take utmost care such that all the COs are addressed during the teaching of the course.

The Course Outcomes of each courses are mapped with various questions of assessment components such as CE, SEE and with LPW. Considering the COs of the sample course (Kinematics) already listed in Table IV, mapping of COs (ME301.1 to ME301.4) with questions of assessment tools is shown in Table V. It is to be noted that in this case, the assignment is mapped with two COs i.e. ME301.1 and ME301.2, hence the value of multiple mapping for the assignment is 2. Similarly, LPW component is mapped with three COs; ME301.2, ME301.3, ME301.4 CO2 and CO3, hence the value of multiple mapping for LPW component will be 3. The remaining questions are mapped with only one CO therefore the value of the multiple mapping for these questions will be 1. Table V is only an illustration for demonstration purpose. The information in Table V is not used further in this paper.

Table 5 : Mapping of Various Questions of Assessment Components With The Cos.

CO	Semester End Exam (SEE)						Continuous Evaluation (CE)					LP W	
							Class Test		Sessio nal Exam		Assign ment		
	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 1	Q 2	Q 1	Q 2			
ME3 01.1	√	√										√	
ME3 01.2			√	√				√				√	√
ME3 01.3					√		√						√
ME3 01.4						√			√	√			√

The determination of attainment level of CO1 for the sample course ME602 Machine Design, a course studied by UG Mechanical Engineering students is demonstrated here. The absolute marks obtained by 15 students in various components which are mapped with CO1 and attainment level of CO1 for the individual student as well as the entire class are shown in Table.VI.

The following points provide the gist of determination of individual CO attainment level for the individual student as well as for the entire class.

- 1) Total weighted marks and percentage weighted (PWM) marks obtained by student are calculated as

Table 6 : Marks Obtained By Students In Various Questions Of CO1

Component		Assignment (CE)	Semester End Examination (SEE)	Class Test (CE)	LPW (CE)	Sessional Exam (CE)	Total weighted Marks(TWM)	Percentage of weighed marks (PWM) obtained	CO Attainment level of Student
Weightage		0.4	0.4	0.4	0.2	0.4			
Question No		-	Q.1 A, B, Q.3 A, C	Q-1, Q-5		Q 1 B, Q 2 B,			
Multiple mapping		2	1	1	4	1			
Maximum Marks		30	22	8	100	16			
Sr. No	Column-> Student	C1	C2	C3	C4	C5	C6	C7	C8
1	Student 1	18	14.0	5	74	5	16.9	57	1
2	Student 2	23	17.0	4	87	6	19.8	67	2
3	Student 3	24	21.0	7	88	10	24.4	83	3
4	Student 4	20	12.0	6	66	6	16.9	57	1
5	Student 5	28	20.0	7	77	10	24.3	82	3
6	Student 6	18	17.0	7	66	9	20.1	68	2
7	Student 7	24	19.0	7	89	13	24.9	85	3
8	Student 8	24	12.5	5	75	4	17.2	58	1
9	Student 9	25	20.0	6	79	10	23.4	79	3
10	Student 10	20	14.0	5	64	6	17.2	59	1
11	Student 11	19	18.0	6	78	6	19.7	67	2
12	Student 12	19	13.0	5	63	5	16.2	55	1
13	Student 13	16	13.0	5	58	7	16.1	55	1
14	Student 14	21	18.0	6	72	7	20.2	69	2
15	Student 15	16	15.0	4	71	6	16.8	57	1
16	CO attainment level of entire class based on Average Percentage Weighted Marks)							67	2
Summary									
CO attainment level		3	2	1	0	>=2 (in %)			
No. of students		4	4	7	0	53.33 %			

$$\text{Total weighted mark (TWM)} = \frac{\sum \text{Marks obtained in each component} \times \text{corresponding weightage}}{\text{value of multiple mapping of the component}}$$

$$\text{Percentage Weighted Marks (PWM)} = \frac{\text{weighted marks obtained by the student} \times 100}{\text{max weighted marks}}$$

For Student 1, the calculation is as follows

$$TWM = \frac{18 \times 0.4}{2} + \frac{14 \times 0.4}{1} + \frac{5 \times 0.4}{1} + \frac{74 \times 0.2}{4} + \frac{5 \times 0.4}{1} = 16.9$$

$$PWM = \frac{16.9 \times 100}{29.4} = 57.48\%$$

2) The CO attainment Level of a particular CO of the student is determined based on the PWM scored by the student and the criteria for the same are mentioned in Table VII.

Table 7 : Criteria For Co Attainment Level of A Student For A Particular Co

Attainment level	3	2	1	0
Criteria	PWM $\geq$ 70%	70% > PWM $\geq$ 60%	60% > PWM $\geq$ 40%	PWM < 40%

Hence, the attainment level of CO1 for "student 1" is 1.

3) Attainment Level of CO for the entire class is calculated based on the Average percentage weightage marks (APWM) for the class. The APWM is calculated as

$$APWM = \frac{\sum PWM \text{ for all the students}}{\text{No of students}},$$

The criteria for CO attainment level of the entire class is shown in Table VIII.

Table 8 : Criteria For Co Attainment Level of The Entire Class For a Particular Co

Attainment level	3	2	1	0
Criteria	APWM $\geq$ 70%	70% > APWM $\geq$ 60%	60% > APWM $\geq$ 40%	APWM < 40%

The CO attainment level of each student as reflected in the last column of Table VI facilitates the teacher to decide and implement corrective measures for each individual student and for the entire class. The CO1 attainment level for Student 1 is 1. CO1 for the course considered for demonstration Machine Design is "Students should be able to evaluate the fatigue life of machine components". The Student 1 can be asked to deal customized assignments such as (i) measuring frequency of fatigue cycles for the component---conducting R R Moore Test for the material of construction--evaluate the fatigue life of components. (ii) Development of fatigue test set up customized for the component and evaluating its fatigue life. (iii) conducting the non-destructive tests to measure the size of initial crack --evaluate final crack size and fatigue life.

The course ME601 consists of four COs. The methodology used for determination of attainment level of CO1 is also used for determination of attainment level of other COs. The summary of attainment level of all the 15 students of the class for all COs of the course is shown in Table IX, which

Table 9 : Summary Of Attainment Level of Cos and Course For Each Students And The Entire Class For The Subject Me601

Column->		C1	C2	C3	C4	C5
CO		CO1	CO2	CO3	CO4	Total
Sr. No	Maximum weighted Marks	29.4	38.2	18.6	13.8	100
Student		Student wise CO attainment level				Student wise course attainment level
1	Student 1	1	2	1	2	1.52
2	Student 2	2	3	3	3	2.71
3	Student 3	3	3	3	3	3.00
4	Student 4	1	2	3	3	2.03
5	Student 5	3	3	3	3	3.00
6	Student 6	2	3	3	3	2.71
7	Student 7	3	3	3	2	2.86
8	Student 8	1	2	3	1	1.75
9	Student 9	3	3	3	3	3.00
10	Student 10	1	3	3	2	2.27
11	Student 11	2	3	3	3	2.71
12	Student 12	1	3	3	2	2.27
13	Student 13	1	3	3	1	2.14
14	Student 14	2	3	3	3	2.71
15	Student 15	1	3	3	3	2.41
16	Course attainment level of the Class					2.47
Percentage of students whose course attainment level $\geq$ 2						86.67
CO		CO1	CO2	CO3	CO4	
CO attainment level of the Class		2	3	3	2	
Percentage of students whose CO attainment level $\geq$ 2		53.33	100	93.33	86.67	

facilitates the calculation of course attainment level for each student as well as for the entire class. Table VI reveals many aspects of teaching learning activities of the course.

The CO attainment level for the entire class as indicated in Sr. NO. 16 of Table VI is 1, the teacher may be required to take some corrective steps for the entire class. The nature of corrective measures can be (i) including more case studies of evaluation fatigue life (ii) organizing an expert lecture of industrial personnel involved in Residual Life Assessment of industrial machinery components. Similar exercise can be performed for the other courses.

The course attainment level for student and that for entire class is calculated as,

$$\begin{aligned} \text{Course Attainment Level for student} &= \frac{\sum(\text{CO attainment level} * \text{Max weightage marks of CO})}{100} \\ &= \frac{\text{Course attainment level for the class}}{\sum \text{course attainment level for all students}} \\ &= \frac{\text{No of students}}{\text{No of students}} \end{aligned}$$

To illustrate, the Course Attainment Level (CAL) for Student 1 is

$$CAL = \frac{1 * 29.4 + 2 * 38.2 + 1 * 18.6 + 2 * 13.8}{100} = 1.52$$

Table IX is the overall reflection of the attainment of the all course outcomes, course attainment for the individual student and for the entire class. As indicated in the Table IX, Student 1 has CO1 and CO3 attainment level 1 and also his/her Course Attainment Level is 1.52 (< 2). This indicated student centric measure to be implemented by the teacher. If the Course Attainment Level for the entire class as reflected by Sr. No 16 of Table IX is less than 2, instructor must make radical changes in teaching methodology, teaching contents, assignments, laboratory practices so that all the students of the class achieve the targeted course attainment level 2.

3. Methodology For Evaluation Of Pos And Psos

Attainment level of POs and PSOs is evaluated using two methods viz. Indirect method and Direct Method. Indirect method is based on the feedback of stake holders such as employers, alumni and also the participation by students in co-curricular and extra-curricular activities. The evaluation of POs and PSOs by indirect method is not discussed in this paper. The weightage for direct method is taken as 80% and that for indirect method is 20%.

The Program Articulation Matrix as shown in Table X is prepared for the program to be accredited. For demonstration, it is assumed that program comprises fifteen courses. Program Articulation Matrix shows the relationship (mapping strength) of course with POS/PSOs. A strong relationship of course with PO/PSO will be designated 3 (Substantial), moderate relationship designated by 2 and marginal relationship indicated by 1 (Slight). The program articulation matrix is prepared from the data of last row of course articulation matrix of each course. The last row of the course articulation matrix of each subject shows mapping strength of the course and the PO/PSO. The last row of the program articulation matrix shows the total weight of each PO/PSO and it is the sum of all mappings for a PO/PSO.

For Example, total weight for PO1 is 20 whereas that for PO2 is 14.

The CO and course attainment level of all the courses are evaluated for the given program and is summarized in Table XI.

Table 10 : Program Articulation Matrix

Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Subject 1	3	2		2	3		3			1		3	3	2
Subject 2	3	3		2		2	2						3	
Subject 3	3	2				3				2			3	
Subject 4	3		1		2		3	1	3	1			3	
Subject 5			2		3	2			3		2		2	
Subject 6	3	2	2		1	1			1					
Subject 7			2			3	2	3		3		2		
Subject 8		2					3		2		3	3		3
Subject 9	3	3		2	3				2				2	
Subject 10	2				2	2			2			2		
Total weight of each PO	20	14	7	6	14	13	13	4	13	7	5	10	16	5

Table X and Table XI facilitate the determination of attainment level of POs and PSOs. The next step is to evaluate the Course wise PO scores for all courses as indicated in Table XII by using the following formula:

$$\begin{aligned} \text{Course wise PO Score} &= \text{Course Attainment Level} \\ &\quad * \text{Mapping of Course with a PO} \end{aligned}$$

Table 11 : Summary Of Co And Course Attainment Level For The Class For All Courses

Course Name	CO 1	CO2	CO3	CO4	CO5	Course attainment level
Subject 1	2	3	3	2		2.47
Subject 2	3	2	2	1	2	1.97
Subject 3	3	3	3	2		2.45
Subject 4	2	2	2	3		2.21
Subject 5	2	2	3	3		2.26
Subject 6	2	3	1			1.80
Subject 7	2	2	2	2		2.18
Subject 8	2	2	2			2.22
Subject 9	3	3	3	3		2.62
Subject 10	2	2	3	2		2.29

For example, the PO Score for the Subject 1 of PO1 is $2.47 \times 3 = 7.41$. Where '2.47' is the course attainment level of Subject 1 as indicated in last column of Table XI corresponding to Subject 1 and '3' is the course mapping strength (strongly mapped) of Subject 1 with PO1 indicated in Table X. Similarly, for each PO/PSO, PO score is calculated for all the subjects.

The Direct Attainment Level of a PO is evaluated as

$$\text{PO Attainment level} = \frac{\text{Total PO score of a PO}}{\text{Total weight of the PO}}$$

Where total PO score of each PO/PSO is the summation of course wise PO score of each PO/PSO. The possible range of the attainment level of any PO/PSO will be between 0 to 3. Assuming that the indirect attainment level of the PO/PSO are provided as mentioned Table 13.

Table 12 : Course Wise Po Score For All Courses Of The Program

Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Subject 1	7.41	4.94	0.00	4.94	7.41	0.00	7.41	0.00	0.00	2.47	0.00	7.41	7.41	4.94
Subject 2	5.91	5.91	0.00	3.94	0.00	3.94	3.94	0.00	0.00	0.00	0.00	0.00	5.91	0.00
Subject 3	7.35	4.90	0.00	0.00	0.00	7.35	0.00	0.00	0.00	4.90	0.00	0.00	7.35	0.00
Subject 4	6.63	0.00	2.21	0.00	4.42	0.00	6.63	2.21	6.63	2.21	0.00	0.00	6.63	0.00
Subject 5	0.00	0.00	4.52	0.00	6.78	4.52	0.00	0.00	6.78	0.00	4.52	0.00	4.52	0.00
Subject 6	5.40	3.60	3.60	0.00	1.80	1.80	0.00	0.00	1.80	0.00	0.00	0.00	0.00	0.00
Subject 7	0.00	0.00	4.36	0.00	0.00	6.54	4.36	6.54	0.00	6.54	0.00	4.36	0.00	0.00
Subject 8	0.00	4.44	0.00	0.00	0.00	0.00	6.66	0.00	4.44	0.00	6.66	6.66	0.00	6.66
Subject 9	7.86	7.86	0.00	5.24	7.86	0.00	0.00	0.00	5.24	0.00	0.00	0.00	5.24	0.00
Subject 10	4.58	0.00	0.00	0.00	4.58	4.58	0.00	0.00	4.58	0.00	0.00	4.58	0.00	0.00
Total PO Scores of each PO	45.14	31.65	14.69	14.12	32.85	28.73	29.00	8.75	29.47	16.12	11.18	23.01	37.06	11.60
Total weights of each PO	20	14	7	6	14	13	13	4	13	7	5	10	16	5
Direct PO attainment level	2.26	2.26	2.10	2.35	2.35	2.21	2.23	2.19	2.27	2.30	2.24	2.30	2.32	2.32

Table 13 : Indirect Attainment Level of Po of The Program

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
Indirect attainment level	2.29	2.07	2.19	2.07	2.15	1.99	2.05	2.16	2.36	2.12	2.07	2.06	2.07

Therefore, the final PO attainment level of the program will be calculated by considering 80 percentage weighted of direct attainment level and 20 percentage weightage of indirect attainment level. Indirect attainment is based on various surveys such as exit surveys, employer surveys, co-curricular activities, industrial visit feedbacks etc. As indirect attainment is based on perception of the individual, its weightage is taken is 20 % in the evaluation of POs. The final PO attainment level of the program is shown in Table XIV.

Table 13 : Final Attainment Level of Pos/psos of The Program

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Direct attainment level (80% weightage)	2.26	2.26	2.10	2.35	2.35	2.21	2.23	2.19	2.27	2.30	2.24	2.30	2.32	2.32
Indirect attainment level (20% weightage)	2.29	2.07	2.19	2.07	2.15	1.99	2.05	2.16	2.36	2.12	2.07	2.26	2.06	2.07
Final Attainment level	2.26	2.22	2.12	2.30	2.31	2.17	2.19	2.18	2.29	2.27	2.20	2.29	2.27	2.27

To maintain the quality of the teaching learning process, the percentage of students in the class who have achieved the target level and above of attainment level of course and CO is also calculated for taking the corrective action if it is below the said target. In this study the target of Course and CO attainment level is taken as 2. Table XV shows the summary of percentage of students whose attainment level is 2 and above (course wise and CO wise).

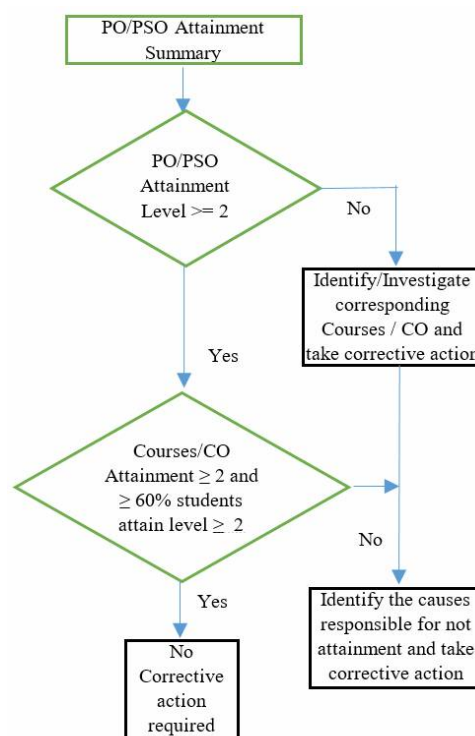
Table 15 : Percentage of Students Whose Attainment Level is 2 And Above Course And Co Attainment.

Course Name	CO1	CO2	CO3	CO4	CO5	Course
Subject 1	53.3	100.0	93.3	86.7		86.67
Subject 2	86.4	81.6	47.2	45.6	68.0	46.40
Subject 3	87.2	81.6	98.4	61.6		76.00
Subject 4	72.8	79.2	80.8	100.0		65.60
Subject 5	71.0	44.4	100.0	100.0		70.20
Subject 6	56.1	75.7	44.6			38.40
Subject 7	88.9	88.9	88.9	88.9		80.95
Subject 8	83.2	73.6	86.4			68.00
Subject 9	100.0	83.1	81.8	100.0		87.80
Subject 10	77.7	68.9	97.3	76.4		71.60

4. Criteria For Deciding Actions Based On Co And Po Evaluation

The CO, course and PO attainment levels form the basis for actions to be taken. These actions are essential to ensure that the students possess required skills/abilities as promised by POs and PSOs. The Figure 1 illustrates the methodology for identifying

the course and the course outcomes which lack the attainment and require some action based on the nature of CO. Figure 1 is drawn considering the target value of PO, PSO, course and CO attainment level as 2 and the target value of percentage of students whose course and CO attainment level is 2 and above is 60%.

**Fig. 1: Flow chart indicating criteria for actions to be taken based on CO & PO Attainment levels.**

Many at times it is observed that all POs are attained vide their mapping with the courses. Hence, PO attainment level should be greater than its target value and this is necessary but not sufficient condition for ensuring effective implementation of OBE. In the event that PO attainment level of all POs/PSOs is greater than the target value, then attainment level of COs/Courses is checked and the corrective actions are to be taken if attainment level of the COs/Courses is below the target value.

5. Conclusions

The paper throws light on a new methodology for evaluation of attainment level of CO, courses and PO / PSO for effective implementation of OBE. The method proposed is unique and comprehensive as

- It takes into account the weightage of various components of the course.
- There exists a provision for multiple mapping of assessment component with COs.
- The CO attainment level for each student and for the entire class can be estimated giving ample scope for multiple possibilities of corrective actions.
- Methodology is also presented for corrective actions based on CO, Course, PO and PSO attainment levels.

At each stage during the evaluation, the methodology facilitates the instructor to adopt student centric / class centric remedial measures or corrective actions based on the attainment levels of CO, Course and the POs / PSOs. It is expected that adoption of this method will simplify the efforts of engineering institutions for accreditation and also help them introspect the teaching learning practices.

References

- [1] Accreditation Board for Engineering and Technology (ABET) (2018), Accreditation policies and procedures <https://www.abet.org/accreditation/accreditation-criteria/accreditation-policy-and-procedure-manual-appm-2019-2020/#1> Accessed on 29 August 2020.
- [2] National Board of Accreditation, NBA (2018) Annexure I of Self-Assessment Report Accessed on 29 August 2020.
- [3] Brandt, R. (1994). On Creating an Environment Where All Students Learn: A Conversation with Al Mamary. *Educational Leadership* 51, 5: 18–23
- [4] Tshai KY, J H Ho, E H Yap H K Ng (2014), Outcome based Education, -The Assessment of Programme Educational Objectives for an Engineering Undergraduate Degree, *Engineering Education*, 9:1, 74-85
- [5] Afida Ayob, Hamimi Faziati, Norhana Arsad, Ahmad Ashrif, Hafizah Husain, (2011), Assessment of student Program Outcomes through a Comprehensive Exit Strategy, *Procedia social and Behavioral Sciences*, 18, 33-38.
- [6] Izham Zainal Abidin, Adzly, Anuar, Norshah Hafeez (2009), Assessing the attainment of course outcomes for an engineering course, *Proceedings of 2nd International Conference of Teaching Learning*, INTI University, Malaysia, 1-7.
- [7] Hamimi Fadaiti, Afida Ayob, Wan Mimi Diyana, Hafizah Hussain, Aini Hussain, Siti Salasiah Mori, (2011), Program Outcomes Measurement and Assessment Processes, *Procedia Social and Behavioral Sciences*, 18, 49-55.

LabMIMO: An Open-source Virtual Laboratory for Process Control

Alpesh Patel¹, Dr. Jignesh Patel²

^{1,2} Electronics and Instrumentation engineering Department, Institute of Technology, Nirma University

¹alpesh.patel@nirmauni.ac.in

²jbpatel@nirmauni.ac.in

Abstract: The “LabMIMO” is an open-source, interactive, and user-friendly virtual learning workbench. This workbench is designed for nonlinear process control edification. This virtual laboratory offers the platform to comprehend and validate the essentials of a control system for the nonlinear coupled MIMO process. This paper presents the development details and impact of virtual labs on an engineering study. The process considered in the tool is unique and innovative Quadruple Conical Tank System (QCTS). The said system is developed and the mathematical model used in the tool is validated with actual physical laboratory setup. The LabMIMO consists the eight different experiments on open-loop and closed-loop system analysis for single-input single-output system and multi-input multi-output configurations of QCTS. It also covers the study on interaction and coupling effects for the nonlinear process. Diverse experimentations were intended to improve the knowledge on design and performance analyses of different classical and model-based control algorithms like MPC (Model Predictive Controller), Fuzzy Logic Controller (FLC), PID Controller. To ease E-learning, LabVIEW based a very accessible Graphical User Interface (GUI) developed. To address the very important requirement of virtual laboratory setup, the tool is made freely

downloadable in a license-free executable file version.

Keywords : Virtual laboratory, MIMO Process Control, Nonlinear control, PID controller

1. Introduction

Looking at the classroom teaching methodology of the past and current age, there is lots of development from teaching methods to experimentation platforms, and it is rapidly changing due to upgrades in technology. The utilization of computer-based platforms in the teaching-learning process has become very popular in recent times. Across the world, lots of advances are going on for interactive virtual laboratories in an engineering discipline (S. Dormido, January 2003). Virtual laboratories also provide a comprehensive platform for learner in higher education, especially in engineering, to understand and enhance domain-specific knowledge using the online resources and keep scholar learning engaging up-to-date (Katsikis, September 2012). LabVIEW and MATLAB are widely used platforms for simulation and experimental research in engineering. The binary distillation column is a very complex and multivariable process. LabVIEW-based virtual laboratory for complex binary distillation columns is designed to understand dynamic aspects of distillation processes. The distillation column process is monitored through a LabVIEW-based SCADA package. The distillation plant and the computer connected through ILUDEST®. (Katsikas,

Alpesh Patel

Electronics and Instrumentation engineering Department,
Institute of Technology, Nirma University
alpesh.patel@nirmauni.ac.in

September 2012). Many researchers have designed a different virtual platform for the engineering discipline like process control, electronics. A laboratory course in electronics at the undergraduate level developed on integrated electronics. This platform provides a remotely-triggered electronic circuit laboratory involving simultaneous simulation and real experiments. SPICE-based NI Multism; WEBEMA and NI LabVIEW tools are used for the implementation of the laboratory (Chinmay K Maiti, 2012). LabVIEW-based online exercise for DC motors is designed and available openly for the users. The system largely focused on speed control, position control and modeling of direct current operated motors using a classical PID controller. It is a straightforward tool for a basic understanding of the control system fundamentals (Hiral Patel, August 2015). The Internet of Things (IoT) platform-based remote access-based laboratory provides realistic hands-on experiments over video flowing and telecontrol. The Internet of Things (IoT) platform-based experiments are now running using interface hardware like Arduino and R-Pi. Many open-source remote access-based laboratories provide more than 200 experiments in the engineering domain. (Hongwei Zhang, July 2017). Another familiar platform for research is MATLAB. It is a scientific tool for technical calculation and engineering applications, and many researchers have designed virtual laboratories for control systems on these platforms, especially in the Modeling of mechanical, electrical, and electromechanical systems. A very rich simulation-based practical is designed using MATLAB. There were many facilities available to find the transfer function of the system, open loop and close loop behavior of the system, root locus, bode plots, Nyquist plots, transient response, and steady-state response. (M.L.Roz, 2010). A JavaScript-based virtual laboratory for the benchmark Quadruple tank system is designed to perform experiments on multivariable system dynamics (S. Dormido, January 2003). The interaction and coupling effect add complexity in Control of Multiple-input Multiple-Output (MIMO). Undergraduate and postgraduate students facing lots of problems in understanding and designing a controller for a nonlinear MIMO system. Nonlinearity and constraints on inputs and output, other parameters like time delay, stability, and tuning problems of the controller, selection of manipulating, controlling variables add more complexity in the MIMO system (Karl Henrik Johansson, 2002). "LabMIMO" provides the platforms to perform the simulation for experiments on Quadruple Conical

Tank System (QCTS). QCTS is a benchmark system to understand the working of the MIMO process. Level control of the conical tank is a challenging task due to its nonlinearity and constant change in the cross-sectional area, which depends on the cone inclination angle, the height of the cone, and the radius of the cone. Various control system-related experiments were designed in LabMIMO. This paper is mainly focused on designing and developing LabMIMO, the virtual laboratory platform for the control system, and its impact on the students. This article is divided into four sections. Section II illustrates the Quadruple conical tank system along with system model equations. LabMIMO tool and various experiments, and its usage are described in section III. The impact analysis of virtual labs for undergraduate students is concluded in section IV.

2. Quadruple Conical Tank System

In industry, the majority of the processes are nonlinear and multivariable by nature. Major challenges in the nonlinear process are varying dynamics and changes in operating points. Interaction between the input and output variable, pairing of controlled and manipulated variables, constrained on input and outputs of the system, and stability and controller tuning are the key issues of the MIMO process. To understand all the major dynamics of the nonlinear MIMO process, the Quadruple Conical Tank System (QCTS) is the most suitable laboratory-scale system. The quadruple conical tank system consists of four interconnected conical-shaped tanks as shown in figure 1. The motive is to control the levels of the bottom two tanks by controlling the input pump voltage. Pump1 passes the liquid to tank 1 and tank 4 and pump2 passes the liquid to tank 2 and tank 3 through a three-way valve. The flow rate of the liquid in the tanks is controlled by the position of the three-way valve which is represented by γ . Thus, by controlling the value of γ , each pump pumps the liquid to two tanks i.e., one of the bottom tanks and its diagonally placed tank.

The interacting valves R1 create interaction between the bottom two tanks and R2 create interaction between the upper two tanks. The degree of interaction can be varied by changing the values of R1 and R2. If the R1 and R2 values are kept 0 then the QCTS is without interaction and when the values of R1 and R2 are 1 then the QCTS is with interaction. This interaction adds non-linearity to the system.

Mathematical Modelling is key to learn the behaviour of any system with time under the impacts of any changes and designing of the controller needs to develop the model. The validation of the model can be proved through a comparison of two different ways, one is experimentally and theoretically.

The first principles-based process model is obtained and validated with an experimental model of a physical system which together defines the system.

3. Labmimo Virtual Laboratory Platform

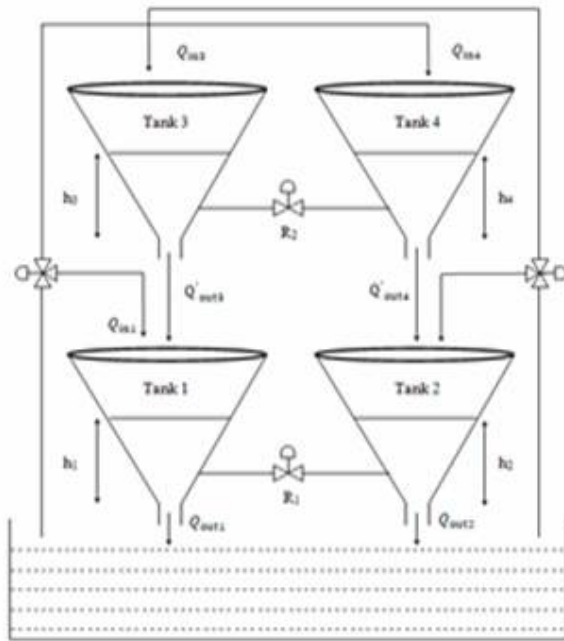


Fig. 1. Schematic of Quadruple Conical Tank system with interaction

A LabVIEW is the software platform provided by National Instrumentation (NI). The purpose of designing and developing a LabMIMO virtual laboratory is to address the need for free and open-

$$\begin{aligned} \frac{dh_1}{dt} &= \frac{1}{\omega h_1^2} [\gamma_1 K_1 V_1 + a_3 r_3 \sqrt{2gh_3} + \text{sign}(h_3 - h_4) R_2 a_{34} r_3 \sqrt{2g|h_3 - h_4|} - a_1 r_1 \sqrt{2gh_1} - \text{sign}(h_1 - h_2) R_1 a_{12} r_1 \sqrt{2g|h_1 - h_2|}] \\ \frac{dh_2}{dt} &= \frac{1}{\omega h_2^2} [\gamma_2 K_2 V_2 + a_4 r_4 \sqrt{2gh_4} + \text{sign}(h_3 - h_4) R_2 a_{34} r_4 \sqrt{2g|h_3 - h_4|} - a_2 r_2 \sqrt{2gh_2} + \text{sign}(h_1 - h_2) R_1 a_{12} r_2 \sqrt{2g|h_1 - h_2|}] \\ \frac{dh_3}{dt} &= \frac{1}{\omega h_3^2} [(1 - \gamma_2) K_2 V_2 - a_3 r_3 \sqrt{2gh_3} - \text{sign}(h_3 - h_4) R_2 a_{34} r_3 \sqrt{2g|h_3 - h_4|}] \\ \frac{dh_4}{dt} &= \frac{1}{\omega h_4^2} [(1 - \gamma_1) K_1 V_1 - a_4 r_4 \sqrt{2gh_4} + \text{sign}(h_3 - h_4) R_2 a_{34} r_4 \sqrt{2g|h_3 - h_4|}] \end{aligned}$$

Equations Parameters:

H (cm) – Total Height of conical tank (75cm)

R – Radius of Top of Tank (19cm)

h – Height of liquid in Tank

r - Radius of water in Tank

h_1, h_2, h_3, h_4 (cm) – Height of liquid in tank 1,2,3,4 respectively

V_1, V_2 (V) – Voltage of pumps 1 & 2

g_1, g_2 – Flow distribution to the lower and upper diagonal tank of valve 1 and 2

A_i (cm²) = $(\pi \frac{R^2}{H^2}) h_i^2 = (\alpha) h_i^2$ The cross-sectional area of ith Conical Tank

V(cm³) – Volume of the conical tank

a (cm²) – Cross-sectional area of Pipe

Q_{in} ($\frac{cm^3}{sec}$) – Input Pump flow

Q_{out} ($\frac{cm^3}{sec}$) – Output flow

g ($981 \frac{cm}{sec}$) – Acceleration due to gravity

K_1, K_2 – Pump Flow Constant ($70.67 \frac{cm^3}{sec}$)

r_1, r_2, r_3, r_4 – Drain valves of tank 1,2,3,4 respectively

γ_1, γ_2 – Diverter Valve Constants

R_1, R_2 – Manual Valve for Interaction

a_{12} – Area of the pipe between Tank 1 and Tank 2

a_{34} – Area of the pipe between Tank 3 and Tank 4

source online/offline research laboratories for students working in the control and automation domain. In designing the LabMIMO platform, mainly the control design and simulation module of LabVIEW is used along with other modules. Industrial standards and the user-friendly graphical user interface are designed. A scholar can download all the required laboratory program files from the google website: <https://sites.google.com/view/labmimo-virtual-laboratory/home>, <https://labmimo.in/>. Eight experiments are designed in the area of the control system. All the experiment's detailed theory and explanation are also available in PDF format. All the experiments operating step along with graphics are available under the help menu of LabMIMO laboratory. Details of Experiments:

1. First principle based modeling of the nonlinear MIMO process.

- The main aim of this experiment is all about enhanced fundamental knowledge of mathematical modeling of Nonlinear Coupled

MIMO systems.

- In this experiment, students have to generate the first principle-based mathematical Model of the Quadruple Conical tank system.
- Students/Users have to verify the effect of interactions and coupling in mathematical modeling for different configurations of QCTS. There are six different configurations like, coupled conical tank interacting-noninteracting, Single input single output first, second and third order system and MIMO system.

2. Perform open-loop response analysis for the Nonlinear MIMO system.

- This experimentation teaches the effect of coupling and interaction using open-loop step response analysis.
- In these experiments, the QCTS process model is used as a reference model, and use/students can generate open-loop step response for different configurations of QCTS system along with different operating conditions of three-way diverting valves, drain valves and interaction valves.
- Detailed comparative analysis performed for various operating conditions and the result is generated in tabular and graph forms.

3. Design a PID controller for a nonlinear SISO Conical Tank system.

- PID is a very Classical Model Free controller. The idea behind this experiment is to test and validate the performance of the PID controller on the nonlinear system.
- Students have to find the ideal or most optimal suitable parameter by a hit and run method to cover the entire range of operating points of the tank system.
- Obtain an open-loop response and conclude what needs to be improved
- Set a proportional control gain optimal value to control the rise time

- Set an integral control gain optimal value to control the compensate steady state
- Set a derivative control to gain optimal value to control the compensate overshoot.

4. Performance analyses of Two loop decentralized PID controller for the MIMO system

- In this experiment, the two-loop decentralized PID controller is planned for a multi-input multi-output system.
- Users can do PID controller Performance analysis based on setpoint tracking and important error.
- Post-analysis facilities are available. All results available on an excel sheet by single click and error analysis can be done using different methods.

5. Design a Dynamic decoupler using Relative Gain Array (RGA) methods for MIMO systems.

- This experimentation teaches about the effect of coupling and how to eliminate the impact of the undesired cross-couplings using simple Steady-State Decoupling.
- Relative gain array methods for identifying the proper pairing of input and output variables for the MIMO system.

6. Comparative analysis of different Tuning rules of PID controller on SISO/MIMO system

- This experiment provides fundamental knowledge about the selection of a proper PID auto tuner for a nonlinear MIMO system.
- Experiment having the facilities for testing the PID auto tuner performance for internal model control, Ziegler-Nichols, Cohen-coon, and Chien Hornes Reswick rules.
- Users/Students can set the tuning specification for servo and regulatory.

7. Fuzzy logic-based Controller

- This experiment is designed to understand the behaviour of the Fuzzy Logic Controller (FLC). The decentralized fuzzy controller scheme is the

learning outcome of this experiment. The designed scheme controls the dual separate loops and the height of Tank 1 and Tank 2.

- The rules-based FLC is designed for all the possible configurations of QCTS.
- There were two approaches implemented. Considering the entire operating range of the conical tank system, a single rule-based fuzzy system is designed. In the second approach, the operating range of the conical tank is divided into different regions and for each region different zone-wise rules are implemented to address the nonlinearity of the conical tank system.
- To design a multi-input fuzzy system interface model, 'error' and 'change in error' are considered as input. and one output 'voltage' for a bottom tank is considered as a manipulated variable. Students can select different membership functions for control and manipulated variables.

8. MPC controller for SISO and MIMO process

- This experiment is designed to enhance the fundamental knowledge of Model-based Control algorithms.
- In this experiment, the students/user selected the different configurations of the MIMO system and obtained the process model.
- Model-based control algorithms for SISO and MIMO can be performed using dual or barrier optimization methods.
- Effect of weight and constraint on input and output variables can be tested and validated using Constrained MPC.

Case Study 1: This example demonstrates how to use the PID Autotuning Design to obtain PID parameters based on setpoint and process variables collected in another loop.

Learning Outcome of Case study 1:

Effect of PID controller parameters on the nonlinear conical tank system.

Instructions to be followed by the students:

1. Run the VI (LabVIEW exe) and wait until the process variable (PV) reaches near the setpoint

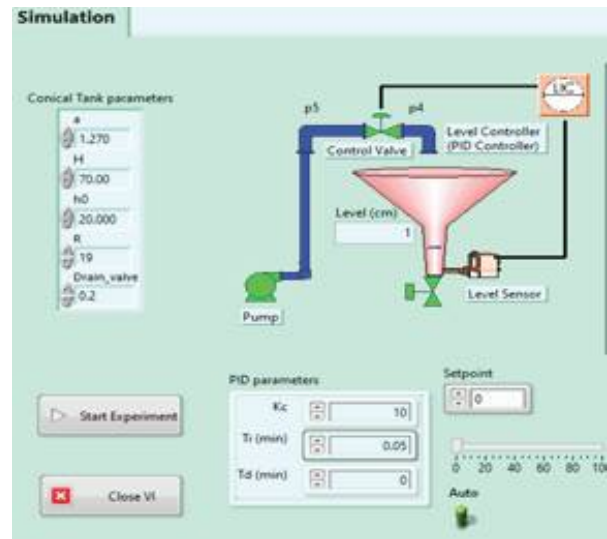


Fig. 2; GUI for PID controller Experiment for SISO Conical Tank

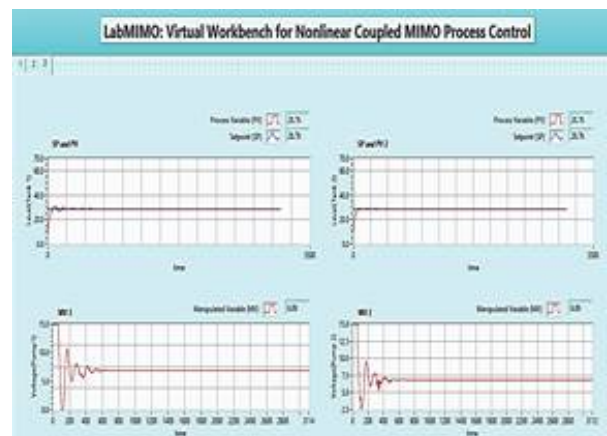


Fig. 3: Results for RGA based Decoupler for MIMO system

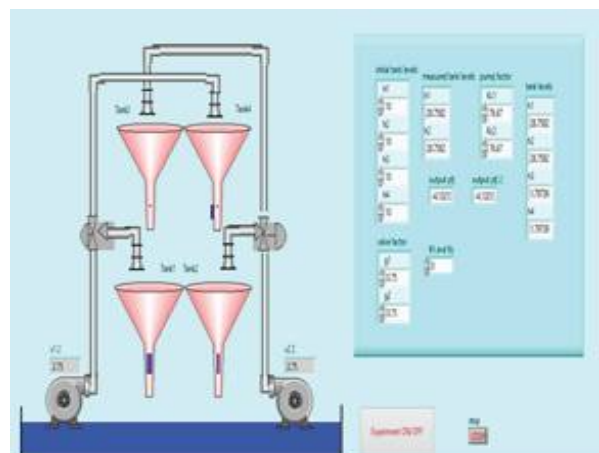


Fig. 4 : GUI for MIMO Two loop PID controller

(SP).

2. In the PID Autotuning Design section, select the type of algorithm, type of controller, and excitation amplitude for the 'open loop step response'. Then, click Autotune to start the process. Select the Identified Plant Parameter tab and see the results from the identification.
3. When the tuned PID gains do not change anymore, the identification is done and you have the option to accept by clicking Accept gain, which will transfer the new gain to PID Gains.
4. Click the Autotune button again to go back to the automatic control state. You can try different options and repeat this process.
5. Click Stop to stop the VI.
6. The results are shown in the figure 2-4.

In the Figure 2, users have the settable parameter for gain of PID controller. As the hit and run methods will provide the understanding of the effect of PID controller gains. In the figure 3 the system response is improved because of the relative gain array methods and it removes the coupling effect of the manipulated variables and provides a fast and desirable set point trajectory. Figure 4 shows the user interface for MIMO software.

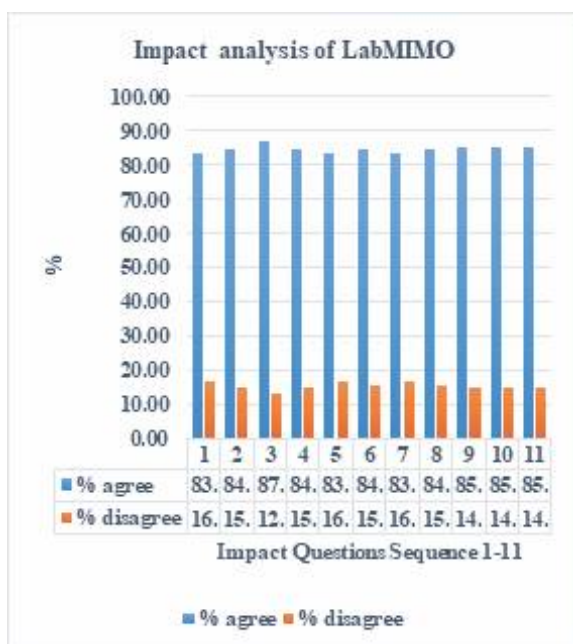


Fig. 5 : Impact analysis of LabMIMO

4. Benefits And Impact Of Virtual Labs

Scholars need theoretic and technical preparation to engage in an expressive hands-on laboratory. Virtual lab's like LabMIMO will serve the purpose and enhance the student's knowledge in the field of Process Control. This virtual laboratory is a part of the curriculum and used by the undergraduate students of Instrumentation and control engineering. The required software and manual are available to all the students on the Google website. Impact analysis for benefits of virtual lab covers the participants consisted of 62 students. Figure 5 shows the impact analysis of LabMIMO tool.

Questionnaire for impact analysis is listed below.

1. Learning and using the " LabMIMO tool" easy or not?
2. Is 'LabMIMO' provide a way to acquire more knowledge in the area of nonlinear control systems in an efficient manner?
3. Can 'LabMIMO' make the learning of topic nonlinear control systems more enjoyable?
4. Any prior knowledge of LabVIEW required to use the "LabMIMO" tool?
5. Do you like the design and layout of the GUI of 'LabMIMO'?
6. Conceptual learning of PID controllers covered?
7. Conceptual learning of MPC controllers covered?
8. Experiments Images and graphics help me to learn and understand problem recklessness.
9. LabMIMO Knowledge helps to solve industrial problems?
10. Do you feel relevant with the practical problem of linear and nonlinear behavior?
11. Conceptual learning of Fuzzy controllers covered?

5. Conclusion

Open-source virtual laboratory-based learning is a requirement for engineering education. It offers scholars the possibility to get industrial experience

and a problem solving approach without hardware. This paper presented a collaborating proposed solution for the nonlinear process control area. A virtual laboratory “LabMIMO” enhances the student's knowledge and provides a better platform to do analysis, design, development, implementation, and evaluation of PID controller, Fuzzy logic controller, and MPC controller in a better way concerning practical nonlinear process applications.

Acknowledgment

We gratefully thankful to Management of Nirma University for Funded Minor Research project.

References

- [1] Chinmay K Maiti, S. M. (2012). Integrated Simulation and Measurement-based Remotely-Triggered Electronic Circuit Laboratory for Undergraduate Education. 3rd (ICEA 2012), Singapore.
- [2] Danica Rosinov, M. (2008). Robust Control of Quadruple Tank Process. ICIC International (pp. 231-238). ICIC Express Letters.
- [3] Esquembre, S. D. (2003). The quadruple-tank process: an interactive tool for control education.
- [4] Hiral Patel, J. P. (August 2015). LabVIEW Based ‘Nonlintool’ for Analysis and Design of Nonlinear Control System. willey online .
- [5] Hongwei Zhang, A. K. (JULY 2017). Remote laboratory: using Internet-of-Things (IoT) for E-learning. The Vth International Conference Advanced Information Systems and Technologies, AIST 2017.
- [6] Karl Henrik Johansson, A. H. (2002). Teaching multivariable control using the quadruple-tank process. Proceedings of the 38th IEEE Conference on Decision and Control (Cat. No.99CH36304),IEEE.
- [7] Katsikis, V. N. (September 2012). MATLAB- A Fundamental Tool for Scientific Computing and Engineering Applications. National and Kapodistrian University of Athens.
- [8] M.L.Roz, F. F. (2010). teaching control with first order time delay model and pi controllers. IFAC procedding volume-42, (pp. 31-36).
- [9] Miklos Istvan Szavuly, A. T. (06 July 2019). From modeling to virtual laboratory development of a continuous binary distillation column for engineering education using MATLAB and LabVIEW. (pp. 1019-1029). WILEY .
- [10] S. Dormido, F. E. (January 2003). The quadruple-tank process: An interactive tool for control education. National Distance Education University.
- [11] Alpesh Patel, J. P. (2019). Comparative studies of control performance for a nonlinear coupled quadruple conical tank system. Sixth Indian Control Conference (ICC). IEEE.
- [12] Alpesh Patel, J. P. (2021). about. Retrieved from experiments-list: <https://labmimo.in/>
- [13] Alpesh Patel, P. J. (2017). Parametric analysis of Quadruple conical tank system. 2017 Nirma University International Conference on Engineering (NUICONE). IEEE.
- [14] P a t e l , A . (2 0 2 1) . <https://sites.google.com/view/labmimo-virtual-laboratory/home>. Retrieved from <https://sites.google.com/view/labmimo>

Experience of Distance Learning Under Emergency Conditions of the COVID-19 pandemic

Veniamin Aleksandrovich Norin¹, Natalia Vladimirovna Norina², Yurii Vladimirovich Pukharensko³

¹norinveniamin@yandex.ru

²bennor@yandex.ru

³tisk@spbgasu.ru

Abstract : Actions to organize learning under the conditions of coronavirus pandemic (COVID-19) are currently being taken worldwide. In most countries, learning institutions are fully or partially closed, while all students are adopting distance learning. Closure of universities and emergency adoption of distance learning are related to obvious issues mainly caused by insufficient equipment and no or poor preparedness of teachers to work in new conditions. The current level of hardware and software development, limited opportunities of the Internet, and the level of distance learning organization fail to ensure high-quality education that would be comparable to traditional offline classroom education. These and other issues challenge the education system in a crisis situation. This study intends to analyze the modern situation and measures taken to arrange distance learning in the conditions of leaving conventional classroom learning for distance learning. This gave an insight on preparedness of students, university teachers to ensure continuous education in the time of crisis. The obtained data revealed primary issues of adopting distance learning

and advantages of online studies, the need to develop and implement a new model of learning process that can be called combined. Traditionally, this model combines full-time attendance using online courses with synchronous distance learning. The article describes the revealed drawbacks of MS Teams in the learning process and solutions on how to eliminate them.

Keywords : online learning - COVID-19 pandemic; higher education; adopting distance learning.

1. Introduction

A rapid adoption of distance learning in all learning facilities has become a global challenge to the modern education system. There is no doubt that the field of higher education is one of those mostly affected by the pandemic. It should be said that distance learning is not an absolutely new form of learning since it has been used in higher education before the pandemic, but as an auxiliary method (Glukhikh & Norina 2015; Pukharensko & Norin 2016). However, during the quarantine, this form revealed multiple issues related to how the learning process is organized (Effects of COVID-19 pandemic on higher education and master courses 2020).

On the one hand, a rapid adoption of online learning made skeptics plunge into new opportunities and find how rich and convenient modern technology

Veniamin Aleksandrovich Norin

norinveniamin@yandex.ru

is, but, on the other hand, it disclosed weaknesses and imperfections in the technology some of which were uncovered in a wide-scale online learning only (Fominykh 2020). First of all, these issues are related to how the Internet functions, unreliable operation of modern equipment supporting distance learning, unreliable operation of software, and how teachers explore advanced platforms that could be potentially used to organize learning in accordance with the Russian Federal State Learning Standards (FSSES). Students also face challenges during studies in electronic informational learning environments. It should be understood that it is not sufficient to digitize some course materials and the distance format is not part-time education. Here, we see an issue of remote management over building competencies in students in accordance with FSSES (Tsener & Oshkina 2020; Seale 2020; Covid-19: Higher Education challenges and responses 2020; Larionova 2020).

We should admit that the respective information technology has emerged, which is a must, but requires technical, methodological, and organizational improvement (Altbakh & Hans de Vit 2020). A balance must be found between conventional classroom studies and online learning, and new technologies must be developed, which allow keeping full-scale communication between participants of the learning process. Further advancement of education, its technical, methodological, and organizational support will show whether such an abrupt adoption of online learning will become a breakthrough, a flight or will cause decay of education and longing for its older forms.

Such an adoption was technologically, but not methodologically complete. The learning processes have been transferred to a different plan almost without change since there has been no time for them: Zoom, Teams and Skype lectures are almost the same both in content and form (Dikova 2020). Nevertheless, it seems apparent that online learning tools must feature more opportunities and consider the cognitive area, features of attention, motivation, and psychological condition of students.

2. Covid19 Pandemic. International Context

Universities in 130 countries have taken part in an unprecedented experiment – closure of campuses and adoption of distance learning (Karpenro O.M. (2020). Thanks to the development of online learning and digital technology, most higher education systems had

an experience and infrastructure in 2020 that helped them keep the learning process organized. These systems experienced similar processes in the countries with various levels of economic development, area, and political conditions (Analytical report. Stress-test lessons: universities during and after pandemic 2020; Education responses to covid-19: embracing digital learning and online collaboration 2020; AI-powered COVID-19 watch 2020; Kapasia et al 2020; Nguyen et al 2020; Manzoor 2020).

In most countries:

- campuses were rapidly closed and mobility of students and teachers was restricted;
- IT infrastructure was adjusted to organize distance learning;
- regulatory framework was developed at the national level to adopt remote work (especially in terms of entrance and graduation examination);
- channels of informational support were arranged for students and teachers;
- specific formats of psychological support were provided;
- measures were taken to support higher education institutions financially;
- all national systems of higher education faced the challenge of income reduction and that was especially prominent in countries with a high share of extra-budget funding (including universities with a high share of foreign students).

While the risk to financial stability (that may lead to closure of a significant number of universities) was a major risk for Western learning systems (Onder 2020; Vedder 2020; Maloney & Kim 2020), the primary challenge for many developing countries is an increased growth of inequality of access to education caused by infrastructure and economic difficulties that students face and with insufficient methodological training of most teachers (Huang et al 2020). Issues of ensuring proper quality of education have also appeared to be pressing for most countries. More than 60% of universities all over the world claim that they could implement online courses in

response to the pandemic, but in reality, no more than one third of all universities managed to master this format (Martin & Furiv 2020). All countries face challenges in organizing distance learning for multiple engineering and medical professions, in the field of culture, art, etc.

There are differences in forms and features of adopting distance learning in various countries. As the expert interview with UNESCO (United Nations Educational, Scientific and Cultural Organization) specialists (COVID-19 Impact on Education 2020) and Organization for Economic Cooperation and Development (OECD) (Key country policy responses 2020; Learning remotely when schools close 2020) shows, the Russia has the following specific features (Analytical report. Stress-test lessons: universities during and after pandemic 2020):

- rapid adoption of distance learning by one of most massive systems of higher education in the world – 450 universities – in two weeks. In other large countries, universities adopted distance learning by decision of local authorities;
- attention to extra-curriculum student activities and organization of volunteering;
- organization of special measures to protect employees older than 65 against possible infection;
- involving leading universities in development of regulatory documents and promotion of methodological solutions for the entire system;
- from the early days, considering issues of job loss by students and stimulation of students' employment in universities.

3. Russian Higher Education Under the New Conditions of Learning, Working and Living

The unique situation related to the COVID-19 pandemic can be undoubtedly deemed a natural experiment. An unexpected invaluable experience that we have as a result of a forced adoption of distance learning shall be studied. Implementing remote technologies in the field of education under the coronavirus conditions was primarily based on existing technologies of video-conferences, computer equipment being owned by students and teachers, which would allow using those technologies, and

having enough skills to use those technologies (Volchik & Shirayayev 2020).

Under the said conditions, organizational mechanisms of learning activity have changed. Remote management is related to efficient coordination. This issue is driven by a multitude of communication means used for management. As a rule, phone communication (calls and SMS), messengers (like WhatsApp), emails (corporate and personal), messages in Microsoft Teams, Zoom, MOODLE, etc. are used for communication. The same communication channels transmit information not related to learning activity management. In this situation, attention of teachers is dispersed and disoriented (Covid-19: Higher Education challenges and responses 2020).

Many studies (Tsener & Oshkina 2020; Blinov et al 2020; Gorlushkina & Fillipov 2020; Skrypnikova 2020) consider increased labor expenses and loss of direct contact with students as the primary disadvantages of digitization. The authors have personally experienced a multiply increased paper flow. Distance learning that had always been shaped as a means to reduce time for organization of a learning process proved to be more time-consuming in practice. A constant need to invent means to solve issues that previously seemed to be simple, such as obtaining signatures for practice reports, issuing examination sheets, and eliminating technical shortcomings takes too much time.

The practice under the pandemic conditions showed that development of digital technologies creates an illusion of saving time in terms of organizational communications. In reality, a relative simplicity and accessibility of electronic forms related to bureaucratic regulation (Volchik & Maslyukova 2018) lead to a rapid increase in reporting, which inevitably takes time that could be used to advance the primary learning and scientific activity.

The issue of expanding bureaucratization in the field of education had specific manifestations during the struggle with coronavirus infection. Due to no opportunity of interaction between teachers and students, with student record books still requiring to be filled in by hand and thesis and practice reports requiring collection and retention, there is a dilemma about how bureaucratic rules can be fulfilled in terms of processing these documents during the lockdown. It is notable that processing hard copies of those

documents is still a must (Volchik & Shirayayev 2020).

While online work was previously undertaken for small groups of part-time students, today full-time students have also adopted distance learning and they are required to perform better during classes. The agenda now includes the question whether it is possible to keep the quality of education should distance learning be adopted in full. The issue of education quality may have various solutions. The education quality may be both improved or reduced as a result of adopting distance learning. On the one hand, distance learning can help many students to take part in classes. Those who can't attend the class for some reasons may take part in a video-conference. On the other hand, distance learning prevents from transferring some part of implicit knowledge (Volchik & Maslyukova 2018; Volchik & Maslyukova 2019). New opportunities for invisible slacking off classes appear.

Those practices that will be successfully reproduced under the conditions of coronavirus struggle or new practice that will be formed under those conditions will most likely remain after the crisis period is over. For example, many students and teachers form habits associated with the use of remote technologies and perhaps they will change their preferences. This manifested itself within a short period of time (September-October 2020) during classroom learning. Nevertheless, students did not come to personal consultations and sent their papers via e-mail, Teams, MOODLE. Quitting distance learning and getting used to regular studies requires some expenses. Therefore, if it is possible to retain some elements of distance learning in some cases, participants of the learning process will do it. A similar effect can be seen for other practices formed in the conditions of coronavirus struggle (Lomovtseva & Zarechneva 2020).

Distance learning certainly have advantages towards which the authors (School graduates and students told about distance learning 2020; Aleshkovskiy et al 2020; Savitskaya 2020) tried to find attitude of students. As the respondent said, a giant advantage is a comfortable atmosphere and flexibility of the learning process expressed in an ability to freely and independently plan classes and studies, individual work during the course, e.g., an ability to maneuver and adapt the curriculum to your own timetable and rhythm of life.

Development of high-quality products of online learning requires significant time expenses and competences that we lack now, but in the future this issue can be successfully solved. Now we need to develop and launch tools of learning analytics that will help defining weaknesses of online courses, learning modules and programs. It is especially valuable to analyze those forms of learning and individual courses that have a high rating among students (Dikova 2020).

Learning analytics should also consider the opinion of teachers. It is important to be able to get consultations, organize experience exchange, share impressions since now we are devoid of such opportunity due to high intensity of work. A deep analysis of the learning process in the current conditions of spontaneity, ambiguousness and instability will give us a clearer vision of how to solve such issues in the future, what competences should be developed and how to promptly and flexible respond to challenges of time (Volchik & Shirayayev 2020).

Currently, there is no information concerning the quality of distance learning. Efficiency of distance learning can be measured in several years. The new form of education has both opportunities and restrictions (Larionova 2020). When assessing efficiency of a new learning technology or an learning model, it seems very tempting to compare the results of education obtained when using this technology with those in the conventional model of full-time learning. However, this comparative analysis gives no substantiated statistically relevant conclusions since it requires (Distance learning in extreme conditions 2020):

- strict experimental design;
- content identical in scope and differing in format;
- similar testing materials and conditions of final assessment;
- a sufficiently large sample randomly formed for each model (technology) of training;
- preventing influence on experimental results from external factors reducing the experiment validity.

Moreover, this analysis defines efficiency as performance of students and does not consider other success factors. Success can be measured based on

interests of various participants in the learning process. For teachers, that is the academic progress of students, and for students, apart from performance, motivation and involvement into the learning process play a huge role and directly affect their achievements. For university administration, values like the percentage of students completing a training course, reducing workload of teachers and their improved labor productivity, and market capture and volume of raised extra-budgetary funds are important. For the founder (the Ministry of Science and Higher Education), accent shifts towards the quality of education, sufficiency of human resources and reliability of IT infrastructure, global competitiveness of the Russian education, and fulfilling values of national and federal projects.

Efficiency evaluation of online learning and use of distance learning technology can be performed through the prism of the target values, but such an evaluation is appropriate in the conditions of systematic adoption of a new model of learning process. Under extreme conditions of rapid re-formatting of learning process and limited internal and external resources, quite different evaluation criteria become relevant. They can be divided into 4 types: evaluation of background (pre-requisites) of changes, evaluation of feasibility and economic efficiency of changes, evaluation of processes of changes and outcomes (products), both direct and secondary.

In this connection, to evaluate a current forced adoption of distance learning, universities will have to answer the following questions:

- what factors (social, institutional, administrative) defined preparedness of universities to distance learning, attitude of participants to changes and affects efficiency of these changes?
- are internal and external resources sufficient for such an adoption? In particular, is the development level of IT infrastructure sufficient for technical support of changes? Do employees and teachers have necessary competencies to perform assigned tasks?
- what stages of the adoption process were most complicated for participants? What organizational mechanisms failed?
- what are results of distance learning adoption for

students, teachers, auxiliary personnel? What is the reason for failure to achieve goals and negative feedback from participants? What issues must be solved to improve results?

This evaluation is more intended to analyze pre-requisites, demands, and processes than outcomes. In this case, efficiency is defined as the ratio between outcomes and resources spent, considering the urgency of assigned tasks. Finally, it is now more important to draw conclusions from this global experiment and organize systematic correction of errors to avoid them in the future.

The issue of comparing online and classical classroom learning has been urgent for the last several decades. Scientists tried many times to find the best format. As a result, hundreds of studies can be found who assert that online learning is more efficient than classical one and the same number of researchers that defend the contrary point.

Today many experts come to the single conclusion that it is incorrect to compare online and classroom learning (Surry & Ensminger 2001; Cherepanova 2020). Both formats have their undeniable advantages and efficiency will be different for each specific case. The result depends on the background, subject, goals of learning, personal characteristics of students, quality of implementation of the study product and an indefinite number of more obvious factors.

The market of online education is quite diverse: there are wide-scale open online courses (like Coursera, EdX, Udacity, Udemy), universal learning platforms, various learning management systems (LMS), mobile applications and computer games for learning, tools for video conferences, virtual lessons with teachers, etc. It is more important to understand how to properly combine formats and tools to achieve the best result. It is not accidental that, after the first wave of pandemic, most leading universities of the world declared that they planned to implement the mixed learning style with classical classroom lessons being supplemented by an online platform (Analytical report. Stress-test lessons: universities during and after pandemic 2020). This decision is caused by the need to prepare to next waves of the virus and by some objective reasons: according to the poll taken in the US, 81% of students believe that using auxiliary digital tools significantly improves their performance at the university (Impressive E-Learning Statistics for 2020, 2020).

The Ministry of Education and Science of Russia and the Institute of Social Analysis and Prediction undertook a large-scale poll of teachers at universities concerning development of online environment under the conditions of coronavirus pandemic (Teachers commented upon forced adoption of online learning (2020). The total of 58,612 respondents took part in the wide-scale research of teachers' attitude to distance learning under the conditions when their professional activity and organization of personal life have been changed greatly. After selection, 33,987 teachers were polled, or about 15% of the overall general population of teachers.

The research showed that teachers do not psychologically accept such an abrupt gap with conventional classroom learning. Such a skeptical attitude is driven by specifics of subjects taught (for example, technical and experimental ones) and conservative ideas about the nature of learning. Formally, teachers are loyal towards the situation and accept adoption of distance learning. But the degree of internal latent disapproval of distance learning is strong for all professional disciplines irrespective of gender, age, or social and professional status of teachers.

The poll found two positive social characteristics of professional community of university teachers: acceptance of state policy of combating the coronavirus and skills needed to operate in the online environment as well as computer competence (Analytical report. Stress-test lessons: universities during and after pandemic 2020):

- 77% of respondents called the situation serious or more likely serious; 91% agree that the measures taken by the university are necessary and sufficient;
- 83% of respondents are almost all the time present in the online environment using mobile and stationary devices; 75% of respondents evaluate their competence in computer science as generally higher than that of their colleagues.

The poll data indicates that teachers are competent in working online and most of them have learned to use the online environment. Along with that, adoption of distance learning, a break of a usual lifestyle and normal daily routine that distributes work and leisure in both time and space have caused stress and resulted in nonacceptance of distance learning (Teachers

commented upon forced adoption of online learning 2020):

- 66% of teachers indicate that they don't like working from home;
- 34% of teachers have no place at home for comfortable work;
- 85.7% of teachers feel that they have less free time and believe that their workload has increased;
- 87.8% of teachers think that it is better to give lessons in classroom.

Acceptance of distance learning are mainly influenced by relations in family and personal preferences of working from home. In this manner, such an abrupt adoption of distance learning causes nonacceptance (or discontent) of teachers that is mainly associated not with the level of qualification but with disruption of the usual lifestyle and the need to re-consider one's workplace and search for individual approaches to learning.

Those teachers who have a liberal opinion towards education (more freedom to teachers and students in selecting learning formats) and representative of military subjects who are more disciplined and accustomed to follow orders are more adapted to challenges of distance learning. It is not improbable that such reaction is related to a rapid and almost instantaneous adoption of unusual forms of work when most teachers had no necessary online skills and had to take a zero cycle in mastering them. It is possible that the situation may change when such skills are received and necessary infrastructure is developed.

The teachers have three primary requests:

- physical items (computer equipment and software);
- communication (environment for communication necessary and sufficient to support distance learning, inclusion into the community and maintenance of a high level of learning);
- organization (reducing bureaucratic pressure and providing more freedom in selecting means and methods of learning).

36.5% of respondents agree and 46.1% disagree that the education tends to individualization and adaptation to each student. 41.5% of respondents agree and 42.8% disagree that the teacher's freedom in selecting means and methods of learning rises. Those who have a positive attitude to adoption of distance learning and hope that education quality will be improved (Teachers commented upon forced adoption of online learning 2020) dominate among those who see the future of higher education as a sphere of free and individualized forms of knowledge transfer.

The following are called as the primary menaces related to the lack of opportunity to liberalize education and adopt distance learning (Analytical report. Stress-test lessons: universities during and after pandemic 2020):

- 1) reduced motivation of students to learning;
- 2) insufficient skills in students to maintain discipline and eagerness in distant learning;
- 3) emotional breakdowns in students and teachers;
- 4) growth of teachers' workload;
- 5) no individual approach in the education system, impersonality;
- 6) no ability to control the level of knowledge;
- 7) restriction of distance learning in some areas (first of all, technical and mathematical ones)
- 8) formalization of learning process, tendency towards templates and unified solutions.

According to the research (Storm of first weeks: how higher education made a step to the reality of pandemic 2020):

- 96.2% of respondents personally adopted distance learning.
- 87.8% of teachers think that it is better to have lessons in classroom.
- 67.8% of teachers do not agree that most lectures and seminars will be online in a year.

- 53.2% of teachers undertook courses in distance learning during the last month.

A profound analysis of this data showed that, in general, teachers managed to mobilize to working under new conditions but the issue of the first weeks was insufficient awareness of working conditions and available resources. Key deficiency was not technological but methodological one, related to the fact that teachers do not have modern methodological means to organize distance learning. The second poll conducted in two months showed that 36% of teachers improved necessary competences during the period to have classes online by undertaking respective refresher courses.

Teachers who worked synchronously noted a difficulty to keep attention and involvement of students as a specific methodological challenge. 65% of teachers believe that lectures in distance format will unlikely allow for control over involvement of students into the learning process. Many customary formats were less efficient than in classroom learning. For example, more than 70% are afraid that the practice of unfair behavior among students during exams will rise, which is more difficult to control in distance learning (Teachers of Russian universities on development of online-environment in pandemic conditions 2020). Teachers of subjects that require laboratory or special equipment found themselves in an awkward situation. In most cases, they had no methodological or technological support at all.

In response to challenges of adopting the new format, the support system grew quite rapidly. Almost all universities provided methodological recommendations to their teachers. But only 60% of universities created special websites or sections at official websites to inform and support teachers. Universities launched programs of methodological support for teachers (using in-house or external resources). Many teachers used respective websites of leading universities. Most active teachers shared their experience and resources through social media and conducted special webinars. It is also important to note infrastructure support of teachers – at the time of adopting distance learning, about 19% of teaching staff had issues with the equipment required for work, while the share of such teachers fell down to 13% by the end of May (Covid-19: Higher Education challenges and responses 2020).

For some teachers, distance learning appeared to be more comfortable – in both planning of personal working time and in terms of learning organization. Moreover, 15% of teachers believe that the education quality has become much better. However, almost 60% doubt the quality of online learning and do not plan to continue its active use after the self-isolation regime ends. In another research, most teachers agree that this acute situation helped them master new tools and practices of online learning (Savitskaya 2020).

According to the Ministry of Science and Higher Education of the Russian Federation, teachers at Russian universities, during a stress test, were divided into four groups (Analytical report. Stress-test lessons: universities during and after pandemic 2020):

1. Teachers of subjects that require a significant scope of practical and laboratory work – for the most part, they had no serious substitution to their teaching methods. They were engaged in methodological and organizational work and helped other teachers – those were averagely 5% of the total number of teachers. This group was totally against using distance learning and new technologies in the future.
2. Teachers who had actively used digital technologies (including online courses and resources) before the pandemic. They managed to quickly expand the use of their usual tools of communication and create digital resources and learning management systems – their share was about 25% (60% at leading universities). In general, this group supports expansion of distance learning and believes that education quality in certain online courses can be comparable with education quality in classroom learning.
3. Teachers familiar with digital technologies (including beyond their professional activity), Internet search, and email communication have quickly mastered new tools, including synchronous learning, but that required substantial effort – those were about 40% (50% at leading universities). This group got tired of increased scope of work and the need to master new technologies quickly. Generally, representatives of this group do not support substantial expansion of distance learning (including the use of leading platforms of open education), but in some cases they see opportunities to use communication technology, learning process management

systems, and additional digital learning courses.

4. Teachers who failed to explore new tools of learning organization, collective work and expanded use of digital resources have, in fact, adopted the part-time learning style sending assignments and recommendations to students – their share is 5% to 30% depending on the university. For those teachers, the experience of adoption was traumatic and very complicated. They do not believe in efficiency of distance learning or their ability to master new learning technologies.

In this manner, most teachers have various negative attitudes to online learning that almost have changed during the period of distance learning. This is associated with the following issues:

- labor intensity, need to increase methodological load and intensity of learning – only 12% of teachers believe that distance learning did not make their work more labor intensive.
- not being ready for efficient use of digital technology – more than 60% of teachers noted that even by the end of the distance learning period they had no sufficient competencies in the use of university learning management systems and third-party digital services, support and assistance of students using messengers, social media, collective work services to work with documents, etc. Even more teachers show methodological deficiencies of designing lessons that deal with involvement of students into activity during online classes, attention management, organization of productive feedback, mastering modern methods of online assessment, and providing intermediate and final assessment.
- distance learning is perceived as total opposition to the conventional method based on the black and white principle. In case of rigid comparison, almost 90% of teachers prefer conventional format in terms of quality of education and 85% believe that that conventional format is more convenient for them.

Along with that, the share of teachers who see new opportunities in digital technologies to improve availability of high-quality education have risen from 30% to 70% during the period of distance learning (Analytical report. Stress-test lessons: universities

during and after pandemic 2020). For example, 41.2% of teachers believe that the freedom of teachers in selecting means and methods of learning will expand in the nearest future (Olkhovaya & Poyarkova 2020).

4. Methods

All publicly available sources of information describe the research results of COVID-19 effects on educational practice at Russian universities undertaken in spring 2020 during the first wave of the pandemic. There are no research results for fall 2020 – spring 2021 in available publications. Therefore, the authors have studied the effects of COVID-19 in the educational process as a case study of a single university, the Saint Petersburg State University of Architecture and Civil Engineering (SPSUACE), by researching students' opinions collected electronically under set conditions. The research covered 289 students in total. The total number of students is 13,383. The first stage (April 2020) involved 126 students while 163 students took part in the second stage (March 2021). Randomly selected second, third and fourth-year Bachelor's degree students and second-year Master's degree students took part in the polling. For the first stage of research, email was used as the way to communicate, while Microsoft Teams was used for the second stage. Total 126 questionnaires were sent to the participants, and 114 questionnaires with answers were received in the first case, while 163 questionnaires were sent to the participants, and 121 questionnaires with answers were received in the second case. The students were asked to answer questions concerning distance learning they were currently engaged with.

To level off the shift upon the year of study, course-weighted data was used in processing of the data received. In terms of ethics, all study participants received the detailed information concerning the research conditions like goal, data confidentiality, voluntary participation, and having a right to quit at any time.

5. Results and Discussion

A. Students under the Conditions of Unexpected Adoption of Distance Learning

Distance learning has suddenly become a reality for millions of Russian students starting with the second half of March 2020. The digital competence of the students was almost out of question. But the issue

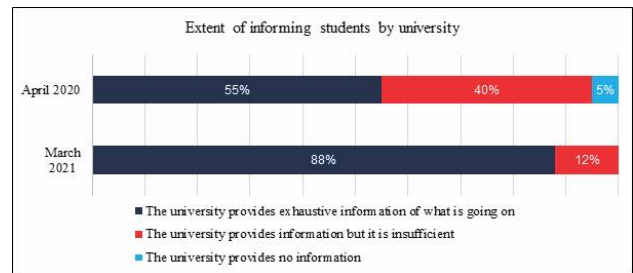


Fig. 1 : Extent of information provided to the students by their university

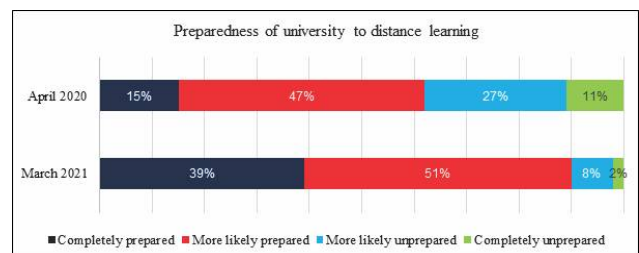


Fig. 2 : Students' opinion of university being prepared for distance learning

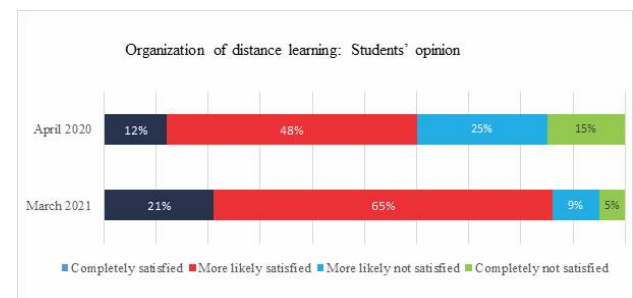


Fig. 3 : Satisfaction by organization of distance learning at the university

of informing students of new rules and communication tools (Storm of first weeks: how higher education made a step to the reality of pandemic 2020) appeared to be pressing. About 5% of universities had no system of electronic communication with students. In such universities, students got 'lost' and had to be contacted by phone, through their coursemates and families. In most other universities, students were not sufficiently informed of the new curriculum and new requirements as well.

The polling results of the SPSUACE students in April 2020 showed that only 55% (SD = 6) of respondents were fully satisfied with the extent of information provided by the university. During April 2020-March 2021, the situation around providing students with necessary data regarding the current

conditions and changes in terms of distance learning was improved and only 12% (SD = 4) of respondents considered the data insufficient (Fig. 1).

More than a third (38%) of respondents claimed that their university and teachers were completely (11%) or more likely not prepared to adopting distance learning (Fig. 2). The share of those who were not satisfied by organization of distance learning in their universities is 40% (Fig. 3). In March, these values fell down to 10% and 14%, respectively.

Most respondents (95%, SD = 5) note that, regarding all or some subjects, teachers sent them lecture materials for individual study and gave specific assignments. Almost 10% (SD = 3) of responders said that teachers started to deliver classes online using video communication equipment. More than a half (53%, SD = 7) report that all or some teachers delivered their classes in the university's LMS environment.

Students find video conferences (webinars) the most convenient method of communicating with their teacher, when they can communicate via monitor screen and, if necessary, ask questions and receive prompt answers. The format of video conferences reflects the full-time learning to the maximum extent with the only difference that teachers are on the other side of the screen. As many as 27% (SD = 6) of the polled students note that teachers of some subjects provided literature for independent studies only.

According to the respondents, despite adoption of distance learning, teachers remain available for communication concerning the subject. Only 5% (SD = 2) of students note that most teachers were not available. By March 2021, the situation has improved by nearly all the parameters; 99% (SD = 1) of all classes for all subjects were delivered using Microsoft Teams and video communication equipment. This became possible thanks to Microsoft Teams training courses provided by a certified Microsoft coach and organized by the university management.

But problems remained – most respondents (65%, SD = 4 – April 2020/75%, SD = 7 - March 2021) believe that their studies have become less efficient after switching to distance learning (Fig. 4). Most students (58%, SD = 9/32%, SD=11) started to postpone fulfillment of their assignments more frequently. Despite all difficulties related to the sudden adoption of online studies, 32% (SD=5)/23%

(SD = 6) of students replied that they like distance learning more than classroom learning.

It is symbolic that less than 10% (SD = 2) of respondents indicate no necessary technical skills and competencies in organizing their study online. This means that the current generation of young people is rather adapted and integrated into the digital learning space. They feel confident in the digital environment and experience no significant discomfort due to the necessity to technically arrange their learning process. In this manner, they significantly differ from their teachers who see a serious and even stressful problem in the necessity to quickly master new technical skills, software and resources as well as the technical component of working in the digital environment.

It should be noted that, despite good knowledge of digital technology, only 14% of students say that they find the situation completely fine. Perhaps, those who are completely content with the online format would be more, if not for a slight problem. One-tenth of all students had no necessary equipment like tablets, laptops and WiFi routers at home. Some respondents (21%, SD = 6/18%, SD = 8) believe that it is easier to send questions to the teacher online. As many as 55% (SD = 8) / 49% (SD = 11) of responders now have more time to sleep, 36% (SD = 12/32% (SD = 9) are less tired from their studies. Students distinguish the following advantages of online learning. Online format simplifies catching up the missed classes and re-passing of previously failed tests related to practical and laboratory activities and lectures. In this case, students feel more convenient to log in to the platform and watch a video of a lecture or class and fulfill assigned tasks independently.

Now 99% of respondents have Internet access at home while 90% (SD = 3) of respondents have their own PC or laptop; 84% (SD = 9) / 87% (SD = 11) note that equipment available to them complies or more likely complies with functionality requirements for learning; 51% (SD = 8)/91% (SD = 9) have access to all software necessary for learning (Fig. 5).

This indicator falls down to 70% in the group of students with an extremely low income (9% of the sample); almost one-third of the students of low-income groups have no sufficient functional equipment. Those who face this problem cannot buy new equipment due to financial limitations. Three quarters of respondents noted that they face various challenges (Fig. 6). Most common issues of students

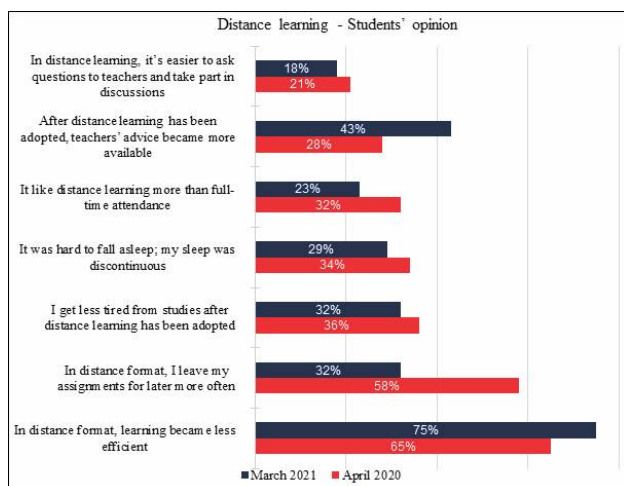


Fig. 4. Feedback on distance learning

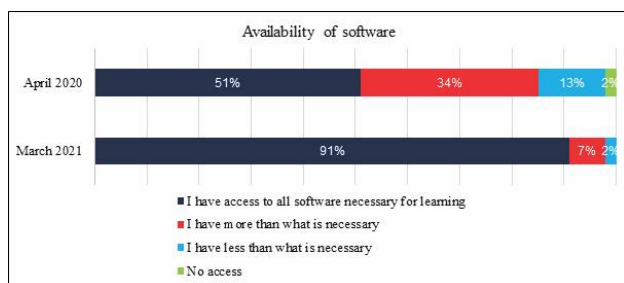


Fig. 5 : Software availability for students

are lack of communication with groupmates (43% (SD = 6) - April 2020 / 35% (SD = 9) - March 2021, lack of in-person discussions with teachers (33%, SD = 9 / 64%, SD = 7), technical issues of various kind, and Internet access failures (34%, SD = 12 / 75%, SD = 8). By March 2021, the number of people dissatisfied with unstable Internet connection associated with increased online loads had grown. In April 2020, the distant learning was organized on MOODLE. In March 2021, all classes were set up in MS Teams that had higher requirements for the speed of Internet connection.

It should be noted that, in March 2021, students reported that there were not enough personal discussions with teachers more often than in the previous year, even though MS Teams has more communication functions than MOODLE. In April 2020, it was only a month since the beginning of distance learning, and students had fresh memories of personal discussions and contact with their teachers. At that time, everybody hoped that the pandemic would end soon and life would turn back to normal. For this reason, lack of communication with teachers was not acute like in the year that followed. In March

2021, students grew tired from distance learning. They had an acute need to communicate with teachers.

A great challenge under the new conditions is how to keep students' attention; half of respondents claim that it was challenging for them to keep attention while watching a video lecture. In online format, students are not ready to perceive a one-and-a-half-hour lecture. It is known that students perceive well the video lectures that last no more than 15-20 minutes (TED – What is it and why do we need it? 2019, Soper 1999). Then their attention declines, they get distracted by other things and the learning process becomes inefficient. A year ago, only 15% of students reported having attention difficulties. At that time, MS Teams only started to be implemented in the learning process. When students started using the software and listened to lectures online, they found it new and interesting. They had no problems with attention keeping.

Under the new conditions of online learning, lecturers have to find a new way to interact with the audience, new methods must be learned such as augmented and virtual reality, discussions must be ongoing.

The unusual format influenced the social and psychological climate of learning. The following problems are rather common: the students found it difficult to concentrate when studying individually (27%, SD = 6 / 41%, SD = 12), it was challenging to study at home (27%, SD = 15 / 37%, SD = 12), feeling lonely and isolated (24%, SD = 9 / 23%, SD = 14), difficult to ask questions to the teacher (39%, SD = 8 / 25%, SD = 11), The last issue is also associated with Internet connection failures. Besides, not every student had modern personal computers and laptops capable of playing audio and video files of high quality. During the classes in MS Teams, these parameters may determine the quality of communication between teachers and students.

Most respondents (52%, SD = 8 - April 2020 / 61%, SD = 12 - March 2021) are sure that it is more challenging to pass an online examination.

Most respondents (59%, SD = 4) find blended learning an optimal option when all possible ways of communication between the teacher and student are used. This data fully confirms a modern trend to gradually adopt blended learning that combines

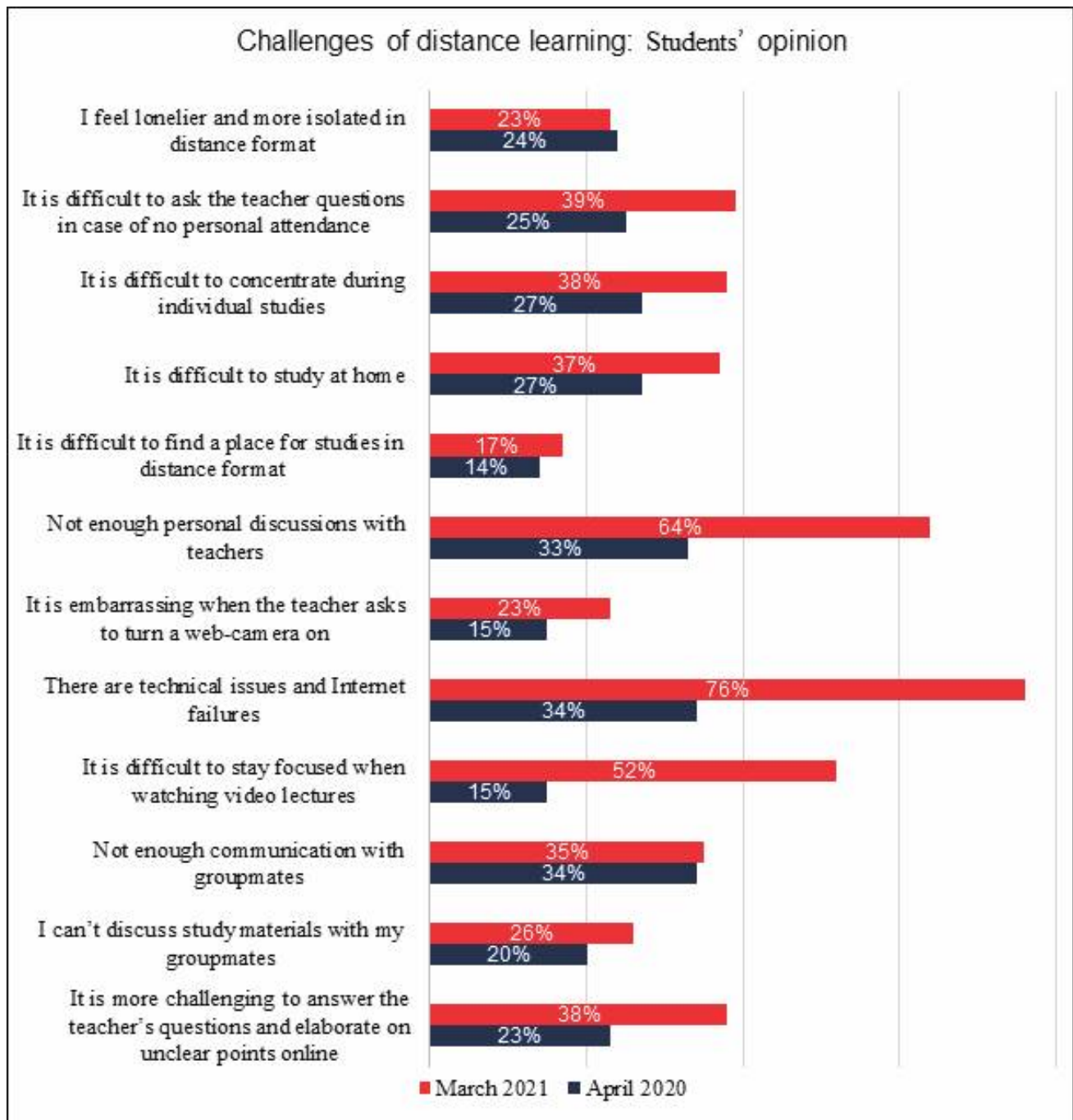


Fig. 6 : Challenges that the students face during distance learning

conventional learning, distance learning and online methods. In particular, T. Jovsi, J. Foster et al. note that blended learning can have a positive effect and it actually influences students' achievements when used to supervise and maintain the distance learning (Jowsey et al 2020; Massoud et al 2011; Picciano 2009; Moskal et al 2013).

In this manner, according to the research, it may be asserted that the sudden and forced adoption of distance learning was rather smooth but had problems and outcomes as expected. Surveys of the like should be frequent to obtain feedback from students and track the dynamics of their attitudes. New organizational measures should be taken backed by research results.

B. Recommendations to Eliminate Disadvantages of Microsoft Teams

The analysis of issues that SPSUACE teachers face when working with Microsoft Teams and that they reported in their personal accounts at the university portal as well as own experience of working with this platform allowed the authors to identify a number of disadvantages that must be eliminated to ensure more efficient work at the platform.

1. The authors believe that working with Teams in the area of higher education requires a different approach to creating teams. Teams must be created according to discipline names, for example, Metrology (Fig. 7). The number of students divided into groups and studying various subjects can be different. Sometimes it can be a single group, while in other cases it can be 30 groups or more. In the first case, the current procedure to organize work in Teams is rather convenient for lectures and practical classes. The situation is much more complicated when the discipline is studied by a high number of students divided into several lecture flows. Each flow includes 4-5 groups of students. Lectures and practical classes are given by different teachers. The current organization of work in Teams allows giving lectures at the General Channel and at additional channels. However, it is inconvenient to give practical class at additional channels since it is impossible to use such a powerful tool as Assignments. To distribute assignments to students, deliver completed assignments to teachers for checking, correction of mistakes and comments, considering students' works, their evaluation, etc., teams for individual groups of students must be additionally created. This is inconvenient for either teachers or students. Therefore, the authors believe that it would be reasonable for developers to provide access to the Assignments tool at additional channels to organize a convenient learning process at Teams.
2. It should be also noted that the integrated Word 365 is fiercely blamed by both teachers and students. This usually includes compatibility issues with other Word versions.
3. The following issues are identified when working with the Assignments tool:
 - When delivering the completed work for the first time, students forget to press Deliver after uploading the file. In this case, the student's work receives Viewed status rather than Delivered as it should be when the work is delivered. Therefore, the teacher does not notice this work.
 - A similar situation occurs when the work is re-delivered after check by the teacher. In this case, the work remains in the Returned section where checked works are located which are passed or require correction. Such works are not tracked or checked by the teacher. The authors believe that the program developers should prevent an opportunity to leave this page without pressing the Deliver button.
4. When checking PDF files, it is impossible to make comments and highlight mistakes in the text when working in the Teams environment.
5. When making a video record of the meeting, Teams does not support White board record which is very convenient when taking lectures using a

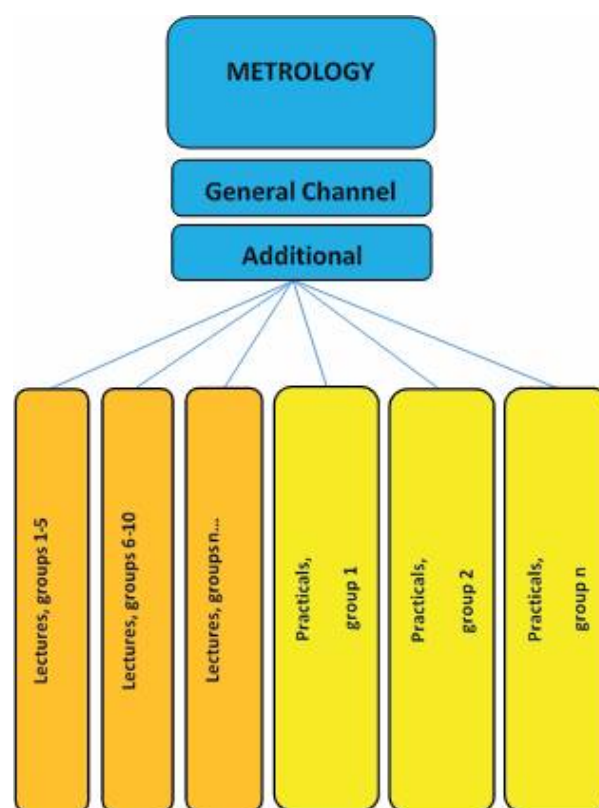


Fig. 7 : Organization of the learning process at the Microsoft Teams platform

drawing tablet. This creates an environment very close to giving lectures in a classroom using a usual board. Viewing this video record will give little help to the student in studying the discipline.

6. The proctoring system must be improved. To minimize unfair behavior of students when taking exams in Teams, it would be reasonable to provide student's video camera control, which is not combined with the monitor. The video camera must provide panoramic image of the student's position at the desk during examination and an ability to zoom in the image. In this case, the teacher would be able to control all student's actions during the exam, see what is on the desk and prevent the use of cribs by the student.

6. Conclusion

The analysis of adopting distance learning allows making several paramount conclusions:

- according to respondents, the conventional form of learning is currently the most efficient, up-to-date and high-quality since it includes the most important part of the learning process – personal communication with the teacher, quick feedback, discussion of pressing issues, finding gaps in own knowledge by communicating with the teacher in class;
- the existing state of the art and development of necessary software, restricted Internet capabilities, current levels of organizing distance learning prevent from high-quality education comparable with the quality of education provided by classical full-time learning;
- primary complications in adoption of distance learning include no personal communication with the teacher and no instantaneous feedback since the teacher spends much more time than in personal communication to give an answer to the student's question. Feedback in distance learning can depend not only on dialog participants but also on equipment, Internet connection, server failure or blackout, etc.;
- students require flexible learning pathways and diverse forms of learning. This means that our universities must meet this demand by removing barriers for flexible and customized learning pathways;

- we need a development program for digital tools and digital content necessary for organization and delivering online practical classes, virtual laboratories, using simulators, virtual and augmented reality.
- applying MS Teams in distance learning allowed us to reveal the drawbacks in the organization of educational activities on this platform. We offered some solutions to compensate for these drawbacks and make the platform more comfortable for the learning process organization.
- a serious issue is deficiency of practices for online evaluation of students' performance. Examination sessions and thesis defense in Russian universities were only possible in person and there is no experience of massive use of the monitoring system. It is required to expand the use of high-quality and objective tools of online evaluation.

In case of more detailed consideration of distance learning, there is a lot of additional opportunities for students and teachers. On the other hand, distance learning is significant today and will be in the future (some scope of various subjects can be given as a distance lecture). The necessity to develop and implement a new model of learning process that can be called combined has become obvious. In this model, conventional interaction of students and teachers, practical, scientific and social activity in usual forms are combined with online-courses and trainers, synchronous distance learning and digital didactics.

In our digital century, we must use all technological ideas and skills to keep up with the times. It is not required to fully replace a classroom teacher and personal communication but reasonably combine various functions of technical progress and full-time attendance. This will result in modernization and improving of the entire learning process, and objectives of the education system will be achieved.

References

- [1] AI-powered COVID-19 watch (2020). Retrieved April 04, 2021 from <https://www.oecd.ai/p/covid-19>
- [2] Aleshkovskiy I.A., Gasparishvili A.T., Krukhmaleva O.V. et al. (2020). Students of Russian universities of distance learning:

- evaluation and opportunities // Higher education in Russia. No. 10. pp. 76-91.
- [3] Altbakh F. K.J., Hans de Vit (2020). Informational technologies in COVID-19 conditions: a turning point? // International higher education, No 103. pp. 6-8. M.: National Research University - Higher School of Economics.
- [4] Analytical report. Stress-test lessons: universities during and after pandemic (2020). Retrieved May 06, 2021 from https://www.hse.ru/data/2020/07/06/1595281277/003_%D0%94%D0%BE%D0%BA%D0%BB%D0%B0%D0%B4.pdf.
- [5] Blinov V.I., Sergeyev I. S., Esenina E. Yu. (2020). Unexpected distance learning: The first month of emergency work (according to express research and express poll): 2 parts // Professional education and labor market No. 2. — pp. 6-33.— 001 10.24411/2307-4264-2020-10201.
- [6] Cherepanova Yu. (2020). Between the first and the second: online education at the wave of pandemic. Retrieved April 14, 2021 from <https://education.forbes.ru/authors/online-education-vs-covid>
- [7] COVID-19 Impact on Education (2020). Retrieved May 21, 2021 from <https://en.unesco.org/COVID19/educationresponse>
- [8] Covid-19: Higher Education challenges and responses (2020). Retrieved April 05, 2021 from <https://www.iau-aiu.net/Covid-19-Higher-Education-challenges-and-responses>
- [9] Dikova V.V. (2020). The future is now, or Teachers in online mode // Professional education and labor market. No. 2. - pp. 53-54. - DOI 10.24411/2307-4264-2020-10211
- [10] Distance learning in extreme conditions. (2020). Retrieved April 09, 2021 from <https://academia.interfax.ru/ru/analytics/research/4491/>
- [11] Education responses to covid-19: embracing digital learning and online collaboration (2020). Retrieved April 05, 2021 from https://read.oecd-ilibrary.org/view/?ref=120_120544-8ksud7oaj2&title=Education_responses_to_COVID-19_Embracing_digital_learning_and_online_collaboration
- [12] Effects of COVID-19 pandemic on higher education and master courses (2020). Retrieved April 14, 2021 from <https://www.ntf.ru/sites/default/files/Vliyanie%20pandemii%20COVID-19%20na%20sektor%20vysshego%20obrazovaniya%20i%20magistraturu.pdf>.
- [13] Fominykh E. A. (2020). Jump to online: flight or fall? // Professional education and labor market. No 2. - pp.49–50. - DOI 10.24411/2307-4264-2020-10209.
- [14] Glukhikh V.N., Norina N.V. (2015) Experience of technical disciplines remote training at the St. Petersburg State University of Architecture and Civil Engineering. Education and Information Technologies DOI: 10.1007/s10639-015-9390-8
- [15] Gorlushkina N. N., Fillipov R. K. (2020). Speculations about organization of online learning // Professional education and labor market. No. 2. - pp 68-69. — 001 10.24411/2307-4264-2020-10218.
- [16] Huang, R.H., Liu, D.J., Guo, J., Yang, J.F., Zhao, J.H., Wei, X.F., Knyazeva, S., Li, M., Zhuang, R.X., Looi, C.K., & Chang, T.W. (2020). Guidance on Flexible Learning during Campus Closures: Ensuring course quality of higher education in COVID-19 outbreak. Beijing: Smart Learning Institute of Beijing Normal University.
- [17] Impressive E-Learning Statistics for 2020 (2020). Retrieved April 04, 2021 from <https://techjury.net/blog/elearning-statistics/#gref>
- [18] Irzawati, I. (2017). Utilizing a web-based learning medium in ELT: how students perceived WebQuest in promoting English skills. Journal Didascen Bahasa, Vol. 3, No. 1, 1-9. Retrieved April 16, 2021 from

<https://eprints.ukmc.ac.id/838/5/ARTIKEL%20JURNAL.pdf>

- [19] Jowsey T., Foster G., Cooper-Ioelu P., Jacobs S. (2020). Blended learning via distance in pre-registration nursing education: A scoping review // *Nurse Education in Practice* Vol. 44. March. DOI: Retrieved April 30, 2021 from <https://doi.org/10.1016/j.nepr.2020.102775>
- [20] Kapasia N, Pintu P., Roy A., Saha J., Zaveri A., Mallick R, Barman B, Das P., Chouhan P. (2020). Impact of lockdown on learning status of undergraduate and postgraduate students during COVID-19 pandemic in West Bengal, India // *Children and Youth Services Review*. Vol. 116. September. DOI: Retrieved April 30, 2021 from <https://www.sciencedirect.com/science/article/pii/S0190740920310604?via%3Dihub>
- [21] Karpenro O.M. (2020). Educational workers and artificial intelligence in the conditions of digital transformation of education. *Human capital*. 2020. №S12-1. P. 69-75
- [22] Key country policy responses (2020). Retrieved May 06, 2021 from http://www.oecd.org/coronavirus/en/?utm_source=Adestra&utm_medium=email&utm_content=Image%3A%20Country%20Policy%20Tracker&utm_campaign=What%27s%20New%20-%2006%20April%202020&utm_term=demo#country-tracker
- [23] Larionova V. (2020). Distance learning under extreme conditions (2020). Retrieved April 04, 2021 from <https://academia.interfax.ru/ru/analytics/research/4491/>
- [24] Learning remotely when schools close: How well are students and schools prepared? Insights from PISA (2020). Retrieved April 04, 2021 from <https://www.oecd.org/coronavirus/policy-responses/learning-remotely-when-schools-close-how-well-are-students-and-schools-prepared-insights-from-pisa-3bfd1f7/>
- [25] Lomovtseva N. V., Zarechneva K. M. (2020). Technologies to adopt online learning // *Professional education and labor market*. No. 2. - pp. 83-84. - DOI 10.24411/2307-4264-2020-10223.
- [26] Maloney, E.J. & Kim, J. (2020). 4 Worries About Higher Education in the 2020s. *Inside Higher Ed - Learning Innovation*. A space for conversation and debate about learning and technology. [online] Retrieved April 23, 2021 from <https://www.insidehighered.com/digital-learning/blogs/learning-innovation/4-worries-about-higher-education-2020s>.
- [27] Manzoor, A. (2020). Online Teaching and Challenges of COVID-19 for Inclusion of Persons with Disabilities in Higher Education. Retrieved April 29, 2021 from <https://dailytimes.com.pk/595888/online-teaching-and-challenges-of-covid-19-for-inclusion-of-pwds-in-higher-education/>
- [28] Martin M. & Furiv U. (2020). COVID-19 tests the resilience of higher education. Retrieved April 04, 2021 from <https://www.universityworldnews.com/post.php?story=20201211130427131>
- [29] Massoud A., Iqbal U., Stockley D., Noureldin A. (2011). Using Blended Learning to Foster Education in a Contemporary Classroom. *Transformative Dialogues: Teaching & Learning Journal*. Volume 5 Issue 2 November 2011
- [30] Moskal P., Dziuban Ch., Hartman J. (2013). Blended learning: A dangerous idea? *Internet and Higher Education*, Vol. 18, 15-23. Retrieved April 19, 2021 from https://www.westernsydney.edu.au/_data/assets/pdf_file/0020/530336/Reading7_BlendedLearning-ADangerousIdea.pdf
- [31] Nguyen D.V, Pham G.H., Nguyen D.N. Impact of the Covid-19 pandemic on perceptions and behaviors of university students in Vietnam (2020). *Data in Brief*. 2020. Vol. 31. August. DOI: Retrieved April 04, 2021 from https://www.researchgate.net/publication/342308074_Impact_of_the_Covid-19_pandemic_on_perceptions_and_behaviors_of_university_students_in_Vietnam
- [32] Olkhovaya T.A., Poyarkova E.V. (2020). New practices of engineering education in distance learning conditions // *Higher education in Russia* Vol. 29. No. 8/9 pp. 142-154.

- [33] Onder G., Rezza G., Brusaferro S. (2020). Case-fatality rate and characteristics of patients dying in relation to COVID-19 in Italy //Jama. [https://ioe.hse.ru/data/2020/05/26/1551527214/%D0%A1%D0%90%D0%9E%206\(36\)_%D1%8D%D0%BB%D0%B5%D0%BA%D1%82%D1%80%D0%BE%D0%BD%D0%BD%D1%8B%D0%B9.pdf](https://ioe.hse.ru/data/2020/05/26/1551527214/%D0%A1%D0%90%D0%9E%206(36)_%D1%8D%D0%BB%D0%B5%D0%BA%D1%82%D1%80%D0%BE%D0%BD%D0%BD%D1%8B%D0%B9.pdf)
- [34] Picciano A. G. (2009). Blending with purpose: The multimodal model. // Journal of asynchronous learning networks, Vol. 13, No. 1, 7-18. Retrieved April 04, 2021 from <https://files.eric.ed.gov/fulltext/EJ837540.pdf>
- [35] Pukharensko Yuri, Norin Veniamin (2016) Issues of teaching metrology in higher education institutions of civil engineering in Russia. Education and Information Technologies: 1–14. DOI: 10.1007/s10639-016-9486-9
- [36] Savitskaya N. (2020). After pandemic, the higher education will not be the same. Retrieved April 04, 2021 from https://www.ng.ru/education/2020-03-25/8_7826_education1.html
- [37] School graduates and students told about distance learning (2020). Retrieved April 16, 2021 from <https://wciom.ru/index.php?id=236&uid=10304>
- [38] Seale C. (2020). Distance Learning During The Coronavirus Pandemic: Equity And Access Questions For School Leaders. Retrieved April 19, 2021 from <https://www.forbes.com/sites/colinseale/2020/03/17/distance-learning-during-the-coronavirus-pandemic-equity-and-access-questions-for-school-leaders/?sh=676acc411d4d>
- [39] Skrypnikova N. N. (2020). Future of education: total distance learning or total refusal thereof? // Professional education and labor market. No. 2. - pp 58-59. - 001 10.24411/2307-4264-2020-10213.
- [40] Soper Paul L. (1999). Foundations of art of speech. [Book of the science to convince: Bibliopolical publication edition] / Paul L. Soper. - M.: Fenix, 1999 - 448 p. - ISBN 5-222-00179-2
- [41] Storm of first weeks: how higher education made a step to the reality of pandemic (2020). Retrieved April 04, 2021 from [https://ioe.hse.ru/data/2020/05/26/1551527214/%D0%A1%D0%90%D0%9E%206\(36\)_%D1%8D%D0%BB%D0%B5%D0%BA%D1%82%D1%80%D0%BE%D0%BD%D0%BD%D1%8B%D0%B9.pdf](https://ioe.hse.ru/data/2020/05/26/1551527214/%D0%A1%D0%90%D0%9E%206(36)_%D1%8D%D0%BB%D0%B5%D0%BA%D1%82%D1%80%D0%BE%D0%BD%D0%BD%D1%8B%D0%B9.pdf)
- [42] Surry Daniel W. and Ensminger David (2001). “What's Wrong with Media Comparison Studies?” Educational Technology, vol. 41, no. 4, 2001, pp. 32–35. JSTOR, Retrieved May 06, 2021 from <https://www.jstor.org/stable/44428679>
- [43] Teachers commented upon forced adoption of online learning (2020). Retrieved May 09, 2021 from https://minobrnauki.gov.ru/press-center/news/?ELEMENT_ID=21584
- [44] Teachers of Russian universities on development of online-environment in pandemic conditions (2020). Retrieved April 17, 2021 from https://www.ranepa.ru/documents/2020_14-116_May.pdf
- [45] TED – What is it and why do we need it? (2019). Retrieved April 30, 2021 from https://bizneszarabotok.ru/rost_lichnosti/ted/
- [46] Tsener T.S., Oshkina A.V. Specifics of online learning in higher schools under forced conditions. Retrieved April 19, 2021 from <https://elibrary.ru/item.asp?id=42969004>.
- [47] Vedder, R. (2020). Higher Education and the COVID-19 Pandemic. [on-line] Retrieved from Retrieved April 30, 2021 from <https://www.mackinac.org/higher-education-and-the-covid-19-pandemic>.
- [48] Volchik V. V., Maslyukova E. V. (2019). Reforms, implicit knowledge and institutional traps in the sphere of education and science // Terra Economicus, 2019, Vol. 17, No. 2, pp. 146-162
- [49] Volchik V.V., Maslyukova E. V. (2018). Trap of metric, or why implicit knowledge is underestimated in regulation of education and science // Journal of Institutional Studies Vol. 10, № 3. pp. 158 - 179. DOI: 10(3).10.17835/2076-6297.2018.10.3.158-179

- [50] Volchik V.V., Shiryayev I. M. (2020). Distance higher education under self-isolation conditions and issue of institutional traps // Urgent issues of economics and law. Vol. 14, No 2. pp. 235-248. DOI: <http://dx.doi.org/10.21202/1993-047X.14.2020.2.235-248>

Opening Students' Creativity and Innovation through CAD Learning in Collaboration with Small and Medium-Sized Enterprises

Bayu Rahmat Setiadi¹, Sugiyono², Thomas Sukardi³

^{1,2,3} Department of Mechanical Engineering Education, Universitas Negeri Yogyakarta
Yogyakarta, Indonesia

¹bayursetiadi@uny.ac.id

²sugiyono@uny.ac.id

³thomas_sukardi@uny.ac.id

Abstract : Currently, student product design work is based on product design examples that the lecturer has determined. This can provide the scope of creativity and innovation of student product designs to be limited to old textbook-based designs and not real problems in the world of work. The research method uses an experiment with a One-Group Double Posttest-Only Design. Respondents are students who take CAD courses. The research scenario was the first week without treatment and the second until the fifth week of treatment with the CAD learning method in Small and Medium-sized Enterprises (SMEs). There are three SMEs as the research location. The research was divided into eight student groups. The data analysis technique uses descriptive statistics to represent the qualities of creativity and innovation. Combined and partial difference tests were carried out by analyzing variance from the experiment's class. Learning CAD in SMEs requires preparation in planning, implementation, and evaluation. Conservatively, there is an increase in student

creativity and innovation from time to time when they are in SMEs. Students give a good impression of improving their CAD skills with growing confidence and solving industrial product design problems. In addition, the inferential results show differences in student creativity and innovation from time-to-time experiments.

Keywords: creativity, innovation, Small and Medium-sized Enterprises, CAD learning, design product.

1. Introduction

The need for skilled CAD workers in Indonesia is very high because it is supported by experience and education level (Salaryexplorer, 2021). The difference in salary received and understanding in applying various kinds of CAD software. CAD designers in Indonesia can fill the groups of companies in Indonesia which are divided into four namely micro (1-4 workers), small (5-9 workers), medium (20-99 workers), and large enterprise (+100 workers) (Tambunan, 2019). The presence of CAD workers tends to be at medium and large enterprises. Especially for the medium level, the National Team for the Acceleration of Poverty Reduction states that owners and workers in SMEs tend not to have formal education and higher levels of education as found in large industries (Burger et al., 2015). The observations

Bayu Rahmat Setiadi

Department of Mechanical Engineering Education,
Universitas Negeri Yogyakarta, Yogyakarta, Indonesia
bayursetiadi@uny.ac.id

of several local SMEs confirm this in Yogyakarta that the number of CAD workers ranges from 1-3 workers. This is not in line with the dynamic workload of workers with many demands for fast and complex orders.

SMEs can open up innovation by collaborating with universities and other industries for new product development (Prabowo, Singgih, Karningsih, & Widodo, 2020). The aim is to ensure the down streaming of university research results into product and technology commercialization (Galushko & Sagynbekov, 2014). Fundamental innovation problems such as product design must be resolved immediately through quadruple helix innovative actors, among which university-SMEs actors (Morisson & Pattinson, 2020). Students can utilize the limitations of SMEs product design ideas through CAD learning. Collaboration of CAD, students, and CAD workers is always important in engineering because it involves multi-software (Eves, Salmon, Olsen, & Fagergren, 2018). Product design software is increasingly competitive in offering advanced modeling, assembly, animation, structural analysis, presentation, and simulation designs. However, even the slightest assistance in the scope of learning is needed for local SMEs to improve product design quality. At this point, the role of students in building their creativity and innovation through CAD learning in SMEs.

CAD learning is one of the computer-aided mechanical drawing courses used by mechanical engineering vocational students in designing products in both 2-dimensional and 3-dimensional modeling (B. R. Setiadi, Puspito, Sudiyatno, Kurniawan, & Kartowagiran, 2020). CAD is a communication medium between designers (students) and design readers (SMEs). Students can use various software such as Autodesk Inventor, AutoCAD, CATIA, Solid work, Ansys, and other vendors. Combining multi-CAD software means that students can think in hybrid creativity, which combines artistic and technological creativity (Dare-Abel, Uwakonye, & Opoko, 2016). Although students have heterogeneous CAD skills, lecturers need to direct students v. CAD learning is the foundation for mechanical engineering vocational students to equip product design, prototyping, and manufacturing processes. Therefore, students who acquire CAD skills are trained to enrich creativity and innovation in design quality (Veisz, Namouz, Joshi, & Summers, 2012).

Creativity and innovation are two soft skills related to product development in CAD learning (Poh Kiat Ng, Kian Siong Jee, & Nurul Izah Anuar, 2012). Innovation and creativity become employability skills for graduates to compete with others (Suarta, Suwintana, Fajar Pranadi Sudana, & Dessy Hariyanti, 2018). Creativity is an individual's ability to create an imaginative picture in ideas and logical perspectives (Winn & Banks, 2012). Creativity in CAD is needed, especially in selecting tools, enhanced visualization, communication, premature fixation, circumscribed thinking, and bounded ideation (Robertson, Walther, & Radcliffe, 2007). Creativity in CAD learning has several inherent indicators: generating ideas, critical originality, thinking enjoyment, aesthetics, and risk-taking (Vandeleur, 2001).

Creativity is a crucial element in design innovation and product development (Williams, Ostwald, & Askland, 2010). Innovation is a step to commercialize creativity, so a good fit for users (Kumar, 2009). Regarding CAD learning, innovation will grow if students have a design project that stimulates their competence (Goncher, Chan, & Schunn, 2017). CAD learning that has been observed tends to be monotonous and challenging to provide innovation space for students. An indication of the success of CAD learning innovation is to demonstrate creating new products, creating processes, product development, process improvements, and adding a creative touch by duplicating and integrating production factors and new methods (Wankel & Stoner, 2008).

This research focuses on developing learning methods for CAD courses in collaboration with local SMEs. The encouragement of collaboration will trigger students' creativity and innovation in engineering industrial products. As a comparison, the research was directed in a CAD class experimentation at Universitas Negeri Yogyakarta, Indonesia.

This research aims to develop the creativity and innovation of CAD students in solving product design problems in SMEs. Students will indirectly optimize their CAD skills in providing SMEs with several design ideas and product designs. In Yogyakarta, SMEs have limited innovation due to CAD human resources with high school education level, out-of-date software, and minimal skills. For this reason, the presence of students in SMEs will provide product design innovation and access to skills from universities.

2. Research Method

A. Research Setting

The research setting uses a quantitative process approach. Proof of the CAD learning method collaborates with SMEs using experimental research with a one-group pretest-posttest design. The choice of multiple posttests aims to cover the weaknesses of the first pretest and post-test internal validity (Salkind, 2010). The double posttest was used to observe changes in students' creativity and innovation during their stay in SMEs. The experimental design is listed in table 1 below.

Table 1 : Research Experimental Design

Weeks				
1	2	3	4	5
Traditional CAD Learning (Pretest)	Treatment with CAD Learning Method in SMEs	Posttest I	Treatment with CAD Learning Method in SMEs	Posttest II

Table 1 explains that the first-week students were given a worksheet-based CAD learning. Before students are assigned to SMEs, traditional CAD learning is still given to assess creativity and innovation through a pretest as initial data. Students develop creativity and product design innovation in SMEs from the second to the fifth week. Every two weeks, continually evaluate with a posttest regarding the quality of student creativity and innovation.

The experiment used one CAD practicum class in the Department of Mechanical Engineering Education, Universitas Negeri Yogyakarta. This study uses 5th-semester students who take 3D CAD courses for the 2021/2022 academic year. Respondents are students who take 3D CAD courses with a total student of 20 people. A lecturer was involved in this research as a collaborator with SMEs. The target of competency material is 3d modeling, simulation, and detail drawing. The research was conducted in the product design laboratory at universities and SMEs. The collecting data was five weeks with a week on campus and four weeks in SMEs.

B. Collecting Data

The data collection technique used the questionnaire. The questionnaire instrument consists of two instruments, including self-assessment on creativity and innovation. For indicators of creativity,

refer to Azuma (Vandeleur, 2001), which consists of generating ideas, critical originality, thinking enjoyment, aesthetics, and risk-tasking. At the same time, innovation refers to the innovation theory summarized by Stoner et al., which suggests that innovation consists of creating new products, creating processes, product development, process improvements, and adding a creative touch by duplicating and integrating production factors and new methods (Wankel & Stoner, 2008).

The instrument used the Likert scale through a score of 1 to 5 with the gradation of answers adjusting the self-assessment rubric. Respondents can self-assessment their creativity and innovation abilities according to the conditions and facts. The development of the instrument went through a coherent phase, starting with determining the indicators of creativity and innovation, determining the instrument grid, expert judgment, testing the questionnaire in a limited class, analyzing the validity and reliability, and revising the instrument.

To ensure the research formulation is ready to be researched, it is necessary to experimental prerequisite testing. The test of prerequisite is the normality test with Kolmogorov-Smirnov and homogeneity test. Data analysis techniques are used to solve research problems using one-way analysis of variance. In addition, measuring the difference between each treatment was carried out to ensure significant differences in each test performed. The quality of each test and descriptive statistics are also needed, both in tables and in percentages.

3. Results and Discussion

Study programs in collaborative research routinely carry out cooperation with SMEs. Final project courses and industrial internships are the mainstays of the collaboration. This research broadens the scope of partnership implementation of CAD learning on campus and SMEs.

A. Development of CAD Learning Methods in SMEs

CAD learning methods in SMEs require planning, implementation, and evaluation support. Planning based on CAD competencies includes the curriculum structure, revitalizing material content adapted to SMEs' development, and applied lesson plan with CAD evaluation tools. Planning is the basis for successfully implementing experiments in CAD

practicum classes. In the implementation, the needs are prepared, especially the willingness of students and SMEs, the Implementation of Arrangements (Cooperation Contract), and the schedule in SMEs. Students will fully implement their CAD skills to get various SMEs' product designs downstream and commercialize collaboration with partners. Capable computer equipment is an obstacle but can be optimized with supporting facilities for CAD learning in SMEs. In this section, students are also required to increase their creativity and innovation to contribute to the development of local SMEs. The evaluation stage requires an evaluation tool to measure student creativity and innovation in SMEs, measured at third and fifth weeks.

The implementation of CAD learning in SMEs is a sustainable collaboration between technical and vocational universities and SMEs. This micro elaboration is a dual system concept that benefits both as implemented and successfully in Germany (Herr & Nettekoven, 2017). The advantage obtained by the university is the development of competencies and experiences that impact student creativity and innovation (Hoffman & Schwartz, 2015), and SMEs benefit by solving industrial problems in the scope of product design, line mass production, and product innovation (Prabowo et al., 2020). This encourages the activeness of both parties to carry out design evolution. An overview of the CAD learning method that combines both parties is summarized in Figure 1.

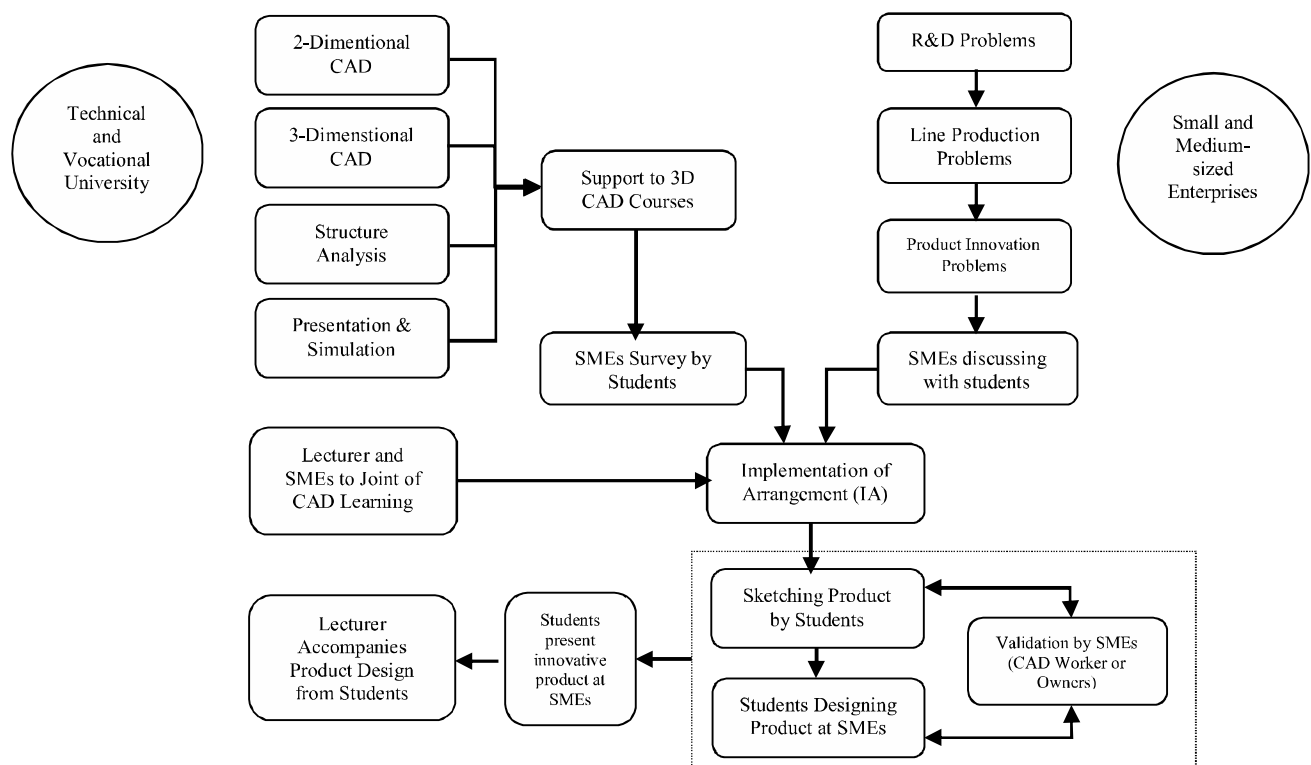


Fig. 1 : CAD learning methods in SMEs

The CAD learning method in SMEs (see Figure 1) shows a mature readiness of students with the provision of mastered software. The software includes AutoCAD for sketching, Autodesk Inventor for making parts, assembly, and presentations, and Ansys for computing structural analysis. The combination of multi-CAD software is a capital that needs to be considered to support the success of CAD learning in SMEs, affecting student hybrid creativity-innovation (Dare-Abel et al., 2016).

The CAD learning method has several advantages and disadvantages. The benefits of using SMEs collaborative CAD learning methods are (1) the quantity and quality of collaboration with SMEs are getting stronger, (2) industrial product design problems are solved by collaborative CAD learning, (3) student product design creativity and innovation are growing fast, (4) experience students' reality of the complexity of SMEs product design problems, and (5) synchronization of CAD learning materials on

campus with empirical conditions in SMEs. However, on the other hand, there are several drawbacks to this method, including (1) the need for an integrated curriculum structure to support CAD courses, (2) determining SMEs that are appropriate to the field of mechanical engineering, and (3) for ordinary SMEs, the lack of openness about design issues. Industrial products.

Students will directly select a variety of problems in SMEs ranging from simple to complex and comprehensive difficulties. Students can convey the results of their product design innovations to SMEs. The application of the CAD learning method involves 3 SMEs were students in grouping each SME located in Yogyakarta, Indonesia. The product design jobs were carried out by 20 students divided into eight groups with the distribution described in Table 2 below.

Group	SMEs	Product Design	Sum of Students
1	ED Aluminium	Car Velg	3
2		Tap and Back Pad Wheelchair	3
3		The frame of the Electric Bike	3
4	WL	Mold and Dies	2
5	Aluminium	Electric Panel Box	2
6		Wheel Drum	2
7	PT. Hari Mukti Teknik	Laundry Rotary Shaft	2
8		The frame of CNC Cutting Laser	3

Table 2 : Student Employment in Smes

The presence of students in SMEs provides significant changes to existing product designs. For example, by utilizing multi-CAD software, students can recommend evaluating SMEs modeling products in models, materials, and product weights (see figure 2). SMEs need this simple thing significantly to increase productivity, reduce production costs, streamline production, and increase company turnover .

B. The quality of student creativity and innovation

The quality of student creativity and innovation in CAD learning in SMEs refers to research indicators. Students are fully respondents in filling out the self-assessment questionnaire. They independently measure the extent to which the creativity received can be felt in every face-to-face in SMEs. Based on student self-assessment (Figure 3), both creativity and innovation instruments from the first week, third week, and fifth week showed a significant increase.

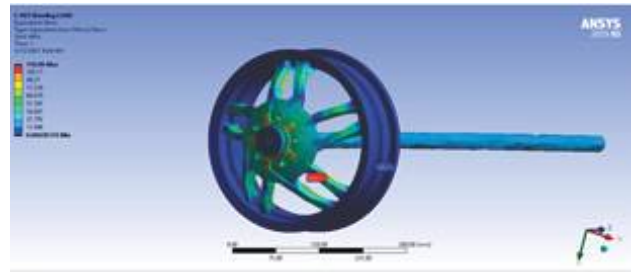


Fig. 2 : Creativity and innovation of student product design at SMEs. a) structure analysis of car velg;

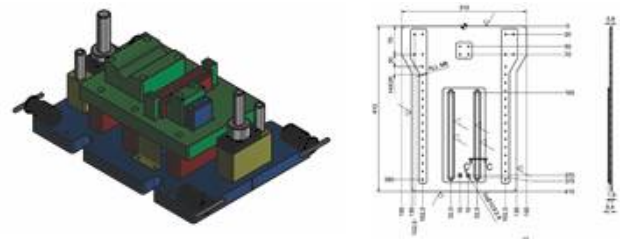


Fig. 2 : b) 3d-modeling of mold and dies, and c) mechanical drawing of tap and back pad wheelchair.

Based on the assessment of each quality (see Figure 3), visually, the graph shows a significant contribution after implementing CAD learning in SMEs. The highest aspect that dominates the histogram is how students express ideas to SMEs. In addition, students are also encouraged to provide critical and original concepts based on their experience, lectures, and other learning resources. The quality average of student creativity in the pretest position was 53.62%, after the third weeks' implementation of CAD learning method in SMEs was 71, 31%, and after the fifth week of treatment increased to 81.54%. This shows an increase in students' creativity from week to week after applying CAD skills in SMEs.

Based on the assessment of each quality (see Figure 3), visually, the graph shows a significant contribution after implementing CAD learning in SMEs. The highest aspect that dominates the histogram is how students express ideas to SMEs. In addition, students are also encouraged to provide critical and original concepts based on their experience, lectures, and other learning resources. The quality average of student creativity in the pretest position was 53.62%, after the third weeks' implementation of CAD learning method in SMEs was 71, 31%, and after the fifth week of treatment increased to 81.54%. This shows an increase in students' creativity from week to week after applying CAD skills in SMEs.

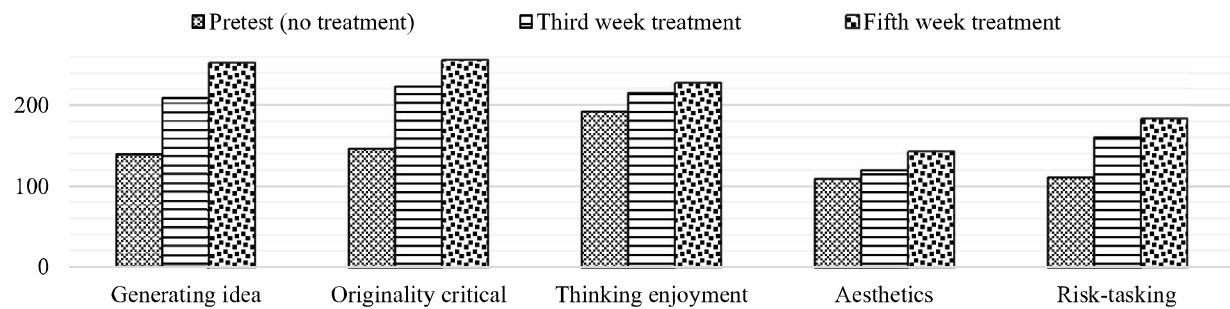


Fig. 3 : The quality of student creativity in CAD learning

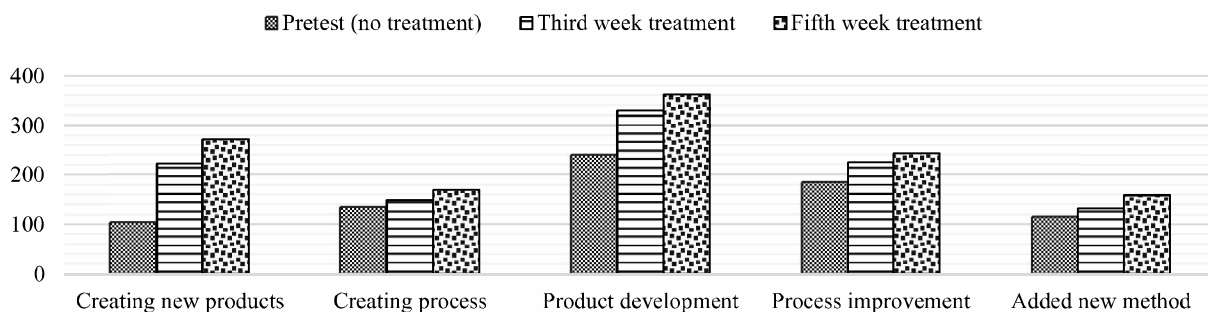


Fig. 4 : The quality of student innovation in CAD learning

The quality of innovation seen in Figure 4 increases after being given the CAD learning method in SMEs. The graph of a sharp increase can be seen in how students can create a new product and develop a product in SMEs. Students' skills in using several CAD software make it easier for them to innovate product designs to create new designs or reverse engineering existing designs (Kostic, Radakovic, Cvetkovic, Trajkovic, & Jevremovic, 2012). The results of the overall relative quality show that the first week with a percentage score of 55.71%. After the third week, the application of CAD learning methods in SMEs increased to 75.71%. In the fifth week, the quality of student innovation became 86.21%. This improvement in the quality of innovation is supported by students' motivation and interest in learning to make several innovative breakthroughs beneficial for SMEs.

C. Experimental prerequisite testing

The data analysis can be continued in-depth, so it

Table3:Data Normality Test With Kolmogorov-smirnov

Variables	Treatment Time	Statistic	df	Sig.
Creativity	The first week (pretest)	0.106	20	0.200*
	After the third week (posttest)	0.189	20	0.059
	After the fifth week (posttest)	0.133	20	0.200*
Innovation	The first week (pretest)	0.150	20	0.200*
	After the third week (posttest)	0.137	20	0.200*
	After the fifth week (posttest)	0.130	20	0.200*

Table 4: Homogeneity Test

Based on Mean	Levene Statistic	df1	df2	Sig.
Creativity Score	1.056	2	57	0.354
Innovation Score	0.338	2	57	0.715

needs testing of experimental prerequisites. Prerequisite tests include normality test with Kolmogorov-Smirnov and homogeneity test. The normality test was carried out on three variables: no treatment, after treatment at the third week, and after treatment at the fifth week. The normality and homogeneity tests are distributed in Table 3 and 4.

Based on the analysis of the normality test (Table 3) and the homogeneity test (Table 4), which refers to the significance value, the data is normal and homogeneous. The value is concluded based on a significant value above 0.05. Because the prerequisite test is fulfilled, the inferential analysis can be breakdown comprehensively.

D. Testing the differences of experimental times

The test was carried out in three experiments—the first experiment without special treatment or using learning methods with practicum job sheet. The second experiment was carried out using the CAD learning method, where students were in SMEs until the third week and continued with a posttest assessment. The third experiment was that students

continued their learning activities in SMEs until the fifth week, and in the last session, a posttest assessment was carried out.

From the results of the prerequisite test, it has been concluded that the data between variables is

homogeneous and normal. This becomes a trigger to determine whether the three experiments have significant differences. The analysis uses one-way ANOVA through multiple comparisons from Bonferroni between experimental times, both creativity and innovation variables

Table 5 : Testing The Difference in Experimental Time Together

Variables	Analysis of Groups	Sum of Squares	df	Mean Square	F	Sig.
Creativity Score	Between Groups	3372.633	2	1686.317	119.985	0.000
	Within Groups	801.100	57	14.054		
	Total	4173.733	59			
Innovation Score	Between Groups	4705.633	2	2352.817	204.890	0.000
	Within Groups	654.550	57	11.483		
	Total	5360.183	59			

Table 5 shows that testing CAD learning methods in SMEs together significantly affects student creativity and innovation. The significance value of 0.000 indicates that the experimentally observed show

differences, and there is no visible similarity in the data. To ensure the difference between each experiment of the two variables, a post hoc test of comparison multiple was carried out with the results as presented in Table 6 and Table 7.

Table 6 : Bonferroni's Multiple Comparisons on Aspects of Student Creativity

(I) Creativity of CAD Learning	(J) The creativity of CAD Learning	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
No Treatment	After the 3 rd week	-11.500*	1.186	0.000	-14.42	-8.58
	After the 5 th week	-18.150*	1.186	0.000	-21.07	-15.23
After the 3 rd week	No treatment	11.500*	1.186	0.000	8.58	14.42
	After the 5 th week	-6.650*	1.186	0.000	-9.57	-3.73
After the 5 th week	No treatment	18.150*	1.186	0.000	15.23	21.07
	After the 3 rd week	6.650*	1.186	0.000	3.73	9.57

Table 7 : Bonferroni's Multiple Comparisons on Aspects of Student Innovation

(I) Innovation of CAD Learning	(J) Innovation of CAD Learning	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
No Treatment	After the 3 rd week	-14.000*	1.072	0.000	-16.64	-11.36
	After the 5 th week	-21.350*	1.072	0.000	-23.99	-18.71
After the 3 rd week	No treatment	14.000*	1.072	0.000	11.36	16.64
	After the 5 th week	-7.350*	1.072	0.000	-9.99	-4.71
After the 5 th week	No treatment	21.350*	1.072	0.000	18.71	23.99
	After the 3 rd week	7.350*	1.072	0.000	4.71	9.99

The comparison table shown in table 6 for creativity and table 7 for innovation shows the difference between experiment times. Both creativity and innovation that have used the CAD learning method in SMEs showed a significant difference with a reference value of 0.000. Every time the treatment is given results in a different score, a substantial change in score occurs.

Collaborative CAD learning with SMEs positively impacts lecturers, students, and partners. The results of confirmatory interviews with CAD lecturers revealed that in implementing product design collaboration with SMEs, lecturers could provide intervention on product design ideas. Lecturers have an in-depth understanding of fundamental issues in SMEs product design. Students gain experience

providing product design recommendations to SMEs and increasing creativity and product design innovation. The presence of lecturers and students at SMEs can solve product design problems. SMEs with limited resources can be empowered by maximizing the role of students in collaborative CAD learning. The three parties involved benefit from each and must be disseminated in other CAD learning. In essence, SMEs need the presence of universities in the development of product design innovations to compete with global industries.

The CAD learning method in SMEs provides an increase in both student creativity and innovation. This happens because students are motivated from time to time to do better. After all, they position themselves as workers or teamwork of CAD in a

company that emphasizes quality and quantity (Poh Kiat Ng et al., 2012). An engineering student requires creativity and innovation during the CAD courses (Bayu R. Setiadi, Suparmin, & Samidjo, 2018). External encouragement can also be one of the triggers to provide students with increased product design skills. Every design work carried out by students is constantly monitored by industry and course lecturers.

4. Conclusion

CAD learning methods in SMEs provide creativity and innovation of students to increase from time to time. This change occurred because students considered product design courses like a student's future workplace, so they needed to be serious about product design. This can be seen there is a significant difference between the experimental time from the start without treatment to the treatment given until the fifth week. A collaboration between the Technical and Vocational University and SMEs will significantly influence educational institutions to get to know job occupations, and SMEs are assisted by product design engineering.

References

- [1] Asperl, A. (2005). How to teach CAD. *Computer-Aided Design and Applications*, 2 (1 – 4) , 4 5 9 – 4 6 8 . <https://doi.org/10.1080/16864360.2005.10738395>
- [2] Burger, N., Chazali, C., Gaduh, A., Rothenber, A. D., Tjandraningsih, I., & Weiland, S. (2015). Reforming policies for small and medium-sized enterprises in Indonesia. RAND Corporation in collaboration with Tim Nasional Percepatan Penanggulangan Kemiskinan (TNP2K). Retrieved from [http://www.tnp2k.go.id/images/uploads/downloads/Reforming SMEs_0529_lowres_2015-1.pdf](http://www.tnp2k.go.id/images/uploads/downloads/Reforming_SMEs_0529_lowres_2015-1.pdf)
- [3] Dare-Abel, O., Uwakonye, O., & Opoko, A. (2016). The Effect of CAD on Architecture Students' Creativity and Enthusiasm. *INTED2016 Proceedings*, 1(March), 8 5 3 0 – 8 5 3 6 . <https://doi.org/10.21125/inted.2016.0984>
- [4] Eves, K., Salmon, J., Olsen, J., & Fagergren, F. (2018). A comparative analysis of computer-aided design team performance with collaboration software. *Computer-Aided Design and Applications*, 15(4), 476–487. <https://doi.org/10.1080/16864360.2017.1419649>
- [5] Galushko, V., & Sagynbekov, K. (2014). Commercialization of University Research in Canada: What Can We Do Better? *International Journal of Business Administration*, 5(5). <https://doi.org/10.5430/ijba.v5n5p1>
- [6] Goncher, A., Chan, J., & Schunn, C. D. (2017). Measuring design innovation for project-based design assessment: Considerations of robustness and efficiency. *Revista Bitácora Urbano Territorial*, 27(4), 11–18. <https://doi.org/10.15446/bitacora.v27n4Esp.68959>
- [7] Herr, H., & Nettekoven, Z. M. (2017). The Role of Small and Medium-Sized Enterprises in Development. *Nigerian Chapter of Arabian Journal of Business and Management Review*. Berlin: Friedrich-Ebert-Stiftung. <https://doi.org/10.12816/0040342>
- [8] Hoffman, N., & Schwartz, R. (2015). *Gold Standard: The Swiss Vocational Education and Training System International*. Washington, DC: National Center on Education and the Economy.
- [9] Kostic, Z., Radakovic, D., Cvetkovic, D., Trajkovic, S., & Jevremovic, A. (2012). Comparative Study of CAD Software, Web3D Technologies, and Existing Solutions to Support Distance-Learning Students of Engineering Profile. *International Journal of Computer Science Issues*, 9(4), 181–187.
- [10] Kumar, V. (2009). A process for practicing design innovation. *Journal of Business Strategy*, 30 (2 – 3) , 9 1 – 1 0 0 . <https://doi.org/10.1108/02756660910942517>
- [11] Morisson, A., & Pattinson, M. (2020). Industry collaboration: a policy brief from the policy learning platform on. Lille.
- [12] Poh Kiat Ng, Kian Siong Jee, & Nurul Izah Anuar. (2012). Enhancing Creativity Through

- Teamwork, Continuous Improvement And CAD: A Review. 3rd International Conference on Engineering and ICT, (April), 68–73.
- [13] Prabowo, R., Singgih, M. L., Karningsih, P. D., & Widodo, E. (2020). New product development from inactive problem perspective in Indonesian SMEs to open innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, 6(1). <https://doi.org/10.3390/JOITMC6010020>
- [14] Robertson, B. F., Walther, J., & Radcliffe, D. F. (2007). Creativity and CAD tools: Lessons for engineering design education from the industry. *Journal of Mechanical Design, Transactions of the ASME*, 129(7), 753–760. <https://doi.org/10.1115/1.2722329>
- [15] Salaryexplorer. (2021). CAD Drafter Average Salary in Indonesia 2021. Retrieved from www.salaryexplorer.com/salary-survey.php?loc=101&loctype=1&job=90&jobtype=3
- [16] Salkind, N. J. (2010). *Encyclopedia of research design. Dictionary of Statistics & Methodology*. Singapore: SAGE Publications Asia-Pacific P t e . L t d . <https://doi.org/10.4135/9781412983907.n439>
- [17] Setiadi, B. R., Puspito, J., Sudiyatno, Kurniawan, D., & Kartowagiran, B. (2020). Isn't it effective if the transformation of product design tests into 3-dimension modelling? *Journal of Physics: Conference Series*, 1700(1). <https://doi.org/10.1088/1742-6596/1700/1/012004>
- [18] Setiadi, Bayu R., Suparmin, & Samidjo. (2018). Preparing engineering students for entrepreneurial creative industries. *Global Journal of Engineering Education*, 20(2), 127–131.
- [19] Suarta, I. M., Suwintana, I. K., Fajar Pranadi Sudana, I. G. P., & Dessy Hariyanti, N. K. (2018). Employability skills for entry-level workers: A content analysis of job advertisements in Indonesia. *Journal of Technical Education and Training*, 10(2), 49–61. <https://doi.org/10.30880/jtet.2018.10.02.005>
- [20] Tambunan, T. (2019). Recent evidence of the development of micro, small and medium enterprises in Indonesia. *Journal of Global Entrepreneurship Research*, 9(1). <https://doi.org/10.1186/s40497-018-0140-4>
- [21] van Rijn, R. A. C., van Esch, P. M. R., Price, R. A., Oonk, M. M. E. M., & Netten, M. P. (2018). U and I: Insights from a University-Industry Design Collaboration. 21st DMI: Academic Design Management Conference Next Wave, (August), 1–2.
- [22] Vandeleur, S. (2001). Indicators of creativity in a technology class: a case study. *South African Journal of Education*, 21(4), 268–272.
- [23] Veisz, D., Namouz, E. Z., Joshi, S., & Summers, J. D. (2012). Computer-aided design versus sketching: An exploratory case study. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing: AIEDAM*, 26(3), 317–335. <https://doi.org/10.1017/S0890060412000170>
- [24] Wankel, C., & Stoner, J. A. F. (2008). *Innovative Approaches to Global Sustainability*. New York, NY: Palgrave Macmillan.
- [25] Williams, A., Ostwald, M., & Askland, H. H. (2010). Assessing Creativity in the Context of Architectural Design Education. *Proceedings of Design Research Society (DRS)*, (June), 1–9.
- [26] Winn, D., & Banks, F. (2012). CAD and Creativity – A New Pedagogy, (2001), 488–495

The Influence of Multidisciplinary Factor on the Technical Universities' Positions in International Rankings

Leonid Sobolev

Moscow Aviation Institute (National Research University), Moscow, Russia
sobolevlb@yandex.ru

Abstract : The article is devoted to a comparative analysis of world-class technical universities (TUs) ranks in the International Quacquarelli Symonds (QS) ranking 2021. The top-100 of QS-2021 includes only one Russian TUs, and there are no TUs of large industrial countries such as India and Brazil. Many Russian TUs were founded in the 30s of the last century, were related to certain industry ministries and have retained their narrow orientation up to the present time. However, the manufacturing of modern high-tech products (aircraft, robotics, electronics, medical equipment etc.) requires engineers to have knowledge from various fields of science (multidisciplinarity), supported by profound interdisciplinary researches. In addition, multidisciplinary TUs provide the opportunity for students to change their specialty or adjust it during their undergraduate and graduate studies. The analysis showed that leading positions in international rankings are occupied by multidisciplinary research TUs that conduct training and interdisciplinary research at the intersection of various scientific

activities. This study can be useful not only for Russia, but also for the transformation of TUs in other countries.

Keywords: multidisciplinary, technical university (TU), engineering specialties, training, transformation

1. Introduction

Universities were created historically as educational and research institutions and included the wide spectrum of disciplines available at that time. The development of interdisciplinary research in universities and the organization of regional multidisciplinary universities are global trends. In addition, the employers and the enrollees pay more attention to the position of a university in international rankings. In fact, there is competition between universities for talented students by providing them with the freedom of choosing specialization and the possibility of obtaining practical skills in research activity within the university. The quality of higher education is one of the important factors for the successful development of the country economy. The transition to the knowledge economy is possible only if the country has world-class universities with modern learning and research laboratories, highly qualified staff, and stable relations with companies in industry [1].

Leonid Sobolev

Moscow Aviation Institute
(National Research University), Moscow, Russia
sobolevlb@yandex.ru

Most modern technical (polytechnic) universities, in addition to technical faculties, have faculties of natural sciences, bioengineering and medicine, social sciences and arts. Such structures of the TU corresponds to the desire of many young people to get higher education at the intersection of technical and humanitarian sciences, to change specialization during the learning process and to have more job opportunities after graduation. Among the alumni of world-class TUs, there are famous entrepreneurs, Nobel and other prestigious prizes laureates, scientists, public and statesmen, and even actors. The employers prefer to hire graduates who have acquired skills of a practical and scientific nature at the university. Successful alumni and innovations create the reputation of the university, which is the one of the main factors influencing the university rank in international rankings. Russia is represented by a small number of universities in the global rankings, and the top-100 includes only Lomonosov Moscow State University [2].

The greatest influence on the transformation of Russian TUs towards international standards has been Russia joining the Bologna Convention in 2003 and the creation of national research universities (NRU) and federal universities (FU) in the districts of the Russian Federation. The Government «5-100» project played an important role in increasing the competitiveness of Russian TUs. According to this project, the Russian Government provided financial support to more than twenty Russian universities with the aim to enter into the top-100 of authoritative international rankings: Quacquarelli Symonds (QS), Times Higher Education (THE) and Academic Ranking of World Universities (ARWU). This project was not implemented for a number of reasons, but it undoubtedly increased interest in international rankings [3].

In the last decades, Russia has seen profound transformation from a command economy to a free market economy. These economies differ profoundly in their attitude to ownership on production means, pricing of goods and services, competition in manufacturing and sales, forming a labor market and the role of the Government in the economy. The transition to a market economy requires an adequate reform of higher education, in particular, modernizing learning programs, improving the research base of TUs, introducing competition among students and professors, increasing the role of English for communication with foreign colleagues and much

more. Obviously, the low position of Russian technical universities in international rankings leads to the low competitiveness of domestic products in international markets.

The Federal budget remains a main source of financing Russian universities, while world-class TUs, in addition to the Government subsidies, usually have several sources of financing such as regional budgets, tuition fees, preferential contracts from Government and private organizations, private donations and research funds. The big budgets and endowments of the Western universities permit the creation new research laboratories and inviting famous professors and scientists from all over the world. In these conditions, the countries with limited financial resources are looking for ways to improve the ratings of universities without fundamentally breaking the existing higher education system. One of the ways to improve the ranks of TUs is multidisciplinary (similar to the creation of conglomerate companies in industry) through increasing the number of academic programs and schools or mergers with other universities.

The purpose of the article is to analyze the influence of a multidisciplinary factor on the TUs rank in the Subject and Global QS rankings 2021 and the possibility of raising this rank through the merger process.

2. Methodology

The universities in QS rankings are assessed on the basis of several indicators with different weightings: reputation (the opinion of the academic community and employers about the university), quality of learning (feedback from graduates, the number of Nobel and other well-known prizes among university professors and researchers), innovation and practical value of research works, publication activity and citations, and the proportion of foreign students and professors. In QS ranking 2021 an assessment of a university is given not only by global indicators, but also by a subject principle, including 48 specialties (disciplines) [4].

These specialties are collected into five subject groups:

- Engineering & Technology (E&T),
- Natural Sciences (NS),

- Social Sciences (SS),
- Life Sciences & Medicine (LS&M),
- Arts & Humanities (A&H).

The methodology of this article is based on the interdependence and complementary nature of all five subject groups in the multidisciplinary TUs, the E&T being the core of this scientific and educational system (Fig. 1). Thus, innovations in NS allow conducting applied researches and creating the innovative products in E&T. The feedback also works: the demand for new scientific equipment for NS is met by E&T. Innovations in SS (especially in the economics) drive the successful commercialization of innovative products created by E&T, and consequently successful startups are case studies for economics programs.

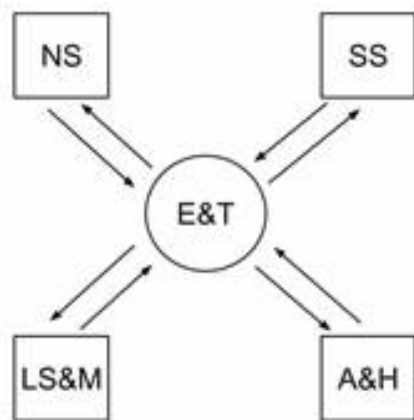


Fig.1 : Interdependence of the subject groups in the multidisciplinary TUs

Modern civilization considers human health and the environment as the priorities for scientific and industrial activity. Therefore, each TU should have strong LS&M, set tasks for creating new instruments and equipment for medicine and environmental protection. And vice versa, the knowledge of medical practice leads to developing unique devices (for example, Da Vinci Surgical System). In addition, the important requirement for modern technical devices and machines is the ergonomics and aesthetics (design) created in A&H. The innovative engineering solutions and technologies open up new opportunities for leisure and sports. Thus, multidisciplinary TUs have competitive advantages over industry TUs due to both better student selection and a greater variety of scientific research.

3. Results

3.1. General information

The top 100 of the Global QS-2021 are represented by the following regions:

- North America (USA and Canada) - 30
- Europe (excluding Russia and the CIS) - 33
- Asia - 26
- Oceania - 8
- South America - 2
- Russia and the CIS - 1
- Africa – 0.

In general, the number of high-quality universities corresponds to the contribution of the respective regions in the Global GDP and reflects the interaction of their industrial potential with the quality of engineering education. Tables 1-3 show the ranks of the 15 best TUs of three regions (North America, Europe and Asia) in the Subject and Global QS-2021. These TUs have not only good engineering schools, but also provide good training in disciplines, at first glance, little connected with engineering. Today the most demanded engineering specialties (computer and robotics engineering, aerospace engineering, military engineering, etc.) require the knowledge from various scientific fields. In addition, students can adjust their specialization during learning process at the multidisciplinary TUs [5].

3.2 Multidisciplinary TUs of North America

Table 1 shows the ranks of the five best US' and Canadian TUs in the subject and global QS-2021. We see that all of these universities have high ranks not only in technical disciplines, but also in other subject rankings, which provides them with a high global rank. These universities are “old” (founded in the 19th century or earlier) and then have been developed as multidisciplinary institutions. All these universities have a research status and high quality learning process. Three of them (MIT, Stanford and Harvard) are private, and two others (University of Berkeley and University of Toronto) are public. The main

difference between private and public universities is state subsidies. The private research universities have a low enrollment rate (5-8%) and considerably higher tuition. They tend to have much larger endowments to cover the difference between tuition and the cost per student. For example Harvard's endowment is more than \$40 billion. The impressive endowment of Harvard is a consequence of the fact that many successful entrepreneurs and statesmen who graduated from this university continue to sponsor the university and its research activities. The private universities also apply to federal and private agencies for research grants. The public universities accept more students and have a higher enrollment rate (25% at UB and 43% at UT). They are funded almost entirely by state and local governments and can also apply to federal and private agencies for research grants. Their endowments are smaller than private universities. The tuition fees that students pay cover much less than the cost per student [6].

Table 1: Top 5 North American TUs in Subject and Global QS-2021

University	Country	E&T	NS	LS&M	SS	A&H	Global
Massachusetts Institute of Technology (MIT)	USA	1	1	6	5	5	1
Stanford University	USA	2	2	4	3	16	2
University of California, Berkeley	USA	5	6	15	7	-	30
Harvard University	USA	12	3	1	1	2	3
University of Toronto	Canada	18	18	13	18	17	25

Source: created by author, QS-2021

All North American TUs have many research laboratories in various fields of sciences and conduct a wide range of interdisciplinary research. For example, MIT has the Lincoln Laboratory, known for its achievements in aerospace and computer technologies. Stanford University has the Stanford Artificial Intelligence Laboratory (SAIL), known for its achievements in bioinformatics, computer vision, decision theory, image processing, machine learning, artificial intelligence, sensors and robotics. Stanford alumni have founded many successful companies such as Google, Yahoo, Hewlett-Packard, Sun Microsystems, and Instagram. This university has graduated 59 Nobel laureates and 30 billionaires. The University of Berkeley is known primarily for research in the natural sciences. At the Lawrence National Laboratory new chemical elements, such as neptunium, plutonium, berkelium, californium and others were discovered and 11 scientists were awarded Nobel prizes. The engineering departments of these TUs closely cooperate with industrial companies, which together with federal and local

governments fund applied research, intellectual property protection and technical transfer, organize internships for students and offer jobs to alumni [7].

The engineering specialties at the American TUs, as a rule, are chosen by less than 50% of students, the rest prefer to study economics, physics or history. As result, the 2019 Nobel Prize in Economics was awarded to two visiting professors from MIT and one professor from Harvard for their practical methods of fighting poverty. If you trace the history of these universities, the emergence of new faculties was dictated by technical progress and demand for new specialties. The wide range of academic programs allows for interdisciplinary research, and the students form their own specialty in the learning process. They usually determine their specialty only in the third year and choose the main area of professional interest for writing their bachelor's diploma. This diploma can be performed at the junction of various disciplines, taking into account the interest of a potential employer. The alumni showed success in research work and can look forward to continuing their masters and doctoral studies at the university, in order to pursue a career as at the university and industry, or try to start their own business [8].

3.3 Multidisciplinary TUs of Europe

Europe (excluding Russia) is represented in the top 100 E&T ranking by 27 universities, five of which are included in Table 2. All European TUs joined the Bologna Declaration and develop their educational and research policies in accordance with the accepted pan-European standards and national interests.

Table 2: Top-5 European TUs in Subject and Global QS-2021

University	Country	E&T	NS	LS&M	SS	A&H	Global
University of Cambridge	UK	3	4	3	5	3	7
ETH-Zurich Swiss Federal Institute of Technology	Switzerland	4	6	53	56	134	6
Politecnico di Milano	Italy	20	150	-	117	124	137
Technical University of Munich	Germany	29	31	68	216	-	50
Ecole Polytechnique	France	52	26	-	238	-	61

Source: created by author, QS-2021

Table 2 shows that European TUs (especially from UK and Switzerland) occupy high ranks in both Subject and Global QS rankings and continue to maintain their reputation for innovation, advancements in research and enterprise. It is no wonder that many European TUs constantly rank high

amongst their global peers as some of the top places to study engineering.

Most TUs participate in the Erasmus exchange program, giving students a chance to experience other parts of Europe and indeed, the world.

The University of Cambridge is closest to American TUs in terms of both structure and tuition fee. Cambridge is the wealthiest university in Europe by both endowment size (£7.12 b) and budget size (£2.3 b). The alumni, faculty and research staff awarded 121 Nobel and 11 Fields Prizes that confirms the thesis about the importance of multidisciplinary for occupying a high position in international rankings. Cambridge also has a research partnership with MIT (USA). The ETN-Zurich is close to Cambridge in structure and funding. In the rest of European TUs the tuition fee is lower and, state budgets and funds are the main source of funding. The technical disciplines (multidisciplinary) correspond to the industries' demand in these countries. The university budgets show that European investment in education and research, especially from private sources, is insufficient to compete with universities of North America and shows an ever-widening gap [9]. The European Union is Russia's largest industrial and trading partner, therefore the Russian TUs should be close in structure and quality to European ones. Russia is interested in the experience of creating science parks and business incubators at the European TUs, increasing funds from private sources, building multidisciplinary TUs through mergers and weaker forms of cooperation [10].

3.4 Multidisciplinary TUs of Asia

Asia has the largest number of first-class universities in the most developed countries: Japan, China (including Hong Kong), South Korea and Singapore. Although higher education in these

Table 3: Top-5 Asian TUs in Subject and Global QS-2021

University	Country	E&T	NS	LS&M	SS	A&H	Global
Tsinghua University	China (Mainland)	9	16	129	32	19	15
National University of Singapore	Singapore	10	14	144	-	30	11
Korea Advanced Institute of Science and Technology	South Korea	16	44	217	89	-	39
The Hong Kong University of Science and Technology	Hong Kong (SAR)	18	40	355	33	15	27
University of Tokyo	Japan	20	13	33	34	22	24

Source: created by author, QS-2021

countries has a long history, in the post-war years Japan adopted the American model of the university, while Singapore and Hong Kong are based on the British model of higher education. The best TUs in these Asian countries are summarized in Table 3, which shows that these top Asian universities are multidisciplinary.

The experience of reforming Chinese universities is very interesting for Russia, because up until the 1980s China copied the system of the Soviet Union higher education and the organization of science. However, at the same time with market reforms in the economy, the Chinese Government began deep reforms in higher education and science in accordance with Western (market) models. China has implemented two projects ("211" and "985") aimed to improve the quality of education at universities and getting Chinese universities in the top-100 world-class universities. The Chinese Government provided great finance support to universities for academic and research activities. Many postgraduates get opportunities to have internships at the best world universities. The "Backflow" program implemented the return of Chinese scientists to China. As a result six Chinese universities enter in the top-100 of the QS ranking 2021. The abovementioned reforms have allowed the creation of research infrastructure, strengthened cooperation with business and the attraction of eminent professors and researchers from all over the world [11]. India has three multidisciplinary TUs (IITB, IITD and IITM), ranking high in E&T but significantly lower in other subject rankings, especially in LS&M. The Government of India, supported by the academic community, has also announced its desire to create world-class multidisciplinary universities [12].

3.5 Multidisciplinary Russian TUs

There are 724 universities in Russia [13], 200

Table 4: Top-5 Russian TUs in Subject and Global QS-2021

University	E&T	NS	LS&M	SS	A&H	Global
Lomonosov Moscow State University	67	21	278	55	53	74
ITMO University	160	256	-	-	-	360
Bauman Moscow State Technical University	174	401-450	-	451-500	-	282
Peter the Great St. Petersburg Polytechnic University	180	265	-	-	-	401
Moscow Institute of Physics and Technology	186	66	-	-	-	281

Source: created by author, QS-2021

situated in Moscow and St. Petersburg. At 28% of Russian universities' students learn engineering specialties and they have 50% of budget-funded places. It is possible to study at the TUs for free if entrants pass the Unified State Examination and score the required number of points. Table 4 shows the top 5 best Russian TUs in the E&T ranking, as well as their ranks in Global QS-2021.

Table 4 shows that the Lomonosov Moscow State University holds the highest rank in E&T and global rankings. The low ranks of other four TUs included in Table 4, are due to a lack of multidisciplinary and consequently interdisciplinary research. The most fundamental research is carried out in the scientific institutes of the Russian Academy of Sciences, while the universities have low level research laboratories and most students do not have an opportunity to participate in research. The lack of LS&M specialties in the Russian TUs is alarming, creating problems with medical equipment and medicine in Russia. The low positions in the SS rankings can be explained by the weakness of economic and sociological research in most TUs, which leads to incorrect marketing estimates and low level management at the State companies. The lack of Russian TUs in the A&H ranking is the result of neglecting industrial design. So, the scarcity of academic and scientific fields is one of the reasons of the low Russian TUs' ranks in world rankings and, at the same time, a reserve for improving a situation.

In Russia there are no private TUs with their large budgets and endowments, strong research laboratories and close cooperation with companies included in the Forbes 500 list. Nevertheless, it is possible to adopt an experience of creating multidisciplinary public TUs with engineering schools in specific areas, such as at the University of Berkeley (physics), Purdue University (aeronautics) or the University of Michigan (robotics).

Five more Russian TUs occupy 200+ positions in E&T and Global QS-2021 and have good chances to improve their positions in international rankings. Two of them (St. Petersburg State University and Tomsk State University) belong to the "old" (imperial) universities, have been multidisciplinary since their inception, but have relatively weak results in research. Novosibirsk State University has close scientific cooperation with the Siberian Branch of the Russian Academy of Sciences. The Higher School of Economics solves the problem of multidisciplinary

through mergers and, finally, MEPhI, can improve its rank, following the example of the University of Berkeley (USA). The first-year undergraduates of Russian TUs are sometimes disappointed in their chosen specialty and want to change it. The limited choice of disciplines for students leads to a high attrition in the first years [14].

4. Mergers of the universities as one of the methods to achieve multidisciplinary

Mergers are an effective method to create multidisciplinary universities. They can be divided into horizontal mergers (the merging universities have a similar specialization) and conglomerate mergers, leading to creation of multidisciplinary universities. The strategic motivations for university merger activities may have different particular features. The large universities tend to be more competitive nationally and globally (to achieve better positions in international rankings). But only conglomerate mergers can achieve these goals, enhancing a reputation and funding from different sources [15].

University mergers have occurred throughout the history of all countries. The list of university mergers in USA includes about 130 cases, more than 30 having occurred after 2000. These mergers mainly concern small universities in states [16]. The US' multidisciplinary universities have an advantage over highly specialized ones not only in terms of opportunity for interdisciplinary research and expanding the horizons for students, but also from the practical side to fill university budgets and create scientific and industrial clusters.

In Europe there are more than 4 000 universities, but most of them are small and only one in ten teaches more than 20 000 students. University mergers are widespread in Europe. It is estimated that since 2000 there have been nearly 130 mergers and acquisitions of universities belonging to the European Association of Universities. The mergers have taken many forms over the past 20 years. They receive increased attention in the context of unifying European higher education, as well as exploring new ways of interuniversity cooperation. It is believed that by increasing the size and multidisciplinary, these universities will be able to increase competitiveness and attract additional resources. Much attention in many EU countries is paid not only to mergers, but also to the creation of network structures in the form of cooperative agreements and alliances. Cooperation

refers to specific arrangements at the institutional level, focused on a specific area and covering agreements for partnerships and the creation of new organizations such as joint institutes, schools or faculties [17].

Asian universities are also involved in merger processes to improve their positions in international rankings. For example, the Tsinghua University left a polytechnic model and incorporated a multidisciplinary model emphasizing collaboration between distinct schools within the broader university environment. The merger process has been particularly successful in China, being a part of government program to improve the quality of higher education [18].

The Russian system of engineering education is undergoing serious transformations initiated by the Government in order to improve the quality of higher education. TUs introduce new educational programs in the most popular specialties and innovative teaching methods into the educational process, develop international academic mobility and strive for improving positions in international rankings. The TUs try to achieve leadership in Russian higher education and propose competitive educational programs for the international educational market. The multidisciplinary TUs sometimes have a geographically distributed structure, uniting regional educational and research institutions.

Most Russian universities (not only TUs), created in the 30s of last century (MAI, MADI etc.), mainly concentrated in Moscow and St-Petersburg continue to train students for the definite industries, despite that most large enterprises were removed from both cities. According to the author, the Russian TUs having a status of "national research universities" (especially in megacities) should gradually move away from narrow disciplines to multi disciplines. Tables 4 shows a successful example of creating a multidisciplinary university due to merger processing. ITMO University achieves the greatest success in moving up in the QS-2021 and absorbed three universities: Academy of Management Methods and Techniques, Institute of International Business and Law and the St. Petersburg State University of Low-Temperature and Food technologies. Higher School of Economics (HSE) absorbed Moscow State Institute of Electronics and Mathematics (MIEM). HSE is one of the elite universities and enjoys great prestige among Russian leadership. In the SS rating-2021, HSE ranks highest

among Russian universities (48th), ahead of Moscow State University (55th) and St. Petersburg State University (123th). The merger is beneficial to both united universities. HSE gained a strong position in engineering due to merger of MIEM and took a step towards creating a multidisciplinary university. MIEM received a new building equipped with modern scientific equipment and raised the passing score of enrolled applicants. The teaching staff increased the number of publications in international journals and grants for applied research. The new HSE has taken a step towards models of world-class universities such as MIT (USA) or Cambridge (UK) [19]. An example of a horizontal merger is the merger of two aerospace universities in Moscow: the Moscow Aviation Institute (MAI) and the Moscow Aviation Technological Institute (MATI). However, this horizontal merger did not lead to a significant improvement in the position of the united university in international rankings.

5. Discussion

Through this study, the influence of the multidisciplinary of world-class TUs on their rank in the international QS ranking is traced. Many TUs have been multidisciplinary since their inception, and the challenge is to develop all disciplines evenly. The industry TUs can be transformed into multidisciplinary ones through the process of mergers or acquisitions, creating new laboratories and inviting foreign professors and scientists.

The problem of the leading national universities' rank is discussed not only in Russia, but also in India [12]. The author of the article analyzed the ranks of Indian TUs in the QS rankings. Seven of them are in the top-200 of the E&T ranking, but only two are at the end of the Global QS ranking top-200. Perhaps, as in Russia, this fact is a consequence of low ranks in other Subject rankings. The problem of multidisciplinary in Indian universities is discussed by Marisha at al. [20].

The ideas of multidisciplinary, interdisciplinarity and transdisciplinarity have been widely applied to the relationship between sciences. The problems of terminology are taken into consideration to clarify the meaning of the word 'discipline' and its cognates. Also the relationship between sciences and technologies are a common practice among strict sciences and technologies [21].

Many researchers consider a multidisciplinary environment as an important factor for research collaborations, especially interdisciplinary researches that involve researchers from different disciplines. The higher level of multidisciplinary within a university is associated with internal collaborations that are more prevalent and more interdisciplinary. The analysis suggests that multidisciplinary universities are more collaborative and more interdisciplinary [22].

Economics and engineering played a vital role in addressing the challenges posed by economic and technological progress. Looking at the history of the relationships between the two disciplines, there are three paradigms for the economics–engineering alliance: economics “for/and/as” engineering. This alliance is seen as an interaction of the two disciplines and transdisciplinarity. The mission of the alliance is to restore a unified perspective of knowledge and to estimate the complexity in the future [23].

Bibliographic studies show a large number of references to multidisciplinary and interdisciplinary research works. Many citations refer to papers that are published in journals covering adjacent scientific disciplines. This suggests that modern sciences are closely interconnected and based on interdisciplinary cooperation [24].

6. Conclusions

The analysis of world-class TUs shows that they are multidisciplinary and have high academic and research reputation in all groups of disciplines. They continue the traditions of the earlier centuries, adding new disciplines and programs in accordance with scientific and technological progress. The students receive practical skills under the guidance of researchers and university professors, starting from their first years of study in the research university laboratories. In addition, the universities have big budgets, allowing not only to meet contracts from government agencies and large international corporations of civil and military profiles, but also to invite qualified professors and researchers.

The «old» Russian universities (Moscow State University, St. Petersburg State University, Kazan state university and Tomsk state university) are partly multidisciplinary. However, after the exhaustion of short-term factors, such as publication activity, attraction of additional public funds and foreign

students increasing, the entering into the “top-100” requires the use of long-term factors, such as increasing the efficiency of research work, attracting significant financial resources from business, competitive selection of teaching staff and researchers, publications in peer-reviewed international journals, participation in international conferences etc. The alumni of Russian TUs sometimes do not find interesting jobs and change their field of activity or leave to work abroad.

Russian TUs have not had significant results in such important areas as social sciences (primarily industry economics), life sciences and medicine, design and leisure activities. The problem of expanding the scientific and practical base of TUs can be fundamentally solved only through the inclusion of industrial and research institutes in the structure of universities. However, such a reform faces the resistance from leaders of state research institutes and the Russian Academy of Sciences. The problem is partially solved by creating branches of university departments in research institutions. Only the strong research university laboratories are able to rejuvenate and modernize the teaching staff of universities, to prepare the candidate and doctor dissertations of practical value, to stop the emigration of young scientists and engineers from Russia.

The multidisciplinary can be reached through university mergers. The article demonstrates the examples of successful mergers of Russian universities that have lead to improve position of the merged universities in the international rankings.

Multidisciplinary is one of the general trends in the development of the TUs and increasing their ranks. However multidisciplinary is a necessary but not sufficient condition for the success of TUs in the international rankings. In addition, the TUs should have good links with industrial companies, strong research laboratories, strict competitive selection of professors and students, various sources of funding, autonomy and other success factors.

Disclosure statement

No potential conflict of interest was reported by the author.

ORCID

Leonid Sobolev <https://orcid.org/0000-0001-6955-1271>

References :

- [1] J. Salmi, The Challenge of Establishing the World Class Universities // The World Bank. DOI:10.1596/978-0-8213-7865-6
- [2] L. Sobolev, Russian Engineering Universities in International Ratings // Universal Journal of Educational Research, Vol. 8, No. 12A, pp. 7487 - 7493. DOI: 10.13189/ujer.2020.082532
- [3] G. Kliucharev and A. Neverov, Project «5-100»: some interim results // RUDN Journal of Sociology 18(1): 100-116. DOI: 10/22363/2313-2272-2018-18-1-100-116
- [4] QS World University Rankings – Methodology (2021) // Available at: <https://www.topuniversities.com/qs-world-university-rankings/methodology>
- [5] T. Mednikova T. and V. Senashenko, Engineering Education in the USA // Higher Education in Russia- No.11- pp. 140-148 Available at: <https://vovr.elpub.ru/jour/article/viewFile/71/21.pdf>
- [6] M. V. Dobrynina M.V, US policy on engineering education after World War II: the 1958 reform and its strategic importance. // Theories and Problems of Political Studies, 8 (4A), pp. 63-70. DOI: 10.34670/AR.2019.45.4.059
- [7] A. Y. Derevnina, Research universities in the USA: cooperation with industry and business. University Management: Practice and Analysis.2010-4-60-66. (In Russ.)
- [8] N. Mowlae, How Multidisciplinary Engineering Studies Can Accelerate Your Career // Available at: <https://interestingengineering.com/multidisciplinary-engineering-studies-accelerate-career>
- [9] J. Enders, H. De Boer and D. Westerheijden, Reform of Higher Education in Europe // University of Twente, The Netherlands, 28 p. DOI:10.1007/978-94-6091-555-0
- [10] M. Zieliński, A. Rogala, and M. Takemura, Business Model of Science and Technology Parks: Comparison of European Best Practice, The Bulletin of the Faculty of Commerce Meiji University, 2014 nr 1 - Meiji: Meiji University Press. pp. 15-28. Available at: <https://www.researchgate.net/publication/280053029>
- [11] M. Li and R. Yang, Governance reforms in higher education: A study of China // UNESCO, International Institute for Educational Planning (IIEP). // Available at: <https://unesdoc.unesco.org/ark:/48223/pf0000231858>
- [12] The point of multidisciplinary research universities in India. Available at: <https://www.hindustantimes.com/education/the-point-of-multidisciplinary-research-universities-in-india/>
- [13] Gokhberg L. et al. (2020) Education in Figures: A Brief Statistical Book / M: NRU HSE, 2020. - 120 p. DOI: 10.17323/978-5-7598-2306-3
- [14] E. Shmeleva and I. Froumin, Factors of Attrition among Computer Science and Engineering Undergraduates in Russia // Educational Studies, Moscow. 2020 - 3 - 110 - 132. DOI:10.17323/1814-9545-2020-3-110-136
- [15] Y. Cai, R. Pinheiro, L. Geschwind and T. Aarrevaara, Towards a novel conceptual framework for understanding mergers in higher education // European Journal of Higher Education. 2015, 6(1):1-18 DOI: 10.1080/21568235.2015.1099457
- [16] List of university and college mergers in the United States (2021) Available at: <https://en.wikipedia.org/wiki/>
- [17] E. Pruvot, T. Estermann and P. Mason, Thematic Report 2: University Mergers in Europe // European University Association. Available at: <https://eua.eu/resources/publications/363:define-thematic-report-university-mergers-in-europe.html>
- [18] Y. Wan and M. Peterson, A case study of a merger in Chinese higher education: the motives, processes, and outcomes // International Journal of Educational Development 27(6):683-696 DOI: 10.1016/j.ijedudev.2006.07.007

- [19] T. Agasisti, A. Egorov and M. Maximova, Do Merger Policies Increase University Efficiency? Higher School of Economics, Research Paper No. WPBRP, 226/EC/2020
- [20] Marisha, S. K. Banshal & V. K. Singh, Research Performance of Central Universities in India 2017, *Current Science*, 112(11):2198-2207 DOI: 10.18520/cs/v112/i11/2198-2207
- [21] D. Alvargonzalez, Multidisciplinarity, Interdisciplinarity, Transdisciplinarity, and the Sciences. *International Studies in the Philosophy of Science*, 2018, Vol. 25, No. 4, pp. 387–403 DOI: 10.1080/02698595.2011.623366
- [22] Z. Zuo & K. Zhao, The more multidisciplinary the better? – The prevalence and interdisciplinarity of research collaborations in multidisciplinary institutions. *Journal of Informetrics*, 2018, 12, 736–756. <https://doi.org/10.1016/j.joi.2018.06.006>
- [23] S. Mariotti, Forging a new alliance between economics and engineering. *Economia e Politica Industriale*, 2021, 48(1):1-22 DOI:10.1007/s40812-021-00187-w
- [24] Leeuwen T.V. & Tijssen R. Interdisciplinary dynamics of modern science: Analysis of cross-disciplinary citation flows. *Research Evaluation*, 2000, 9(3):183-187 DOI: 10.3152/147154400781777241
- [25] Sobolev Leonid B. – Dr. Sci. (Tech.), Prof. of Department Economics, Moscow Aviation Institute, Russia, sobolevlb@yandex.ru

Factors Influencing Technopreneurial Intention among Undergraduate Engineering Students in the Philippines

Zachariah John Aviles Belmonte¹, Carl Sebastian C Cruz², Prince Adriel P De Castro³,
Lexter A Estoesta⁴, Elijah John A. Mitra⁵, Pamela Eyre Victoria R Lira⁶

¹zachariahjohn_belmonte@tup.edu.ph

²carlsebastian.cruz@tup.edu.ph

³princeadriel.decastro@tup.edu.ph

⁴lexter.estoesta@tup.edu.ph

⁵elijahjohn.mitra@tup.edu.ph

⁶prlira@up.edu.ph

Abstract : In the Philippines, students exhibit a low interest in entrepreneurship despite numerous programs implemented and mandated by the government. The emergence of technopreneurship is now confronted by several issues, mainly in developing competent and versatile technopreneurs. Until now, there are inadequate studies related to technopreneurship specifically those dealing with technopreneurial intention among engineering students. This study aims to determine the factors associated with technopreneurial intention. Simple random sampling was used to collect necessary data from 200 undergraduate engineering students from selected universities in the Philippines. Multiple Regression Analysis and Pearson Correlation Analysis were used to test the hypotheses and examine the relationship between independent and dependent variable respectively. The findings revealed that among the five identified factors, only Computer Ability, Access to Capital, and Entrepreneurial Experience have a significant and positive effect on intention towards technopreneurship.

Keywords : Computer Ability; Entrepreneurial Experience; Entrepreneurial Orientation; Internet Ability; Technopreneurial Intention

1. Introduction

Through the years, the Philippine government has developed a variety of methods to assist and encourage youth involvement in technopreneurial activity. Particularly, the partnership between the Department of Science and Technology (DOST,) University of the Philippines (UP), and the Philippine Economic Zone Authority (PEZA) established the DOST-UP Enterprise Center for Technopreneurship in 2011 which aimed in assisting young entrepreneurs to taking the first steps toward establishing their enterprises through technopreneurship courses, grant application support, product testing, and tailored business support (DOST-PCIEERD, 2012). Aside from the diligent effort of the Philippine government through institutions like DOST and DTI, there are some private organizations that wish to offer ambition to underprivileged youths and university students with possibilities for self-determination in social and economic participation via entrepreneurship. Youth at Venture Philippines is a private, non-profit organization that helps disadvantaged, motivated, and passionate youth and university students with entrepreneurial mindset gain or improve their knowledge, skills, and attitudes towards entrepreneurship.

Zachariah John Aviles Belmonte

zachariahjohn_belmonte@tup.edu.ph

Additionally, it is worth noting that graduates of universities who start their businesses help the government reduce the responsibility of producing public-sector job possibilities (Singhry, 2015). Moreover, because of the unfavorable economic conditions following the COVID-19 pandemic, employment has been a challenge for youth and fresh college graduates. Although the Philippine government is eager to make attempts, not many Filipino youths regard entrepreneurship as their professional choice. Statistics have shown from a study that out of 5,953 youths, 86.12% were salaried and classified into Permanent Employment, Short-Term, Work on different jobs daily or week to week, and unclassified. In contrast, 248 or 4.17% are unemployed, and only 578 or 9.71% were self-employed. From this it can be interpreted that most youths are mainly employed rather than entrepreneurial (Gozun and Rivera, 2019).

The term "technopreneurship" refers to a new breed of entrepreneurship that is technology-based. As a result, it confronts various problems in training and developing competent technopreneurs (Jusoh & Halim, 2006; Tan, Karl & Mohamed, 2010). It entails bringing individuals together who are intelligent, determined, innovative, tech-savvy, enthusiastic, and willing to take measured risks. Unlike entrepreneurship, Technopreneurship is rarely a one-person show as the team's success depends on how effectively they work together. The concept of entrepreneurship can also be applied in technopreneurship, where the greater the person's intention to become an entrepreneur, the more likely they are to succeed (Hisrich, Peters & Shepherd, 2017). However, only few researchers have dealt with technopreneurship as most studies tend to focus on the conventional type of entrepreneurship. Additionally, the scarcity of literature has created a void in our understanding of the factors promoting technopreneurial purpose. Thus, the objective of this study will determine the characteristics that may impact engineering students' inclinations toward technopreneurship.

2. Review of Related Literature

A. Computer Ability

An analysis of the relationship between computer ownership and entrepreneurship at the individual level provides evidence that individuals with access to home computers are substantially more likely to

become entrepreneurs over the following 12–15 months (Fairlie, 2006). From Buckley and Montes' (2002) study, majority of businesses make relatively large investments in computers and communication equipment. This is because exposure to computers make it substantially easier for a potential entrepreneur to create an experimental business plan, obtain information, research competition, and lower operating and marketing costs. Computer Ability such as using spreadsheets, word processing, and database programs, are valuable for creating and managing entrepreneurship.

B. Internet Ability

According to Bandura (1986), self-efficacy deals with "how people evaluate their ability to obtain a certain type of performance by planning and accomplishing the courses of action needed. Skills and knowledge in Information Communication Technology (ICT) are crucial in technopreneurship specifically for relaying and acquiring important information to maximize business opportunities (Watson, 2016). Students with adequate IT abilities and real-world experience in starting IT enterprises would be more successful in IT-related entrepreneurship. Moreover, the self-efficacy in terms of internet and computer are connected to the internet's perceived usefulness and the individual desire to use technology (Aesaert et al., 2015; Courtois et al., 2014; Ong & Lai, 2006)

C. Individual Entrepreneurial Orientation

According to Bolton (2012), Individual EO would be valuable at a collective level, which includes resourcefulness, dynamic, and courage, which may be possible by extending it to the level of individuals. In addition, the three components of EO were connected to a student's desire to its intent in pursuing entrepreneurship. Certainly, a person's willingness to take risks and tolerance for risk affected their entrepreneurial ambitions (Yurtkoru, Acar & Teraman, 2014). It was also discovered that Malaysian students' inclination for risk-taking was linked to their desire to engage in entrepreneurial activity (Embi, Jaiyeoba & Yussof, 2019). Additionally in Abdulgani's study (2016), personal attributes, enthusiasm, entrepreneurial and commercial enterprise abilities which are connected to an individual's preferences, mentalities, inclinations, and ability to recognize and seize the great opportunity, have been identified to affect the emergence of technopreneurship.

D. Entrepreneurial Experience

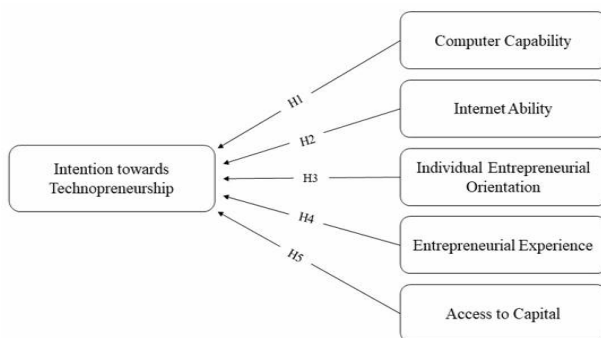


Fig. 1: Research Framework

According to (Kautonen et al. 2011), an individual's work experience and educational background have become the focus of attention of research in developing Entrepreneurial Intention. A better understanding of how Entrepreneurial Intention is influenced by an individual's type of work was derived from previous studies that analyze the difference between individuals with different work experiences (Zapkau et al. 2015). Scholars have also recommended prioritizing this type of experience and analyzing whether it is converted to knowledge (Politis, 2005), particularly, considering the concept of Entrepreneurial Experience as a factor that will describe the variation brought about by an individual's background in building Entrepreneurial Intention (Miralles et al. 2016).

E. Access to Capital

From Aragon-Sanchez, et al. (2017), the capacity of economic, personal, and material support was observed in response to individuals' decisions to establish new businesses and their succeeding sustainability, development, and revenue growth. Entrepreneurial inclinations are usually instilled in children from affluent households since the youth are already able to recognize the importance of economic resources in a company's success. Thus, university students are expected to understand that a financial constraint reduces the probability of success and increases potential risk, hence lowering the value and viability of pursuing the objectives.

3. Methodology

A. Data Collection

Due to the presence of COVID-19, the Philippine Government has enforced a lockdown that require the people to stay at home (Dizon, 2020). As a result, the

researchers have gathered the data during the COVID-19 pandemic through an online questionnaire with the use of Google Forms which was distributed using different social media platforms such as Facebook and Twitter and relayed the questionnaire in different group chats via Facebook Messenger. The population of this study were engineering students from State Universities in Metro Manila that offer a variety of engineering courses such as Polytechnic University of the Philippines (PUP), Rizal Technological University (RTU), Taguig City University (TCU), and Technological University of the Philippines – Taguig Campus (TUP-T). The student participants have also took up the course Technopreneurship 101 as mandated by CHED to all Higher Education Institutes (HEIs) throughout the Philippines that provide engineering programs.

B. Theoretical Framework

The research framework of the study was based on the study of Alias, Arham, Koe, Krishnan, & Mahphoth (2021) on factors influencing technopreneurial intention. It became a driving factor for the researchers to find out the outcome in different populations with additional factors, which are also believed to be also significant. Each factor was gathered from a variety of other academics' investigations which lead to the development of the study's research model. It adopted the concept of an individual's orientation, resources, experience, and self-efficacy. This study determines whether the factors (Computer Ability, Internet Ability, Entrepreneurial Orientation, Entrepreneurial Experience, and Access to Capital) impact an individual's technopreneurial intention.

C. Hypothesis

Utilizing the theoretical framework presented in this study, the researchers identified the relationship of independent factors to the dependent factor:

H1: Intention towards technopreneurship is positively influenced by computer capability

H2: Intention towards technopreneurship is positively influenced by Internet Ability

H3: Intention towards technopreneurship is positively influenced by Individual EO

H4: Intention towards technopreneurship is positively influenced by Entrepreneurial Experience.

H5. Intention towards technopreneurship is positively influenced by Access to Capital.D. Hypothesis

D. Questionnaire

The researchers used a five-point Likert scale questionnaire (1=Very Unlikely to 5 = Very Likely), and the respondents were requested to input their answers on self-administered survey forms, which were sent online with the use Google Forms. To guarantee the credibility and efficacy of the items, the questions were adopted from past research (Aesaert, Voogt, Kuiper & van Braak, 2017; Bolton & Lane, 2012; Wu & Tsai, 2006; Liñán & Chen, 2009). The questions were divided into six sections: (a) Computer Ability (CA), (b) Internet Ability (IA), (c) Entrepreneurial Orientation (EO), (d) Entrepreneurial Experience (EE), (e) Access to Capital (AC), and (f) Technopreneurial Intention (TI).

Table 1 : Research Instruments

Factors	Items	Questions	Source
Computer Ability (CA)	CA01	Use a word processor to create documents.	Kay (1993)
	CA02	Learning a software package that you have never used before.	
	CA03	Identify basic parts of a computer and its functions.	
	CA04	Read a computer program.	
	CA05	Can operate Microsoft applications and other computer-aided software skillfully.	
Internet Ability (IA)	IA01	Search information by using keywords in search engines	Tsai (2004)
	IA02	Capable of searching information by using images in reverse image search engines	
	IA03	How good can you judge if the information on a website is true or false?	
	IA04	How good are you in creating a new product of information when gathering information from several websites using a computer?	
	IA05	How good can you use e-mail to ask a clear question that is completely understandable for the receiver?	
Entrepreneurial Orientation (EO)	EO01	I like to take bold action by exploring outside my intellectual capability	Bolton & Lane (2012)
	EO02	I am willing to invest a lot of time and/or money in something that might yield a high return	
	EO03	I tend to act "boldly" in situations where risk is involved	

	EO04	I usually act in anticipation of future problems, needs, or changes	
	EO05	I tend to plan ahead on projects	
	EO06	I prefer to "step up" and get things going on projects rather than sit and wait for someone else to do it	
	EO06	I prefer to "step up" and get things going on projects rather than sit and wait for someone else to do it	
Entrepreneurial Experience (EE)	EE01	Thanks to my experience, I know how to start a viable business	Miralles et al (2017)
	EE02	Thanks to my professional experience, I know well clients' problems	
	EE03	It is easy for me to identify business opportunities in my professional area	
	EE04	Thanks to my knowledge, I am comfortable at my work as I know how the business works	
Access to Capital (AC)	AC01	My immediate family would give me money when I start a business	Aragon-Sanchez et al (2017)
	AC02	If my family had a business, they would facilitate me in creating a business	
	AC03	My immediate family together with a financial institution will provide financial assistance for me to start a business	
Technopreneurial Intention (TI)	TI01	I am ready to do anything to be a technopreneur	Liñán & Chen, (2009)
	TI02	My professional goal is to become a technopreneur	
	TI03	I will make every effort to start and run my own firm	
	TI04	I am determined to create a firm in the future	
	TI05	I have very seriously thought of starting a firm	
	TI06	I have the firm intention to start a firm someday	

4. Data And Results

A. Data Analysis

With the use of the software Statistical Package for the Social Sciences (SPSS), the researchers were able to employ a quantitative approach by examining the relationships between independent variables, and independent variables to dependent variables with the use of Pearson Correlation Analysis. The researchers also conducted Multiple Regression analyses to test the hypotheses in this study. The table of Regression Coefficients, Model Summary, and F value from ANOVA will be used to determine the outcome of the study.

B. Demographics

The researchers successfully collected 200

Table 3 : Demographics Profile

Variable	Category	Number (N)	Percentage (%)
Gender	Male	117	58.5%
	Female	83	41.5%
Schools	PUP	50	25%
	RTU	50	25%
	TCU	50	25%
	TUP-T	50	25%
Age	18 to 20 years old	127	63.5%
	21 to 23 years old	69	34.5%
	24 to 26 years old	4	2%
Course	ME	82	41%
	CE	56	28%
	EE	17	8.5%
	ECE	15	7.5%
	BET	12	6%
	IE	10	5%
	CpE	8	4%

responses out of four different state universities. The percentage of the sample out of 200 per state university is 25%, wherein the researchers acquired 50 engineering students from four different state universities. It is found out that most of the respondents are Males (58.5%; n=117) and Females (41.5%; n=83). In terms of age, most of the respondents aged from 18- 20 (63.5%; n=127), second were ages 21-23 (34.5%; n=69), and lastly ages from 24-26 (2%; n=4). Moreover, majority the students are Mechanical Engineering (ME) students (41%; n=82), second are Civil Engineering (CE) students (28%; n=56), third are Electrical Engineering (EE) students (8.5%; n=17), fourth are Electronics and Communication Engineering (ECE) students (7.5%; n= 15), fifth are from the BET courses (6%; n=12), sixth are Industrial Engineering (IE) students (5%; n=10), and lastly are from Computer Engineering (CpE) students (4%; n=8). The table below are the demographic data of the respondents.

C. Descriptive statistics

Table 3 : Item Analysis

Factors	Items	$\bar{x}$	σ
Computer Ability (CA)	CA01	4.4600	.84971
	CA02	4.1150	1.12164
	CA03	4.4000	.83876
	CA04	3.8500	1.12420
	CA05	4.3750	.78579
Internet Ability (IA)	IA01	4.6500	.68546
	IA02	4.2300	1.03560
	IA03	4.3400	.75979
	IA04	4.0300	.86187
	IA05	4.2250	.81096

Entrepreneurial Orientation (EO)	EO01	4.2500	.91195
	EO02	4.4000	.82669
	EO03	4.0400	.97114
	EO04	4.2700	.80019
	EO05	4.3850	.84875
	EO06	4.3450	.79948
Entrepreneurial Experience (EE)	EE01	3.8750	1.12949
	EE02	3.8600	1.14760
	EE03	3.9600	.99668
	EE04	4.0000	1.01744
Access to Capital (AC)	AC01	3.6400	1.33390
	AC02	4.1100	1.11540
	AC03	3.7450	1.23597
Technopreneurial Intention (TI)	TI01	4.0700	1.02976
	TI02	3.8450	1.16954
	TI03	4.1400	.96178
	TI04	4.1650	.92849
	TI05	4.0550	1.02823
	TI06	4.1250	1.01217

Legend: $\bar{x}$ = Mean; σ = Standard Deviation

As shown in Table III, the individual item analysis, the Computer Ability of engineering students has the highest rating in item CA01 in creating documents in a word processor ($\bar{x}$ =4.6; from Likely to Very Likely), while they have the lowest rating on item CA04 on having difficulty in reading a program ($\bar{x}$ =3.85; from Neutral to Likely). In their Entrepreneurial Experience they have the highest score in item EE04 which assessed how knowledge helped them to know how business work and it makes them comfortable ($\bar{x}$ =4.00; Likely on Likert Scale), while they score the lowest in the item EE02 regarding professional experience helping them in identifying their client's

Table 4 :Pearson Correlation Analysis And Reliability

			Std.	CA	IA	EO	EE	AC	TI
	α	Mean	Deviation						
CA	.802	4.2400	.71369	1.00					
IA	.794	4.2950	.62121	.669**	1.00				
EO	.858	4.2817	.65917	.614**	.692**	1.00			
EE	.942	3.9238	.99155	.626**	.625**	.667**	1.00		
AC	.875	3.8317	1.10175	.688**	.596**	.598**	.696**	1.00	
TI	.935	4.0667	.89011	.634**	.529**	.555**	.528**	.667**	1.00

Legend: α : Cronbach's Alpha; CA: Computer Ability;
IA: Internet Ability; EO: Entrepreneurial Orientation;
EE: Entrepreneurial Experience; AC: Access to Capital;
TI: Technopreneurial Intentions;
**: Correlation is significant at level <0.001 (Two-tailed)

Table 5 : Correlation Coefficient Interpretation

Value of Correlation Size	Analysis
0.90 - 1.00 (-0.90 - -1.00)	Very High Positive (-) Correlation
0.70 - 0.90 (-0.70 - -0.90)	High Positive (-) Correlation
0.50 - 0.70 (-0.50 - -0.70)	Moderate Positive (-) Correlation
0.30 - 0.50 (-0.30 - -0.50)	Low Positive (-) Correlation
0.00 - 0.30 (0.0 - -0.30)	Insignificant Correlation

Source: Hinkle DE, Wiersma W, & Jurs SG (2003)

Table 6 : Rule of Thumb For Cronbach's Alpha

Cronbach Alpha Value	Strength of Association
Less than 0.6	Poor
0.6 - <0.7	Moderate
0.7 - <0.8	Good
0.8 - <0.9	Very Good
Greater than or equal to 0.9	Excellent

Source: Hair et.al (2003)

problem ($\bar{x}=3.86$). Lastly, in terms of financial access of the engineering students, they score the highest in item AC02, where an individual's family business can be a factor for them to create a new venture ($\bar{x}=4.11$), while they rated lowest on item AC01, where an individual will most probably receive financial support from their family when they start a business ($\bar{x}=3.875$).

From the results of Pearson Correlation Analysis, the correlations between all independent variables were moderately positive and significant. While reliability analysis shows that the questionnaire items of independent variables and dependent variable ranges from Good to Excellent.

The values correlation coefficient (r) for independent variables ranges from ($r=.596$; sig <0.01; IA to AC) as the lowest, to ($r=.696$; sig <0.01; EE to AC) as the highest. Moreover, the independent variables (CA, IA, EO, EE, AC) were all moderately positive and significant to the dependent variable (TI). The highest correlation was found between AC and TI ($r=.667$; sig <0.01) while the weakest correlation was found between EE and TI ($r=.528$; sig <0.01). Since none of the calculated values of r were higher than 0.9, the results show that there is no multicollinearity between the variables (Pallant, 1996). Furthermore, the values of Cronbach Alphas (α) ranges from ($\alpha=0.794$; IA) as the lowest, too ($\alpha=0.942$; EE) as the highest and shows internal consistency on all items from Good to Excellent.

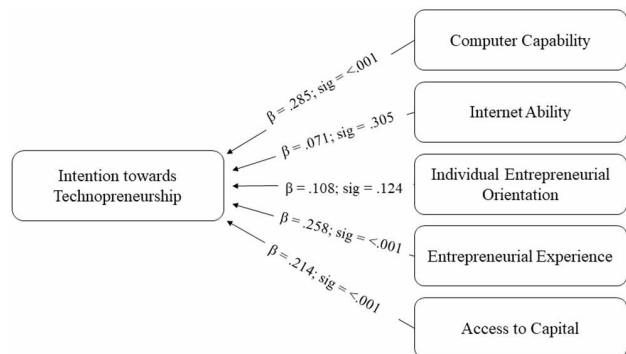
E. Pearson Correlation Analysis

Multiple Regression Analysis was used to test the five hypotheses to determine which predictors are significant to the technopreneurial intentions of engineering students, and the results are indicated in Table VII.

Table 7 : Multiple Regression Results

Model	STD Beta	(β)	t	Sig.	Tolerance	VIF
1						
CA	.285		4.298	<.001	.450	2.223
IA	.071		1.028	.305	.410	2.440
EO	.108		1.544	.124	.404	2.475
EE	.258		3.562	<.001	.379	2.638
AC	.214		3.439	<.001	.512	1.954

F Statistics: (F (5,194) = 62.086, $p < 0.05$; sig <0.001)
R Square: 0.615

**Fig. 2: Multiple Regression Results**

In table XI, it shows that the overall study model was statistically fit (F statistics = 62.086; sig. <.001) by having a large value of F. The $R^2 = 0.565$ indicates that 61.5% of the variance of technopreneurial Intention was explained by the predictors (Computer Ability, Internet Ability, Entrepreneurial Orientation, Entrepreneurial Experience, and Access to Capital). The results show that, the Computer Ability ($\beta=.285$; sig.= <.001), Entrepreneurial Experience ($\beta=.258$; sig.= <.001), and Access to Capital ($\beta=.214$; sig.= <.001) significantly affect the intention towards technopreneurship with a positive correlation. As a result, the hypotheses H1, H4, H5 were accepted.

F. Findings

After data analysis, the researchers interpret the data for each school. Entrepreneurial Orientation (sig.=.041) was the only factor that influences technopreneurial intentions for engineering students from PUP. While engineering students from RTU

indicated that Computer Ability influences intention towards technopreneurship ($\text{sig.}=0.006$). Additionally, results show that Computer Ability and Access to Capital were the most influential factor in technopreneurial intention of TCU students with a score of ($\text{sig.}=0.29$) and ($\text{sig.}=0.16$), respectively. Lastly, engineering students of TUPT believe that Entrepreneurial Experience is the sole factor that promotes technopreneurial intention with a score of ($\text{sig.}=0.005$)

Overall, three factors have been identified to have a significant effect to the intention towards technopreneurship of engineering students from selected universities, namely: Computer capability, Access to Capital, and Entrepreneurial Experience with a score of ($\text{sig.} = <0.001$) for all. As for the rankings, from the coefficient table (Table XI) they find that Computer Ability of an individual is the most influential factor among the three ($\beta = .285$) wherein every 1 unit in Computer Ability accounts for .285 units in technopreneurial experience. Secondly there was the Entrepreneurial Experience of an individual ($\beta = .258$), wherein every unit increase in Entrepreneurial Experience, the intention of being technopreneur as a career path increases by .258 units. Lastly, in terms of Access to Capital of an individual ($\beta = .214$), a unit increase increases technopreneurial intention by .214.

G. Practical Implications

The findings were able to analyze computer capability as a factor for technopreneurial intention which conformed to the discussion of prior studies of Aesert et al. (2017), Windarata (2014), and Okorie et al. (2014). According to Hidayat and Yunus (2019), technological proficiency or the capacity to utilize technology efficiently is inextricably linked to entrepreneurial since it equips entrepreneurs to deal with Industrial Revolution 4.0 that promotes further use of technology in a workplace. As a result, students were presumed to be adept and skilled at using the computer in an effective method. Since ICT is inextricably linked to technopreneurship, they must be familiar with the significance of ICT before they enter technopreneurial venture. Furthermore, the research was able to show that Entrepreneurial Experience (EE) has a strong influence on technopreneurial intention which is supported by discussions from previous studies of Kautonen et al. (2011), Miralles et al. (2016), and Zapkau et al. (2015). It implies that prior entrepreneurial

experience is integral in gaining knowledge and skills needed to boost technopreneurial intention especially before embarking in technopreneurship. Lastly, Access to Capital has also been found to be a significant factor as explained in studies by Aragon-Sanchez et al. (2017) and Sandhu et al. (2011). Access to capital or the availability of resources is a strong determinant of a student's technopreneurial intention as it is perceived by students to be an important in starting a business and crucial to its success.

H. Social implications

Learning institutions should design an advanced curriculum that will support technopreneurship. The curriculum should prioritize developing creativity and analytical thinking, promoting innovation and most especially, the utilization of technology. Moreover, learning institution should have reliable employees that are competent of implementing new learning method for entrepreneurial education. With the collaboration initiated by CHED and a non-profit organization in the Philippines, Technopreneurship 101 was established to encourage science and engineering students to pursue entrepreneurial and Research & Development career opportunities. The program is based on PhilDev's entrepreneurial courses, which encompasses subjects including entrepreneurship fundamentals, conceptual design, feasibility and distinctiveness, market analysis, and company strategy development. They also introduced Technopreneurship 101 at all 539 Higher Education Institutes (HEIs) throughout the Philippines that provide engineering programs.

The government's responsibility in developing various technopreneur should really be addressed. The authorities should be the driving force behind the country's development of technopreneurship. To illustrate, government initiatives in encouraging technopreneur include creating a favorable market environment and implementing the tactical and systematic method (Okorie et al., 2014). In addition, the government should initiate and provide programs such as funding and granting capital that will support aspiring students who have interest to venture technopreneurship.

5. Conclusion

The researchers conclude that the Computer Ability, Access to Capital, and Entrepreneurial Experience of an individual significantly affect an

individual's technopreneurial intention while the Internet ability and Entrepreneurial Orientation are statistically insignificant.

Consequently, this study not only supports the statement of Hoque et al. (2017) that the self-efficacy of an individual had a substantial and favorable effect on their intention to pursue careers as technopreneurs, but also add another predictor (Computer Ability). The findings of this research further support the study of Aragon-Sanchez et al. (2017) that students with better access financially have a stronger technopreneurial intent not just on secondary students but also to the tertiary students

On the other hand, the results also imply that most of the engineering students are literate in creating documents in word processors but lack in program-reading. Families of these individuals will most likely encourage them in creating a business than providing financial support when they start a business venture. Also, they agreed that having knowledge of the business allows them to feel at ease at their job because they understand how it operates.

Acknowledgment

The researchers would like to extend their deepest gratitude to the Technological University of the Philippines for supporting this study.

References

- [1] Abdulgani, M.A., Mamangkiang, J., & Islam, M.S. (2016). Factors that affect technopreneurship: A meta-analysis. *Academia.edu*. <https://www.researchgate.net/publication/311954125>
- [2] Aesaert, K., Voogt, J., Kuiper, E., & van Braak, J. (2017). Accuracy and bias of ICT self- efficacy: An empirical study into students' over- and underestimation of their ICT competences. *Computers in Human Behavior*, 75, 92- 102. <https://doi.org/10.1016/j.chb.2017.05.010>
- [3] Alias, N. E., Arham, A. F., Koe, W. L., Krishnan, R., & Mahphoth, M. H. (2021). Factors influencing intention towards technopreneurship among university students. *Journal of Educational and Social Research*, 11(1). <https://doi.org/10.36941/jesr-2021-0016>
- [4] Aragon-Sanchez, A., Baixauli-Soler, S., & Carrasco-Hernandez, A. J. (2017). A missinglink: The behavioral mediators between resources and entrepreneurial intentions. *International Journal of Entrepreneurial Behavior & Research*, 23(5), 752–768. <http://dx.doi.org/10.1108/IJEBr-06-2016-0172>
- [5] Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. N J : P r e n t i c e - H a l l . <https://doi.org/10.2307/258004>
- [6] Bolton, D.L., & Lane, M.D. (2012). Individual entrepreneurial orientation: Development of a measurement instrument. *Education + Training*, 54 (2 / 3) , 219 - 233 . <https://psycnet.apa.org/doi/10.1108/00400911211210314>
- [7] Buckley, P., & Montes, S. (2002). Main street in the digital divide age: How small and medium-sized businesses are using the tools of the new economy. US Department of Commerce, Economics and Statistics Administration, USGPO, Washington, DC.
- [8] Courtois, C., Montrieux, H., De Grove, F., Raes, A., De Marez, L., & Schellens, T. (2014) Student acceptance of tablet devices in secondary education: A three-wave longitudinal cross-lagged case study. *Computers in Human Behavior*, 35 , 278 - 286 . <https://doi.org/10.1016/j.chb.2014.03.017>
- [9] Department of Science and Technology - Philippine Council for Industry, Energy, and Emerging Technology Research and Development, "DOST-UP facility prepares technopreneurs for business success", Available: <https://pcieerd.dost.gov.ph/news/latest-news/29-dost-up-facility-prepares-technopreneurs-for-business-success>
- [10] Dizon, N. (2020, July 31). Duterte and his generals: A shock and awe response to the pandemic. *Rappler*. Retrieved from: <https://www.rappler.com/newsbreak/in-depth/duterte-shock-and-awe-coronavirus-pandemic-response-generals>
- [11] Embi, N.A.C., Jaiyeoba, H.B., & Yussof, S.A. (2019). The effects of students' entrepreneurial characteristics on their propensity to become

- entrepreneurs in Malaysia. *Education + Training*, 61 (7/8), 1020-1037. <https://doi.org/10.1108/ET-11-2018-0229>
- [12] Fairlie, R. W. (2006). The personal computer and entrepreneurship. *Management Science*, 52(2), 187-203.
- [13] Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). Canonical correlation: A supplement to multivariate data analysis. *Multivariate data analysis: A global perspective* (7th ed.). Pearson Prentice Hall Publishing. <http://dx.doi.org/10.4324/9781315716862>
- [14] Hidayat M., & Yunus U. (2019). The Entrepreneurship Learning in Industrial 4.0 Era (Case study in Indonesian college). *Journal of Entrepreneurship Education*.
- [15] Hinkle, Wiersma, & Jurs (2003). *Applied Statistics for the Behavioral Sciences* (5th ed.). <https://oak.ucc.nau.edu/rh232/courses/EPS525/Handouts/Correlation%20Coefficient%20Handout%20-%20Hinkle%20et%20al.pdf>
- [16] Hisrich, R.D., Peters M.P., & Shepherd, D.A. (2017). *Entrepreneurship* (10th Ed). NY: McGraw Hill. <https://studydaddy.com/attachment/188305/Entrepreneurship+-+10th+edition+-+Hisrich+Peters.pdf>
- [17] Hoque, A.S.M.M., Awang, Z., & Siddiqui, B.A. (2017). Technopreneurial intention among university students of business courses in Malaysia: A structural equation modeling. *International Journal of Entrepreneurship and Small & Medium Enterprise*, 4, 1-16. <https://www.researchgate.net/publication/323642577>
- [18] Jusoh M.A., & Halim, H. (2006). Role of technopreneurs in Malaysian economic. *Journal of Global Business Management*.
- [19] Kautonen, T., Luoto, S., & Tornikoski, E. T. (2011a). Influence of work history on entrepreneurial intentions in “prime age” and “third age”: a preliminary study. *International Small Business Journal*, 28(6), 583–601. <https://doi.org/10.1177%2F0266242610368592>
- [20] Liñán, F. and Y.W. Chen, Y.W. (2009). Development and cross-cultural application of a specific instrument to measure entrepreneurial intentions. *Entrepreneurship Theory and Practice*, 33(3), 593–617. <http://dx.doi.org/10.1111/j.1540-6520.2009.00318.x>
- [21] Miralles, F., Giones, F., & Riverola, C. (2016). Evaluating the impact of prior experience in entrepreneurial intention. *International Entrepreneurship and Management Journal*, 12(3), 791–813. doi:10.1007/s11365-015-0365-4.
- [22] Okorie, N.N., Kwa D.Y., Olusunle, S.O.O., Akinyanmi, A.O., & Momoh, I.M. (2014). “TECHNOPRENEURSHIP: An urgent need in the material world for sustainability in Nigeria,”. Retrieved from: <https://eujournal.org/index.php/esj/article/view/4441>.
- [23] Ong, C.-S., & Lai, J.-Y. (2006). Gender differences in perceptions and relationships among dominants of eLearning acceptance. *Computers in Human Behavior*, 22(5), 816–829. <https://doi.org/10.1016/j.chb.2004.03.006>
- [24] Pallant, J. (2016). *SPSS Survival Manual: A Step-by-Step Guide to Data Analysis Using SPSS Program* (6th ed.). London, UK: McGraw-Hill Education.
- [25] Politis, D. (2005). The process of entrepreneurial learning: a conceptual framework. *Entrepreneurship Theory and Practice*, 29(4), 399–424. <https://doi.org/10.1111%2Fj.1540-6520.2005.00091.x>
- [26] Rivera, J., & Gozun, B. (2019). Estimating the effect of government programs on youth entrepreneurship in the Philippines. *DLSU Business & Economics Review*, 28(3), 112-120. <https://www.dlsu.edu.ph/wp-content/uploads/2019/10/11-rivera-gozum-041519.pdf>
- [27] Kay, R. (1993) A Practical Research Tool for Assessing Ability to Use Computers, *Journal of Research on Computing in Education*, 26:1, 16-27, DOI: 10.1080/08886504.1993.10782074

- [28] Sandhu, M. S., Sidique, S. F., & Riaz, S. (2011). Entrepreneurship barriers and entrepreneurial inclination among Malaysian postgraduate students. *International Journal of Entrepreneurial Behavior & Research*, 17(4), 428-449.
- [29] Singhry, H.B. (2015). The effect of technology entrepreneurial capabilities on technopreneurial intention of nascent graduates. *European Journal of Business and Management*, 7(34), 8-20. <https://doi.org/10.3390/su12166455>
- [30] Tan, W.L., Karl, E., & Mohamed, O. (2010). National Venture competition and technopreneurship development in Malaysia. *Journal for International Business and Entrepreneurship*, 11(2), 69-81. <https://jibe.uitm.edu.my/>
- [31] Tsai, M.J. (2004). Developing the Internet Self-Efficacy Scale (ISES). Association for the Advancement of Computing in Education (AACE). Retrieved from : https://www.researchgate.net/publication/277845893_Developing_The_Internet_Self-Efficacy_Scale_ISES
- [32] Watson, L. (Mar 22, 2016). The importance of technopreneurship today. Medium.com. Retrieved from : <https://medium.com/@luckywatson/the-importance-of-technopreneurship-today-2348cf2311e>
- [33] Wiradinata, T (2014). Insights from Technopreneurship Subjects: The Case of Informatics Engineering Department. Retrieved from <https://dspace.uc.ac.id/bitstream/handle/123456789/934/RS1412053.pdf?sequence=5&isAllowed=y>
- [34] Yurtkoru, E.S., Acar, P., & Teraman, B.S. (2014). Willingness to take risk and entrepreneurial intention of university students: An empirical study comparing private and state universities. *Procedia - Social and Behavioral Sciences*, 150, 834-840. <http://dx.doi.org/10.1016/j.sbspro.2014.09.092>
- [35] Zapkau, F. B., Schwens, C., Steinmetz, H., & Kabst, R. (2015). Disentangling the effect of prior entrepreneurial exposure on entrepreneurial intention. *Journal of Business Research*, 68(3), 639-653. doi:10.1016/j.jbusres.2014.08.007.

Team Teaching: A Blended Learning Tool in Engineering Mathematics

S. R. Sharma

Chitkara University School of Engineering and Technology, Chitkara University, Himachal Pradesh (India).
sita.ram@chitkarauniversity.edu.in

Abstract: In this article we discussed the effects of team teaching (TT) as a blended learning tool in teaching of course Engineering Mathematics, offered to students, bachelor of Engineering in Chitkara University Himachal Pradesh. A case study discussed here for 8 sections (appx.420 students) taught by teachers. Distribution of topics among team members and how we implemented TT as a blended learning tool is discussed here using tables and diagrams. Analysis of TT presented here by means of its merits and demerits. Statistical analysis of improvements in various parameters have also presented here.

Key Words: Team Teaching, Blended learning, Engineering Mathematics, Learning process.

1. Introduction

Blended learning (BL) is the process in which traditional methods of teaching are made more effective by introducing more strategies of teaching, adding new innovations, so that leaning process become more effective and interesting. Different

strategies in transforming this teaching and learning process are being used See, Bates & Sangra, (2011), Andrew, Ewens & Maslin-Prothero, (2015). According to Halverson, Graham, Spring, Drydale and Henrie (2014) and Maurice Taylor, Sait Atas, Shehzad Ghani (2017), BL is an important model of instruction for higher educational institutes. It has advantages like effective communication, good collaboration among students, new knowledge generation and engagement of students, flexibility in teaching learning process and technology oriented learning, Garrison and Kanuka (2004) and Chew (2009). BL makes the learning process more active and gives flexibility to learner. It was observed that learners improved their outcome in terms of results and has excellent learning experiences, Saliba, Rankine & Cortez (2013) and Maurice Taylor, Sait Atas, Shehzad Ghani (2017). John, Tanzania, Rahat and Eliamani (2018) and Chantelle, Elsa and Gerda (2019), in their work focused on collaborative components of BL which helps in making learning environment more cooperative.

Here in our institute, in teaching of Engineering Mathematics course for students of year-1 Bachelor of Engineering (BE) we experimented with TT as a blended learning tool. Before this we were using traditional method of teaching i.e. lecture method, problem solving method etc., in which one teacher teach one class for full semester. Use of various teaching aids like power point presentations, showing videos, use of internet facilities while solving questions, interactive sessions during this formal process of teaching were used McCombs and Miller

S. R. Sharma

Chitkara University School of Engineering and Technology,
Chitkara University, Himachal Pradesh (India).
sita.ram@chitkarauniversity.edu.in

(2007) and Andrew, Ewens and Maslin-Prothero (2015).

Here in this article my aim is to discuss how TT made functional in our institute. Results of improvements due to TT for various parameters like interest of students, attendance in class etc. are analysed using statistical methods. Merits and demerits of TT also discussed here.

2. Current Method of Teaching

There are different methods of teaching mathematics like;

Lecture method

Demonstration method,

Lecture cum demonstration method

Problem solving method

Project method

And many more

In which teacher occupy central position or students occupy central position. Most of the courses of mathematics in our institute are generally learned and taught using traditional methods listed above.

3. Description of Engineering Mathematics-I Course

The course Engineering Mathematics is a major basic course offered in year-1 for all BE students. The course is divided in two parts, Engineering Mathematics-I in odd semester and Engineering Mathematics-II in even semester. Engineering Mathematics-I is offered for 60 hours and is a 5 credit course, it consist of topics like Matrices, Partial Differentiation, Multiple Integral and Vector calculus with almost equal weightage in terms of time and awards. Course is designed in such a way that each topic is application oriented. Student's hands in their application oriented assignments on regular basis and evaluated continuously. Teachers are there to answer queries of students on regular basis. At the end of the semester students take their closed book examination and their marks are determined from end semester examination and records throughout the semester. Students are evaluated out of 100% and a mark of less

than 40% is deemed to be a failure.

4. Why TT

In a class of 60 students, different students have different taste of learning the content. On the other hand a teacher has unique style of teaching. Which may not be suitable for all students? If there is a lack of coordination between teacher, students and contents to be taught, the students will be on the losing end, because they start losing interest during learning process. It's well said by Han (2004) keeps improving the art of teaching.

So keeping in mind the variable learning interest of student's there is a need for TT as a BL tool, McCombs and Miller (2007), Das Lekha, Sharma, Megha (2020).

5. What is TT?

TT is a process of teaching and learning in which a course is taught to students by team of faculty members. Single faculty is not responsible for completion of course but a team teaches course as per their expertise related to contents of the course. The team is answerable for the full course taught.

6. Role of TT in Engineering Mathematics

The course Engineering Mathematics consists of four units and offered for year-1 students of bachelor of technology. There are 8 sections(S-1 to S-8) of almost equal strength and a team of six faculty members [Teacher, T-1 to T-6] was indentified for TT of this course. Course consisting of four units distributed into five different modules for TT. Then topic of interest was taken from each faculty members and on the basis of their topic of interest, a schedule of delivery of lectures was planned as per Table-1, keeping in mind needs of students (Maxwell and White, 2017). The schedule was planned in such a way that teacher got chance to interact with different students in different modules (Mod), so that the teaching learning process become interesting Eison (2010) and Sawhney Sahil, Sharma Kulwant Kumar, Gupta Ankur (2020).

a. Schedule of TT in Engineering Mathematics

TT Schedule Sections

M-Matrices

PD -PD

MI- Multiple Integral

SFVC-Special Function and Vector Calculus

VI-Vector Integral

b. Faculty Assignment for Mod-1 and Mod-2: TT in teaching of Matrices (M) and Partial Derivatives (PD)

Table 1

Sections	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8
Mod-01 12 lectures	M	PD	M	PD	PD	M	M	PD
	T-1	T-2	T-3	T-4	T-5	T-6	T-3	T-4
Mod-02 12 lectures	PD	M	PD	M	M	PD	PD	M
	T-4	T-3	T-5	T-6	T-1	T-2	T-5	T-6
Mod-03 14 lectures	MI	MI	MI	MI	SF VC	SF VC	SF VC	SF VC
	T-3	T-1	T-4	T-1	T-6	T-5	T-6	T-2
Mod-04 14 lectures	SF VC	SF VC	SF VC	SF VC	MI	MI	MI	MI
	T-5	T-5	T-6	T-2	T-3	T-1	T-4	T-1
Mod-05 08 lectures	VI	VI	VI	VI	VI	VI	VI	VI
	T-2	T-6	T-2	T-5	T-4	T-3	T-1	T-3

Topic of interests was taken from each faculty members and on the basis of their topic of their interest teachers identified. T-1, T-3 and T-6 are interested to teach Matrices and T-2, T-4 and T-5 are interested to teach Partial derivatives, see

c. Process of TT in teaching of Matrices (M) and Partial Derivatives (PD)(Mod-1)

So there are two independent units (Matrices and Partial Derivatives) to teach, eight sections to be taught and six numbers of teachers for TT. Contents of two independent units were designed in such a way that each must have equal delivery time and equal weightage. So in Mod-1 consisting of 12 hours we offered Matrices for four sections and Partial Derivatives for remaining sections of students. Each unit has to be completed in 12 lectures. Here in Mod-1, T-1, T-3 and T-6 teaches Matrices to S-1, S-3, S-6 and S-7 and on the other side T-2, T-4 and T-5 teaches Partial Derivatives to S-2, S-4, S-5 and S-8, see Figure-2.

d. TT in teaching of Partial Derivatives (PD) and Matrices (M) (Mod-2)

Mod-2 also consisting of 12 hours here we offered

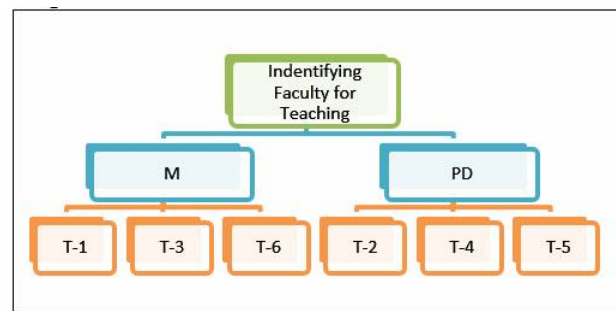


Fig. 1 :Faculty Assignment for Mod-1

Matrices for four sections S-2, S-4, S-5 and S-8 taught by T-1, T-3 and T-6 and Partial Derivatives for remaining sections of students taught by T-2, T-4 and T-5. Each unit is to be completed in 12 lectures, see Figure-3.

So in this way a T-1 is teaching S-1 in Mod-1 and S-5 in Mod-2. Here we found that teachers were more confident, as they have to deliver same topic. It was observed that there is a kind of competition between teachers which strengthen their teaching skills Singer and Stoicescu (2011).

e. Faculty Assignment for Mod-3 and Mod-4: TT in teaching of Multiple Integral (MI) and Special Function and Vector Calculus (SFVC)

Again based on the interests of each faculty member, we identified T-1, T-3 and T-4 are interested to teach Multiple Integral and T-2, T-5 and T-6 are interested to teach Special Function and Vector Calculus see Figure-4.

Similarly in module 3 and 4 two units Multiple Integration and Vector Calculus were chosen and TT

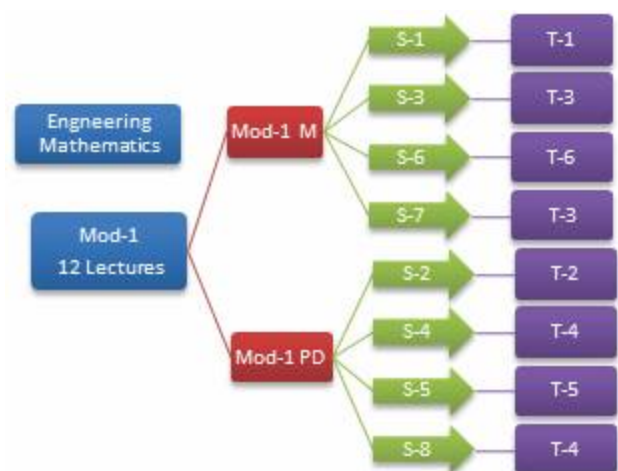


Fig. 2 : Process of TT in Mod-1

applied with same group of faculty members. Each unit was given 14 lectures. Here T-1 is teaching section 2, 4 and 8 in Mod -3 and Mod-4. And in the last module which consist of 8 lectures the group of TT has to teach vector integral. So almost 86.66% of the contents of the course were taught using TT. Remaining 13.34% of the contents were taught by all teachers due to time constraints.

7. Methodology and Results:

At the end of each module attendance of students were analysed and it was found that most of the students were interested in TT. Also teacher was found very active during each module and curious about their interaction with new group of students whenever

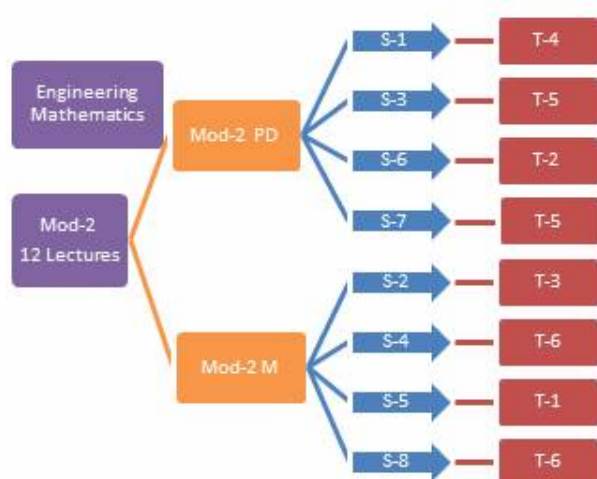


Fig. 3 : Process of TT in Mod-2

modules of teaching changed. Statistical methods were used to analysis various parameters and the outcome is shown in the form of Pi-charts

a. Analysis of Attendance and Marks:

It was noted that Students attendance was better this time as compared to attendance of previous batch of students. The students of current batch performed better as compared to previous batch of students in terms of marks in course Engineering Mathematics, see Table-2

b. Analysis of Interest:

Feedback related to TT was taken from students on prescribed format with three parameters very much interested, interested and not interested It was found that interest of students was on high level. About 71%

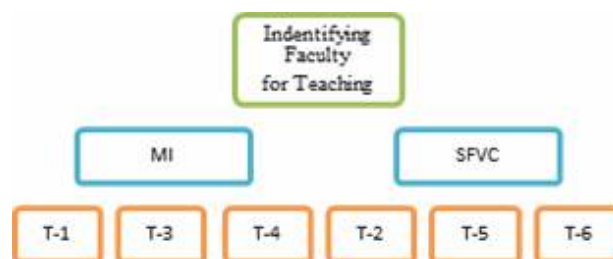


Fig. 4 : Faculty Assignment for Mod-3 and Mod-4

of students shown great interest in TT, only 5% students found not interested in TT and want to study from single teacher, see Figure-5.

c. Analysis of outcome of TT:

Outcome of TT was measured on the basis of five parameters: Excellent, Very good, Good, Average and Poor. It was found that 74% students had given very good and excellent response for TT. Poor responses were noted for only 5% students out of 420 numbers of students see Figure-6.

It was found that there was an improved learning in Engineering Mathematics (Deslauriers, Schelew and Wieman, 2011).

8. Discussion:

Following advantages were observed:

- Student got chance to study from all six teachers.

Table 2 : Analysis of Attendance and Marks

Batch	Previous Batch (412 students)	Current Batch (420 students)
Percentage Average Attendance	80%	89%
Percentage Average Marks	60%	66%

The TT schedule was planned in such a way that student got chance to study from all teachers involved in TT. So students got a balanced type of teaching where they interacted with very intelligent and intelligent teacher, teacher having excellent, very good and good teaching feedback.

- Student Interest was on high level. It was observed that learning interest of students was different than the traditional class room teaching learning

process. Every new module comes with new teacher and hence new content.

- Learning experience of students was great as they were taught by teacher expert of his/her area of expertise. Teachers were identified on the basis of their expertise in the contents of Engineering Mathematics. So here during TT they taught at their best.
- Punctuality: It was observed that students were more punctual than the traditional teaching learning process. So improvement in punctuality

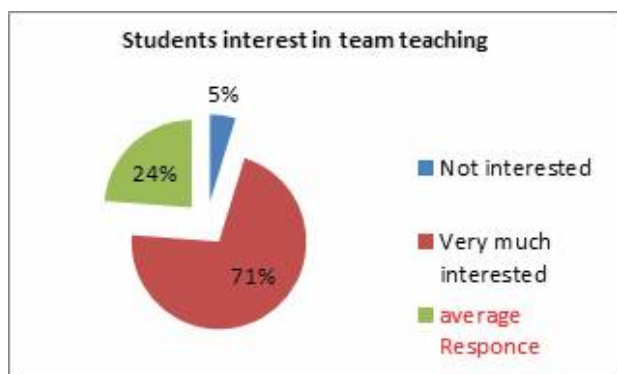


Fig. 5 : Analysis of Interest

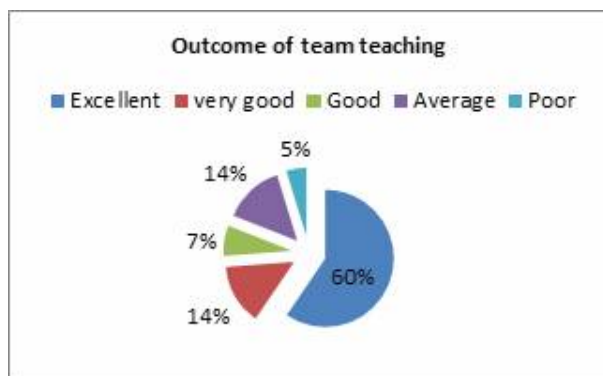


Fig. 6 : Analysis of outcome of TT

of student found. Their class attendance was found more than normal.

- Team spirit observed among teachers. Teachers taking same unit were found interacting with each other through personal meetings or course meetings. How one is teaching other wants to know about it. All were discussing problems got from students and they were found solving the problems as a team.
- Good coordination between teachers found.

Teachers were sharing notes with each other, following teaching style and teaching skills to deal with a particular topic during the course of TT. If a teacher is on leave than the lecture got adjusted between the team members only.

- Strengthening competency of teachers. There was a healthy competition between teachers. Each teacher wants to give their best as he/she wants to be best among team of TT.
- It was found that the passing percentage of students were higher as compared to previous batch.
- Completion of course: The course was completed in all sections on the same day as per the time allotted i.e. in 60 hours.
- More options for students to clear their doubts. In traditional teaching learning process students got an opportunity to interact with only one teacher and clear doubts from the same teacher. But here students got chance to get solution of their problems by interacting with a team of teachers involved in this teaching and learning process with TT as BL tool.

Following disadvantages were observed:

- Lack of bonding between teacher and student. Due to very less time spent by teacher in a particular section the bond between students and teacher was found weak.
- Course design/lecture allotment as per modules [see Table-1], i.e. we have to select contents in such a way that units in each module must be completed at same time, in equal number of lectures.
- Record keeping: Who will keep the records like marks, attendance, assignments etc.? So record keeping was lacking.
- Few students want to study from single teacher and not interested in TT. Some students shared their experiences that different teacher has different style of teaching and they fail to adapt to the teaching style of some teachers in TT of Engineering Mathematics.

- Teachers interest to teach full course. Some

teachers were interested to teach full contents of the course. As full course expertise may help them in further competitive examinations.

9. Conclusions

Change in teaching techniques or method of teaching motivate students for learning. Different methodology in teaching learning process increases the interest of students (Levy H.M. 2008), as well as teachers and is a key tool for BL. So here in this article we found that by means of TT students have shown great interest in this leaning process, improvement in marks and attendance. Good coordination between teachers observed, students got chance to interact with different teachers and learn from his/her teaching skills, improvement in punctuality and results observed. Also Faculty members have to interact with different student's after completion of content of expertise and repeating same content of expertise in other sections of students. Record keeping was a challenge. Few students shown disinterest in TT due to lack of bonding they wanted. There are some advantages and disadvantages in TT but here students have shown huge interest in course, in attending classes of Engineering Mathematics with TT in our institute.

Acknowledgement

Author wants to acknowledge faculty members who were part of TT and made every effort for making TT successful. Author also wants to thanks institute managements for introducing TT in our teaching methodology.

References

- [1] Bates A. W. (2011), Sangra Albert. Managing Technology in Higher Education: Strategies for Transforming Teaching and Learning ISBN: 978-1-118-03856-7.
- [2] Lisa R., Halversona Charles R.,Grahamb Kristian J.,Springa Jeffery S.,Drysdalea Curtis R. and Henriea (2013). A thematic analysis of the most highly cited scholarship in the first decade of blended learning research, 20 , 20-34. <https://doi.org/10.1016/j.iheduc.2013.09.004>
- [3] Garrison R., & Kanuka H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education*, 7, 95 - 105 . doi:10.1016/j.iheduc.2004.02.001
- [4] Chew E. (2009). A blended learning model in higher education: A comparative study of blended learning in UK and Malaysia (Doctoral dissertation). University of Glamorgan.
- [5] Saliba G., Rankine, L. & Cortez, H. (2013). *Fundamentals of Blended Learning*. University of Western Sydney.
- [6] John Marco Pima, Tanzania Michael Odetayo, Rahat Iqbal and Eliamani Sedoyeka (2018). A Thematic Review of Blended Learning in Higher Education. *International Journal of Mobile and Blended Learning (IJMBL)* 10(1),1-11.
- [7] Eison J. (2010), Using active learning instructional strategies to create excitement and enhance learning. Centre for Teaching Excellence at Cornell University. Retrieved from www.cte.cornell.edu.
- [8] Maxwell C. and White J. (2017). Blended (R) Evolution: How 5 ts are modifying the Station Rotation to fit students' needs. *Christensen Institute*. 7 and 23.
- [9] Singer F.M. and Stoicescu D. (2011). Using blended learning as a tool to strengthen teaching competences. *Procedia Computer Science*, 3, 1527--1531.
- [10] Levy H.M. (2008). Meeting the Needs of All Students through Differentiated Instruction: Helping Every Child Reach and Exceed Standards. *Clearing House*, 81(4), 161--164.
- [11] Deslauriers L., Schelew E., and Wieman C. (2011). Improved learning in a large-enrolment physics class. *Science*, 332, 862--864.
- [12] Han Z. (2004). Keep improving the art of teaching in Calculus. *The China Papers*, 4.
- [13] Maurice Taylor, Sait Atas, Shehzad Ghani (2017), Exploring the Experiences of Students and Professors in a Blended Learning Graduate Program: A Case Study of a Faculty of Education *International Journal of Mobile and Blended Learning (IJMBL)*, 9(1), 1-15

- [14] McCombs B. L. and Miller L. (2007). Learner-centered classroom practices and assessments: Maximizing student motivation, learning, and achievement. Thousand Oaks, CA: Corwin Press. (47).
- [15] Andrew L., Ewens B. and Maslin-Prothero, S. (2015). Enhancing the online learning experience using virtual interactive classroom. *Australian Journal of Advanced Nursing*, 32(4), 22--31.
- [16] Das Lekha, Sharma, Megha (2020). Case Study: Use of MOODLE to Improve Teaching Learning Process in Control System Engineering. *Journal of Engineering Education Transformations*, [S.l.], 43-47. ISSN 2394-1707. doi:10.16920/jeet/2020/v33i3/144640.
- [17] Sawhney Sahil, Sharma Kulwant Kumar, Gupta Ankur (2020). Penetration and Prevalence of Strategic Management in Higher Education Institutions in India. *Journal of Engineering Education Transformations*, [S.l.], 7-18. ISSN 2394-1707. doi:10.16920/jeet/2020/v33i3/138205.

Peer-Observation: An Intensive Study and its Impact On the Teaching-Learning Process

Devendra Rawat¹, Nilima Salankar², Monit Kapoor³

¹Assistant Professor, School of Engineering, University of Petroleum & Energy Studies, Dehradun, India

²Associate Professor, School of Computer Science, University of Petroleum & Energy Studies, Dehradun, India

³Chitkara University Institute of Engineering and Technology, Chitkara University, Punjab, India

¹d.rawat@ddn.upes.ac.in,

²nsfulmare@ddn.upes.ac.in

³monit.kapoor@chitkara.edu.in

Abstract : Peer observation in teaching-learning significantly impacts students' learning and understanding experience. It improves the quality of the content delivery by the instructor and provides the learning opportunity to observer also. It is threefold learning from all perspectives. Thus, it is a collaborative idea sharing and achieving excellence by incorporating the best of others. Authors have experimented with the peer observation and feedback strategy to improve students' academic performance and overall teaching cum teaching experience. One semester activity has been conducted to conclude the significance of the study with the help of z and t statistics parameters with alpha value 0.05. Different peer observations are taken into consideration and incorporated to improvise the teaching-learning experience of facilitator and student. As a result, it has been found very helpful and impactful on the students' performance and the development of an instructor's teaching style. Peer observation helps explore the

different approaches that help adapt to future challenges in analogical instructional approaches.

Keywords : peer observation, self-reflection, higher education, academic practices, teaching-learning process.

1. Introduction

With the advent of technology, higher education has become very challenging. Peer Observation [1-4] is a beneficial and vital process of academic development in these challenging situations. This work aims to enhance the teaching-learning process by observing the peer(s). It has many advantages[5-8] like improvement in the teaching process; it helps gain confidence (Bell 2005). Peer observation is an activity, where peer(s) observe each others, they learn and share best practices it is conducive [4] but generally faculty members avoid it. It is not only limited to academics to ensure outcome-based learning but also incorporates the industries and corporates to imbibe the feelings of team building. Some organizations are also using it for appraisals and promotions because it can highlight the individual's strengths and weaknesses. Bell, M. and Cooper, P. (2014) suggested the formation of departmental peer observation groups [10] in the universities. Bell (2013) has also suggested and supported this peer group formation [15] in the departments. Z S SIDDIQUI et al. suggested twelve tips [13]

Devendra Rawat

Assistant Professor, School of Engineering,
University of Petroleum & Energy Studies, Dehradun, India
d.rawat@ddn.upes.ac.in,

for peer observation of teaching enlisted are

1. Choose observer carefully.
2. Set aside time for peer observation
3. Clarify expectations
4. Familiarize yourself with the course
5. Select instrument wisely
6. Include students while formalizing
7. Be objective
8. Resist the urge to compare with your teaching style
9. Do not intervene
- 10 Follow general principles of feedback
11. Maintain confidentiality
12. Make it a learning experience.

These techniques are beneficial and effective in peer observation. Peer observation helps groom new persons in academics [25] by providing them motivation, confidence, and exposure. They can learn and find the best environment to create a great experience of learning and exposure. Primarily peer observation is an opportunity to improve the quality of teaching [19]. Peer observation helps in identifying the shared pool of best practices. These best practices will improve the efficiency of teaching-learning and students' interest in optimized learning. Erika Daniels et al. [34] support the development of a forum where enthusiastic practitioners can share their best ideas and practices that can support the growth of a teacher and provide motivation and an improved environment of learning to the students. Jacinta Brix et al. [35] investigated the peer review of teaching in schools (K-12) education and found it much effective to be used. Fred-Ole Sandt (2012) describes the peer observation-action research project that focuses and considers various issues like resistance to peer observation, contexts of power relations in this process, and peer observation for professional development, not for performance evaluation [36]-[38]. The survey says that 55% of teachers want to participate in this process because they desire to improve and build reflective practices continuously. The paper structure has been

organized into six sections. Section II presents the material and methods, Section III talks about the observations, section IV discusses the study's results and discussion, section V describes the learning and best practices, and finally, section VI presents the conclusions and future work.

2. Material And Methods

A. Material

Teaching data of complete one semester has taken into consideration for screening subjects under control and experiment group. The screening semester ranges from Jan 2019-June 2019, segregated into various evaluation stages. Evaluation stages involve 1. Test 2. Quiz 3. Assignments 4. Mid Semester Exam 5. End Semester Exam. Test quiz and assignments are internal assessment that has 30%

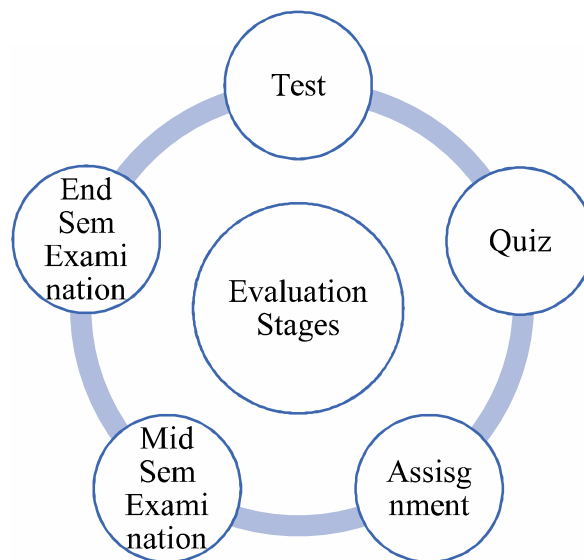


Fig. 1: Evaluation Stages

Table I Assigned Weightage for evaluation.

Evaluation Stages	weightage
Test+Quiz+Assignment(Internal Assessment)	30%
Mid Semester	20%
End Semester	50%

Weightage, mid-semester examination has 20% and end semester exam has 50% weightage in the evaluation as shown in table I. The Test, quiz, and assignments appear twice for evaluation; one set before the mid-semester and another after the mid-semester. The criteria set for screening was the

average marks of all the components considered under the evaluation stages. A population size of 103 is considered for the study purpose, out of which 50 students are in the experimental group, and the control group holds the data of 53 students. Moreover, the experimental group includes students whose average marks of all the aforementioned components under the evaluation stages are 60-75. Students scoring more than 75 marks were put in the control group. Size of the control group (53×8) as eight evaluations has been carried out and experimental group (50×8). All students were medically fit to pursue their four-year Bachelor of Engineering degree. The main objective of conducting this study is to check the impact of the inclusion of peer observations in order to improvise the teaching style and how it would influence the learning experience of the experimental group. However, the traditional teaching method has been continued with the control group. In order to verify the impact of the proposed intervention, in the form of peer feedback, the next semester July 2019-Dec 2019, has taken for the subject, which requires higher-order thinking skills, and the experimental group has been exposed to interventions-based teaching methods, whereas the control group was treated with regular teaching practice.

B. Intervention Used

As shown in Figures 2 and 3, the pilot scheme incorporated has been used as part of the intervention, and the attainment level achieved is tested for both groups.

C. Hypothesis Tested

H0: Intervention has no impact on the attainment level of students.

H1: Intervention has a significant impact on the attainment level of students

D. Statistical Study of Parameters

A statistical test has been used to check the relevancy of the results. z statistics have been used to analyze the impact of the proposed intervention on academic performance, which gradually leads to an increase in attainment level. A t-test is used to analyze significance between non-control (experimental) and control groups. As well ANOVA test has been carried out for comparison purposes.

The entire study has been carried out to evaluate the effectiveness of peer observation and improve the performance of students and the instructor by incorporating the best practices. Peer observation and feedback modes effectively enhance the teaching-learning experience [25]. Peer observation is an opportunity to share and support the best academic practices that are very helpful in attaining quality education[40]. Based on the peer observation protocol, different peers have to attend the session of each other and provide reflections about teaching-learning. The objective of this activity was to assess the students learning effectiveness and identify the best collaborative practices with the following vital highlights.

1. The extent of achievement on learning outcomes with applied teaching pedagogy, modality, and resources.
2. The extent of learner's interaction and participation.

Figures 2 and 3 describe the peer observation process and a pilot scheme in detail [19]. This process involves various sub-steps in all three stages of peer observation.

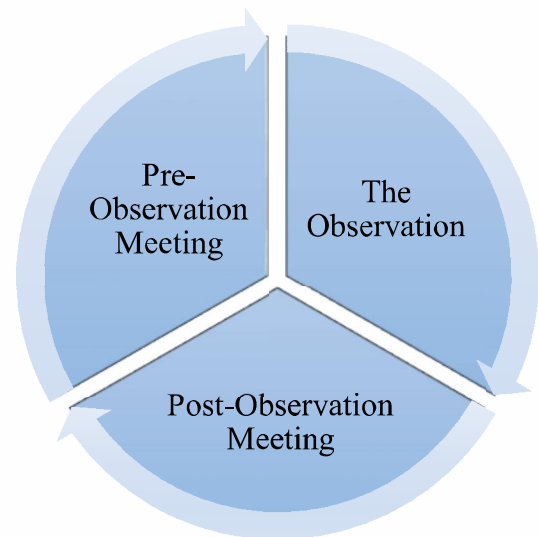


Fig.2: Peer Observation & Collaborative reflection [19]

The entire process has been executed twice in one semester. As per the designed pilot study, significant objectives have been achieved. During the observation, the adopted teaching methodology and its effectiveness were analyzed. The assessment parameters solely depend upon student learning

effectiveness (by student's interactions and classroom management). As a part of the improvement and outcome of this study, participants were expected to develop a capacity to anticipate and respond to change and practice collaborative learning techniques. As described by Martin, Graham A., and Jeremy M. Double [9], pre-observation meetings and pilot schemes (shown in Figures 2 and 3) were followed in pre-observation and post-observation forms.



Fig. 3 : Pilot Scheme of Peer Observation [19]

3. Observations

Observation plays a vital role in every experimental process. The various levels of observation called- observation cycle are enlisted in Figure 4.



Fig. 4 : The Observation cycle

During pre-observation, peers were made acquainted with the rules and regulations to be followed. It is mandatory that no comparison has to be done for self and presenter teaching style during observation feedback, as everybody has one(s) teaching style. Sharing of prescribed forms has been done during this course of time [9]. During the post-observation meeting, the results of the entire activity were reported and finalized.

Table 2 : Statistical Values For Control and Experimental Group

	Control Group	Non-Control Group	Control Group	Non-Control Group
	z-statistics		t-statistics	
Blended mode for content delivery	1.76	2.34	1.55	3.12
Style of initiation of class and its impact on engagement during the entire course of the session	1.23	3.23	1.52	4.23
Collaborative exercise and its impact on critical thinking	1.45	3.12	1.34	3.45
Usage of technology freedom during the session	1.34	3.12	1.23	4.23
Raise attainment level of weak students	1.77	3.56	1.56	3.12
Frequent questioning session during session	1.45	4.23	1.23	4.56
Note of eye contact	1.34	3.45	1.45	2.12

Alpha Value=0.05 t value 1.6651 z value 1.8922

The benefits of this experimentation have been reported in various ways, and it has been proven effective in reflectively understanding the teaching style as suggested by Hammersley- Fletcher, Linda, and Paul Orsmond [6]. Key observations are based on statistical differences between two groups control group, and the experimental group has been analyzed based on performance as shown in TABLE II.

A. Pre-observation Meeting

The idea behind this meeting was to explain the pre-observation as a process to both the observer and the person to be observed [19]. The pre-observation meeting aimed to finalize the common agenda and attributes to observe. Peers' pre-observation forms were shared among the peer groups well before time. Table III presents the attributes considered for observing the sessions.

Table 3: Attributes of the experiment

S.No	Attribute
1	Aim/objective/outcomes to be achieved during this session
2	Description of the student's profile and their understanding level.
3	Teaching pedagogy to be adopted with appropriate reason for students' needs and equal opportunities
4	Session plan: contents to be covered with time duration
5	Scope for participation & interaction.
6	Techniques to be applied to measure the extent of the student's learning during this session
7	Resources used.

B. Post Observation Meeting

Post observation meeting is a feedback-sharing meeting, which aims to identify the positive traits of the observed person and areas of improvement.

After the peer observation, the observer shared the observation as highlighted in Table III below. This exercise in two cycles and mutual discussion among the peer groups; as a result, all the peers involved identified and picked some good practices. This post-observation meeting aimed to develop higher education teaching skills through peer observation and collaborative reflection, as suggested by Martin, Graham A., and Jeremy M. Double [19]. Post-observation meeting reflects the learnings in the observation by the observer. Pre observation attributes were the basis for this observation, and twelve tips of peer observation, as suggested in [13], provided the guidelines. The learnings and best practices which were the outcomes of this study are presented in section IV. These learnings and best practices are quite helpful for students and the instructor; they show enthusiasm in instructor and motivate the students. These techniques are a tool to achieve student attention & involvement. The adopted best practices and pedagogical methods were

Table 4 :Observed Attributes

S.No	Attribute
1	The content was delivered with full understanding. Students were interactive during the session. Communication was good. The content was delivered in such a way that all the students were able to focus. Relevant examples made clarity in the content.
2	Students raised several questions and were well answered by peer members. The peer member was very enthusiastic during the lecture. The biggest motivation was the applications of these algorithms.
3	Following tools were utilized in the delivery of the lecture. 1. Powerpoint presentation. 2. Whiteboard and Marker.
4	Yes, Students were attentive they were asking questions and involved in the process.
5	Classroom management was good. It involved all the students it can further be improved by asking questions to the students in a critical thinking way.
6	The content was delivered with full understanding. Students were interactive during the session. Communication was good. The content was delivered in such a way that all the students were able to focus. Relevant examples made clarity in the content.
7	Asking questions can improve the attention of students this can make the content delivery effective. Peer members effectively utilized the technique of questioning.
8	Yes to the maximum extent. Clear and timely feedback is very important. Peer member has effectively given feedback when students answered the questions.

integrated into the classroom activities based on the observations. This activity is constructive and impactful on student performance, as the instructor can create students' interest by using these best practices identified. Table IV contains the observed attributes below.

4. Results And Discussion

With an intent to adopt best practices in teaching style, this study was conducted on the experimental group. The significance of the strategy adopted and its effectiveness has been observed by the level of rising of an attainment level as per the designed hypothesis, and as shown in Table II null hypothesis has been successfully rejected by the control group.

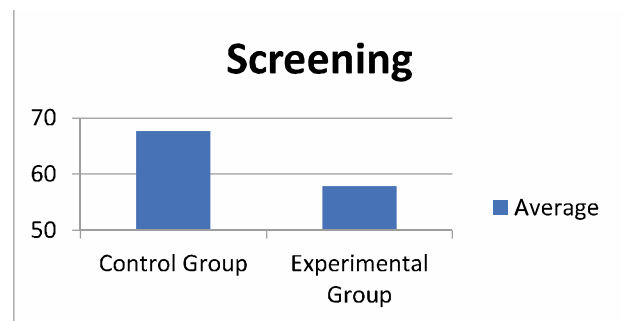


Fig. 5. Student's performance consolidated for screening pre-intervention

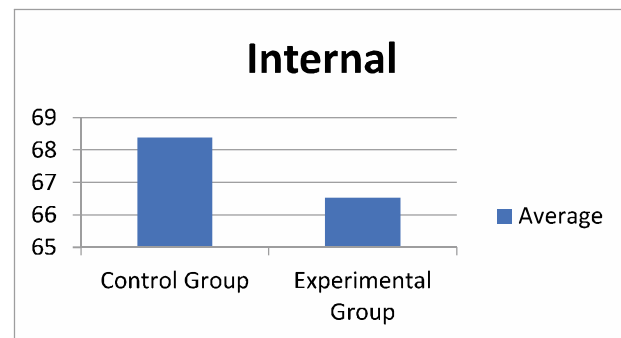


Fig. 6.: Student's internal performance post-intervention

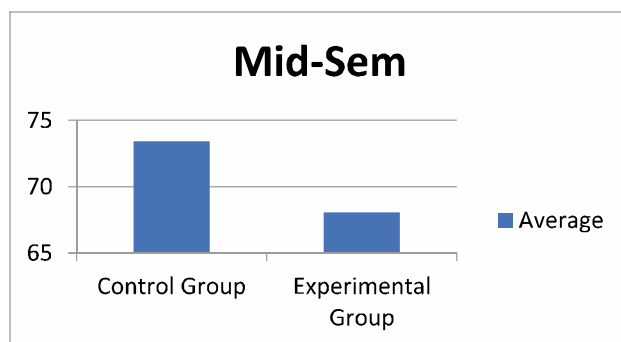


Fig.7. Student's Mid Sem performance post-intervention

In contrast, none of the observed parameters has fulfilled those criteria for the experimental group. Thus, it is proven a very effective intervention strategy to raise the teaching and learning level, and its impact is proven two-fold for the facilitator and the audience. Based on students' average marks, an initial screening was performed, and students were divided into two groups: the control group and the experimental group. Figure 5 shows the results for screening. Both group students' performance in all stages of evaluation criteria is compared and presented in Figure 6-8. It shows improvement in both segments. Figures 6 and 7 show the student's internal and mid sem performance post-intervention; this is higher for the control group due to this control group having level 3 CIA (cumulative internal assessment). Figure 8 shows the end semester performance of both groups; here, the experimental group has higher average marks, which resulted in improved performance and higher-level achievement. This was our intended objective. Therefore, due to this peer observation, the experimental group showed improved performance.

Figure 9 shows the consolidated performance of both groups. Figure 10-11 shows the attainment level achieved to assess the students learning outcome. Figure 12 and 13 shows the attainment levels of each course outcome (CO) in End semester examination. It has three attainment levels named Level* 1, 2, and 3, shown in Table V.

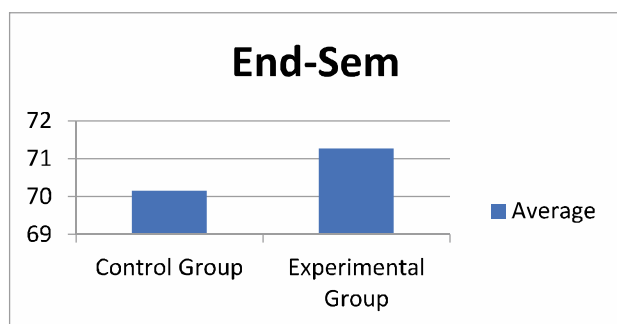


Fig. 8 : Student's End Sem performance post-intervention

Table 5: Attainment levels

Level 1	40% of the class strength scores more than 50% of the total marks in the examination
Level 2	50% of the class strength scores more than 50% of the total marks in the examination
Level 3	60% of the class strength scores more than 50% of the total marks in the examination

CIA is a cumulative internal assessment that contains test quizzes and assignments components. The experimental group achieved Level 3 in end-semester exams and level 2 in CIA, while the control group achieved level 2 in end-semester and level 3 in CIA; this proves the effectiveness of the proposed method.

The effectiveness of the proposed intervention has reflected in our study and is well presented in Figure 9. During the screening process, the index value is 9.73, which is the difference between the control and experimental group, and our set hypothesis has to reduce this index value. For reducing the index value difference, we focused on the experimental group by conducting multiple activities under the internal assessment criterion, and the result has shown the index value difference to 1.84, which is gradually improved. Though the proposed intervention has not shown promising results during mid-semester evaluation on the experimental group, it has risen from 1.84 to 5.35. However, the reason might be because of high course coverage compared to internal assessment. The experimental group still needs more special attention sessions to reduce the index value difference. Therefore, we have rigorously introduced interventions in a group activity to cover the maximum portion of the syllabus after mid-semester. The outcome positively impacts the experimental group's performance in the end semester examination by raising the index difference value -1.12. The range of difference index has deviated from $9.73 \rightarrow 1.84 \rightarrow 5.35 \rightarrow -1.12$. In literature [40-42], authors have presented the impact of peer observation and its inclusion to improve student performance. In [40], Paul A.K presented a study of implementation of peer-observation to enhance and improve the performance of instructor(s).

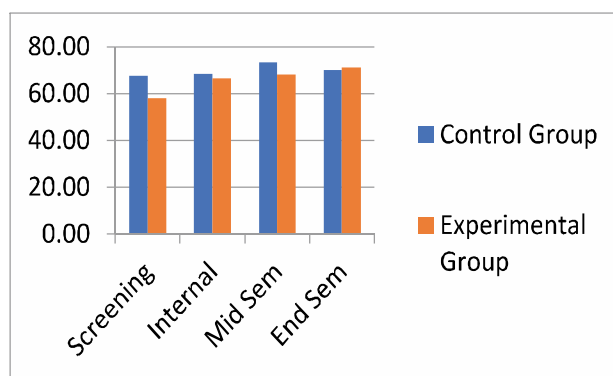


Fig. 9 : Consolidated impact of pre and post-intervention

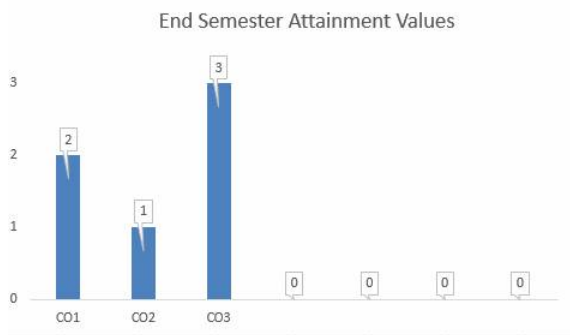


Fig. 10 : Student's attainment Experimental Group

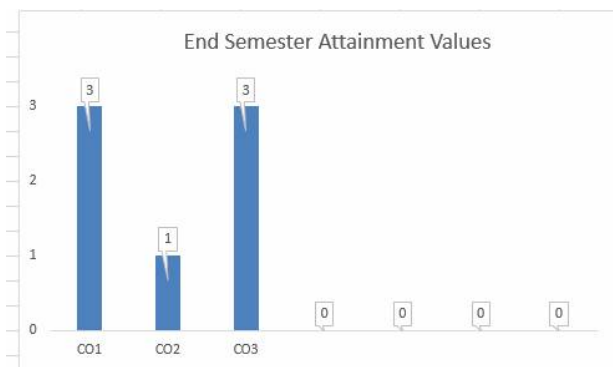


Fig. 11: Student's attainment Control Group.

Overall Attainment of Basic Electronics Engineering (ECEG-1002) (CO wise):						1.99
Overall Attainment of Basic Electronics Engineering (ECEG-1002) (End-Total Marks, Remaining as per CO wise):						1.99
50% of CIA Attainment+50% of End Semester Attainment of Basic Electronics Engineering (ECEG-1002):						1.83
50% of CIA (Total Marks) Attainment+50% of End Semester (Total Marks) Attainment of Basic Electronics Engineering (ECEG-1002):						2.5

Table: Achieved Attainment Levels Info							
Criteria	CO1	CO2	CO3	CO4	CO5	CO6	CO7
Class Test Quiz-1	Level-3 Achieved	Level-3 Achieved					
Class Test Quiz-2		Level-3 Achieved	Level-2 Achieved				
Assignments/Tutorials	Level-3 Achieved	Level-3 Achieved	Level-3 Achieved				
Mid Semester	Level-2 Achieved	NOT Achieved	NOT Achieved				
CIA	Level-3 Achieved	Level-1 Achieved	Level-1 Achieved				
End Semester	Level-2 Achieved	Level-1 Achieved	Level-3 Achieved				
Avg. Attainments of CIA+END	Level-3 Achieved	Level-1 Achieved	Level-2 Achieved				
CIA (Total Marks)				Level-3 Achieved			
End Semester (Total Marks)				Level-2 Achieved			

Fig. 12 : CO Level achieved (Experimental Group)

Overall Attainment of Basic Electronics Engineering (ECEG-1002) (CO wise):							2.25
Overall Attainment of Basic Electronics Engineering (ECEG-1002) (End-Total Marks, Remaining as per CO wise):							2.6
50% of CIA Attainment+50% of End Semester Attainment of Basic Electronics Engineering (ECEG-1002):							1.8
50% of CIA (Total Marks) Attainment+50% of End Semester (Total Marks) Attainment of Basic Electronics Engineering (ECEG-1002):							2.5
Table: Achieved Attainment Levels Info							
Criteria	CO1	CO2	CO3	CO4	CO5	CO6	CO7
Class Test Quiz-1	Level-3 Achieved	Level-3 Achieved					
Class Test Quiz-2	Level-3 Achieved	Level-3 Achieved	Level-3 Achieved				
Assignments/Tutorials	Level-3 Achieved	Level-3 Achieved	Level-3 Achieved				
Mid Semester	Level-3 Achieved	NOT Achieved	NOT Achieved				
CIA	Level-3 Achieved	Level-1 Achieved	NOT Achieved	NOT Achieved	NOT Achieved	NOT Achieved	NOT Achieved
End Semester	Level-3 Achieved	Level-1 Achieved	Level-3 Achieved				
Avg. Attainments of CIA+END	Level-3 Achieved	Level-1 Achieved	Level-2 Achieved				
CIA (Total Marks)				Level-3 Achieved			
End Semester (Total Marks)				Level-3 Achieved			

Fig.13 : CO Level achieved (Control Group)

5. Learnings And Best Practices

Peer observation exercise was a successful experiment performed in one module. It facilitated the teaching-learning process largely. It was proven as an effective technique for enhancing the students learning. While performing the observations, a few best practices and learnings were listed. Table VI presents the summary of these best practices and learnings.

Table 6 : Best Practices and Learnings

Lectures may be more effective by using teaching methodologies that give students attention.
Always try to connect with students through more and more interactions.
The use of Collaborative techniques helps students in more gaining.
Make the session outcome-based. Keep the session outcomes ready and assess them at the end of a session by asking questions for 2 minutes at the end of the session.
Be the facilitator of the session; guide them for their better understanding.
Practice using the reflective journal for our sessions that will help us identify our class's observations and behaviour in particular situations.
Feedback is essential; always try to give meaningful feedback quickly. It should also reflect the area of improvement.
21st-century education demands changes; we learned to identify those changes and be reflective in following those changes.
The instructional strategies at the course and unit levels effectively improve content delivery. Using Bloom's taxonomy helps us design the course objectives, course outcomes, and unit learning objectives [3].
Academic integrity is the very fundamental thing in the teaching-learning process. We should instruct students and motivate them to follow academic integrity.

6. Conclusion

Peer Observation is the collaborative idea sharing and achieving excellence by sharing the best practices. It is very much effective in the teaching-learning process. With the growth in technology, learner's aspects are also increasing. We conducted the peer-observation experiment among the peers, which improved the students' performance and given a chance to improve the instructor's teaching style. The significance of this study was vetted by z and t statistics parameters. As a result, it is incredibly

beneficial and effective on student performance and developing an instructor's teaching style.

Peer observation gives the collaborative techniques among a group of peers of different expert domains. These collaborative techniques help students gain more insights of the subject and make the sessions more interesting for them. In addition, if an instructor is reflective in his practices, he will be ready to cope with the changes coming with the advent of technology. Therefore, peer observation is for the three-fold benefit, i.e. for the learners and other peer groups.

Acknowledgment

This entire experimental study has been carried out as a part of a certification program PGCAP (Postgraduate certification in academic practices) executed at UPES University of Petroleum and Energy Studies, Dehradun, India. I would like to express my sincere gratitude to UPES, team PGCAP, and the Department of Electrical & Electronics Engineering, for their continuous motivation and support during the experimental study. My sincere thanks to my students who are an integral part of this study.

References

- [1] <https://www.education.vic.gov.au/school/teachers/teachingresources/practice/improve/Pages/peerobservation.aspx>
- [2] <https://onefaculty.laureate.net/>
- [3] Fletcher, Jeffrey A. "Peer observation of teaching: a practical tool in higher education." *The Journal of Faculty Development* 32.1 (2018): 51-64.
- [4] Cosh, Jill. "Peer Observation in Higher Education--A Reflective Approach." *Innovations in education and training international* 35.2 (1998): 171-176.
- [5] Seaman, Mark. "BLOOM'S TAXONOMY." *Curriculum & Teaching Dialogue* 13 (2011).
- [6] Scanlan, Craig L. "Strategies to promote a climate of academic integrity and minimize student cheating and plagiarism." *Journal of allied health* 35.3 (2006): 179-185.
- [7] Bell, Maureen. "Supported reflective practice: a program of peer observation and feedback for academic teaching development." *International Journal for Academic Development* 6.1 (2001): 29-39.
- [8] Bell, A., & Mladenovic, R. (2008). The benefits of peer observation of teaching for tutor development. *Higher Education*, 55(6), 735-752
- [9] .Bell, M. (2001). Supported reflective practice: a programme of peer observation and feedback for academic teaching development. *International Journal for Academic Development* 6(1), 29-39.
- [10] Bell, M., & Cooper, P. (2014). Implementing departmental peer observation of teaching in universities. In Sachs, J., & Parsell, M. (Eds.), *Peer review of learning and teaching higher education: International perspectives*. (151 – 164). Springer.
- [11] Hamersley-Fletcher, Linda, and Paul Orsmond. "Reflecting on reflective practices within peer observation." *Studies in higher education* 30.2 (2005): 213-224.
- [12] Chism, N. (2007). *Peer review of teaching: A sourcebook* (2nd ed.). Bolton, MA:
- [13] Siddiqui, Zarrin Seema, Diana Jonas-Dwyer, and Sandra E. Carr. "Twelve tips for peer observation of teaching." *Medical teacher* 29.4 (2007): 297-30
- [14] Donnelly, Roisin. "Perceived Impact of Peer Observation of Teaching in Higher Education." *International Journal of Teaching and Learning in Higher Education* 19.2 (2007): 117-129.
- [15] Bell, Maureen, and Paul Cooper. "Peer observation of teaching in university departments: A framework for implementation." *International Journal for Academic Development* 18.1 (2013): 60-73.
- [16] Shortland, Sue. "Peer observation: A tool for staff development or compliance?." *Journal of further and higher education* 28.2 (2004): 219-228.
- [17] Bell, Amani, and Rosina Mladenovic. "The benefits of peer observation of teaching for tutor

- development." *Higher Education* 55.6 (2008): 735-752.
- [18] Norbury, Linda. "Peer observation of teaching: A method for improving teaching quality." *New Review of Academic Librarianship* 7.1 (2001): 87-99.
- [19] Martin, Graham A., and Jeremy M. Double. "Developing higher education teaching skills through peer observation and collaborative reflection." *Innovations in Education and Training International* 35.2 (1998): 161-170.
- [20] Woldegiorgis, Emnet Tadesse. "Conceptualizing harmonization of higher education systems: The application of regional integration theories on higher education studies." *Higher Education Studies* 3.2 (2013): 12.
- [21] Thomas, Susan, et al. "A qualitative review of literature on peer review of teaching in higher education: An application of the SWOT framework." *Review of Educational Research* 84.1 (2014): 112-159.
- [22] Cosh, Jill. "Peer observation: a reflective model." (1999): 22-27.
- [23] Sullivan, Peter B., et al. "Peer observation of teaching as a faculty development tool." *BMC medical education* 12.1 (2012): 26.
- [24] Blackwell, Richard. "Peer observation of teaching & staff development." *Higher education quarterly* 50.2 (1996): 156-171.
- [25] Hammersley-Fletcher*, Linda, and Paul Orsmond. "Evaluating our peers: is peer observation a meaningful process?." *Studies in higher education* 29.4 (2004): 489-503.
- [26] Carroll, Conor, and Deirdre O'Loughlin. "Peer observation of teaching: enhancing academic engagement for new participants." *Innovations in Education and Teaching International* 51.4 (2014): 446-456.
- [27] Swinglehurst, Deborah, Jill Russell, and Trisha Greenhalgh. "Peer observation of teaching in the online environment: an action research approach." *Journal of computer-assisted learning* 24.5 (2008): 383-393.
- [28] Mento, Anthony J., and Andrea Giampetro-Meyer. "Peer observation of teaching as a true developmental opportunity." *College Teaching* 48.1 (2000): 28-31.
- [29] Yield, Jenny, Saranne Weller, and Ian Kinchin. "Peer observation of teaching: The interaction between peer review and developmental models of practice." *Journal of Further and Higher Education* 38.4 (2014): 465-484.
- [30] Byrne, Jenny, Hazel Brown, and Doreen Challen. "Peer development as an alternative to peer observation: A tool to enhance professional development." *International Journal for Academic Development* 15.3 (2010): 215-228.
- [31] Blackmore, Jacqueline A. "A critical evaluation of peer review via teaching observation within higher education." *International Journal of Educational Management* 19.3 (2005): 218-232.
- [32] Marshall, Brian. "Learning from the academy: From peer observation of teaching to peer enhancement of learning and teaching." *Journal of adult theological education* 1.2 (2004): 185-204.
- [33] Lomas, Laurie, and Gill Nicholls. "Enhancing teaching quality through peer review of teaching." *Quality In higher education* 11.2 (2005): 137-149.
- [34] Daniels, Erika, Ron Pirayoff, and Steve Bessant. "Using Peer Observation and Collaboration to Improve Teaching Practices." *Universal Journal of Educational Research* 1.3 (2013): 268-274
- [35] Brix, Jacinta, Peter Grainger, and Angela Hill. "Investigating mandatory peer review of teaching in schools." *Australian Journal of Teacher Education* 39.4 (2014): 5.
- [36] Fred-Ole Sandt (2012) Peer Observation Action Research Project, School Leadership & Management, 32:4, 355-373, DOI: 10.1080/13632434.2012.712511
- [37] Salankar, N., Koundal, D., & Hu, Y. C. (2021). Impact on the personality of engineering students based on project- based learning. *Computer Applications in Engineering Education*.

- [38] Nilima, S. Impact of Rubrics, Addie and Gagne Model on the Performance of Students in Programming. Evidence from a field experiment in English secondary schools. *Journal of Labor Economics*, 39(4), 1155-1186.
- [39] Paul, A. K. (2021). Enhancing Performance of Teachers through Peer Observation: A Critical Review for Implementation In Bangladeshi Colleges. *International Journal of Asian Education*, 2(1), 64-78.
- [40] Burgess, S., Rawal, S., & Taylor, E. S. (2021). Teacher peer observation and student test scores: [41] Hendry, G. D., Georgiou, H., Lloyd, H., Tzioumis, V., Herkes, S., & Sharma, M. D. (2021). 'It's hard to grow when you're stuck on your own': enhancing teaching through a peer observation and review of teaching program. *International Journal for Academic Development*, 26(1), 54-68.

Journal of Engineering Education Transformations (JEET)

Call for Papers

Journal of Engineering Education Transformations (JEET) is a forum to facilitate conversations among engineering educators who would like to showcase their transformational work as publications reviewed by expert educators from across the world. Indo US Collaboration for Engineering Education (IUCEE) is publishing this Journal in partnership with Rajarambapu Institute of Technology. "Journal of Engineering Education Transformations" is a transformed version of "The Journal of Engineering Education", which was being published by a pioneer of engineering education, Prof. Ratnalikar, since 1985.

Types of Papers:

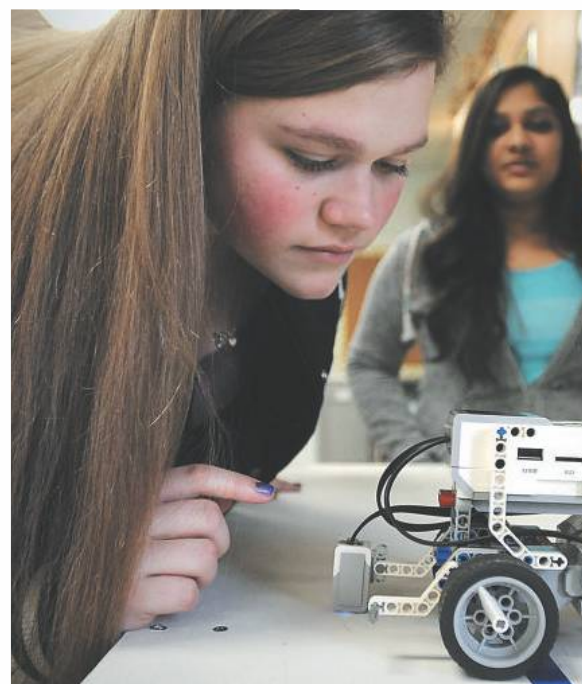
Authors are invited to submit manuscripts for following sections: Research Articles, Emerging Issues, and Best Practices and Short Communication. Manuscripts should report original research that contributes significantly to the body of knowledge in the field of engineering education. Quantitative, qualitative, and mixed methods research designs are accepted. The JEET generally publishes two types of manuscripts: empirical investigations and research reviews.

Author's Guidelines

- Manuscripts are accepted only in English. British English spelling and punctuation are preferred.
- Submitted manuscripts must not have been published as copyrighted material nor be submitted for consideration for publication as copyrighted material while in review by the Journal, whether in print or electronic form. By submitting a manuscript, the author(s) agree that the copyright will be transferred to JEET if the manuscript is accepted for publication.
- The manuscript pages are expected to fall between 15 to 25 pages, including references. Manuscripts that greatly exceed the word limit will be critically reviewed with respect to length. Authors should include a word count with their manuscript.
- Abstracts of 250 words are required for all manuscripts submitted. A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone.
- Each manuscript should have 2 to 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, "and", "of"). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible.
- Manuscripts must be submitted in electronic form only at the Journal's Web site: <http://www.journaleet.org/>



Published by
KE Society's
Rajarambapu Institute of Technology
Rajaramnagar, Maharashtra, India



www.journaleet.in