MASTER OF SCIENCE IN TECHNICAL EDUCATION
(MECHANICAL ENGINEERING SPECIALIZATION**)**

DESIGNING A TEACHING-LEARNING FRAMEWORK FOR THE EFFECTIVE ONLINE-BASED LABORATORY CLASSES IN BANGLADESH

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Thesis submitted in partial fulfillment of the requirements for the degree of **Master of Science in Technical Education** with specialization in **Mechanical Engineering.**

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RECOMMENDATION OF THE BOARD OF EXAMINERS

The Thesis title is **"Designing a teaching-learning framework for the effective online-based laboratory classes in Bangladesh"** Submitted by **Shibli Sadik, MScTE, Student ID: 191031101** of the Academic Year 2021-2022 has been found Satisfactory and Accepted as partial fulfillment of the requirement of the degree of **Master of Science in Technical Education (M.Sc.T.E.)** in May 2022.

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This thesis work is reliable, and it is the result of an investigation conducted by **Shibli Sadik**, under the supervision of **Prof. Dr. Md. Abu Raihan**, Department of Technical and Vocational Education (TVE), Islamic University of Technology (IUT), Organization of Islamic Cooperation (OIC), Gazipur-1704, Bangladesh. This thesis, or any portion of it, has never been submitted to any other institution for the award of a degree or diploma. All references to literature and contributions are acknowledged in full.

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DEDICATION

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ABSTRACT

Prior to COVID-19, almost all laboratory activities were completed collaboratively, it encouraging students' independent thinking and continuing to support their sense of independence. The transition of online learning brought with it new challenges in terms of organizing vast class schedules beyond the routine school time. To address these challenges, the completely redesigned online-based laboratory activities restructured comparatively small and independent work. Some assignments required students to work collaboratively, and others students required to work independently. Students were highly compelled to communicate with the teacher during online class or to schedule a meeting for the assigned tasks that promoted independent learning in order to receive feedback and suggestions on their assessment. As they shared their concepts, the teacher noticed an interesting sense of confidence and pride in the students who attended the online-based laboratory class. The purpose of this research is to investigate the appropriate framework in the laboratory-based teaching and learning process in universities. Specifically, this study will be identified the knowledge and benefits of using online-based laboratory classes to perform laboratory classes as perceived by students studying education programs. This study involved teachers and students in universities and provide questionnaires to collect data. Data analyzed using descriptive statistics. The study tried to find out students' knowledge and experiences on online-based laboratory classes to do lab classes and a positive view on it. The study suggested a teaching-learning framework that can facilitate to perform laboratory classes in different universities students in their learning process and this effective framework will provide a user-friendly interface and navigation to support students' learning on practically oriented courses. This thesis does not investigate quantitatively the relative effectiveness of online versus physical laboratories in achieving specific learning outcomes. The question of whether virtual laboratories are better or worse than physical laboratories is not addressed in this thesis. Instead, it addresses the question of what issues must be considered in online-based laboratory class design and expresses these issues in the form of a set of design guidelines in the COVID-19 and post COVID-19 teaching-learning framework for effective online-based laboratory classes.

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Chapter-1 Introduction

1.1 Overview

The global Covid-19 pandemic posed numerous challenges for Higher Education teaching, particularly for engineering students who must learn a variety of laboratory techniques as part of their degree program. A proper framework for an effective online-based laboratory class requires these laboratory-based skills. Due to the university's closure due to the COVID-19 pandemic, this research intends to focus on essential skills of practical knowledge on engineering courses in order to fill the skills gap during distance learning. Because of improvements in information technology infrastructure and the use of e-learning in engineering education, online-based laboratory classes have become increasingly popular. E-learning improves individualized student learning, allows for greater flexibility in learning, and helps rural students overcome the limitations of space and time. The use of web-based technology tools has had an impact on the current teaching and learning environment. Students' higher-order analytical skills are enhanced through the use of Technological tools, which also serve as a source of information for lifelong learning resources. In today's increasingly interconnected world, it is undeniably true that technology has the capacity to transform the educational experience. Devices and the cloud are transforming the way in which people operate all around the world, and the same is true for the way education is delivered. Incorporating technology into teaching and learning practices has become commonplace in educational institutions all around the world. The benefits of technology in education include the ability to learn at any time and from any location, access to high-quality academic and professional resources for everyone, improved student independence, conscience learning, peer learning, and knowledge sharing, among other things. E-learning is a technique that makes use of technology to allow individuals to learn from any location and at any time. A successful e-learning platform's primary goal is to provide a comprehensive learning opportunity that makes it feel similar to a traditional classroom practice, while also providing traditional classroom attributes (such as teacher-student engagement, conversation, sports, group projects, quizzes, and so on) but over a device (such as a laptop or desktop, smart phone). Creating these critical learning environments is accomplished through the use of learning platform features and technologies that encourage the level of interactivity and engagement of student’s needs (Thaoge, A proposed

framework for designing an online based (E-learning) Work Integrated Learning (WIL) module for the Diploma in Biotechnology, 2021).

Researcher analyzed the feedback from participants in the online-based laboratory classes. According to the analysis, a large percentage of the participants were pleased with the online-based laboratory classes, and they stated that their learning process improved as a result of the experiments.

Keywords: Online-based Laboratory class, 3D animations, web-based learning, simulation, ADDIE model, Engineering education, science process skills, E-learning, University education. Online learning, LMS.

1.2 Background and present state of the problem:

Prior to COVID-19, almost all laboratory activities were completed collaboratively, it encouraging students' independent thinking and continuing to support their sense of independence. The transition of online learning brought with it new challenges in terms of organising vast class schedules beyond the routine school time. To address these challenges, The completely redesigned online-based laboratory activities restructured comparatively small and independent work. Some assignments required students to work collaboratively, and others students required to work independently. Students were highly compelled to communicate with the teacher during online class or to schedule a meeting for the assigned tasks that promoted independent learning in order to receive feedback and suggestions on their assessment. As they shared their concepts, the teacher noticed an interesting sense of confidence and pride in the students who attended the online-based laboratory class. COVID-19 also has an impact on laboratory teaching; it has made it necessary to focus on what is taught and how it is taught (Coleman, 2021). For the demands of learning methods in the modern era that require innovative thinking to improve the learning style so that students are not distracted and unengaging from learning process, the development of online-based practical learning is expanding. Theoretical courses in educational programs perform effectively online by using various types of learning management systems, but practical courses are frequently difficult to perform through the online-based platform without a proper framework, that's why it is vital to develop an effective teaching-learning framework so that students can perform effectively their laboratory classes during COVID-19. The online laboratory class is expected to increase students' independence, creativity, and ease the implementation of learning that can be done anywhere and at any time. Furthermore, the online learning create it simple to manage students laboratory tasks.

Administration, material delivery, assessment, monitoring, and communication are all part of an online-based laboratory class. Teaching-learning materials in pedagogical and professional competencies created with multimedia packaging such as text, animation, video, sound etc. for use in an online-based laboratory class. Online-based laboratory classes will be designed with a proper framework to fill the learning gaps on practical activities framework focused on online-based laboratory classes for online content, such as courses that assist teachers with course management. It will provide a variety of services for content management, including the creation, import, and export of learning objects. The framework's set of available tools will represent all of these services that aid in the management of the teaching process and the interaction between teachers and learners. However, it has been reported that students have difficulty to understand the course content and instructions in traditional laboratory settings (N. Kapilan, 2021) as a result of inadequate laboratory facilities and inattentiveness from students and the laboratory teacher. Furthermore, in a traditional laboratory, students' reflective practice and depth of learning are low. The abundance of newest laboratory equipment will encourage students to learn by providing them with practical learning experience with newest technology. It is proposed that an innovative design or a proper framework oriented online-based laboratory can be created to encourage and involve the learners in laboratory activities. A creative framework is needed to integrate learning and knowledge processes that aid in problem solving, teamwork, and the design of new experiments (N. Kapilan, 2021). The previous mentioned issues can be resolved with the assistance of an online-based laboratory classes. Online-based laboratory classes can assists students in conducting experiments in a traditional or virtual learning environment using a appropriate computer-based interface. The Online-based laboratory classes also can be used in addition to the traditional laboratory to help students learn more which can also enhance the knowledge. It assists students in becoming independent learners because it used in a variety of ways. It is less expensive than a traditional laboratory because it does not require the equipment, support staff, maintenance, or operating costs that a traditional laboratory does (N. Kapilan, 2021). According to the findings of a study conducted in Slovenia, online-based laboratory classes help in the greater understanding of acquiring knowledge. The online-based laboratory classes have the potential to open up new possibilities for the sustainability of university education. An investigation carried out in China found that the online-based laboratory classes used as a different instructional instrument for undergraduates, and they suggest blended laboratory is always the finest type of laboratory for this purpose. According to the findings of a study conducted in Taiwan, online-based laboratory

classes can recover students' understanding while also enriching their acquiring knowledge. It is possible to use online-based laboratory classes to support engineering education fields because they assist students in gaining practical related skills as well as in comprehending the laboratory course-content. A research study directed in the USA in order to develop an online-based laboratory classes relating to fluid mechanics they conducted by online-based laboratory classes as a pre-laboratory instructional tools, and that students found this strategy to be very informative and useful in their learning. The students also stated that the online-based laboratory classes on pump experiment is simple and takes less time than the other experiments. According to research conducted at Texas A&M University in the United States, female students spent significantly more time in the online-based laboratory classes tutorial (N. Kapilan, 2021). According to the findings of a study conducted in Denmark, the online-based laboratory classes facilitates interactive learning by allowing students to understand the operation of biological and biochemical equipment used in the laboratory as well as analyze the results of the experiments. After participating in the online-based laboratory classes, it is recommended that the students have high levels of confidence, feel comfortable handling laboratory equipment, and actively involved in laboratory work. Additionally, it has ability to improve the students' preparation for the laboratory. The findings of a study conducted in Saudi Arabia on online-based laboratory classes indicate that online-based laboratory class activities supporting science based learning areas as well as in acquiring practical skills. The use of online-based laboratory classes can help to overcome the limitations of the conventional teaching and learning process (N. Kapilan, 2021).

1.3 General objectives:

The general objective of the study is to explore an effective mechanism using for conducting online-based laboratory classes for engineering (EEE,CSE) discipline in the universities of Bangladesh.

1.4 Specific objectives

The specific objectives of this study are:

i) To identify the effective instructional methodologies followed for conducting the online-based laboratory classes in the engineering universities of Bangladesh.

ii) To assess the best learning management systems for conducting online-based laboratory classes.

iii) To design an effective teaching-learning framework for the online-based laboratory classes.

1.5 Possible Outcomes:

The framework on online-based laboratory classes will state online laboratory class design that can break the space limitation for traditional experimental work and provide a collaborative learning environment. The framework which the researcher will design as an online pedagogical model and a tentative set of guidelines to assist the designers of online-based laboratory tools which can increase the engagement level of students for online-based laboratory classes.

1.6 Research questions

i) Which instructional methodologies are followed for conducting the online-based laboratory classes in the engineering universities of Bangladesh?

ii) Which is the best learning management systems for conducting online-based laboratory classes.

iii) Designing a teaching-learning framework by using the ADDIE Instructional Design (ID) method is effective for the online-based laboratory classes?

1.7 Significance of the Study

The study will represent the performance and problems of using Online-based laboratory class as well as some potential solutions for teachers. Furthermore, by presenting information derived from the students' findings. This study will open the path for future researchers to incorporate student and teacher attitudes.

1.8 Limitations:

Due to the limited time, it was unable to implement the proposed framework into action or evaluate the effectiveness and usefulness of the framework in its current state. This study was conducted in some particular universities and results cannot be extrapolated to cover the country and the framework on online based laboratory classes will provide the students a practical flavor of online based laboratories to gain practical knowledge virtually. Its eligible for soft skills like software design, simulation, MATLAB, programming etc. It is not a mature tool ready for wider deployment. And its not eligible for hard skill like heavy mechanical works practice (welding, lathe/ drill/ shaper/ milling machines operation etc.).

Researcher only use quantitative research and questionnaire tools with designing some questionnaires to collect the data. If researcher think further research on it then researcher will use mixed method both descriptive statistics and quantitative method. And data collection tools will be changed also and the sample size will be large to make the thesis more acceptable.

The framework will be designed with the opinion of the respondent. And it will theoretically justified by the expert of the mentioned Universities.

1.9 Purpose of the Study

The purpose of the study was to establish a framework that will be utilized to design an online laboratory course for engineering students. There are numerous options for designing an online-based laboratory class. According to the findings of this research, the process of establishing a framework that will be utilized to create an online based laboratory class has been investigated. This will allow students to complete their practical classes. An action design technique was used in conjunction with a literature review and a field study in order to fulfill the study's objectives. Additionally, the researcher utilized a mixed methods data gathering methodology for data collection, which took into account both secondary and primary data. It was decided to use the ADDIE model for the construction of an online-based laboratory class framework, which comprises of the analysis, design, and development of courses for online systems, as well as their implementation.

2 Chapter-2 Literature Review

2.1 Background of online-based laboratory class

There are a variety of viewpoints on how online labs should be delivered. According to an article by Loike, J. D., and Stoltz-Loike,(2020), Bachelor level science and engineering-based laboratories can be perform successfully which is taught online, supporting an active experimental learning, with certain adjustments. online laboratory activities also are more cost-effective than hosting traditional laboratory activities since they require less human resources and space. According to Loike, J. D., & Stoltz-Loike, (2020), The reviewing of literature and the participants reviewed journals, developing progressive experiments, and analyzing the collected data are only it is the essential activities that need to incorporated in delivering online-based laboratory classes (Gunasekara, M. A., Maddumapatabandi, T. D., & Gamage, K. A. 2021) .

2.2 Covid-19 its impact on the Bangladeshi education system

The economic anxiety experienced during the Covid-19 outbreak is primarily, but not exclusively, related to health systems' inability to deal with more routine health issues during outbreaks (Khan, 2020); costs of infected medical treatment and epidemic control, expenses of the health care system as a whole, both public and private; loss of employee productivity, educational institutions; destabilization of the tourism sector, and so on (Goodell, 2020). Due to the recent unanticipated Covid-19 outbreak, Bangladesh's educational framework takea a innovative opportunity. As a result, distance learning is no longer elective or limited to a select group of learners; rather, it has become a need for most Bangladeshi educational institutions to continue their operations flow of the teaching-learning stream (Ilmiyah & Setiawan, 2020). Always, there have the possibility that various teachers who aren't tech aware won't be able to handle this mode. The faculty's ability to deal with present technology has been questioned as a result of the switch to online mode (Lee, 2020). In Bangladesh, the situation is similar; out of 133 universities, 63 have begun to offer online courses as of April 29, 2020. (both public and private universities). This number is promptly rising (mostly in private universities). Though, there is a distinct divide among public institutions and academicians over their outcomes of the online sessions , as a result, learning. Over the last two months, the University Grants Commission of Bangladesh conducted an online survey on the effectiveness of online higher education (April and May of 2020), Bangladeshi educational institutions must do a lot more to prepare for conducting online classes in order to establish an Online Education Learning Policy

for the current circumstances as well as the future, as suggested by the findings (Dhaka Tribune, 2020). Nonetheless, the number of universities offering online courses is growing by the day (Khan, M. R., & Hossain, S. S. 2021).

2.3 The probable framework which is suitable for Bangladeshi context

The cost-benefit connection is intimately linked to the move of online education with the online-based classroom learning method. However, the specifics will differ depending on each important stakeholder (for example, students, teaching staff, support personnel, the recruiting industry, and the higher educational institution itself) (Wagner et al., 2008). Its difficult to define, and its necessitates substantial research. Many studies have been done on cost-benefit assessments in online learning (Xia, 2015; Legon & Garrett 2018; Harrison, 2019), however Laurillard's research shows that costing models have essentially no impact on practical actions in educational institutions' e-learning innovation planning (Laurillard 2007). They are inconsistent which do not correspond yet to current practices. Showing their necessitate a significant quantity of their effort as a part of innovators and users to calculate the costs that are comes to them as an ordinarily unattainable, and particularly given enigmatic nature of instructional expenses. This is especially important because remote learning methodologies, technologies, handsets, partnership opportunities, rivals, demographics, and delivery models are all rapidly changing (Saunders et al., 2019; Khan et al., 2021). Furthermore, direct stimulus can differ depending on supposed benefits with drawbacks of distant learning. Betts & Heaston (2014) did a study in which academic staff and deans measured their viewpoints against a set of 29 motivating and 20 limiting factors– Researcher observe that teachers with distant education experience think about the most important motivational variables differently than those who don't. The essential influence played by personal drive, according to experienced participants, is an important yet unsurprising conclusion from this study. The key barriers were more similar across groups, and they were divided into three categories: quality, time, and support (Khan, M. R., & Hossain, S. S. 2021).

2.4 Background of Online education

Online education was certainly one of the most effective techniques of teaching and learning for tackling the academic difficulty during the coronavirus outbreak. In Bangladesh, it has traditionally been focused on tertiary education. It has a number of advantages, including keeping students on pace with the learning during moments of crisis, helping students to complete their coursework on time, preparing students for online examinations, and creating strong relationships between teachers and students. On the contrary, the challenges of online

classes include adjusting to virtual classrooms, unstable signals, expensive internet costs, a lack of computer competence, and keeping communication with individuals (Alam, 2020). Furthermore, as traditional classrooms have moved online, the majority of students in underdeveloped nations have run across a variety of issues (Ahmed, 2013). The biggest challenges to online education in Bangladesh are a shortage of technical resources ,expensive costs, inconsistent internet connection, as well as family economic issues and mental stress on learners. Because of the government's lack of technical support, the majority of students were also opposed to the idea of taking online classes (Ramij and Sultana., 2020). Due to two factors, a comparable finding suggested that a considerable absence of communication between teachers and students in online programs. First, students are not able to respond in the classroom due to slow internet connection and excessive internet costs. Second, the majority of students are unable to remind what they studied on university. Furthermore, students who take online courses for an extended period of time experience fatigue and loss of attention (Panday, 2020). Students were concerned about the gap in their studies and were willing to enroll in their online classes to fill it, according to Shama and Ikbal's (2020) research, but they lacked adequate technical resources, such as access to inexpensive information required for online classes. Teachers are interested in teaching in online sessions, where universities unable to provide them with the technological resources and help or support, they need to run effective online lectures. According to Biswas et al. (2020), mobile learning is an efficient educational tool in all developing nations, however it is not employed well in Bangladesh. University students in Bangladesh, on the other hand, are eager to learn online. Furthermore, they conduct their research using a variety of network protocols including social media. During this COVID-19 pandemic, students believe it is highly beneficial to recoup the study gap. For learning, 40% of the university learners choose social media Facebook, 18.1% prefer Google, 19.4% prefer YouTube, and 20% prefer Zoom. According to AlHajri et al. (2017), the access to mobile phones among students is the primary cause for them changing their attention to mobile learning as a means of continuing their education. Smartphone users increasingly want easy access various social networking sites. According to Dutta (2020), students have used a variety of social media apps to obtain academic knowledge. WhatsApp is utilized as a messaging tool for sharing information, papers and presentations, where YouTube is used for self-study, and Google Meet, Zoom, Skype are used for video conferencing software to speed up their learning process. Video conferencing systems, in addition to text messengers, have been frequently employed for interactions between students and teachers. Learners are now confident in their ability to access,

learn, exchange, and produce meaningful information with gaining understanding of subject through technology. Online teaching-learning, according to Rony et al. (2019), has been the way out of a pandemic crisis. This additional dimension, however, necessitates faculty training. Online teacher training is viable in this pandemic situation and can have a significant impact on teachers' attitudes, although there are still certain problems, such as technological issues, inadequate internet access, and a scarcity of experienced trainers. For the reason of network problems, system faults, software updates, and other factors, insufficient internet connection in the margins poses a significant difficulty, even for the middle classes. Nearly 80% of the students who took part in the study found it useful. E-courses are widely used over the world, according to Cimermanov a (2009). Extroverts did not preferred face-to-face communication with teachers over e-learning courses. In contrast to self - directed learners with inter-personal excitement often prefer online learning courses because traditional physical courses and online courses produce similar results. Face-to-face classes are generally preferred by students who are resistant, dependant, and active. As a result, the type of education has little influence on its quality. According to Reeves (2000), online learning environments have grown more common in higher education. Formative and summative assessment, recalling findings, and portfolios are all major obstacles in immersive learning environments vs traditional classrooms. Other appraisal approaches in online learning situations can be used in three ways: efficiency, cognitive and portfolio-based evaluations. This needed specific faculty training as well as professional support in enhancing and integrating a variety of online assessment and activities systems. However, according to another study, online learning provides pupils with a variety of meaningful interactions. For example, cost-effectiveness, flexibility, resource availability, which is a proper-designed class interface. In addition to the positive features, time-consuming feedback from teachers, inaccessible technical and pedagogical support from academics, lack of their self-motivation, lack of involvement, unattractive teaching methodologies, and course material are all unfavorable opinions of online learning (Yang & Cornelius, 2004). Although, according to Jaggars et al. (2010), students' effectiveness of learning outcomes in the online courses are often superior to those in traditional courses. Online students of more than 70% have computer-based learning obstacles, technical difficulties or other factors connected to the course's in online aspect. Prepared and motivated students will not be harmed by online courses, and online education provides ease and flexibility in the locations and schedule of their study. It was considered that students who were interested in studying in their own style and on their own time would benefit. Online learning, according to

students, helps them to maintain self directed learning and a higher level of accountability throughout their studies. Not every experience was pleasant. A key barrier to online learning was the lack of enough opportunities for interpersonal interactions, which was thought to be essential for building peer support and promoting in-depth group debate on the topic. Students' performance expectations for online-based learning were found to be relatively high in this study. To improve the online education system, the focus must be on teaching and learning, not just the technological issue (Sit et al., 2005). According to a study, online classes are a comparable effective learning alternative. Even while the style of instruction has no effect on student achievement, some courses (Research Methodology) are more difficult for the learners who continued in the online-learning environment rather than in the classroom. Furthermore, participation in online classrooms may be less frightening, and the quality and quantity of contact may be increased. Online contact can help students learn more effectively, especially if they are introverted in the classroom (Ni, 2013). The classification of teachers, age, years of teaching experience, or the type of organization, according to Cherry et al. (2017), have no impact on the efficacy of distant learning. Furthermore, there was no link between the couple of years spent teaching courses online and faculty satisfaction with the coursework or institutional assistance. In addition, there is a clear link between technological self-ability and the use of technology-assisted learning approaches. Learners are becoming accustomed to diverse online practices, particularly the development of soft skills, according to Obaidullah and Zubayer (2020), despite several barriers to accessing in e-learning, such as higher pricing, internet slowness, network instability, and access to a computer (Al-Amin, M., Al Zubayer, A., Deb, B., & Hasan, M. 2021).

2.5 The concept of an Online-based laboratory class framework

Although we live in an age of advanced technology and a variety of communication methods, it is amazing that various study have indicated to a continued dependence on conventional teaching, particularly in developing states. Universities are advised to take advantage of the options made available to them by technological advancements in order to give a more in-depth and attractive education. This being the case, it is reasonable to argue that taking advantage of the potential provided by e-learning technology to improve the learning experience is an excellent idea. For the most part, e-learning used in the traditional theoretical courses which enrolled at the university and require a significant amount of theoretical course and assessments. Other universities have discussed the possibility of establishing an online-based laboratory class oriented program, but the notion has not yet gained widespread acceptance. The use of an online-

based laboratory class oriented program can be beneficial to both students and universities in a variety of ways. The capacity for universities to help more students while improving personalization and guidance reducing loneliness. Employability and employer collaboration are other aspects of many e-learning developments. Additionally it can also improve the number of possibilities for formative evaluation, which can lead to increased student motivation and learning as a result. A research published by the Royal Academy of Engineering found that students who participated in an online-based framework teaching-learning process that included practical and interactive lectures performed better than those who did not. Among the advantages were the encouragement of cooperation among students as well as the promotion of contact between students and faculty. As a result, e-learning has the potential to provide enormous benefits in terms of increasing both the efficiency and the effectiveness of education. Technical approaches, ethics, quality standards, and security requirements are all included in online-based laboratory class framework, which are often brief instructions with the goal of educating students about them. Implementation of an online-based laboratory class framework should be similar to that of industry-based work integrated (WIL) modules in that it should be primarily concerned with material handling and solving technical challenges. Generally an e-WIL module should focus on both theory and practice, and an online-based laboratory class framework should include both on-site lecturing and e-learning technologies that are available to the participants. The use of interactive and learning technology for the delivery and transmission of learning content should also be considered. Such as a learning management system, web-based meetings, discussion forums, chat, and social media, among others. as well as digital learning resources such as educational video, instructional guidance, blogs, 3-dimensional applications, and so on (Thaoge, A proposed framework for designing an online based (E-learning) Work Integrated Learning (WIL) module for the Diploma in Biotechnology, 2021). It is required to conduct additional research into learning approaches and build a program that is a combination of many learning styles in order to put in place a successful online-based laboratory class program. So the challenge in developing this online-based laboratory class framework module for Engineering graduates would be to interconnect the knowledge requirements of employers with academic educational approaches in order to create the work - integrated online learning courses through the online-based laboratory class. A course that promotes both theoretical concepts and practice , is targeted at groups of students, and incorporates lectures as well as e-learning technologies that are conveniently available in the workplace or at the student's residence will be developed as a result of this research. The use

of interaction and learning technologies for the distribution and communication of learning content include learning management systems (LMSs), web-based meetings, discussion groups, messaging, social platforms, and digital educational content such as instructional clips and tutorial guides. Other examples include 3D-applications and 3D-modeling (Thaoge, A proposed framework for designing an online based (E-learning) Work Integrated Learning (WIL) module for the Diploma in Biotechnology, 2021).

2.6 Benefits of online-based laboratory class

Online-based laboratory class is a concept that has been widely explored around the world for its benefits to graduates. During the online-based laboratory class, students are introduced to new skills, ideas, and capacities, as well as the opportunity to master the competencies that are considered fundamental to their individual qualification. These skills, which can only be learned on the field, cannot be taught in a traditional classroom setting. Researcher believes that students should be introduced to the day-to-day activities of workplace for their specific profession or vocation in which they are pursuing a degree.

Students must be introduced to practical work as well as soft skills during their online-based laboratory class. The first half of the practical work is devoted to skills that are related to the qualifications, while the second part is primarily concerned with soft skills such as problem solving, teamwork, and project management. Student's online-based laboratory class programs are widely identified as a vital technique for enhancing employability skills in students and improving job prospects for graduate students, particularly in fields that have not traditionally been associated with positive employment results. It has emerged as a dominating theme in the literature about the influence of online-based laboratory class on student career progression or employability capability development, which lends support to current developments in the evaluation of online-based laboratory class framework initiatives and programs. However, the experience acquired via online-based laboratory class does not ensure that students and graduates will be employable after they graduate (Thaoge, A proposed framework for designing an online based (E-learning) Work Integrated Learning (WIL) module for the Diploma in Biotechnology, 2021).

2.7 Development of an Online-based laboratory class framework

Despite the fact that proper planning and effective design are essential for any form of training program, they are much more essential for online-based laboratory class programs.

Traditionalism indicates that the greatest effort be put into the completion of training sessions, whereas e-learning emphasizes the design and construction of structured materials that must be self-contained and capable of using it numerous times without any need for ongoing revisions and modifications. The goal of this work was to identify the criteria which should be considered in order to establish a successful online-based laboratory class framework for engineering students of the EEE and CSE department. The purpose of this research was to build a procedure that will be utilized to design an online-based laboratory class, the university's Learning Management System, as the primary source of information. The ADDIE model, which consists of sequential stages of development through one stage to the next, served as the foundation for this investigation. The evaluation process is the final step of the ADDIE concept, and it is used to assess and evaluate the work done in the preceding phases.

2.8 Conceptual framework

2.9 The ADDIE Model

It is the standard technique to building training and education systems that is known as Instructional Systems Design (ISD). An instructional design model can be used to specify the activities that will be utilized to guide the creation of e-learning activities. Several instructional systems design models are available, the most of which are based on well-known models ADDIE model is one of them. The ADDIE model is the conventional models that is most commonly utilized in the development of e-modules. The ADDIE concept is divided into: analysis, design, development , implementation, and evaluation.

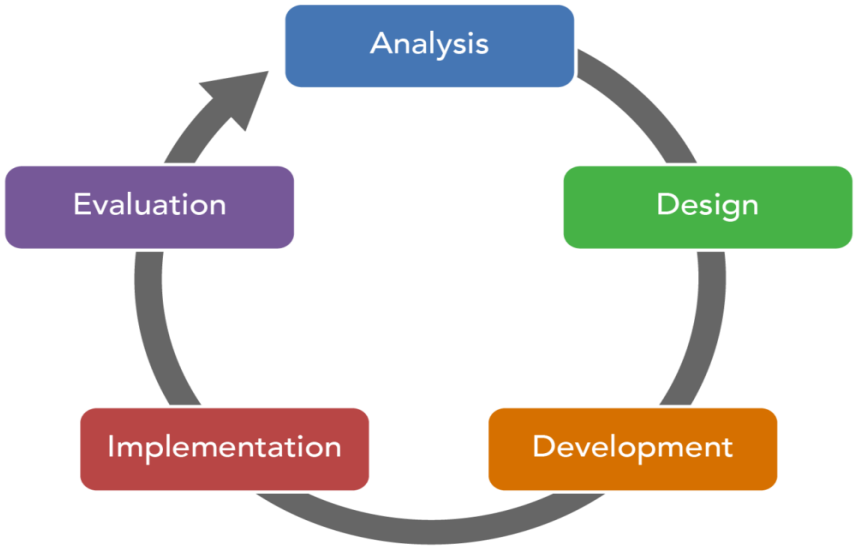


Figure 1 ADDIE Model

Figure. The ADDIE model for E-Learning instructional design

An online-based laboratory class framework model for EEE and CSE engineering students will be developed using this conceptual framework, which will serve as a guide throughout the process of developing a framework. In this project, the ADDIE concept was used to establish a framework for the development of an online-based laboratory class framework model. It will be necessary to apply the ADDIE model for e-Learning Instructional Design (shown in Fig.), specifically for the design and development of an online-based laboratory class framework model, in order to complete the task.

Analysis:

Prior to beginning any development program, it is necessary to do a needs analysis to establish whether the following conditions are met:

i) To establish whether training is required to reduce a gap in occupational knowledge and abilities.

ii) To deliver the course, electronic learning is the most effective method.

iii) What are the objectives of the university/department in providing education and training - in other words, what are they trying to achieve?

iv) Describe the problem(s) that have been recognized by the organization and how they will be resolved during the program of teaching-learning.

v) What abilities or information do the pupils already have, such that there is no duplication or repetition of effort and information that is redundant?

vi) Also, what abilities and information they must have before to enrolling in the course in order to be successful?

After the aforementioned activities have been completed, the researcher will: Establish a relationship between the learning outcomes and productive work ideas from the workplace environment in ensuring that students acquire the required information and job skills possible (Thaoge, A proposed framework for designing an online based (E-learning) Work Integrated Learning (WIL) module for the Diploma in Biotechnology, 2021).

Design

The purpose of this stage of the design process is to develop and define the course outcomes and each concepts into it that will be evaluated and also what platform and materials would be used to assist the e-learning activities, the core content of the course, and, finally, how well the students and the performance of the course itself will be evaluated, among other things. A major component of this section is course development, where the course content will be prepared and organized in a systematic manner.

Development

It is this phase where the real development of what would be planned during the Design phase takes place. Considering that e-Learning will be the medium via which the course would be provided, the significant proportion of the development period will be allocated to the actual creation of the course itself.

i) In addition to instructional aids, resources, tools, and other materials, a comprehensive inventory of all available resources and materials will be completed as well.

ii)This presentation will be cohesive in that it will incorporate all of the content as well as the many resources, tools, and assessment methods.

iii) At this point, the content wil evaluated to make sure that it is meeting the objectives of the organization, which were specified during the Analysis phase.

iv)Resources collection and some portion of course content, as well as some of the course materials, resources and aids may need to be modified in order to develop and improve the objectives of course and the students ' needs.

The creation of multimedia interactive material is divided into three major processes, which are as follows:

Content development: Collecting and writing all of the necessary knowledge and information

Storyboard development: Incorporating instructional approaches (all of the pedagogical aspects required to assist the educational process) and media materials into a single program This is accomplished through the creation of a storyboard, which is one kind of document that can explains all of the components of the ultimate interactive products with including graphics, text, interactions, and also evaluation test, among other things.

Courseware development: To develop interactive components and media, Producing the course in various form for CD-Rom with its Web delivery, and integrating the content materials through a learning platform where the students can access are all responsibilities of the course developer.

The course material can differ significantly based on the resources that are accessible. Simpler resources (those that have little or no interaction or multimedia, like structural Pdf files) can be used in combination with other materials (audio or video content), assignments, and assessments to create elearning content that is more effective. The development of media and technological interactions, would not be possible under that situation.

Implementation and Evaluation

This is the phase during which the course is established and made available to the learners who have been recognized a need for the information being provided. It was not possible to implement and evaluate the framework in its real application for the purposes of this research, however, due to the limited time and resources made available to students. Following the implementation of the course, an online feedback/evaluation system will be developed to ensure that the online-based laboratory class framework module has met the needs of the department, the university, and the students, and that it has been presented as effectively as possible with all of the necessary tools and aids to assist the students.

3 Chapter-3 Research Methodology

3.1 Introduction

The research approach that was applied in the study is detailed in this chapter. The study's methodology, as well as its demographic and sample, are all discussed. The instrument that was used to gather the data, as well as the measures that were taken to ensure that the instrument's validity and reliability were maintained, are all discussed. There are three main research methodologies, often known as research methods, to consider. Which include quantitative, qualitative, and mixed-methods analyses. Rather of focusing on why something is happening, qualitative research seeks to gain a better knowledge of a specific phenomenon by delving into the details of what is happening. Quantitative research, from the other side, refers to investigations in which the data under consideration can be analyzed in terms of numbers and statistics. When doing mixed method research, researcher integrate quantitative and qualitative approaches at different stages of the research process, including sampling strategies, data collecting and analysis, findings interpretation, data integration and reporting. The data obtained, analyzed, and integrated can be numerical, but it can also be textual, visual, or multimedia in nature.

An knowledge of the key aspects that should be followed in order to establish an online-based laboratory class was explored in this study, which used a qualitative research approach to achieve its goal of understanding. The research will also be of a developmental type, which will describe the scenario utilizing the online-based laboratory class as a case study, in addition to the nature of the research. In this research, quantitative and qualitative both of the methodologies were used in combination with one another. Nonnumerical data, such as words and images, were gathered and analyzed using a qualitative technique, whereas numerical data, such as numbers, graphs, or statistics were collected and analyzed using a quantitative approach Thematic analysis which is a method of analyzing qualitative data.

One other key part of the approach towards this research is that it is focused on the construction of a framework that will be used for online-based laboratory class participated students (Thaoge, A proposed framework for designing an online based (Elearning) Work Integrated Learning (WIL) module for the Diploma in Biotechnology, 2021).

In order to conduct this research study, a mixed methods approach was chosen. When conducting mixed methods research, researcher draw methodologies with the quantitative and

qualitative research both paradigms in obtaining a more complete understanding of the issue of interest. "The usage of qualitative and quantitative methodologies is determined and planned from the beginning of such research process and "the processes are carried out in the manner that has been predetermined." The context for the research study is outlined in this chapter, as is the overall mixed methods design, which is defined, and the quantitative and qualitative methodologies that were used are explained in detail (Reece, 2015).

The use of questionnaires as an effective tools for data collection, giving organized and typically numerical data, is commonplace. When collecting data on participants' satisfaction or attitudes toward a certain issue, questionnaires typically include both closed-ended and open-ended questions. A Likert - type scale is used to collect information regarding participants' satisfaction with, or attitudes toward, a certain topic (El-Sabagh, 2011).

Table 1 Five point likert scale

Likert Scale	Acronyms	Points
Strongly Disagree	SD	1
Disagree	D	2
Neutral	N	3
Agree	A	4
Strongly agree	SA	5

Each respondent was given the opportunity to participate and respond to the questionnaire in a free and voluntary manner. Participants notified that their opinions and identities kept confidential, and they informed that they have the right to withdraw their participation at any time. Physical and/or online distribution of the questionnaire made available to the participants. The researcher accessible to provide any clarifications on the required responses if any are required.

3.2 Research design

The goals of the study was to conduct quantitative research to determine how teachers felt about online laboratory courses. It was decided to focus on Teachers who offer BSc Engineering degrees in CSE and EEE at universities and students also to distribute questionnaires to them in order to gather data. Descriptive statistics were used to analyze the research data. The research data was collected through the technique of purposive sampling. The validity of the research tool (questionnaires) checked by the selected respondents of the Engineering Universities. SPSS software used to analyze the data. ADDIE model used as reference to design the framework. The framework designed with the opinion of the respondent. And it theoretically justified by the expert of the mentioned Universities.

3.3 Participants

The participants in this study were teachers and students from public and private universities in Bangladesh that offer engineering degrees in the fields of computer science and electrical engineering with a focus on CSE and EEE. After being exposed to the purposive sampling technique, a total of 150 target populations will be formed from this population. Because the data obtained from the expected population, it is necessary to conduct purposeful sampling. There are seven public universities (such as BUET, RUET, KUET, CUET, DUET, MIST, DU) and seven private universities (such as AUST, DIU, EWU, IUB, NSU, Brac Uni, and UIU) from the two categories of specialization CSE and EEE.

From the individual department the expected responder will be four (4), from each university three individual department (CSE, EEE) responder will be 12

Table 2 Participants List

Public University	Responder of Research(Teacher)	Private University	Responder of Research(Teacher)	Total
BUET	12	AUST	12	24
RUET	12	UIU	12	24
KUET	12	DIU	12	24
CUET	12	EWU	12	24
DUET	12	IUB	12	24
DU	12	NSU	12	24
MIST	12	BRAC UNI	12	24
Total				168

3.4 Research Instruments

This is a quantitative research in which a questionnaire is to be administered to collect data from the participants. A questionnaire that was self-designed and piloted with from strongly agree to strongly disagree, there is a five-point rating scale to consider which are used to collect data. Four components comprise the questionnaire: biographical information about the participant, beliefs about the participant, methods of online-based laboratory classes, and motivations driving participants to participate in online-based practical learning. The validity of the research tool (questionnaire's) will be checked by the selected respondents of the Engineering Universities. That questions send to the some responder and identify whether those questions are reliable or not also its need to modify or nor.

3.5 Data collection process:

In person: In this strategy printed questionnaire is to be distributed to the participants by the researcher after getting the official permission from the respective universities authorities that is to allow the researcher questionnaires and also the contacts of the participants on which the link is to be given to them.

3.6 Data collection procedure

During the data collection phase of this study, a closed-ended questionnaire was used, with just a few open-ended questionnaires being used to allow participants to textually respond. Each participant was given the opportunity to participate and reply to the questionnaire in a free and voluntary manner. Participants were advised that their opinions and identities would be kept anonymous, and they were also informed that they had the option to withdraw from the study at any time. In addition to being distributed in person, the questionnaire was also made available online. In order to provide further justifications regarding the required responses, the researcher was often available face to face or through cell phone.

3.7 Data analysis procedure

The responses to the closed-ended inquiry had already been assigned a numerical value before to the survey. The results of each item's scores were combined to get a composite score for each of the components. A meaningful analysis could only be carried out if the negative elements were reverse coded. Descriptive statistics, such as frequency and percentage, as well as means and standard deviation, were utilized in this research for the purpose of data analysis. A Chi-square (X^2) test (non-parametric) was used to investigate the hypothesis of each item on the questionnaire. A significant value ($p < 0.05$) was obtained for each item using the Chi-square

(X^2) test. The analysis of the data was carried out using the Statistical Package for Social Science software (IBM SPSS v: 25).

When conducting open-ended or textual data analysis, the researcher used thematic analysis through the process. Thematic analysis is a method of interpreting and analyzing qualitative data. The researcher carefully examines the data in order to determine common themes, which are subjects, concepts, and patterns of meaning that appear repeatedly.

3.8 Ethical consideration

The study maintained the legacy and did not violate any of the norms and regulations that governed the data gathering process. In accordance with the regulations of research data collecting, the name and identity of any participant will not be disclosed, and the response from the participant will be strictly used specifically for the purpose of the research. The information obtained from students and teachers of the previously mentioned university was kept totally secret. Before the respondent delivered his or her valuable response, the researcher ensured participants all the terms and conditions of the specific questionnaire.

3.9 Validation of the instruments

After finishing the design of research tools and the construction of questionnaire items (appendices A & B), the validity of the trustees' instruments was checked by submitting both instruments in the form of questionnaires to selected specialists for review. Several changes were made to the document in response to the reviewers' recommendations, including changes to the meaning, accuracy, linguistic clarity, and functionality, as well as the inclusion of or deletion of some items.

3.10 Data Analysis

The teaching learning framework designed based on the collected data from the selected respondent. From the responses. Data software analyzed with the assistance of the Statistical Package for the Social Sciences (SPSS) where regression analysis use to determine the extent to which all the research parameters (teachers' beliefs, ways of using online based practical platform in learning and motivating factors) are to be measured.

4 Chapter-4 Data Analysis and interpretation

4.1 Data analysis and interpretation

In this section, statistical procedures are presented that were used to analyze both the continuous and categorical data collected from teachers and students of different universities of Bangladesh. The respondents data obtained through questionnaires have been tabulated in forms of frequencies and percentages. The first section of this chapter discusses about demographic data of the participants. The second section involves analysis of data related to the first, second, and third research question. Chi-square (x^2) test was conducted by testing the components at 0.05 significant levels. Means and standard deviations were also calculated.

4.2 Frequency Distribution

Statistics

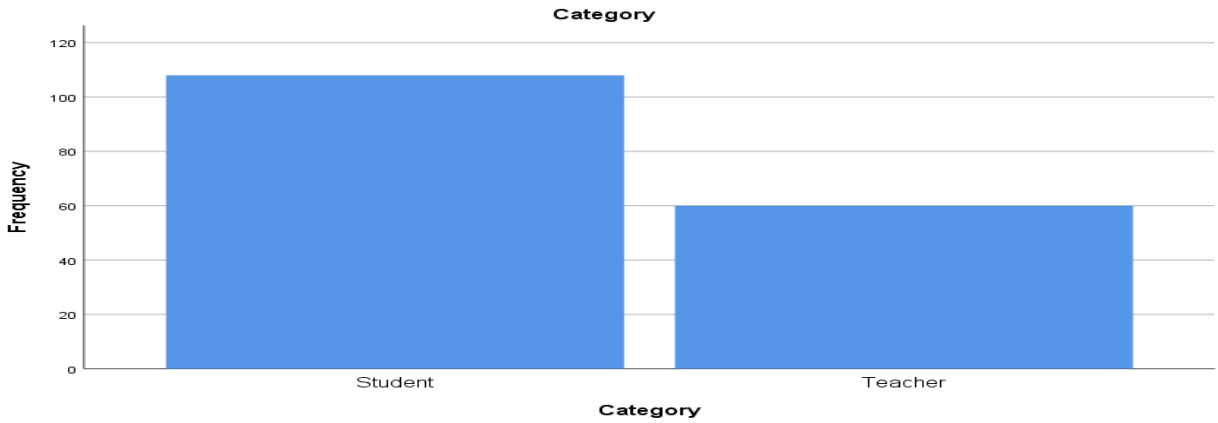
		University	Department	Category	Gender
N	Valid	168	168	168	168
	Missing	0	0	0	0

The number of participants 168 nos. All the respondents participate the research questionnaires.

Category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Student	108	64.3	64.3	64.3
	Teacher	60	35.7	35.7	100.0
	Total	168	100.0	100.0	

Bar Chart



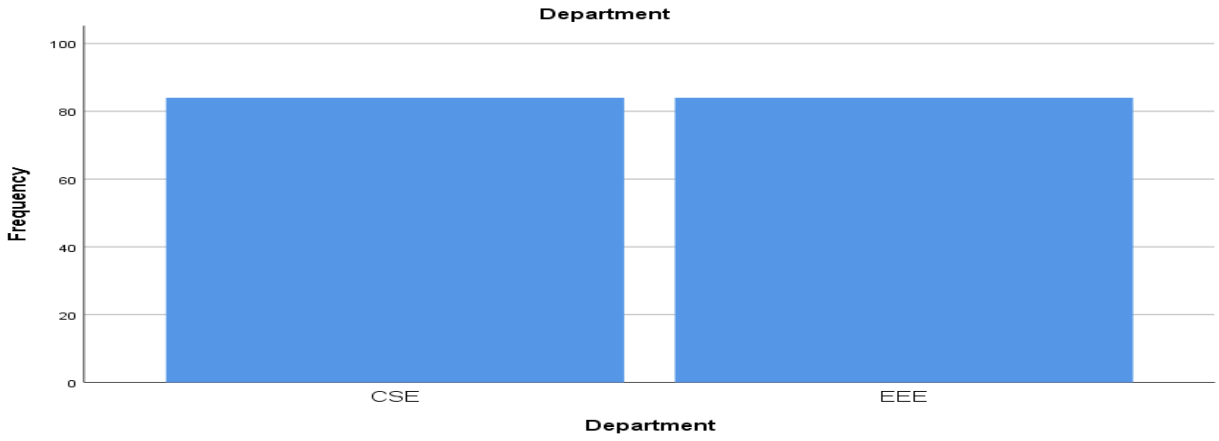
The category of responded are students and teachers from 14 nos public and privet university. 108 nos participants from the students and 60 nos participants from the teachers.

4.3 Department

Department

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	CSE	84	50.0	50.0	50.0
	EEE	84	50.0	50.0	100.0
	Total	168	100.0	100.0	

Bar Chart

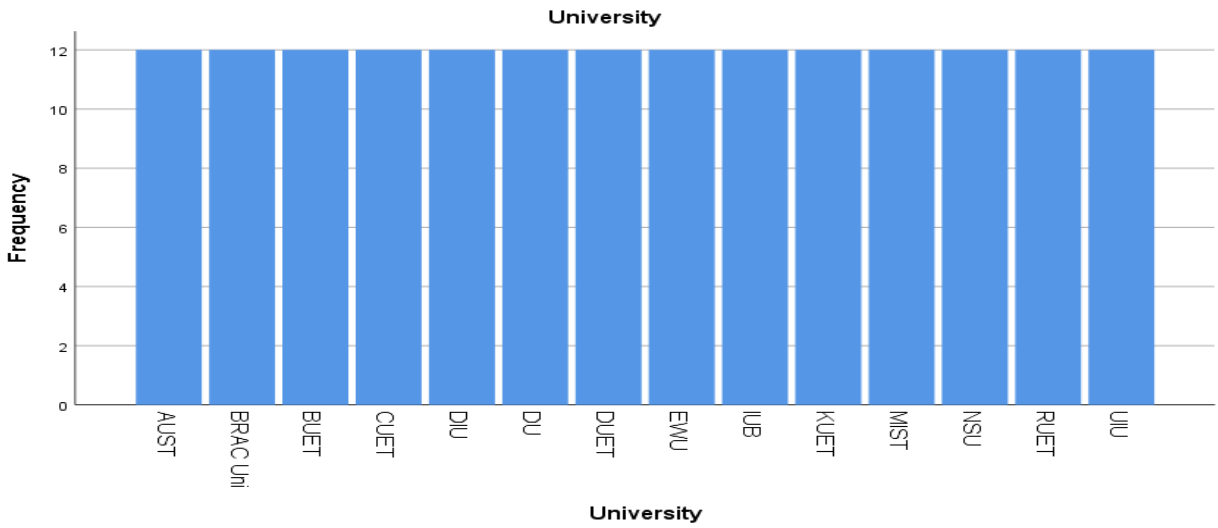


4.4 University

University

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	AUST	12	7.1	7.1	7.1
	BRAC Uni	12	7.1	7.1	14.3
	BUET	12	7.1	7.1	21.4
	CUET	12	7.1	7.1	28.6
	DIU	12	7.1	7.1	35.7
	DU	12	7.1	7.1	42.9
	DUET	12	7.1	7.1	50.0
	EWU	12	7.1	7.1	57.1
	IUB	12	7.1	7.1	64.3
	KUET	12	7.1	7.1	71.4
	MIST	12	7.1	7.1	78.6
	NSU	12	7.1	7.1	85.7
	RUET	12	7.1	7.1	92.9
	UIU	12	7.1	7.1	100.0
	Total	168	100.0	100.0	

Bar Chart



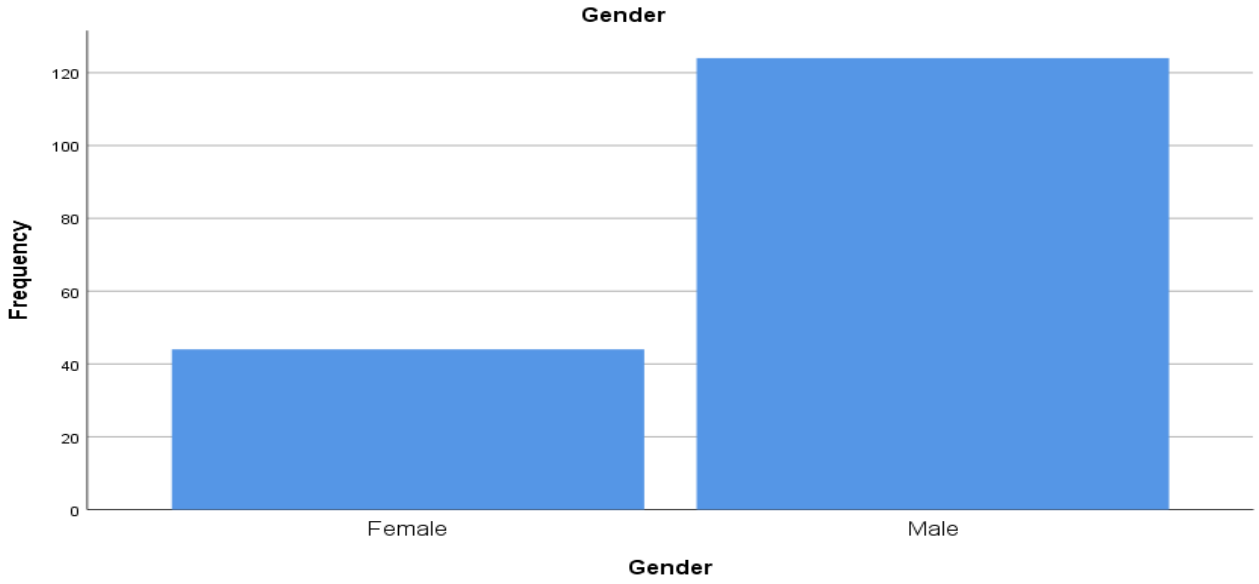
The researcher collected the data from 7 nos of Public University and 7 nos of Privet University. 12 nos of responded (Students and teachers) from each university participated the study for given their opinion about research questionnaires. So the total number of responded from 14 nos universities are 168 nos.

4.5 Gender

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	44	26.2	26.2	26.2
	Male	124	73.8	73.8	100.0
	Total	168	100.0	100.0	

Bar Chart



4.6 Descriptive Analysis

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
EIM	168	40	10	50	6313	37.58	.914	11.841	140.210
BLMS	168	25	27	52	6970	41.49	.409	5.303	28.120
ETLF	168	52	13	65	8164	48.60	1.325	17.177	295.045
Valid N (listwise)	168								

The above table basically described the descriptive statistics status of three objectives. EIM is the objective 1 elaborated effective instructional methodologies for online based laboratory classes, BLMS is the objective 2 elaborated the best LMS (Learning management Systems), and ETLF is the objective 3 elaborated the effective teaching-learning framework for online based laboratory classes. The minimum value in the above table indicate the minimum score of every category, the maximum value indicate the maximum score of the every category. The sum value indicated the total value of the every category. And the mean value indicated the average score of every category. The standard deviation value indicated the standard deviation of every category.

Descriptive Statistics

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
EIM	168	-.802	.187	-.553	.373
BLMS	168	-.542	.187	-.193	.373
ETLF	168	-.802	.187	-.674	.373
Valid N (listwise)	168				

The above table showed the Skewness and Kurtosis of described three research objectives.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
EIM	.165	168	.000	.873	168	.000
BLMS	.091	168	.002	.967	168	.000
ETLF	.257	168	.000	.828	168	.000

a. Lilliefors Significance Correction

4.7 Analysis of Objective 1

(Identify the effective instructional methodologies followed for conducting the online-based laboratory classes in the engineering universities of Bangladesh)

Table 3 Analysis of Objective 1

Sl	Statements	N		SD	D	N	A	SA	Chi-Square	df	Asm. Sig.
1	Online-based laboratory classes are effective for EEE and CSE departments in engineering universities of Bangladesh	168	f	18	18	17	47	68	18.071	4	0.001
			%	10.71	10.71	10.12	27.98	40.48			
2	Skills-based online laboratory classes are fruitful and effective for students.	168	f	17	20	17	46	68	12.217	4	0.016
			%	10.12	11.90	10.12	27.38	40.48			
3	PowerPoint presentation-based online laboratory classes are fruitful and effective for students.	168	f	17	20	16	50	65	12.533	4	0.014
			%	10.12	11.90	9.52	29.76	38.69			
4	Multimedia-based online laboratory classes are fruitful and effective for students.	168	f	17	24	12	50	65	12.859	4	0.012
			%	10.12	14.29	7.14	29.76	38.69			
5	Remote control experiments online laboratory classes are fruitful and effective for students.	168	f	13	28	12	50	65	13.799	4	0.008
			%	7.74	16.67	7.14	29.76	38.69			
6	Animation-based online laboratory classes are fruitful and effective for students.	168	f	13	28	12	54	61	21.511	4	0.000
			%	7.74	16.67	7.14	32.14	36.31			
7	Role-Playing based online laboratory classes are fruitful and effective for students.	168	f	13	24	12	58	61	21.487	4	0.000
			%	7.74	14.29	7.14	34.52	36.31			
8	Focused Imaging-based online laboratory classes are fruitful and effective for students.	168	f	13	23	10	61	61	19.765	4	0.001
			%	7.74	13.69	5.95	36.31	36.31			
9	Web-based online laboratory classes are fruitful and effective for students.	168	f	12	21	9	65	61	19.079	4	0.001
			%	7.14	12.50	5.36	38.69	36.31			

10	Learner-centered instruction online laboratory classes are fruitful and effective for students.	168	f	20	13	26	51	58	9.694	4	0.046
			%	11.90	7.74	15.48	30.36	34.52			

Statement one: It was observed that overall 68.46 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Online-based laboratory classes are effective for EEE and CSE departments in engineering universities of Bangladesh. The Chi-square test was conducted at df = 4 with significant value of 0.001, which is less than 0.05 level of significance. Chi-square observed (x^2o) (18.071) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (18.071) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Online-based laboratory classes are effective for EEE and CSE departments in engineering universities of Bangladesh.

Statement two: It was observed that overall 67.86 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Skills-based online laboratory classes are fruitful and effective for students. The Chi-square test was conducted at df = 4 with significant value of 0.016, which is less than 0.05 level of significance. Chi-square observed (x^2o) (12.217) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (12.217) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Skills-based online laboratory classes are fruitful and effective for students.

Statement three: It was observed that overall 68.45 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: PowerPoint presentation-based online laboratory classes are fruitful and effective for students. The Chi-square test was conducted at df = 4 with significant value of 0.014, which is less than 0.05 level of significance. Chi-square observed (x^2o) (12.533) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (12.533) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant

that PowerPoint presentation-based online laboratory classes are fruitful and effective for students.

Statement four: It was observed that overall 68.45 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Multimedia-based online laboratory classes are fruitful and effective for students. The Chi-square test was conducted at df = 4 with significant value of 0.012, which is less than 0.05 level of significance. Chi-square observed (x^2o) (12.859) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (12.859) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Multimedia-based online laboratory classes are fruitful and effective for students.

Statement five: It was observed that overall 68.45 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Remote control experiments online laboratory classes are fruitful and effective for students. The Chi-square test was conducted at df = 4 with significant value of 0.008, which is less than 0.05 level of significance. Chi-square observed (x^2o) (13.799) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (13.799) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Remote control experiments online laboratory classes are fruitful and effective for students.

Statement six: It was observed that overall 68.45 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Animation-based online laboratory classes are fruitful and effective for students. The Chi-square test was conducted at df = 4 with significant value of 0.000, which is less than 0.05 level of significance. Chi-square observed (x^2o) (21.511) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (21.511) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Animation-based online laboratory classes are fruitful and effective for students.

Statement seven: It was observed that overall 70.83 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the

responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Role-Playing based online laboratory classes are fruitful and effective for students. The Chi-square test was conducted at df = 4 with significant value of 0.000, which is less than 0.05 level of significance. Chi-square observed (x^2o) (21.487) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (21.487) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Role-Playing based online laboratory classes are fruitful and effective for students.

Statement eight: It was observed that overall 72.62 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Focused Imaging-based online laboratory classes are fruitful and effective for students. The Chi-square test was conducted at df = 4 with significant value of 0.001, which is less than 0.05 level of significance. Chi-square observed (x^2o) (19.765) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (19.765) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Focused Imaging-based online laboratory classes are fruitful and effective for students.

Statement nine: It was observed that overall 75.00 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Web-based online laboratory classes are fruitful and effective for students. The Chi-square test was conducted at df = 4 with significant value of 0.001, which is less than 0.05 level of significance. Chi-square observed (x^2o) (19.079) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (19.079) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Web-based online laboratory classes are fruitful and effective for students.

Statement ten: It was observed that overall 64.88 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Learner-centered instruction online laboratory classes are fruitful and effective for students. The Chi-square test was conducted at df = 4 with significant value of 0.046, which is less than 0.05 level of significance. Chi-square observed (x^2o) (9.694) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (9.694) > x^2c (9.49), for which the null hypothesis, responses on this

item is not statistically significant, is rejected. Therefore it was statistically significant that Learner-centered instruction online laboratory classes are fruitful and effective for students.

4.8 Analysis of Objective 2

(The best LMS for conducting online-based laboratory classes)

Table 4 Analysis of Objective 2

Sl	Statements	N		SD	D	N	A	SA	Chi-Square	df	Asm. Sig.
1	Conducting online-based laboratory classes by Learning Management Systems (LMS) is easy to assess.	168	f	16	17	26	51	58	10.562	4	0.003
			%	9.52	10.12	15.48	30.36	34.52			
2	Learning Management Systems (LMS) is effective and interactive to conduct online-based laboratory classes.	168	f	10	13	25	63	57	10.542	4	0.000
			%	5.95	7.74	14.88	37.50	33.93			
3	Moodle is the popular LMS for being flexible and easy to access.	168	f	12	17	25	56	58	9.727	4	0.000
			%	7.14	10.12	14.88	33.33	34.52			
4	Google Classroom is the popular LMS for being flexible and easy to access.	168	f	9	10	19	76	54	9.611	4	0.000
			%	5.36	5.95	11.31	45.24	32.14			
5	Mindflash is the popular LMS for being flexible and easy to access.	168	f	66	52	20	15	15	4.975	4	0.000
			%	39.29	30.95	11.90	8.93	8.93			
6	Docebo is the popular LMS for being flexible and easy to access.	168	f	44	60	18	25	21	2.214	4	0.000
			%	26.19	35.71	10.71	12.50	14.88			
7	iSpring Learn is the popular LMS for being flexible and easy to access.	168	f	70	52	23	14	9	1.74	4	0.003
			%	41.67	30.95	13.69	8.33	5.36			
8	TalentLMS is the popular LMS for being flexible and easy to access.	168	f	66	49	23	15	15	5.688	4	0.001
			%	39.29	29.17	13.69	8.93	8.93			
9		168	f	79	57	16	9	7	2.978	4	

	ProProfs LMS is the popular LMS for being flexible and easy to access.		%	47.02	33.93	9.52	5.36	4.17			0.000
10	Canvas LMS is the popular LMS for being flexible and easy to access.	168	f	52	40	29	20	27	2.024	4	0.000
			%	30.95	23.81	17.26	11.90	16.07			
11	Chamilo is the popular LMS for being flexible and easy to access.	168	f	53	43	30	22	20	3.50	4	0.000
			%	31.55	25.60	17.86	13.10	11.90			

Statement one: It was observed that overall 64.88 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement Conducting online-based laboratory classes by Learning Management Systems (LMS) is easy to assess. The Chi-square test was conducted at df = 4 with significant value of 0.003, which is less than 0.05 level of significance. Chi-square observed (x^2o) (10.562) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (10.562) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that conducting online-based laboratory classes by Learning Management Systems (LMS) is easy to assess.

Statement two: It was observed that overall 71.43 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Learning Management Systems (LMS) is effective and interactive to conduct online-based laboratory classes. The Chi-square test was conducted at df = 4 with significant value of 0.000, which is less than 0.05 level of significance. Chi-square observed (x^2o) (10.542) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (10.542) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Learning Management Systems (LMS) is effective and interactive to conduct online-based laboratory classes.

Statement three: It was observed that overall 67.85 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Moodle is the popular LMS for being flexible and easy to access. The Chi-square test was

conducted at df = 4 with significant value of 0.000, which is less than 0.05 level of significance. Chi-square observed (x^2o) (9.727) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (9.727) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Moodle is the popular LMS for being flexible and easy to access.

Statement four: It was observed that overall 77.38 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Google Classroom is the popular LMS for being flexible and easy to access. The Chi-square test was conducted at df = 4 with significant value of 0.000, which is less than 0.05 level of significance. Chi-square observed (x^2o) (9.611) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (9.611) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Google Classroom is the popular LMS for being flexible and easy to access.

Statement five: It was observed that overall 70.24 % responded (students and teachers) opined in the category of disagree and strongly disagree on statement one, which implies most of the responded (students and teachers) were negative (disagree/strongly disagree) regarding the statement: Mindflash is the popular LMS for being flexible and easy to access. The Chi-square test was conducted at df = 4 with significant value of 0.000, which is less than 0.05 level of significance. Chi-square observed (x^2o) (4.975) was smaller than the Chi-square critical (x^2c) (9.49), that is x^2o (4.975) < x^2c (9.49), for which the null hypothesis, responses on this item is statistically significant, is accepted. Therefore it was statistically not significant that Mindflash is the popular LMS for being flexible and easy to access.

Statement six: It was observed that overall 61.90 % responded (students and teachers) opined in the category of disagree and strongly disagree on statement one, which implies most of the responded (students and teachers) were negative (disagree/strongly disagree) regarding the statement: Docebo is the popular LMS for being flexible and easy to access. The Chi-square test was conducted at df = 4 with significant value of 0.000, which is less than 0.05 level of significance. Chi-square observed (x^2o) (2.214) was smaller than the Chi-square critical (x^2c) (9.49), that is x^2o (2.214) < x^2c (9.49), for which the null hypothesis, responses on this item is statistically significant, is accepted. Therefore it was statistically not significant that Docebo is the popular LMS for being flexible and easy to access

Statement seven: It was observed that overall 72.62 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were negative (disagree/strongly disagree) regarding the statement: iSpring Learn is the popular LMS for being flexible and easy to access. The Chi-square test was conducted at df = 4 with significant value of 0.003, which is less than 0.05 level of significance. Chi-square observed (x^2o) (1.74) was smaller than the Chi-square critical (x^2c) (9.49), that is x^2o (1.74) < x^2c (9.49), for which the null hypothesis, responses on this item is statistically significant, is accepted. Therefore it was statistically not significant that iSpring Learn is the popular LMS for being flexible and easy to access.

Statement eight: It was observed that overall 68.46 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were negative (disagree/strongly disagree) regarding the statement TalentLMS is the popular LMS for being flexible and easy to access. The Chi-square test was conducted at df = 4 with significant value of 0.001, which is less than 0.05 level of significance. Chi-square observed (x^2o) (5.688) was smaller than the Chi-square critical (x^2c) (9.49), that is x^2o (5.688) < x^2c (9.49), for which the null hypothesis, responses on this item is statistically significant, is accepted. Therefore it was statistically not significant that TalentLMS is the popular LMS for being flexible and easy to access.

Statement nine: It was observed that overall 80.95 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were negative (disagree/strongly disagree) regarding the statement: ProProfs LMS is the popular LMS for being flexible and easy to access. The Chi-square test was conducted at df = 4 with significant value of 0.000, which is less than 0.05 level of significance. Chi-square observed (x^2o) (2.978) was smaller than the Chi-square critical (x^2c) (9.49), that is x^2o (2.978) < x^2c (9.49), for which the null hypothesis, responses on this item is statistically significant, is accepted. Therefore it was statistically not significant ProProfs LMS is the popular LMS for being flexible and easy to access.

Statement ten: It was observed that overall 54.76 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were negative (disagree/strongly disagree) regarding the statement: Canvas LMS is the popular LMS for being flexible and easy to access. The Chi-square test was conducted at df = 4 with significant value of 0.000, which is less than 0.05 level

of significance. Chi-square observed (x^2o) (2.024) was smaller than the Chi-square critical (x^2c) (9.49), that is x^2o (2.024) < x^2c (9.49), for which the null hypothesis, responses on this item is statistically significant, is accepted. Therefore it was statistically not significant that Canvas LMS is the popular LMS for being flexible and easy to access.

Statement eleven: It was observed that overall 57.15 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were negative (disagree/strongly disagree) regarding the statement: Chamilo is the popular LMS for being flexible and easy to access.. The Chi-square test was conducted at df = 4 with significant value of 0.000, which is less than 0.05 level of significance. Chi-square observed (x^2o) (3.50) was smaller than the Chi-square critical (x^2c) (9.49), that is x^2o (3.50) < x^2c (9.49), for which the null hypothesis, responses on this item is statistically significant, is accepted. Therefore it was statistically not significant that Chamilo is the popular LMS for being flexible and easy to access.

4.9 Analysis of Objective 3

(Design an effective teaching-learning framework for the online-based laboratory classes)

Table 5 Analysis of Objective 3

Sl	Statements	N		SD	D	N	A	SA	Chi-Square	df	Asm. Sig.
1	Zoom is the best platform for online-based laboratory classes.	168	f	18	25	11	51	63	17.044	4	0.002
			%	10.71	14.88	6.55	30.36	37.50			
2	Google meet is the best platform for online-based laboratory classes.	168	f	16	26	9	52	65	14.32	4	0.006
			%	9.52	15.48	5.36	30.95	38.69			
3	ADDIE* model is a popular the effective virtual platform for teaching-learning.	168	f	17	22	10	54	65	11.655	4	0.020
			%	10.12	13.10	5.95	32.14	38.69			
4	LMS is an effective teaching-learning methodology for online-based laboratory classes.	168	f	17	24	11	55	61	17.468	4	0.002
			%	10.12	14.29	6.55	32.74	36.31			
5	Engagement of students and teachers is very	168	f	17	24	12	55	60	19.371	4	0.001
			%	10.12	14.29	7.14	32.74	35.71			

	easy to LMS for laboratory classes.										
6	Individual effective teaching-learning ensured by LMS for laboratory classes.	168	f	17	22	12	52	65	12.872	4	0.012
			%	10.12	13.10	7.14	30.95	38.69			
7	Student Performance and feedback are relaxed by LMS.	168	f	17	22	12	55	62	12.636	4	0.013
			%	10.12	13.10	7.14	32.74	36.90			
8	Resources are available and any time access able in LMS.	168	f	17	23	12	49	67	17.58	4	0.001
			%	10.12	13.69	7.14	29.17	39.88			
9	Review and repeat of the practical session via LMS are possible.	168	f	11	24	12	56	65	17.963	4	0.001
			%	6.55	14.29	7.14	33.33	38.69			
10	Lerner development is very high for laboratory classes via LMS.	168	f	16	20	9	64	59	15.927	4	0.003
			%	9.52	11.90	5.36	38.10	35.12			
11	Teachers are easily delivered the session of laboratory classes via LMS.	168	f	17	24	10	57	60	15.047	4	0.005
			%	10.12	14.29	5.95	33.93	35.71			
12	Offline Course Materials are available in LMS.	168	f	17	24	12	55	60	16.223	4	0.003
			%	10.12	14.29	7.14	32.74	35.71			
13	Communication between teachers and students and among students is easy via LMS.	168	f	17	23	11	50	67	11.858	4	0.018
			%	10.12	13.69	6.55	29.76	39.88			

Statement one: It was observed that overall 67.86 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Zoom is the best platform for online-based laboratory classes. The Chi-square test was conducted at df = 4 with significant value of 0.002, which is less than 0.05 level of significance. Chi-square observed (x^2o) (17.044) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (17.044) > x^2c (9.49), for which the null hypothesis, responses on this item is not

statistically significant, is rejected. Therefore it was statistically significant that Zoom is the best platform for online-based laboratory classes..

Statement two: It was observed that overall 69.64 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Google meet is the best platform for online-based laboratory classes. The Chi-square test was conducted at df = 4 with significant value of 0.006, which is less than 0.05 level of significance. Chi-square observed (x^2o) (14.32) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (14.32) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Google meet is the best platform for online-based laboratory classes.

Statement three: It was observed that overall 70.83 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: ADDIE* model is a popular the effective virtual platform for teaching-learning. The Chi-square test was conducted at df = 4 with significant value of 0.020, which is less than 0.05 level of significance. Chi-square observed (x^2o) (11.655) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (11.655) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that ADDIE* model is a popular the effective virtual platform for teaching-learning.

Statement four: It was observed that overall 69.05 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: LMS is an effective teaching-learning methodology for online-based laboratory classes. The Chi-square test was conducted at df = 4 with significant value of 0.002, which is less than 0.05 level of significance. Chi-square observed (x^2o) (17.468) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (17.468) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that LMS is an effective teaching-learning methodology for online-based laboratory classes.

Statement five: It was observed that overall 68.45 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the

responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Engagement of students and teachers is very easy to LMS for laboratory classes. The Chi-square test was conducted at df = 4 with significant value of 0.001, which is less than 0.05 level of significance. Chi-square observed (x^2o) (19.371) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (19.371) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Engagement of students and teachers is very easy to LMS for laboratory classes.

Statement six: It was observed that overall 69.64 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Individual effective teaching-learning ensured by LMS for laboratory classes. The Chi-square test was conducted at df = 4 with significant value of 0.012, which is less than 0.05 level of significance. Chi-square observed (x^2o) (12.872) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (12.872) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Individual effective teaching-learning ensured by LMS for laboratory classes.

Statement seven: It was observed that overall 69.64 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Student Performance and feedback are relaxed by LMS. The Chi-square test was conducted at df = 4 with significant value of 0.013, which is less than 0.05 level of significance. Chi-square observed (x^2o) (12.636) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (12.636) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Student Performance and feedback are relaxed by LMS.

Statement eight: It was observed that overall 69.05 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Resources are available and any time access able in LMS. The Chi-square test was conducted at df = 4 with significant value of 0.001, which is less than 0.05 level of significance. Chi-square observed (x^2o) (17.58) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (17.58) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant,

is rejected. Therefore it was statistically significant that Resources are available and any time access able in LMS.

Statement nine: It was observed that overall 72.02 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Review and repeat of the practical session via LMS are possible. The Chi-square test was conducted at df = 4 with significant value of 0.001, which is less than 0.05 level of significance. Chi-square observed (x^2o) (17.963) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (17.963) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Review and repeat of the practical session via LMS are possible.

Statement ten: It was observed that overall 73.21 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Lerner development is very high for laboratory classes via LMS. The Chi-square test was conducted at df = 4 with significant value of 0.003, which is less than 0.05 level of significance. Chi-square observed (x^2o) (15.927) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (15.927) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Lerner development is very high for laboratory classes via LMS.

Statement eleven: It was observed that overall 69.64 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Teachers are easily delivered the session of laboratory classes via LMS. The Chi-square test was conducted at df = 4 with significant value of 0.005, which is less than 0.05 level of significance. Chi-square observed (x^2o) (15.047) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (15.047) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Teachers are easily delivered the session of laboratory classes via LMS.

Statement twelve: It was observed that overall 68.45 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the

responded (students and teachers) were positive (agree/strongly agree) regarding the statement Offline Course Materials are available in LMS. The Chi-square test was conducted at df = 4 with significant value of 0.003, which is less than 0.05 level of significance. Chi-square observed (x^2o) (16.223) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (16.223) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Offline Course Materials are available in LMS.

Statement thirteen: It was observed that overall 69.64 % responded (students and teachers) opined in the category of agree and strongly agree on statement one, which implies most of the responded (students and teachers) were positive (agree/strongly agree) regarding the statement: Communication between teachers and students and among students is easy via LMS. The Chi-square test was conducted at df = 4 with significant value of 0.018, which is less than 0.05 level of significance. Chi-square observed (x^2o) (11.858) was greater than the Chi-square critical (x^2c) (9.49), that is x^2o (11.858) > x^2c (9.49), for which the null hypothesis, responses on this item is not statistically significant, is rejected. Therefore it was statistically significant that Communication between teachers and students and among students is easy via LMS.

4.10 Analysis of Open-ended questions

There are 4 nos of open-ended question for all the participants. All the participant means 168 nos of responded participating the textual answer for individual question. Researcher found the preferred instructional methodologies for conducting online-based laboratory classes, suitable LMSs for quick and easy access if you want to take laboratory classes with strong arguments to used LMS, and teaching-learning frameworks for effective online-based laboratory classes. . Each and individual question found a lots of ideas, views, and perceptions. The researcher listed all the answer against individual question. After that the researcher analysis the individual answer by thematic analysis. Which actually focused the importance of responded recommendation or suggestion or understanding against individual question.

Fig: Preferred suitable instructional methodologies for conducting online-based laboratory classes

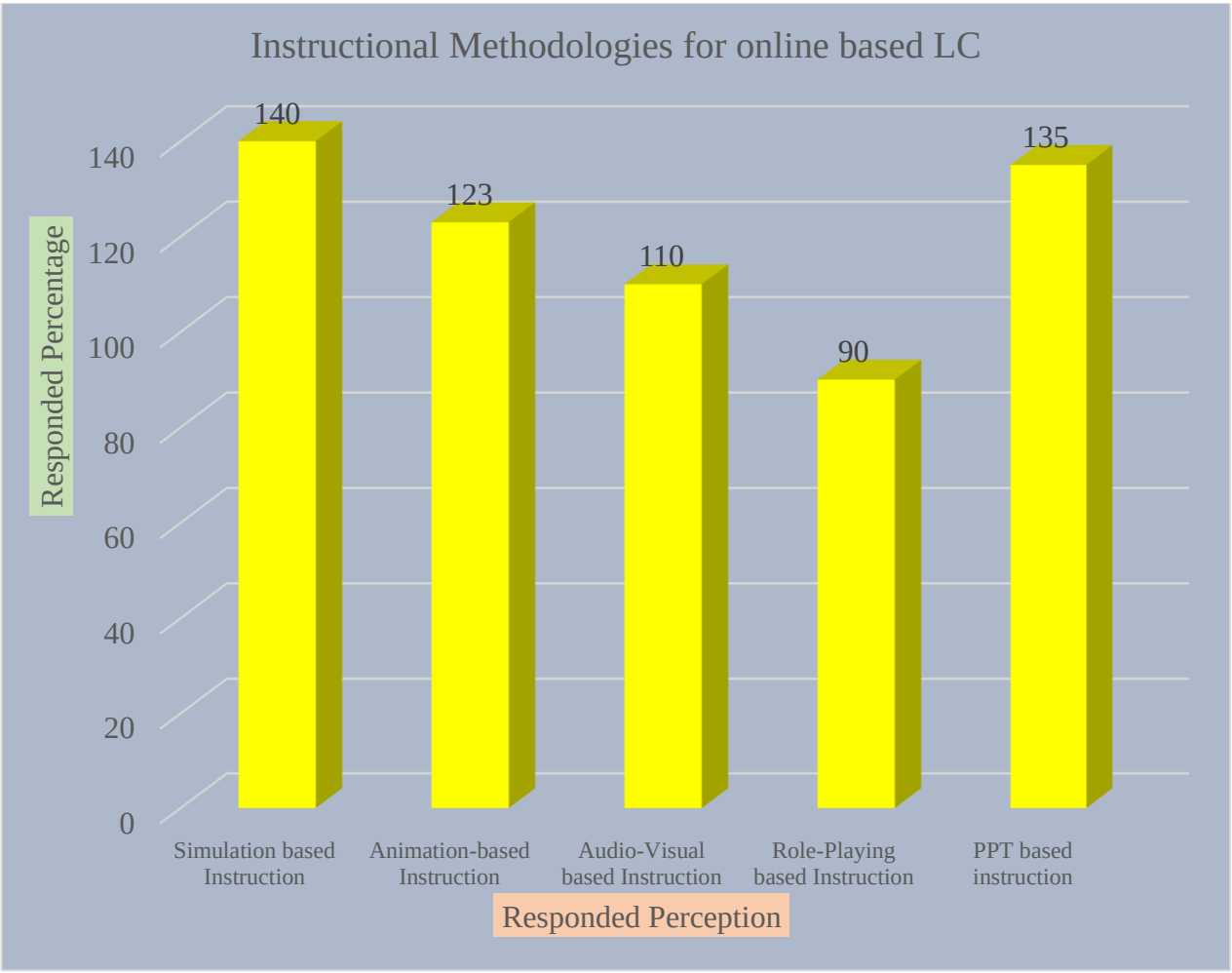


Figure 2 Open-ended Question-1

From open-ended question one the researcher found and categorized 5 nos of the theme of suitable instructional methodologies for conducting online-based laboratory classes from responded textual answers. In each area of the theme, the researcher counts the number of the same answer among 168 nos of respondents. The researcher calculated the average percentage of counted areas of suitable instructional methodologies for conducting online-based laboratory classes under a theme. The average responded percentage of themes are for Simulation based Instruction 83%, for Animation-based Instruction 73 %, for Audio-Visual based Instruction 65 %, for Role-Playing based Instruction 54%,and for PPT (Power Point Presentation) based instruction 80%.

Fig: Suitable LMSs for quick and easy access of online-based laboratory classes

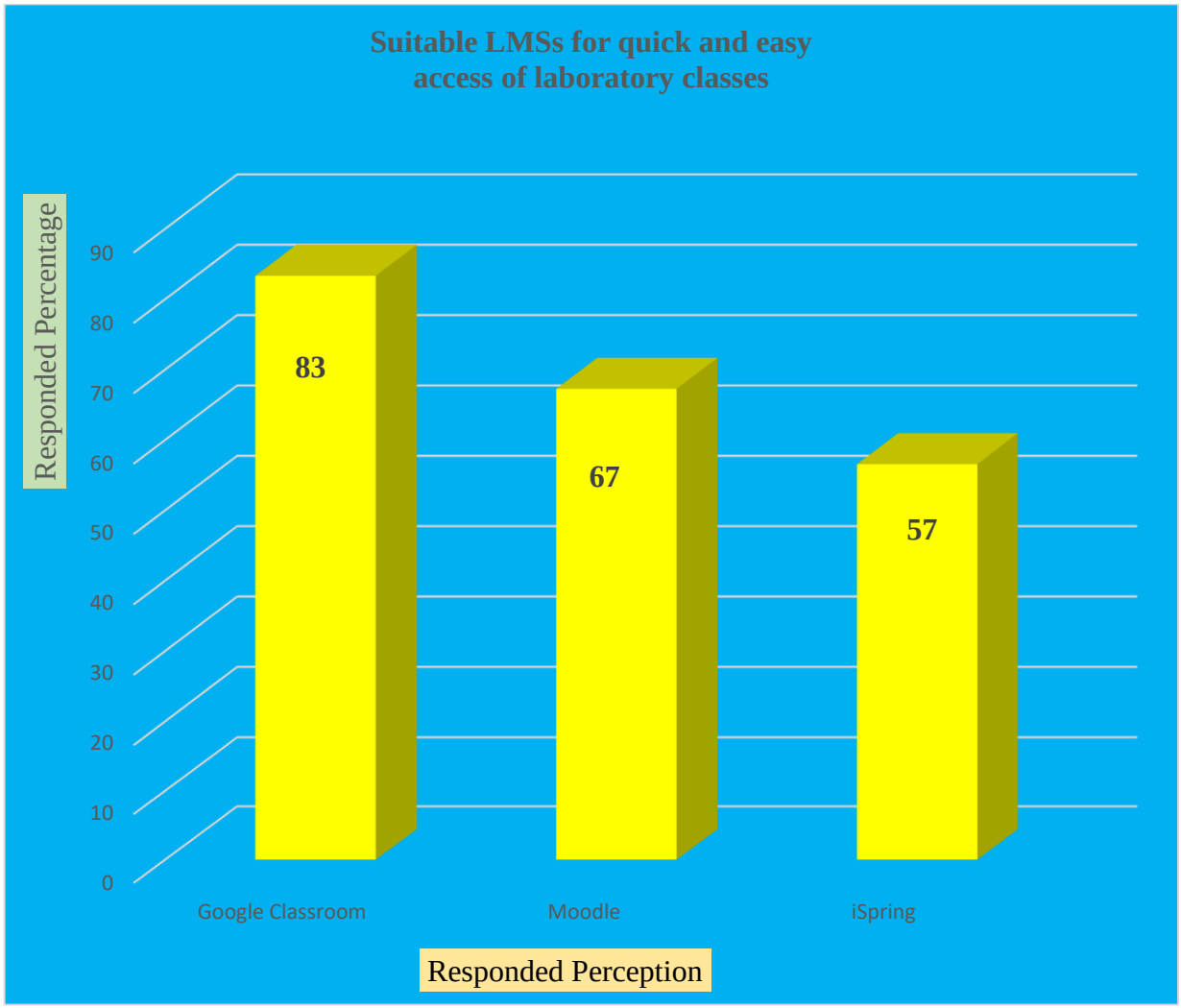


Figure 3 Open-ended Question-2

From open-ended question one the researcher found and categorized 3 nos of Suitable LMSs for quick and easy access of online-based laboratory classes from responded textual answers. The researcher calculated the percentage of counted areas of suitable LMSs for quick and easy access of online-based laboratory classes. The average responded percentage of themes are for Google classroom 83%, for Moodle 67 %, and for iSpring 57 %.

Fig: Preferable reason to use LMS

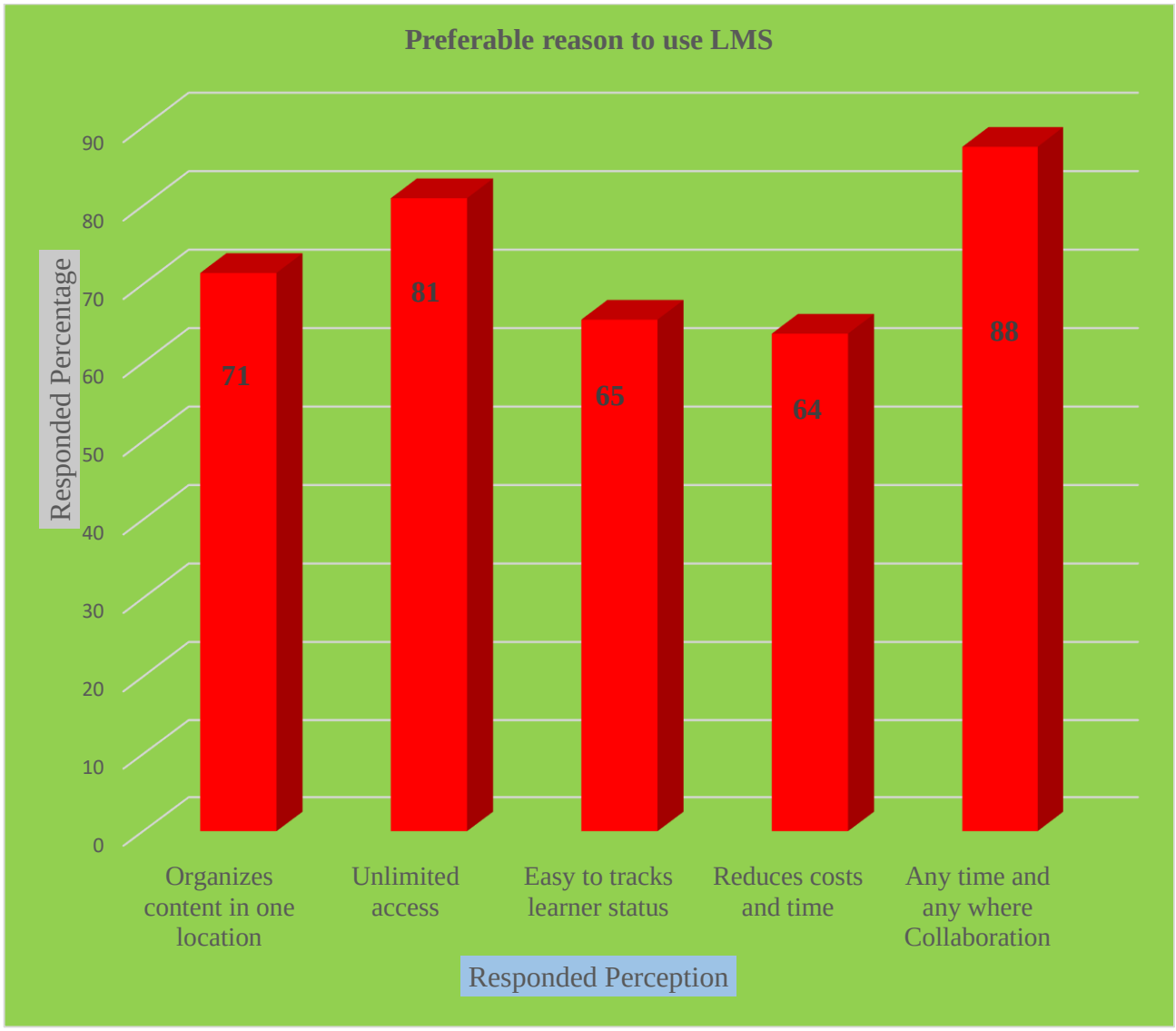


Figure 4 Open-ended Question-3

From open-ended question one the researcher found and categorized 5 nos of the theme for preferable reason to use LMS for conducting online-based laboratory classes from responded textual answers. In each area of the theme, the researcher counts the number of the same answer among 168 nos of respondents. The researcher calculated the average percentage of counted areas of suitable reason to use LMS for conducting online-based laboratory classes under a theme. The average responded percentage of themes are for Organizes content in one location 71%, for Unlimited access 81 %, for Easy to tracks learner status 65 %, for Reduces costs and time 64%,and for Anytime and anywhere Collaboration 88%.

Fig: Factors considered teaching-learning framework for online-based laboratory classes

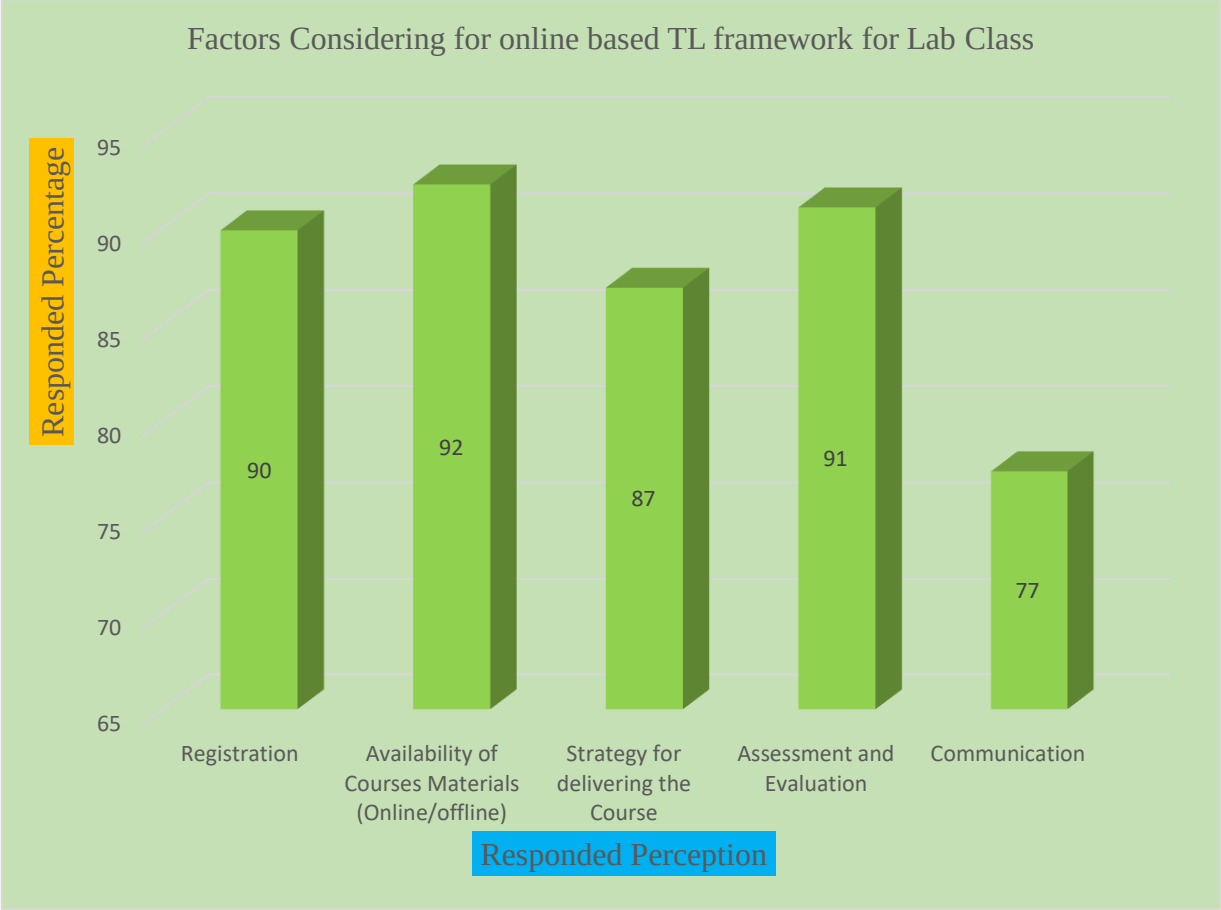


Figure 5 Open-ended Question-4

From open-ended question one the researcher found and categorized 5 nos of the theme for factors considered teaching-learning framework for online-based laboratory classes from responded textual answers. In each area of the theme, the researcher counts the number of the same answer among 168 nos of respondents. The researcher calculated the average percentage of counted areas of for factors considered teaching-learning framework for online-based laboratory classes under a theme. The average responded percentage of themes are for Registration 90%, for Availability of Courses Materials (Online/offline) 92 %, for Strategy for delivering the Course 87 %, for Assessment and Evaluation 91 %,and for Communication 77 %.

Chapter-5 Discussion and Conclusions

5.1 Introduction

This chapter is concerned with the discussion and explanation of the acquired results in relation to the research questions, as well as the impact of the activities and technical components of online-based laboratory. The researcher conducted a review of related literature to demonstrate the validity of the study findings and the overall body of the research. The chapter also contains conclusions with the recommendations to assist future researchers in conducting additional research in this field.

5.2 Personal reflection and lessons learned from the research

In this regard, the framework developed in this study is essentially a learning management template for the integration of the practical component into the development of an online-based laboratory class module for the EEE and CSE disciplines in this study. By following this framework, it may ensure that this module is suitable for the learners. As a result, researcher concluded that it is inevitable that distant learning will start gaining popularity over time. As a result of inadequate funding, students enrolled in online-based laboratory class learning programs will continue to face the same challenges as they experienced in 2020. Many universities are utilizing online platforms for conducting laboratory class sessions. As a result, it is important that the institution engage in incorporating advanced approaches into its teaching and learning processes, by providing of online-based laboratory class framework modules. Students will benefit from the online-based laboratory class framework mode of learning, researcher believe, because it, like other online learning platforms, will offer a rich learning environment that will lead to higher learning outcomes for them. Based on the findings of this research, researcher believe that an online laboratory class is a viable option that can be included into the ADDIE model's already-existing online learning platform in the future. Although researcher observed that it will be easier to integrate the theoretical aspect of the online-based laboratory class module into the curriculum, researcher also observed that the experimental or practical aspect of the online-based laboratory class module may necessarily require some modifications to the curriculum framework in order to allow students to participate in a variety of practical activities. Having clearly defined objectives and understanding intended audience are two other important factors to consider when building an online module, as researcher discovered when conducting research for this work. It was surprised to see that, at the moment, instructional designers do not place a strong emphasis on the analysis phase of the

development process for online-based laboratory class modules, which was unexpected. When developing the online-based laboratory class module, it is emphasize the importance of two elements: establishing the goals/objectives and understanding the intended audience. Despite the fact that this work was developing a framework, researcher realized that understanding the objectives and knowing the intended audience will clearly assist in determining what outputs are desired through learning objectives; thus, aligning the module with delivering the needed results. Second, determine whether or not the course was relevant to the audience that would be participating. Knowing the context of intended audience also helps to make the course more relevant to your students and more effective. Finally, researcher feel that having a detailed plan in the form of the framework that has been produced in this work provides a strong teaching-learning process for the institution as well as a better way of monitoring the process.

5.3 Discussion of the results

Questions were constructed to provide an initial investigation to determine the extent to which LMS in online-based laboratories had an effect on understanding EEE and CSE engineering concepts, learning how to use laboratory equipment, and learning laboratory procedures in engineering course for EEE and CSE majors. In the current study, students who participated in online-based laboratories believed that they learnt more practical concepts as a result of participating in the online-based laboratory class as compared to traditional labs (strongly agree and agree > 50 percent), according to the findings. Students preferred to engage in online-based laboratory classes compared to traditional laboratories, according to the findings of the research (strongly agree and agree > 50 percent), though the reason for this choice could not be determined based on the manner of data collection used. With this study, researcher have made two important contributions to both theory and practice. First and foremost, the findings provide a comprehensive picture of the opportunities and barriers from the teacher's and student's point of view, as well as their perceptions of adaptation, perceptions of the effectiveness of instructional methodologies and the adaptability of different type of LMS, and perceptions of the opportunities and barriers associated with online-based laboratory class learning. In this study the respondents viewed that distance learning provided opportunities for learners to adapt to new systems and learn about emerging technologies; that it allowed new content to be folded back into existing programs and units; and that it allowed existing programs and units to be transformed into a more advanced learning style. For the purpose of this study, it will be necessary to determine the existing state of students' online-based laboratory classroom activities in relation to online classes. The findings indicate that engineering university students

in Bangladesh have an average level of preparedness for online classes, despite the fact that there are some limitations to the activities that may be carried out in the classroom. In terms of many aspects in the online classroom, it is also highlighted that there is a significant gap between the different forms of instructional methodologies and the different types of learning management systems (LMS). As a result, administrators and policymakers should take action only after conducting research to determine whether or not it will help students learning more effectively. It will be recommended for future studies that additional study be undertaken in several specializations in order to generalize the findings of this research. More factors can be introduced into the study, and the study can be undertaken with a focus on all other types of university students. Furthermore, extensive qualitative research with students and teachers might be conducted in order to make the data more detailed and understandable. According to the findings of the current study, the usage of instructional technology within an acceptable framework can help students learn more effectively. The various features of utilizing instructional technology can enhance the interest and engage the students and play a fundamental part in assisting them in achieving higher levels of success by supporting innovative ways to the teaching and learning process. In this case, the importance of implementing online-based laboratory class learning in a variety of instructional contexts is highlighted. Earlier research has found that these conclusions are generally corroborated by the findings of past studies. After considering the facts presented above, it should be noted that the online-based laboratory class had an important promotional purpose for engineering students. Some studies discovered that computer-simulated experiments can increase students' active participation in the learning process while also improving their knowledge of engineering subjects. The findings of this study may be applied to other schools and colleges with comparable populations, curriculums and content that are depends on their level. Researcher predict that a combination of online-based laboratory educational experiences before and after the traditional practical learning laboratory will ultimately deliver the most significant learning benefits, but further research studies must be conducted in order to test this theory further. There is a promising future for online distance education. Many scientific educators are continually experimenting with new strategies in order to create high-quality online learning environments. However, while significant advances in technology-based laboratory instruction are expected to occur over the next twenty years, additional research research investigate student perceptions of online-based laboratories using a variety of research methodologies must be

carried out in order to generate useful data that may lead to improvements in online-based laboratory instruction and in the research literature in this area.

5.4 Conclusions

The framework for the development of the online-based laboratory class framework module was established using the ADDIE development model, with the majority of the activities (categories) falling into three of the five main categories. This is because only three of the five main activities (categories) were used to establish the framework for the development of an online-based laboratory class framework module: analysis, design, and development. Online-based laboratory class framework modules were developed after identifying the learning objectives, outputs, and productive work skills that needed to be integrated into them, as well as the evaluation methodologies to be used. Resources that are currently available and those that may be used to support the online-based laboratory class framework module, such as digital approaches, tools, and media that was included as a significant portion of the framework. In order to complete this work, it was not possible to complete the Implementation and Review phases of the ADDIE model of development. They accommodated only within the framework that has been constructed. In the course of this research, a framework for the establishment of an engineering course EEE and CSE online-based laboratory class framework module was created, which will be used going forward. While applicable to any subject, this framework may be used to construct any online-based laboratory class framework module regardless of the subject being studied. The approach to the research was based on the usage of the ADDIE development technique, but this work also contained extra phases which were included to the ADDIE development process to make it more comprehensive. The online-based laboratory class practical component was also incorporated into the framework that was developed. As a result, it should be highlighted that the framework developed for this research work is a modification of the ADDIE development technique.

5.5 Recommendations

The following are some of the thoughts that were acquired during the research that could be used as recommendations:

- To identify the effective instructional methodologies followed for conducting the online-based laboratory classes in the engineering universities of Bangladesh.
- To assess the best LMS for conducting online-based laboratory classes.
- To design an effective teaching-learning framework for the online-based laboratory classes.

Recommendation of Objective One:

- Simulation based Instructional methodologies, Animation-based Instructional methodologies, Audio-Visual based Instructional methodologies, Role-Playing based Instructional methodologies, PPT based Instructional methodologies are combinedly important for effective online-based laboratory classes for EEE and CSE department.

- Learner-centered instruction is important for effective online-based laboratory classes for EEE and CSE department.

- Focused Imaging-based online laboratory classes and skills based online laboratory classes are important for effective laboratory classes.

Recommendation of Objective Two:

- Google Classroom is most preferable then others to conduct online-based laboratory classes for EEE and CSE department. Also Moodle can be considered but Google Classroom is flexible, available, and user frankly.

Recommendation of Objective Three:

Fig: Design an effective teaching-learning framework for online-based laboratory classes

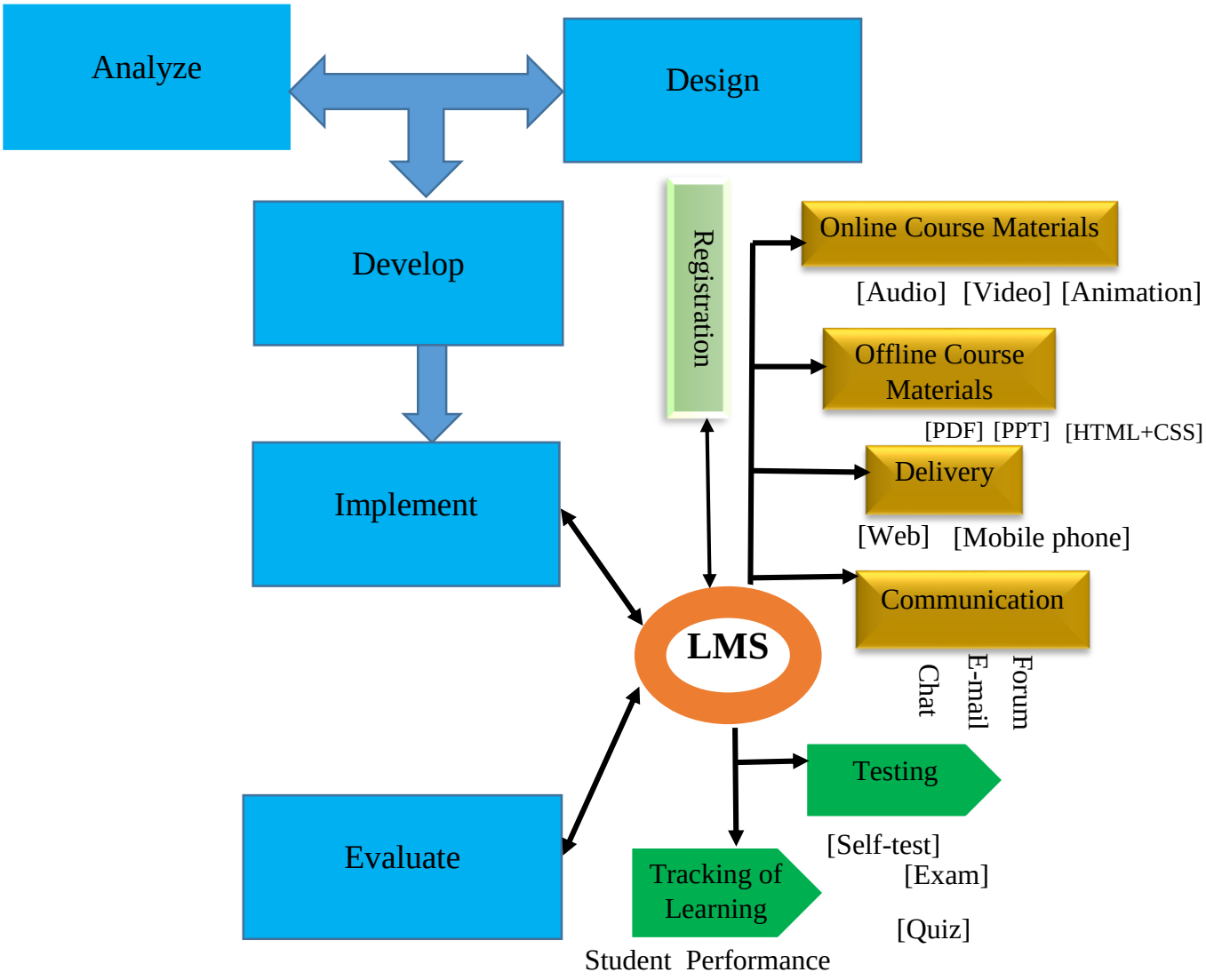


Figure 6 Proposed Effective Teaching-Learning Framework

- The teaching-learning framework for online-based laboratory classes designed for both teachers and students.
- The teaching-learning framework strategies should be based on the needs of the students.
- It will be a recommended ADDIE model where the researcher include LMS to help the teachers build courses through the Moodle Learning Management System.
- All of the students who have registered for the class get access to the learning materials.
- By maximizing diverse of technologies, a number of strategies can be used.
- All of this is feasible if teachers are properly trained well on how to use it and if they are provided the necessary teaching materials.

Further research is required to investigate whether the acquired results can be extrapolated to students from a variety of subpopulations (e.g., normal schools, ethnic groups and different learning styles) who are instructed using online-based laboratory class setting methodologies. Furthermore, the findings of the study suggests that there is a necessity for online-based laboratory class programs to support students while they are learning in classrooms as preparatory and supplemental tools.

5.6 Limitations

Some of the limitations of the existing study could be found and investigated further in the future. Further research should involve a larger number of participants and be conducted over a longer period of time. It should also take into account other specializations such as ME, CE, IPE, and other related skills through the design of other models and prospective via 3D interfaces based environments where Instructional technology has been shown to have significant positive impacts on learners concerning ideas and concepts and fundamental engineering skills. As a result, the researcher proposes that additional studies be conducted in order to achieve more conclusive conclusions rather than relying solely on the findings of a single study. Another essential consideration would be the use of other measurement devices than those utilized in the current investigation.

5.7 Contribution to research

This research may be of interest to researchers who wish to pursue a more in-depth research into the same concentrated region after reading it. Furthermore, it has the potential to attract the attention of educationalists who are attempting to integrate technology into their curriculum as

a result of the findings of this study. This study presents an apparent comparison between following online-based laboratory classes and a single (Conventional methods or Online based education) process, which can assist teachers and students in determining the effectiveness of implementing the blended approach in the educational sectors.

5.8 Further studies

By varying the competency level of students, it is possible to conduct more research in a comparable field. The lack of research in the Bangladeshi context prevented this paper from obtaining a comprehensive picture of the use of online-based laboratory classes in the country. As a result, research can be carried out by selecting a greater number of educational institutions and students with varying levels of learning.

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Appendix A

DEPARTMENT OF TECHNICAL AND VOCATIONAL EDUCATION (TVE)
ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
Board Bazar Gazipur – 1704 Dhaka Bangladesh

QUESTIONN

Dear Respondent/Sir,

A humble request for completion of the below questionnaires

As a student of Master of Science in Technical Education (Mechanical Engineering) of Islamic University of Technology (IUT), I am conducting academic research by supervising Prof. Dr. Md. Abu Raihan, Professor, TVE Department, entitled **"Designing a teaching-learning framework for the effective online-based laboratory classes in Bangladesh".** In this endeavor, I wish to collect data from Teachers and Students of seven public universities (BUET, RUET, KUET, CUET, DUET, MIST, DU) and seven private universities (AUST, DIU, EWU, IUB, NSU, Brac Uni, UIU,) from the two categories of specialization CSE, EEE with 150 target population.

Your response will strictly be used only for research purposes. Your name and identity will always be kept confidential and must be treated with strict confidentiality.

Terminologies Used
LMS: Learning Management System
ADDIE: The ADDIE Instructional Design (ID) method has been used as a framework by educators and instructional designers alike in designing and developing educational and training programs. "ADDIE" is stands for Analyze, Design, Develop, Implement, and Evaluate..

Section A: General Information of the respondents

i) Name of the University: BUET/RUET/KUET/CUET/DUET/MIST/DU/AUST/DIU/EWU/ IUB/NSU/Brac Uni/UIU.

ii) Department: CSE/EEE

iii) Year of the study: 1st year/ 2nd year/ 3rd year/ 4th year. (Students Only)

iv) Gender: Male/ Female.

v) Length of Your teaching Experience: 1-5 years/ 6-10 years/ above 10 years.

Section B: Close-ended questions

Objective-1: To identify the effective instructional methodologies followed for conducting the online-based laboratory classes in the engineering universities of Bangladesh.

For each of the questions below, tick (✓) on a response that you preferred most. Strongly agree(SA), Agree(A), Neutral(N), Disagree(D), Strongly disagree(SD).

SL	Statements	SA (5)	A (4)	N (3)	D (2)	SD (1)
1	Online-based laboratory classes are effective for EEE and CSE departments in engineering universities of Bangladesh					
2	Skills-based online laboratory classes are fruitful and effective for students.					
3	PowerPoint presentation-based online laboratory classes are fruitful and effective for students.					
4	Multimedia-based online laboratory classes are fruitful and effective for students.					
5	Remote control experiments online laboratory classes are fruitful and effective for students.					
6	Animation-based online laboratory classes are fruitful and effective for students.					
7	Role-Playing based online laboratory classes are fruitful and effective for students.					
8	Focused Imaging-based online laboratory classes are fruitful and effective for students.					
9	Web-based online laboratory classes are fruitful and effective for students.					
10	Learner-centered instruction online laboratory classes are fruitful and effective for students.					

Objective-2: To assess the best LMS for conducting online-based laboratory classes.

SL	Statements	SA (5)	A (4)	N (3)	D (2)	SD (1)
1	Conducting online-based laboratory classes by Learning Management Systems (LMS) is easy to assess.					
2	Learning Management Systems (LMS) is effective and interactive to conduct online-based laboratory classes.					
3	Moodle is the popular LMS for being flexible and easy to access.					

4	Google Classroom is the popular LMS for being flexible and easy to access.					
5	Mindflash is the popular LMS for being flexible and easy to access.					
6	Docebo is the popular LMS for being flexible and easy to access.					
7	iSpring Learn is the popular LMS for being flexible and easy to access.					
8	TalentLMS is the popular LMS for being flexible and easy to access.					
9	ProProfs LMS is the popular LMS for being flexible and easy to access.					
10	Canvas LMS is the popular LMS for being flexible and easy to access.					
11	Chamilo is the popular LMS for being flexible and easy to access.					

Objective-3: To design an effective teaching-learning framework for the online-based laboratory classes.

SL	Statements	SA (5)	A (4)	N (3)	D (2)	SD (1)
1	Zoom is the best platform for online-based laboratory classes.					
2	Google meet is the best platform for online-based laboratory classes.					
3	ADDIE* model is a popular the effective virtual platform for teaching-learning.					
4	LMS is an effective teaching-learning methodology for online-based laboratory classes.					
5	Engagement of students and teachers is very easy to LMS for laboratory classes.					
6	Individual effective teaching-learning ensured by LMS for laboratory classes.					
7	Student Performance and feedback are relaxed by LMS.					
8	Resources are available and any time access able in LMS.					

9	Review and repeat of the practical session via LMS are possible.					
10	Lerner development is very high for laboratory classes via LMS.					
11	Teachers are easily delivered the session of laboratory classes via LMS.					
12	Offline Course Materials are available in LMS.					
13	Communication between teachers and students and among students is easy via LMS.					

Section: C Open-ended Questions

Question-1: List your preferred instructional methodologies that is suitable for conducting online-based laboratory classes.

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Question-2: Which are the suitable LMSs for quick and easy access if you want to take laboratory classes?

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Question-3: Why will you prefer this LMS? Explain.

……
……
……

Question-4: What are the factors/components should be considered teaching-learning framework for online-based laboratory classes?

……
……
……
……

Thank you very much for your valuable response
Yours faithfully
Research Student: Shibli Sadik
ID: 191031101
Programme: MScTE (4th Semester)
TVE, IUT, OIC.