

Instructional Design of Engineering Courses with Online Certifications - Reflections and Experiences

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Abstract— Owing to the exploding growth of Internet technologies and IT infrastructure, education from primary to university level has taken a new dimension in online platforms. In Engineering Education perspective, Online educational platforms provide anytime, anywhere access to quality technical content to everyone in the world. Renowned universities and academies have joined hands with MOOC service providers and offer universally recognized certification courses. These online certification courses can be considered as a powerful tool for empowering learners with new-age technical skills and knowledge. This article explores the possibilities of including online certifications in regular academic courses, thereby leveraging them to evolve an effective Instructional Design. A systematic method to include online courses and their corresponding certifications as a part of the assessment in institute-level courses has been developed. The experimental study has been investigated on a sample of three undergraduate engineering courses namely Cloud Computing, Blockchain Technologies and Data Analytics offered for the B.Tech Information Technology undergraduate course. Around 180 learners and three instructors participated in the research study. The proposed instructional design has resulted in a significant enhancement in the learning outcomes and student satisfaction index. Various plans to address the implementation challenges in integrating online certifications are also discussed. The authors believe that the manuscript will guide the faculty interested in utilizing online resources for classroom teaching.

Keywords—Blended Learning; Instructional Design; MOOC; Online Certifications; Online Courses

JEET Category—Practice

I. INTRODUCTION

The need to improve teaching and learning experience has led to many viewpoints. These viewpoints have transformed into theories and models, known as Instructional models. Based on the learning needs, the instructional models are designed for the efficient delivery of instruction and creating a better learning experience. Many research-driven instructional models are developed and practised globally to satisfy the student community.

II. RELATED WORKS

Instructional Design is the analysis of learning needs and systematic development of instruction. Instruction design facilitates to transfer of knowledge, skill and attitude. Instructional models help to create a more effective learning experience. A few Instructional theories and models that are widely used in higher education are Inquiry-Based Learning, The ADDIE Model, Individualized Instruction, Merrill's Principles Of Instruction, and Bloom's Taxonomy Of Learning Objectives. An appropriate Instruction design model that meets the demand is carefully chosen and the instructions are constructed.

To support students in linking learning experience to academic knowledge development within higher education, mARC (more Authentic, Reflective and Collaborative), a three-component instruction model was developed to facilitate the re- and de-contextualisation of knowledge (Slaviša Radović et.al 2021). The authors bridge the gap between learning environments and experiential learning. All five phases of the ADDIE framework (Analysis, Design, Development, Implementation, Evaluation) are applied to the three stages of learning environment Authenticity, Reflection and Collaboration in an iterative fashion. Upon applying the mARC model, authors believe that students will be able to appreciate and engage with the real-world context. [However, the model fails to focus on students' active participation, a dominant success parameter.](#)

FL design model for higher education (Lee, J et.al) was developed to fulfil the pedagogical challenges in higher education. This model helps the course handlers in creating an appropriate blend of individualized online lectures and collaborative face-to-face learning activities. The model uses a macro (Course level) and micro (Topic level) two-level approach and the integrative design of online and face-to-face sessions. Instructional Design elements such as mini-lecture design, online course prototype, worksheet, quiz design, and assignment are elaborated. The model measures the student's level of satisfaction through a survey. The author focuses on the design, ~~and~~ development [and delivery](#) of content at the micro-macro level, but fails to address the assessment components.

Coursera, edX, NPTEL Swayam (India) and many other platforms provide a plethora of courses in multiple domains. It has been estimated that around 80% of course content offered in institutions of higher learning is being delivered online (Allen & Seaman, 2003). Despite high enrollment rates, Online courses face the problem of dropout rates as high as 90% (Ericcson et al., 2017). Students are reluctant towards online courses because of factors namely **academic skills and abilities, prior experience, course design, feedback, social presence, and social support. interaction, course difficulty and time, and commitment.** Hence, educational research works to increase the success rate of online certifications has become essential.

Many instructors use video lessons in online platforms in their instructional design using Flipped classrooms. Learners watch the video lessons as out-of-class activities and do problem-solving as in-class activity with support from their instructors (Nouri, 2016). Most of the time, learners are reluctant towards watching the video lessons as they were not customized to their academic skill sets and nativity. Learners prefer to learn in person rather than online. The proposed instructional design aims at utilizing the assessment component of online courses effectively rather than video lessons. The instructor teaches the topics in the classroom. Learners can complete the assessment of the online course and by the end, they earn a certification/badge with minimal work.

In the experimental study (Room M.et.al,2021) conducted at “The Institute of Computer Science at the University of Tartu”, three Computer Programming MOOCs with different levels of difficulty were organized. The first and second-level courses were designed for learners with little or no previous programming experience whereas the third level requires previous programming knowledge. Respectively, the courses had over 11,800, 7100 and 2700 registrants. About 62%, 55% and 33% of the learners completed successfully. To successfully complete the course, the learners had to perform mandatory programming exercises and take a quiz every week through Moodle. The study examined the dropout learners in different weeks of the course. It was discovered from the study that the dropout rate increases with the difficulty of the course.

In another study (Hegyesi,et. al,2020) carried out at Óbuda University, it is emphasized that online courses are paramount to address the challenges faced by “Z” generation learners. The impact of making academic courses available online is studied. Various factors such as the ability of the ‘Z’ generation learners to be at ease with the digital gadgets and virtual world, and their ability to socialize are found to contribute to the effectiveness of learning online. The results of this study show that even though the “Z” generation learners are inherently capable of adapting to online education, they need the presence of teachers to experience a holistic learning experience.

From the literature, the following are identified as advantages of including online certifications into offerings of regular academic courses.

- Enables the learners to earn well-recognized certifications with minimal effort
- Effectively reduces the dropout rates of online courses
- Exposes learners to a wide variety of assessment items and contemporary technologies
- Allows individualization of instructional design as online courses allow learners to progress at their own pace

Hence adding online certifications to the Instructional design would be an effective way to enhance the quality of content delivery, assessment and attainment of learning outcomes. However, for including online certification courses in academics there are no well-established guidelines.

III. RESEARCH OBJECTIVES

The motivation for the research is supported by the following research questions:

- A. How to effectively include online certification in the Instructional Design of an Engineering course?
- B. What is the impact of including online certifications as a part of instructional design in enhancing learning outcomes?
- C. What are the challenges and issues faced by the instructors and learners in completing online certifications?

IV. MATERIALS AND METHODS

The curriculum for Engineering Programmes usually includes a variety of courses that focus on foundational technical skills, application of technology for building solutions, development of professional skills and advanced technologies. Effective conduct of these courses requires well-planned Instructional design. In the present-day context, Engineering graduates are expected to be industry-ready. So it is essential that the instructional design is charted out in such a way that it provides holistic learning, developing the higher-order thinking skills of the learners in the concerned area. To facilitate this, many novel instructional designs have been developed.

Online learning has become the need of the hour. Online certification courses are considered an authentic way of learning online, especially when one wants to acquire knowledge in one specific area, technology or tool. Many of the online certifications are universally recognized, adding to the professional quotient of the learners.

However, including them in the instructional design requires careful planning and implementation. A five-step methodical approach for embedding online certifications into the ID is proposed in this paper. The high-level overview of the proposed approach is presented in figure 1. The proposed approach is implemented for hand-picked courses of undergraduate B.Tech Information Technology courses at TCE. Each step in the proposed approach is implemented as explained below:

Step 1 - Among the various contents in the course, suitable contents must be identified. The course contents identified

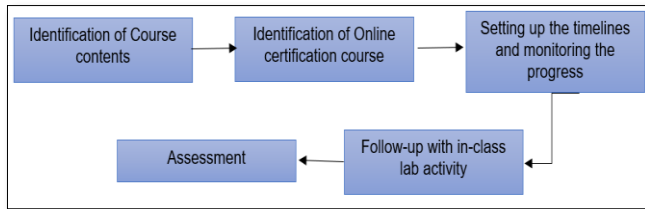


Fig. 1. 5-step approach for embedding Online certifications into ID

such, must be aligned with one or two learning outcomes. This is to ensure that the depth and breadth of the course contents identified are appropriate to be covered through online certification courses. The learning outcomes shortlisted should aim at honing the higher-order thinking skills of the students.

Step 2 - At this step, a suitable online certification course should be identified. It is preferable to identify a free certification course. A number of courses are being offered by IBM Academy, Linux Academy etc., At nominal fees, courses are being offered by Swayam NPTEL of MHRD, Govt. of India. The online course chosen may adhere to the following guidelines.

- The duration of the course should be 2-4 weeks, requiring around 8-12 hours of effort.
- The contents of the online certification course should be in alignment with the learning outcomes of the course.
- The online course chosen should provide exposure to a contemporary tool or technology or paradigm.

Step 3 - The online course is imbibed into the course timelines at this step. Students should be informed well in advance about the course and at least be given 2 weeks buffer time to complete the course. Students who are successfully completing the course should be exempted from submitting one of their regular assignments in the course plan. This would give them more time and space to actively complete the online certification.

Step 4 - This step is considered as an important step in imbibing the online certification courses into the Instructional design. Though the online course itself would have an assessment, it is essential to follow up the progress made by the students through the online course in class. This is carried out by an in-class activity, preferably an activity in the lab. This activity may include Experimentation / Demonstration / Problem-Solving. This facilitates the validation of the student's efforts in completing the online course by the course instructor and provides a solid mapping between the online course and the learning outcomes.

Step 5 - This step deals with the inclusion of an online course in the evaluation and grading. The course instructor may decide on the appropriate weightage given to the online certifications in the grading. The weightage may be decided based on the amount of time required, the level of difficulty

involved. But as a rule of thumb, the online certifications may be given weightage not less than 20%.

V. IMPLEMENTATION

To study the impact of including online courses in academics, the following courses were identified

- 18IT610 - Cloud Computing at VI semester
- 18ITPP0 - Blockchain Technologies at VI semester
- 18ITEA0 - Data Analytics at VI semester

A. Case1: Cloud Computing

This course on cloud computing aims at providing foundation knowledge on Cloud Computing concepts and services, facilitating the learners to leverage Cloud-based services and tools in application development and deployment. The course is a right mix of theoretical concepts and practical implementation procedures. Hence instructional design for this course is charted with a number of components as shown in figure 2 below. One of the novel inclusions in the ID is the online certification course. Following the 5-step process for

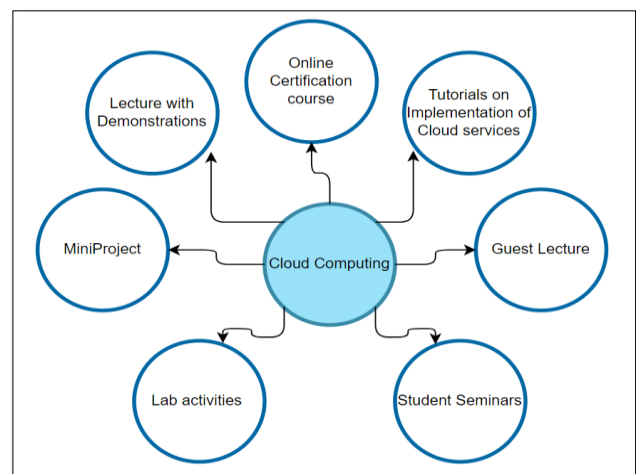


Fig. 2. High-level Instructional Design for Cloud Computing Course

including the online course in the ID, at the initial steps course contents to be covered through the online course in addition to the regular lectures were identified. The identified contents include the Cloud architecture, basics of cloud service models, deployment models, and enabling technologies for cloud computing. The learning outcome aligned with the identified course contents are as follows:

- Explain the key technologies, strengths, limitations and applications of cloud computing
- Categorize the cloud service types, architecture, and contract negotiations needed for cloud service delivery and cloud software development

In the second step, suitable online certification courses preferably available free of cost were surveyed. The platforms include udemy, Coursera, edx, IBM academy etc., Among all the courses surveyed, the one offered by IBM academy was

found to be appropriate (<https://cognitiveclass.ai/courses/introduction-to-cloud>). The online course identified covered all the course contents identified such as Cloud Architecture, service models, deployment models and key enabling technologies of the cloud. The course required 6 hours of effort from students with an end-of-the-course quiz.

The next step involves setting up the timelines and monitoring the progress. Two weeks were given for the students to complete the course and the assignment was initiated during the first term of the semester. Parallely, during the contact hours, the same concepts were discussed allowing the students to get their doubts clarified and giving them an edge to complete the certification with ease. As a follow-up activity at the next step, students were asked to explore at least two Cloud service models and implement the same during the practical hours. Two lab sessions were dedicated to this in-class activity. The cloud service implementations were considered as another assignment and put together 20 out of 30 marks for the internal assessment given for this activity.

Sample of the certifications completed by students may be verified at the links given in table 1

Case 2: Blockchain

The course on Blockchain Technologies is offered as a

TABLE 1
SAMPLE IBM COGNITIVECLASS.AI CERTIFICATIONS ON INTRODUCTION TO CLOUD COMPUTING COURSE

Online Course Name	Certificates earned by Students
cognitiveclass.ai - Introduction to Cloud	https://courses.cognitiveclass.ai/certificate/c65473de05604be5a9ab5820f7c329be
cognitiveclass.ai - Introduction to Cloud	https://courses.cognitiveclass.ai/certificate/d7ece4974c6d4c3db16963ce18bce95f
cognitiveclass.ai - Introduction to Cloud	https://courses.cognitiveclass.ai/certificate/70ac369b893f4dc693920fb9a986c70d
cognitiveclass.ai - Introduction to Cloud	https://courses.cognitiveclass.ai/certificate/e6c8e5dcad574325857e0cb2a48c03c3
cognitiveclass.ai - Introduction to Cloud	https://courses.cognitiveclass.ai/certificate/e6dd1f689fc942138b551419de81ea2b

programme elective in the sixth semester for the students of B.Tech Information Technology. The objectives of the course are to build technical expertise in the development of distributed and decentralized ledgers of events and transactions with strong cryptographic guarantees of tamper resistance, immutability, and verifiability. The detailed contents of the course can be accessed at the link <https://tinyurl.com/TCEBlockchain>. The course has been offered twice in the academic year 2020-21 and 2021-22. The count of enrollments is 67 and 68 in the first and second offerings respectively. The instructional design of the course includes a wide variety of active and collaborative learning strategies like problem-solving with bitcoin testnets, programming with solidity, and application development in healthcare, agriculture and education domains. Few challenges

exist in content delivery like minimal faculty expertise in blockchain, and a limited amount of textbooks and references, as Blockchain is still a technology in the developmental stage. To strengthen the fundamentals of blockchain and to make the students learn from leading academic experts, the following online certifications were identified to be appropriate for inclusion in instructional design.

- *Blockchain - Understanding its Uses and Implications - Offered by The Linux Foundation in edX (4 weeks)*
- *Blockchain Basics - Offered by the University at Buffalo-State University of New York in Coursera (4 weeks)*

These courses were carefully selected owing to the following reasons:

1. The contents of the blockchain courses in Coursera and the edX platform are almost the same in modules 2 and 3 of the institute course on Blockchain. Learners can complete the assessments even without watching the video lessons on online platforms as they have learnt the concepts in regular classrooms.
2. The assessment in the online courses includes practice quizzes, practical exercises and a final graded exam with a focus on higher-order thinking skills for successful certification.
3. The certifications were available for the students at free of cost, as the institute had academic partnerships with Coursera and edX.

In adherence to the Standard Operating Procedure for including online certifications in instructional design, the corresponding implementation for the Blockchain courses has been planned well in advance. The action plan devised carried out to enable the learners to complete the online certification

TABLE 2
ACTIVITY DETAILS FOR BLOCKCHAIN CERTIFICATION

Step	Activity	Blockchain Technologies
1	Identification of topics in regular academics that matches with the online courses	<ul style="list-style-type: none"> • Bitcoin Fundamentals • Structure of Blockchain, Hashing • Merkle Trees • Proof of work • Mining • Double Spending • Case Studies in Blockchain
2	Identification of Courses in Online platform	<ul style="list-style-type: none"> • Blockchain - Understanding its Uses and Implications (edX) • Blockchain Basics (Coursera)
3	Time plan for Completion	<ul style="list-style-type: none"> • Creation of Login credentials in edX/Coursera: Beginning of the semester • Practice Quizzes: Every week or as and when the topics are covered in the class • Final Assessment in online certification: In laboratory as a part of classroom activity on scheduled dates
4	Support by the course instructor for completion of assessments	Discussion Forum in Moodle and Whatsapp Group for clarification of doubts in practice quizzes and graded quiz
5	Award of grades in Continuous Assessment	Certification was counted towards 10% of internal assessment

in Blockchain is presented in Table 2

Around 60 out of 67 learners have completed their certifications in the first offering. Many learners have commented that the online certifications provided good exposure to various assessment items. Also, the certifications added value to their resume during campus placements. Sample certificates earned by the learners in Blockchain are presented in figure 3.

B. Case 3: Data Analytics

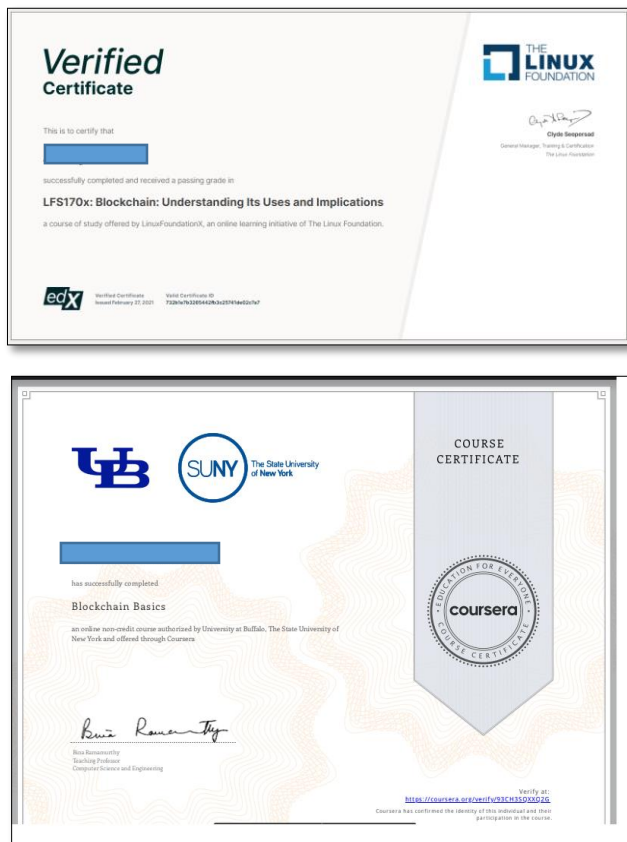


Fig. 3. Sample Certifications in Blockchain from edX.Coursera

This course on Data Analytics is offered to VI semester students. It aims to provide in-depth knowledge on managing, handling and analysing structured or unstructured data. Students establish a baseline understanding of Statistical Modelling, Predictive analytics, Descriptive and Survival analytics concepts and methods. To enhance their understanding and practice on real-world problems, many instructional design elements such as lectures with demonstrations, guest lectures by industrial experts, tool exploration, and online certification are added to the course. A high-level overview of the ID is given in figure 4. online certification was one of the prominent IDs included in the course following the 5-step process. The course faculty identifies the scope for online certification, the effort required, the evaluation method, and grading. Higher-order learning course outcomes are identified. The course outcomes identified include big data analytic platforms, data modelling

methods data analytic tools for developing simple applications with ethical standards. The course outcomes are

- Examine the type of unstructured data, content analysis, frequency analysis with lexical relations and sentiment analysis
- Develop simple applications using big data analytic platforms, data modelling methods and data analytics tools

A list of online courses identified by the course faculty is given in table 3 and the feasibility of the course is decided based on the time required for completion and the cost of the



Fig. 4. Instructional Design for Data Analytics

TABLE 3
LIST OF ONLINE COURSES IDENTIFIED FOR DATA ANALYTICS COURSE

Course Name	Offered by	Duration
Data Analysis Real world use-cases- Hands on Python	Udemy	7 hours
Data Analysis with Python	freecodecamp	50 Hours
Predictive Analytics and Data Mining	Coursera	24 hours
Introduction to Data Analytics	Coursera	24 hours
Social Media Data Analytics	Coursera	13 hours

course.

Social media analytics is a self-paced course offered by Coursera (<https://www.coursera.org/learn/social-media-data-analytics>) that focuses on how to process, and analyse data collected from different social media sources using analytical methods and tools. Students should watch the videos and take

practice tests followed by two quizzes and perform Sentiment Analysis with Twitter data. This course requires 13 hours of effort beyond class hours. Students took around 2 weeks to complete the course. During the regular class hour, students discussed as a team and their progress on the course completion is monitored. Students were asked to analyse and interpret real-world data and submit it as a project for assessment. Successful completion of the online certification was awarded 10 marks, project presentation with 5 marks. Totally of 15 out of 30 marks for Assignments was given to this activity in internal assessment. Sample certificates may be verified in the link <https://tinyurl.com/3hw5zu96>.

VI. RESULTS AND DISCUSSION

A. Discussion on RQ1

To evaluate the first objective of this work i.e effectively and systematically including the online certification courses in the Instructional Design of academic courses, a survey was obtained from the students who have been part of this study.

Around 100 students participated in the survey. The survey elicited student responses on the effectiveness of the online

with which students were able to approach and complete the online certifications. The results of the survey are given below in figure 5. The students' satisfaction survey carried out indicates that except for a negligible number of students, all others were able to adapt well to the methodology adopted and were able to complete the course with ease.

B. Discussion on RQ2

To evaluate the second objective of improving the attainment of learning outcomes through online certification courses, actual attainment of course outcomes and individual scores in Internal exams are considered. In table 4, assessment items used in the courses that participated in this investigation are listed.

Quantitative assessment of the improvement in learning

TABLE 4
COURSE-WISE ASSESSMENT ITEMS OF COs COVERED BY ONLINE COURSES

Case	Course Name	Assessed through
1	Cloud Computing	Internal Exam of 90 minutes and 2 Assignments
2	Blockchain Technologies	Internal Exam of 90 minutes and Practical Test of 60 minutes
3	Data Analytics	Internal Exam of 90 minutes and Project Presentation of 15 minutes.

outcomes is explained for case 2 i.e course on Blockchain Technologies. The course outcomes corresponding to the matching topics in online certification courses and the regular academic course on Blockchain are presented below. These course outcomes were assessed using a written test for a duration of 90 minutes and a practical test for a duration of 60 minutes.

- CO2: Explain the significance of blocks, proof-of-work, and consensus building in Blockchain technology
- CO3: Demonstrate the functional/operational aspects of trading and mining using cryptocurrencies.

Learners were made to complete the practice quizzes and graded quizzes in the identified online courses before the written test schedule. The scores in the online certification serve as a formative assessment enabling the instructors to identify the muddly topics in the course contents. The performance of the learners in Continuous Assessment Test -1 is depicted in figure 6

It could be inferred from figure 6 that around 63% of the learners have secured the top two grades. Also, there were no failures in Continuous Assessment Test -1. The attainment of all the course outcomes is assessed through Continuous Assessment Test, Terminal Exam and Course end surveys and is presented in figure 7. It can be found that the actual proficiency of the course outcomes (corresponding to CO2 and CO3) is greater than the expected proficiency except for CO5, thus demonstrating the effectiveness of the proposed instructional design. The numerical values of the attainment of course outcomes calculated by the automation software of the institute (TCNet) are presented in figure 8. The actual

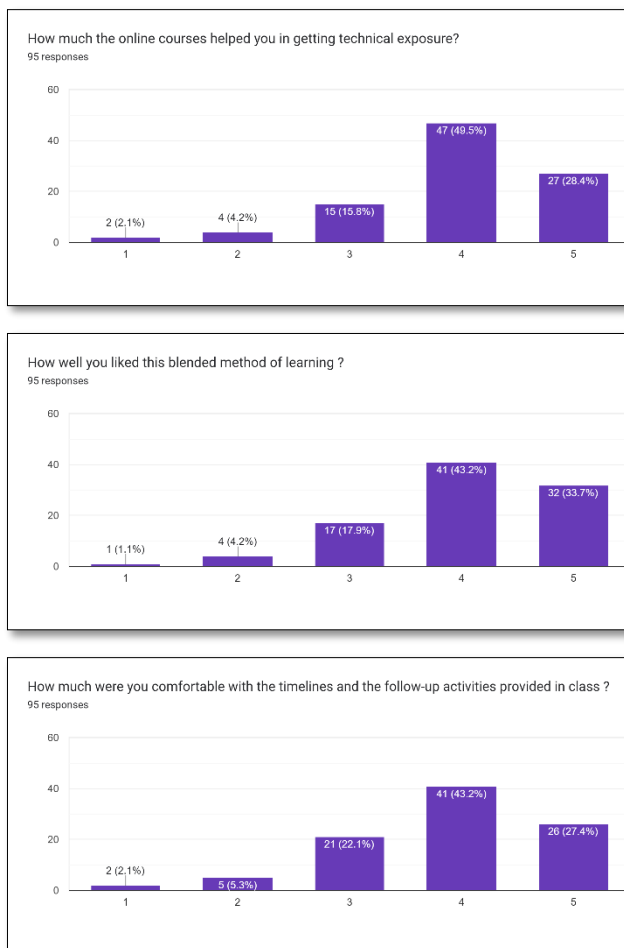


Fig. 5. Students Satisfaction Survey Results

courses in providing additional exposure, and the level of ease

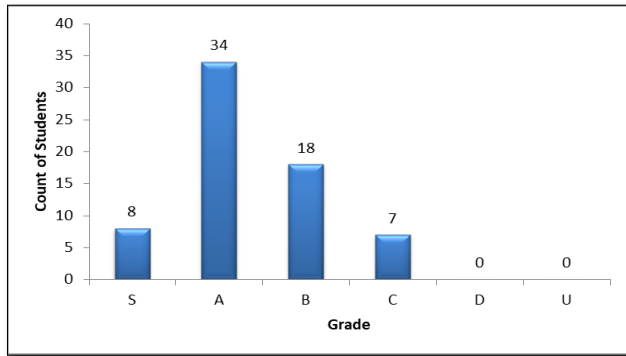


Fig. 6. Students Performance in Continuous Assessment Test 1

attainment of course outcomes CO2 and CO3 are 86.63 and 87.46 respectively and is quite high.

To analyze the effectiveness of the instructional design, a control group with 68 learners was considered during the

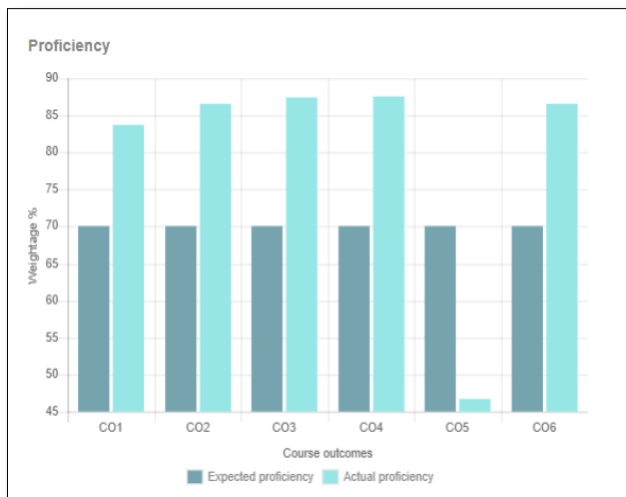


Fig. 7. Overall Course Outcomes Attainment

second offering. The same pedagogy was adopted except for the inclusion of online certification. The comparative



Fig. 8. Quantitative Attainment of COs

performance of the controlled group and experimental group is presented in figure 9. The performance of the learners in the experimental group is significantly higher than the performance of the learners in the controlled group.

Similar results were observed in the offerings of the other two courses considered for the study as well.

C. Discussion on RQ3

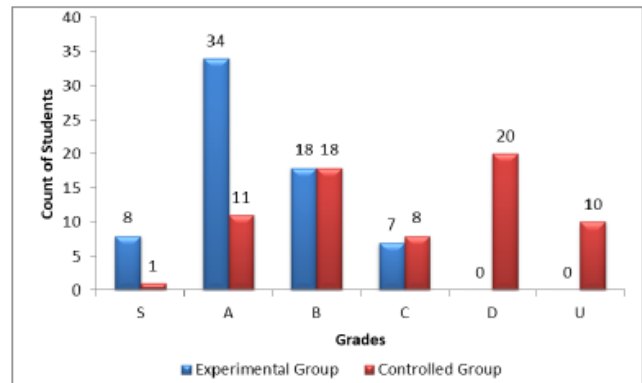


Fig. 9. Comparative Performance of Controlled and Experimental groups

During the experimental study, there were a few challenges in adopting online certifications as part of the instructional design.

It is difficult for the instructor to identify online courses with the exact contents of the regular courses at all times. The

TABLE 5
ISSUES AND MITIGATION STRATEGIES

Issues	Mitigation Strategies
Coverage of online contents beyond curriculum	Learning from peers is encouraged through discussion forums in moodle
Plagiarism in assessments	Minimal weightage in internal assessment for the corresponding certification
Financial support for proctored exams	Conduct of Viva-voce during laboratory sessions to ensure originality of work
Time management for the learners	Reimbursement of fee towards proctored examination by the Institute for top grades/score. Guidelines are populated at the beginning of the semester.
No/less interest shown towards certification	A maximum of three certifications shall be considered towards assessment in a semester. Decision on the same is made during course committee meetings. Rest of the certifications in other courses is made optional. Choices for other equivalent assessments like case study presentation, mini project implementation are provided.

instructor has to spend extra effort on covering the contents beyond the curriculum to enable the learners to complete the assessment of online certifications.

Also, the majority of the certification courses available for free do not have a proctored assessment and hence the genuineness of the student's submission of online courses are to be validated. Plagiarism in assessments is also a major concern. As the assessment questions remain the same for every student in a few online courses, copying of assessments cannot be prevented. It has been represented in the class committee meetings that it was easy for the learners to earn a certification for a single course in a single semester, but it is difficult to do certifications for three or more courses offered

in the same semester. They were not able to cope with other regular academic work. Also, not all learners are interested in earning badges/certifications. The registration fee has to be paid on a few online platforms for proctored examination. Not all interested learners were able to afford the fee. The following measures as presented in Table 5 were adopted to address the above-mentioned challenges during the experimental study.

VII. CONCLUSION

This experimental study on the inclusion of online certification in the instructional design of engineering courses has resulted in the development of a standard operating procedure which could be adopted by fellow academicians. Also, the improvement in the attainment of the learning outcomes of the courses under study has confirmed the effectiveness of the proposed instructional design. It has been inferred from the course end surveys and informal meetings, that the satisfaction index of the learners is also high. The challenges during implementation have also been resolved to a greater extent. Possible extensions of the present research work shall be to study the effectiveness of online certifications in campus placements and higher studies. Also, the impact of online certification in doing quality work in capstone projects and engineering design projects shall be analyzed.

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Talent development glossary - <https://www.td.org/talent-development-glossary-terms/what-is-instructional-design>