Strategies to enhance Active learning of Civil engineering students

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A thesis submitted to the National University of Sciences and Technology, Islamabad, in partial fulfillment of the requirements for the degree of

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ABSTRACT

Students are fastly losing interest in STEM education. Minimum efforts by the teachers and university students to use media, lack of motivation and complex teaching methods can be among the major causes of less learning of students. Moving towards the method of Active learning can ultimately help in bringing back students to STEM education. Active Learning is a method in which students perform all activities by themselves and are the main drivers of studying and performing activities. A lot of active learning techniques have been tried before like flipped classroom method, TILE (Transform, Interact, Learn, Engage) teaching spaces and Activity Based learning. Simulation games have also been tried in some universities as an active learning technique having very positive results. It was found that students were more alert, active and were more involved using simulation games as compare to formal lecture method. This research focuses on the use of simulation games to enhance the learning skills of students in the field of Civil engineering. It provides a prototype to boost learning skills of civil engineering students through a simulation game. Unity 3D gaming software is used as tool for development which used C# language. The game covers topics of development length and bars splicing. Inputs of this game are lengths of bars, diameter of bars, splicing length of bars and hooks lengths. Outputs are visualizing of bars splicing and development length of bars which are actually hooks in beam and column bars. It contains C# coding for every step which includes code for camera movement, code for splicing, code for lengths and diameter fixing. After the development of game it was taught to students in classroom and then time was given to them to practice in classroom.

Also they were taught the targeted topics through traditional method and at the end student's opinion was collected through survey. Student's response in survey was very positive. Students enjoyed the game more as compared to traditional method and marked it very entertaining and engaging. They appreciated that game was easy and really helped them in understanding the topic and that it really covered the topic well and hoped that it can be improved further by including more topics.

Keywords: Active Learning, Simulation Games, Development length, Lap splicing

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CHAPTER 1: INTRODUCTION

1.1 Background

Science, Technology, Engineering and Mathematics (STEM) play an important role in the development of a country, as they have a major contribution in improving the economy of a country. However, with the time, most of the students are losing interest in STEM education. It is observed that only 40% of students in US take interest in STEM education while only 20% finish with a STEM degree(Fang 2012). The minimum use of media and complex methodology of teachers in delivering the lectures has played a huge role in the fear and laziness in learning of students(Coman, Țîru et al. 2020). Lack of motivation can be other cause of less learning of students. Apart from that students lack of aspiration to perform an activity, considering less value of activity and considering learning activities as unpleasant thing to do can be the other reason of lack of motivation (Barkley and Major 2020).

Problems associated with the STEM education can largely be reduced by repeated systematic use of nontraditional teaching methods. The more they adapt to nontraditional teaching methods, the greater the improvements can be expected. With use of new methods, the skill levels of the students will be eventually increase(Felder, Felder et al. 1998). Moving towards the method of Active learning can ultimately help in bringing back students to STEM education. Active Learning is a student-centered-learning method that involves the learner personally in the task. In Active learning learners are the main players of the process in which they perform activities and do critical thinking about what they are doing. Active learning is the combination of effective infrastructure along with

engaging participants and using Technologies effectively(Roehl, Reddy et al. 2013).For increasing the STEM degrees by 33%, The President's Council of Advisors of US on Science and Technology suggested to adopt "empirically validated teaching practices" and results showed that student's performance as well as Retentions rates were improved because it helped them in their problem-solving ability (Fang 2012). The use of media can also greatly help in overcoming the complexity of delivering the lectures as well as it can keep students more motivated and increase their interest in learning (Eison 2010). Students learn well when the teaching method and time available with them for learning is appropriate. The performance and interest of students can increase if the learning methods and time availability is according to the students need(Guskey 2007).

Therefore, this research covers the method of active learning to bring back the students to STEM education. Also, the use of media for the learning purposes is considered.

Furthermore, this research also targets to enhance the learning skills of students through games in the field of Civil engineering. It will provide theoretical framework and a prototype to boost learning through games. Learning through games will enable the students to design different structural infrastructures and their components. Moreover, it will help in developing interest of students by keeping them engaged and contribute to get rid of old traditional teaching methods.

1.2 Active Learning

Active learning is a learning method in which learners are engaged actively with the course material by having discussions, problem solving, case studies, role plays and other

methods. Active learning increases the credibility on the learner but the teacher guidance is still very important in Active learning activities. Main characteristics of Active learning incudes;

- Students are the leading players of the learning process.
- It increases engagement of students
- learner is motivated to participate actively in class activities
- It includes learners work which is built on learning objectives
- Understanding of students is increased because all the efforts are applied by the learner.

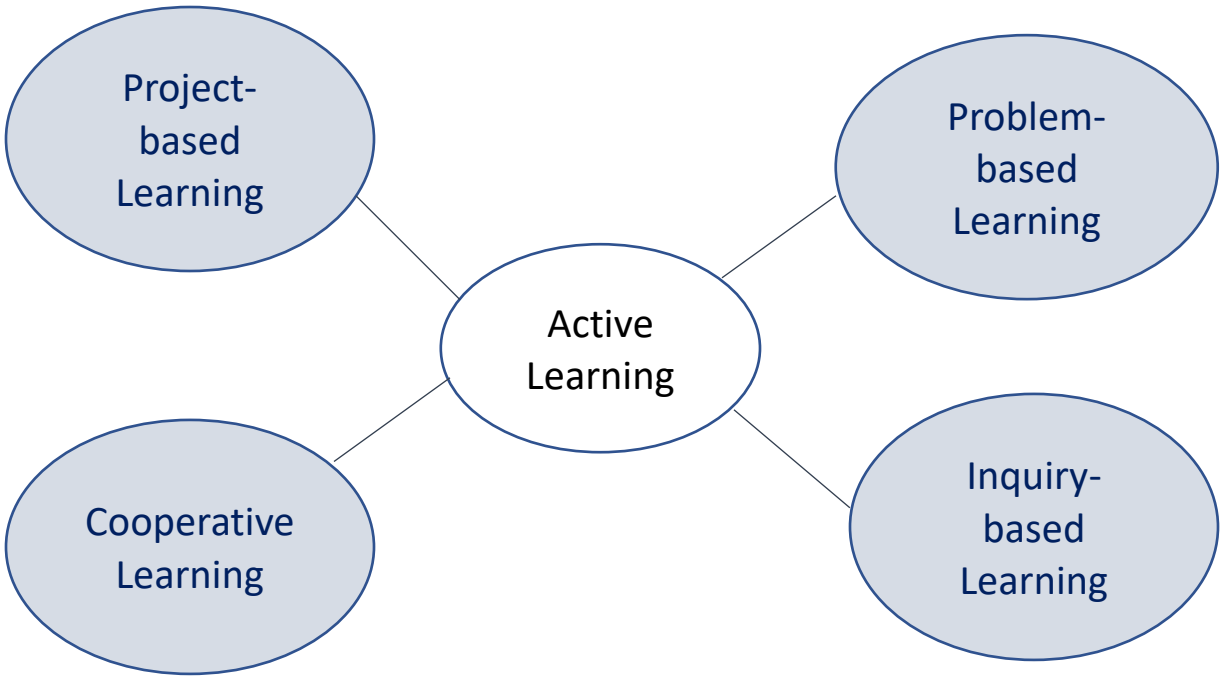

Figure 1.1: Framework of Active learning

1.2.1 AL Techniques

- Project-based learning: In this AL technique students combine knowledge they already know and knowledge gained during the developing of project
- Cooperative-based learning: In this AL technique groups of three or more students are formed and they perform activities such as multiple step exercises.
- Problem-based learning: In this AL technique students in small groups discuss real problem with the help of their previous knowledge and the questions are asked individually and then at the end they reach a collective solution.
- Challenge-based learning: In this AL technique a relevant and challenging situation connected with real world is solved by students and then they come up with a solution.

1.3 Problem Statement

Many researches have been carried out on different active learning techniques all over the world. Gaming is also a useful technique for enhancing the learning skills of students. Recent researches show that this technique has been used in different countries and further work is in progress to make this technique more efficient for students.

In Pakistan, no research has been carried out on enhancing the active learning of students through gaming. This strategy can be used to improve the learning efficiency of the students.

1.4 Research Objectives

- Investigating and observing the conventional teaching methods applied in the classroom.
- Devising a pathway to translate the concepts taught in the classroom in an interactive game.
- Validating the enhancement of student learning through the proposed game.

1.5 Research Significance

World is moving towards different advance non-traditional teaching methods to help students enhance their learning so in Pakistan we also need to adopt those non-traditional teaching methods so this research will provide a framework for enhancing Engineering students learning through those advance teaching methods. By using modern teaching methods students learning ability will improve. Modern methods will improve students' interest in learning.

CHAPTER 2: LITERATURE REVIEW

This chapter provides information about different types of Active learning techniques used previously and mandatory research work that has been done on Active learning techniques.

2.1 Active Learning Strategies used previously:

2.1.1 TILE:

In University of Lowa, the TILE (Transform, Interact, Learn, and Engage) teaching spaces are prepared for teaching different subjects like astronomy and physics to social sciences and business. Special classrooms are prepared with round tables having capacity for nine students, a control station, glass boards and white boards. Along with it three laptops and an LCD screen per table are assigned, and also a wireless mouse is available so that users are free to choose a topic or any task they want to. Performing activities depend on the field of study, but they include discussions, problem-solving and in-class exercises(Hernández-de-Menéndez, Vallejo Guevara et al. 2019). The advantage of TILE teaching spaces technique is that students has to take responsibility of their education and they can't hide and has to participate in classroom (Soderdahl 2011). While it offers potential benefits to enhancing students learning, its effectiveness may depends upon different factors like high cost of technological infrastructure and students readiness for collaborative learning (Van Horne, Murniati et al. 2012) .

2.1.2 Flipped Classrooms:

In University of Queensland, Australia Flipped classroom technique is major technique widely used for Active learning. In flipped Classroom technique video-based lectures were recorded and sent to students who studies it before coming to classroom and then the classroom contact hours were completed dedicated for questions and group-based discussions on real world problems in context with the lecture which helped them immensely in their studies (Hernández-de-Menéndez, Vallejo Guevara et al. 2019). Enhancement of students satisfaction and increase in level of entertainment are the advantages of flipped classroom technique (Akçayır and Akçayır 2018). Limitations of this technique observed were that most of the students participating in the flipped classroom were not comfortable because they preferred working alone (Hernández-de-Menéndez, Vallejo Guevara et al. 2019). Another challenge with this technique is to check whether students has studied the video lectures in homes for which teachers need a proof of individuals may be in the form of written notes from video lectures(Roehl, Reddy et al. 2013).

2.1.3 Activity Based:

In this method students were divided into groups of 3 to 5. Each group was given a specific task one week prior to activity. A series of questions was provided to each group and they were asked to write 2 pages synopsis. Students were allowed to review materials from textbooks, lectures and other primary sources and then in next week each group have to share their answers in the class and in this way, it improved their learning(McCarthy and Anderson 2000). While this method enhances collaborative

learning, its success mainly depends upon student's motivation to participate in activity (Anwer 2019)

2.1.4 Journaling:

This method was applied in nursing which included self-reflection and self-examination to look back over what has happened in order to improve professional growth. Reflecting on your professional role and perspective of others helped in the development of critical thinking(Blake 2005).

2.1.5 Technology Enabled Active Learning (TEAL):

MIT came forth with Technology Enabled Active Learning (TEAL) project in which latest technologies were used in an AL environment to teach students physics. It helped in increasing effectiveness of interactions and problem-solving abilities of students. the classrooms were designed having round tables, whiteboards, screen projectors, computers, wireless microphones and animated simulations. Students were divided into groups and activities contained experiments, lectures, discussions, exercises etc. The problem with this method is the initial cost of infrastructure which is not financially feasible for most institutions (Pirker 2013).

2.1.6 Role play:

Role-play is another effective active learning technique used for learning in which Students has to play different roles provided to them (Stevens 2015). Role play technique brings realism by involving learners in the activity directly and teaches them how to react in real world situations (Alabsi 2016). Successful implementation of this technique may be effected due to less motivation of students because of shyness and lack of no systematic way for checking the quality of role-plays (Chan 2012).

2.1.7 Gaming:

Computer games are exciting as well as motivational when used in free times but they do have the traits to be used for educational purposes. It was found that students were more alert, active and were more involved using computer games as compare to formal lecture method(Grimley, Green et al. 2011).

2.2 Previous work done related to Research:

Nowadays the researches are trying to develop new and efficient learning techniques which could help in seeking knowledge promptly. The modern ways of learning include the use of STEM education techniques such as educating students through games. The research conducted on learning through games describes the usage of simulation games for teaching construction management to students of civil engineering. Two simulation games MUCK game and CANAL game were used including software to monitor their operations. Different construction scenarios were represented through these two games. The MUCK Game includes construction of a dam mainly focusing on planning and control aspects of project managing. Dams' construction includes 99ft high dam of rock and clay having specified constraints such as weather conditions, maximum project duration, income and health and safety issues. The CANAL Game has the same basic processes of clay and rock extraction, movement and placement. However, the canal game is a much larger scale project than the Muck game both in terms of project duration, project size and project income and expenditure. Students were assessed on the basis of their examination having to solve three questions out of four questions along with coursework and then the combination of both formed the final result. Students'

performance was analyzed for each of three years along with students' feedback. Different comments were received having more positive comments along with constructive criticism for improving the efficiency of this type of learning in future(Long, Mawdesley et al. 2009).

In other study Grimley, Green et al. (2011) noted that Computer games are thrilling and motivational when played in free times but they do have the traits when they are used for learning purposes. He investigated that whether used formal lecture approach and learning by computer game approach to investigate whether computer game improve students' performance or not. So, there were total 31 first year students of Bachelor of Arts Education in subject named as computer Games and education. out of 31 only 10 were females and 21 were male students. Subject was offered in 2nd semester. up to midterm students were instructed in basic educational psychology for two hours per week through lectures and it also included weekly labs which were also two hours per week.in midterm they were assessed and then after midterm students were given assignment to design, build and evaluate a game module consisting of educational content taken from course before midterm. Course contained eight topics out of which four were given through lectures while four were delivered through games. At the end examination was taken from all students under similar conditions. Results showed that average exam performance is better for game mode (traditional = 41.0%; game = 46.4%). students experience was also collected through Experience sampling method which recorded their feelings and real time experience. Feelings recorded included how well were they able to concentrate? How much was it difficult to concentrate? How self-conscious were they? Did they feel good about themself? Were you in control of the situation? And their mood

scale was also recorded along with it. Results showed that students were more alert, active and were more involved using computer games as compare to formal lecture method.so computer games have greater potential to improve students' performance without making them bore

Roehl, Reddy et al. (2013) reviewed literature related to flipped classroom model and presented arguments for applying the flipped classroom model in institutions instead of traditional passive instruction methods. He insisted that using classrooms for active learning provides greater motivation, engagement and teacher to student mentoring. According to Roehl (2013) flipping classroom provides us with a wide range of teaching methodologies like creating videos, instruction with visual aids, using YouTube as a source for videos etc. He reviewed Lage et al. (2000) work that he performed a study using the flipped classroom for an economics course. In flipped Classroom technique video-based lectures were recorded and sent to students who studies it before coming to classroom and then the classroom contact hours were completed dedicated for questions and group-based discussions on real world problems in context with the lecture which helped them immensely in their studies. However, Limitations of this technique observed were that Students using the flipped classroom were not comfortable to their new learning technique because they preferred working alone. Also, while the use of the flipped classroom model is discussed limitations of this method are that learners may have less financial resources. Millennial are those individuals who are born between 1982 and 2002(Wilson and Gerber 2008).

In other study Chi and Wylie (2014) outlined several challenges that may occur which includes to prepare lessons to promote active learning, decision by teachers for

selecting best active learning technique and guidelines to modify existing assignments. Chi and Wylie (2014) presented ICAP framework for the student's engagement in which he presented four modes of student's engagement which is supported by results from a large set of activities, domains and student ages which consists of passive mode of engagement in which the learner receives information from the instructional material without doing anything else related to learning e.g., listening to a lecture without noting and underlining anything. Another one is active mode of engagement in which the learner engages with the instructional materials. Focus and attentiveness is basic for active mode of learning e.g., reading a book and underlining important lines. Similarly in constructive mode of engagement, the learner produces extra additional output beyond the material provided. e.g., reading a book and making notes from it. Other example is if a student is solving physics problem and he is making free body diagram if not provided so this is constructive mode of engagement and if provided and he just copies it so it is active mode of engagement. Last one is interactive mode of engagement in which the learner interacts with the learning device. e.g., if you are reading book and then do discussion with your friend. This interactive mode may be either active or constructive. If both the device and player provide input then it is constructive interaction and if only one provides input, then it is active interaction.

Interactive learning > Constructive learning > active learning > passive learning.

Another study shows the gaming and simulation scenarios in detail to teach integrated land use transportation planning to the undergraduate students at the University of Pretoria, South Africa. It focuses on the reduction of gap between integrated transportation and land use planning with help of gaming simulation. This

game helps to gain knowledge about infrastructure investment, land development, efficiency of city of equity outcomes. This course consists of mixture of lectures along with lab practical having contact hours of six per week. Major topics covered in the curriculum include Planning context, planning theory, Planning tools and Supply and demand analysis. This game is designed in a way to control both the land use management and investment in the transportation sector and private-sector real estate developers. Planners and developers both aim to accommodate maximum possible growth and growth are linked to town's success. Also, the game player has to look into both lower and higher income segment of population. The planner success is finalized by the number of objectives attained. The player at the end of game gets a score card. Apart from scorecard students are also assessed subjective and then the combination of both makes final results. Analysis of student's performance showed that learning outcomes has been achieved immensely through gaming. The performance of students proves that the game added to the skills of students to further improve the concepts. The performance of those Students who faced more complex and open-ended tasks was much better and improved then earlier (Venter and Coetzee 2014).

Another study was conducted on second year undergraduate civil engineering students who were having fundamental knowledge of solids and fluids. This game was based on soil behavior subject. Total of 160 students were enrolled in this subject are. A survey was conducted and 62% of students said that they have used computer games in last month. So, a geotechnical engineering game named as "Back to Bedrock" using PLAXIS software was developed. Before proceeding to the main menu ten multiple choice questions were asked from students and only can you proceed if you correct all.

This game consist of two levels (a) Laboratory Experiment, and (b) Earth Structures. The "Laboratory Experiment" level consisted of 4 major soil tests which are Soil Permeability Test, Flow Net Test, Consolidation Test, and Triaxial Shear Test. The purpose of which is to set the required tests to measure soil parameters. The "Earth Structures" level includes design of 6 major infrastructure including Earth Dams, Underground Tunnels, Deep Excavation, Embankments/Slopes, Raft Foundations, and High-rise Buildings on Soft Soil. The students have to select the design topic of their choice and then had 6 weeks to play with like designing. 70 m high dam which is cost effective and stable. Student's survey results showed that students were more engaged through this game. Similarly The results obtained also showed that it's a productive way of teaching and also while playing they had immense fun(Fatahi and Khabbaz 2015).

Furthermore, another study states that using computer and simulation games can immensely promote active learning. Computer games can provide us with a framework which supports structured and guided inquiry. Apart from learning from games, active participation in the game development and design itself is very interesting and best way to learn something(Rieber, Smith et al. 1998). In this research a framework for the development of game has been defined at the University of Ljubljana by the fourth-year undergraduate students. The framework which has been designed known as SADDIE (specification, analysis, design, development, Implementation and evaluation) helps in the development of game. Specification is the first phase of game design process in which students has to select a topic of their own choice from syllabus which is considered as complex and difficult for students. Students have to submit a document in order to defend the selected topic having learning goals from the topic selected and how

implementation of game will help in learning. In Analysis phase of game design help in the collection of all information needed for game design which includes selection of game engine, software for creating visuals, graphics, level of difficulty, interface, type of interaction etc. Design phase includes the design of all graphic elements required for the game such as background specs, characters etc. it also includes animations, audio recording. Development phase the game is developed with the help of game engine. In implementation phase students have to write proposals and discuss different options on how to incorporate learning and educational game. Evaluation and testing phase takes place in parallel or right after implementation. Here game is tested in primary and secondary schools and students measure efficiency of this alternative learning approach by taking feedback from teachers and it shows weather objectives set in the beginning has been achieved or not. As Feedback plays a vital role in simulation games as feedback is a critical part of any effective learning that adjusts challenges(Rugelj 2016).

Furthermore, a study on learning techniques presents the use of simulation games (The Lean Airplane Simulation Game, The Silent Squares Game, the parade of trades game, the Red-Green simulation game etc.) for enhancing learning and understanding of students in engineering subjects. Simulation games are used for teaching lean construction principles (team communication, planning etc. Students increased their understanding by performing different scenarios of topics, they performed trial and error, and they also learned pre planning, cooperation and teamwork with the help of games (Long, Mawdesley et al. 2009). Two surveys were performed one was initial survey at the start of the course session to understand preferences of student's pre-course. And then final survey was conducted and results were compared with initial survey at the end to

assess changes in students' assessment. The simulation games included are The Lean Airplane Simulation Game in which Team work and the impact of supply chain logistics were taught through this simulation game to students. Another one is The Silent Squares game which helps students to learn about design management and the impact of sharing incomplete information while applying an integrated design process. The Parade of Trades game helps students to better understand variability and throughputs in production systems by construction of 45- houses by seven independent contractors and The Red–Green Simulation game teaches students risk management in projects.

Students were asked to rate learning method using five-point likert scale at the beginning of course and at the end of course. The average initial rating of 4.02 out of 5.00 was obtained for the whole class. The rating at the end of course was even higher i.e., 4.69. Survey results showed that these Simulation games provided tangible environment to students to learn lean construction concepts and also they tested different scenarios which enabled these learners to understand the depth of situations more easily. the simulation games helped in improving learning and understanding of students which was also supported by results from assessments(Hamzeh, Theokaris et al. 2017).

Another interesting study about project management through gaming showed that Project manager deals with all the tasks in a project from objectives to finding resources and achieving quality. To train and educate project management professionals is always under discussion. Game based learning proved to be effective tool to learn and improve skills related to operations and management of project. The game used here simulates the development projects from concept stage to closing stage. This game was implemented in one of elective subject offered to 2nd semester postgraduate engineering students in

hongkong in year 2017-2018. Class was comprised of total of 50 student having students of engineering and also some from business and social sciences. Most of the class was comprised of part-time students so the classes were on Saturday and Sunday. Students were divided into groups having 4-5 members and they were provided with clear objectives and constraints and they have to design a new product i.e., paper plane from concept to production stage according to customer specification. They were required to design two products having at least 20 cm length and must be able to fly at least 6m linear distance. Materials provided were white paper and colored paper with specific prices so they have to design in relation to constraints of time and cost. Each student in the team has to go through each stage for the shared goals. Assessment of students contained two tests one at mid stage and other at the end. They also have to submit a report documenting the whole project. Each students have to submit their own reflection on the learning process that what they have learned from the game. It was concluded from results that PM is a difficult subject and the game-based action learning approach can be vital and effective tool in the learning process (Law 2019).

In another study it was investigated to use method of active learning for STEAM education.as laboratories and lectures are still used for steam education so a case study was observed to investigate the usage of active learning for STEAM education. For first two days students were given an introduction to coding using C# and unity game development. The case study was carried out in a workshop in oxford. Participants were divided into groups of 2-3. Then they were introduced to concepts of AR. then they were exercises in unity and visual studio. Finally, they were asked to build their own game by applying knowledge they have gained. So, in the whole workshops they were introduces

to AR, unity software, programming basics. At the end of workshop all the participants were asked to fill a questionnaire. The questionnaire included questions about main reasons and motivations to join the workshop, as well as benefits and. Additionally, the usefulness of the new knowledge and skills in learning STEAM subjects were sought out. Eight (42% of participants) questionnaires were filled. Along with this, interviews with were conducted from teachers (2 out of 4 teachers) to investigate the usefulness of workshop and how can it be improved further. So, it was found out from workshop that AR can be a useful tool in teaching STEAM education. Moreover, the workshop also offers students a chance to develop and practice game concept skills and apply computer-aided design. It was found that students enjoyed lessons and AR technology for enhancing their skill (Jesionkowska, Wild et al. 2020).

Hadi Mogavi, Zhao et al. (2021) is focused on the possible barriers to active learning. The world is moving towards active learning but the barriers halt the active learning growth. This research finds the possible solutions for those barriers. The possible barriers which guide this research are what are the student barriers to active learning in online classes? How experts reflect on these barriers? How could the readers benefit from student barriers found?

To answer these questions qualitative research followed by an inducive approach is carried. This study is divided into three sections. The first section is about studying students' opinions collected through surveys, semi structured interviews a social media content.34 keywords were found out related to active learning education by using Uber suggest. And then using social media platforms used are Twitter, Facebook, Reddit, Stack Exchange, and Google Groups the possible barriers were searched. Then using

advertisements on social media volunteers were find out who have experience with active learning and they were interviewed. A total of 32 students were interviewed having 15 females. Interview questions were sent to them a day before interview so that they prepare well. The interviews were recorded. Study 2 contains expert opinions about the barriers using surveys and semi structured interviews. These experts were having vast experience of interacting with students throughout the years and were better aware of student's barriers. The criteria for the experts were that they should have at least one online experience in the last year. In study 3 Overall, twelve novice educators (3 females) are recruited from six local universities in Hong Kong and they were interviewed. The barrier found were Human side barriers which contained affective (not leaving their comfort zone), cognitive (having less authority like in using YouTube), social (isolation) and teaching (poor interaction between students and teachers), Technological barriers it includes high cost of technology and network issues and Environmental barriers it includes regional internet censorship barriers. Readers can benefit from these barriers by developing new interaction designs based on new input ways like using AR, VR and screen sharing. Improving communication between teacher and students can prove effective by using online active learning techniques.

Another study shows the teachers and students of civil engineering from Wentworth Institute of Technology worked on a project named as "Design of Educational Game for Fluid Mechanics" using UNITY 3d AND C# programming. Twenty-seven students participated in this study after they had been taught fluid mechanics course concepts in detail. Groups comprising of four to five students were formed and then they played different levels of game. Different fluid concepts were described using this game.

The game consists of stages and the player can only go to next stage when he passes previous level using knowledge of fluid mechanics. Stages of game include The Hub world in which player starts the game so first this page appears.it contains doors which represent different levels. Another stage is Pump Power level in which player has to move the water to upper tank by calculating power output of pump.as the player calculate power output so the tank moves downward and the floor moves upward and then player can go to next room. So, by applying conservation energy equation the students can calculate pump head and then calculate pump power. In Jet Height level fluid is present inside tank and the students' needs to calculate required pressure to raise the fluid jet to a specific height so the pressure can be calculated once student knows height of jet, specific gravity of fluid. Once pressure is calculated player can move to other stage. Another level called Hydrostatic Force level which contains a pool having water along with a door closed. The players need to calculate weight to keep on top of door so that moment generated by the weight and the moment generated by hydrostatic force of fluid is equal and the door remains closed. But in this stage the player has time constraint so he needs to calculate the weight in the required time to pass stage. In Buoyancy stage player needs to pass through pool filled with fluid to go through exit door. There is a square platform he can use to travel across pool but for that he needs to find the side length for the square pallet in order to float on the water using the knowledge of buoyancy. And last level is Pump Power & Head loss which contains two pools and the player needs to pump water from pol 1 to pool 2. Player needs to find total head loss due to friction inside the pipe and then player will find pump head and required power by applying conservation of energy equation and. Once he calculates this correctly the water will pour from pool 1 to

pool 2. A Survey was conducted at the end of game which showed that teachers should adopt such nontraditional methods which will improve learning of students along with having fun(Kazemiroodsari and Folajimi 2022).

CHAPTER 3 METHODOLOGY

A systematic methodology was devised to achieve the research objectives. Figure 3.1 shows the pathway for this research.

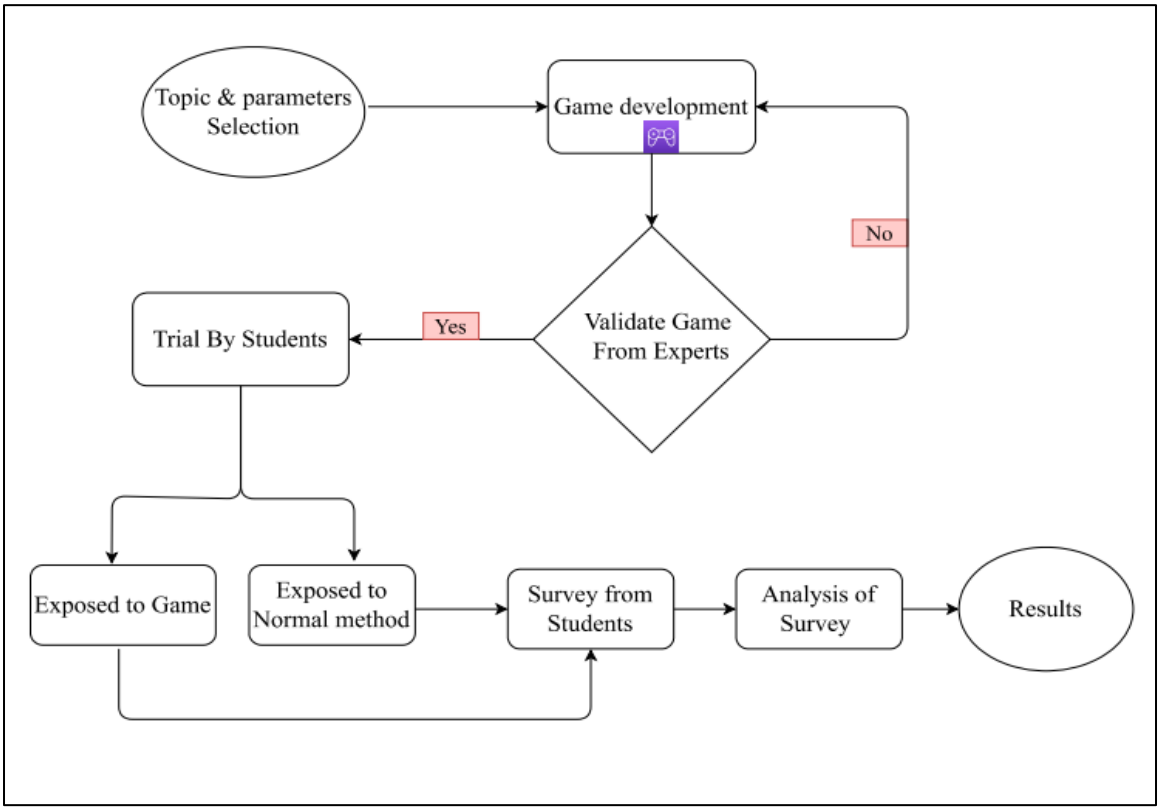

Figure 3.1: Methodology Framework

3.1 Topic selection & Collection of data:

Topic selected was splicing of bars and development length of bars after thorough review of civil engineering course.

3.1.1 Development length (ld):

It is defines as “the minimum length of the bar to be embedded in the concrete block so that the bar is yielded but not pulled out of the concrete block due to bond failure”. If the given length (ℓ) is less than the development length (Ld), so the bar will be pulled out which is called as bond failure.

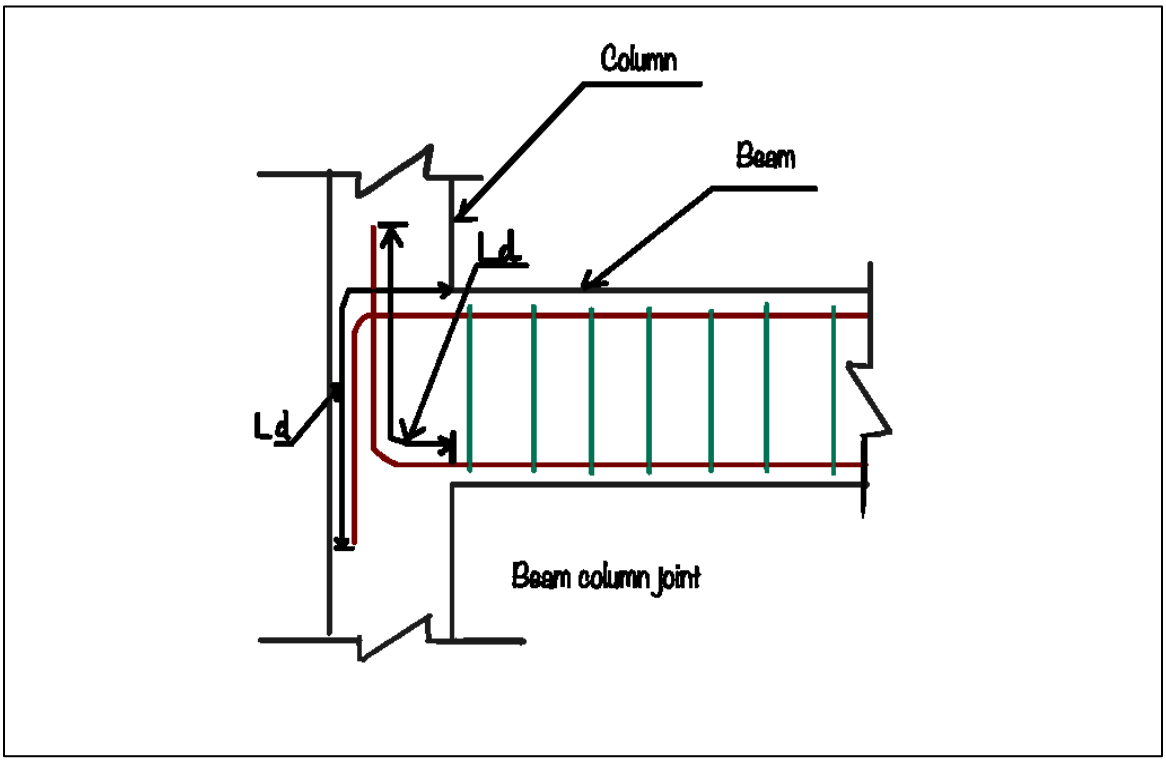

Figure 3.2: Development length

Table 3.1: Development length for straight bars and hooks

Comparison between l_d and l_{dh} for f_c'=3ksi				
Bar No	**Grade 40**		**Grade 60**	
	l_d	**l_{dh}**	**l_d**	**l_{dh}**
#3	11"	5"	17"	7"
#4	15"	6"	22"	9"
#5	19"	7"	28"	11"
#6	22"	9"	33"	13"

Table 3.1 shows development length used for different bars in construction when used straight or in form of hooks.

3.1.2 Bar splicing types

Bar splicing has two main types which are discussed below;

3.1.2.1 Lap Splice:

A lap splice is when two pieces of rebar overlap to form a continuous reinforcement. When we use less than no 11 bars in construction then we do lap splicing.

3.1.2.2 Welded Splice:

We do welding between two bars for their continuation. When we use no 11 or more than no 11 bars in construction then we do welding of bars.

3.1.3 Bloom's Taxonomy

Bloom's taxonomy is a hierarchical model comprised of three domains which covers the learning objectives. For the deliverance of topic through proposed technique of gaming it was necessary that it must cover domains of blooms taxonomy. The three domains are cognitive, affective, and psychomotor which are further divided into different levels;

3.1.3.1 Cognitive Domain

Cognitive domain covers the knowledge and intellectual skills that a student will develop. It is further divided into six levels;

Table 3.2: levels of Cognitive domain

Level	**Description**
Knowledge	It involves remembering facts, terms, definitions, basic concepts.
Comprehension	It involves translation, interpreting problems, instructions in your own words
Application	It involves application of knowledge obtained during classes to real world problems and situations.
Analysis	It involves breaking down information into different components and analyzing them

Synthesis	It involves combining diverse parts to form new structure
Evaluation	It involves judgment in terms of evidence and criteria set.

3.1.3.2 Affective Domain:

Affective domain is related to student's emotions and how they react to other's joy or pain. It is related to emotions, attitude and feelings. It is divided into five levels;

Table 3.3: Levels of Affective domain

Levels	**Description**
Receiving	It's about how well someone receives information and ideas delivered to them. No learning can happen without this level.
Responding	Response of students to what they receive.
Valuing	Giving value to information you receive.
Organizing	Organizing values, information and ideas that students receive.
Characterizing	It involves controlling your behavior and giving your behavior a consistency.

3.1.3.3 Psychomotor Domain:

This domain covers physical movement. It's the ability to use a tool or instrument. It has further seven levels;

Table 3.4: Levels of Psychomotor Domain

Level	**Description**
Perception	It involves using sensory cues to guide motor activity
Set	It involves physical, mental and emotional set due to which a person responds to different situations.
Guided response	It represents early stage of learning a complex skill which involves trial and error.
Mechanism	It represents intermediate stage of learning a complex skill in which a person has gained some confidence.
Complex overt Response	It represents expert stage of learning a complex skill. Here a person performs a skill without any hesitation.
Adaptation	It's the modification of known-skills to new situations after learning the complex skill set completely.
Origination	It is similar to adaptation but here we create new movement patterns to fit a situation.

3.1.3 Collection of data:

Data related to this topic was selected from practical project undergoing in NUST Islamabad. Figure 3.13 shows the game having a beam-column section from a project prototype being tested in laboratory in National University of Science & Technology, Islamabad.

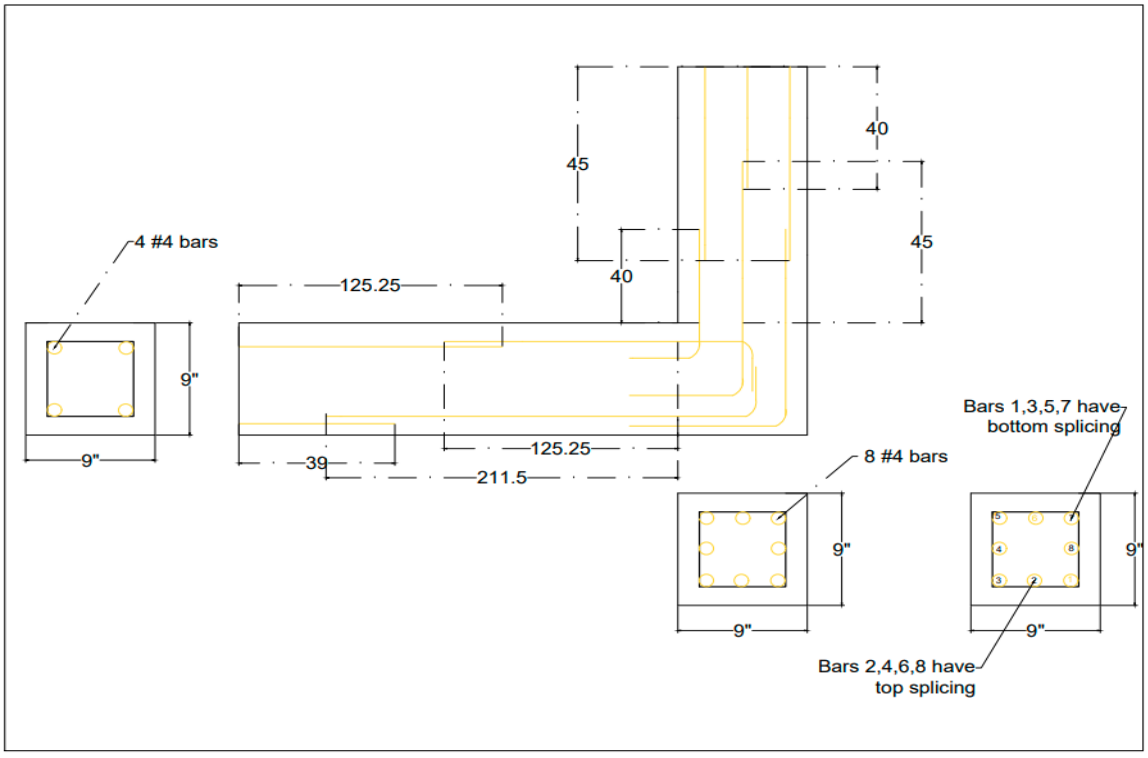

Figure 3.3: beam column section

3.2 About Game:

After the finalization of topic and concepts related to that topic game was developed in unity 3D. Unity 3D is a game development software which uses C# language.it contains different unity objects which were used like cylinders, capsules etc.

- Inputs of this game are lengths of bars, diameter of bars, splicing length of bars and hooks lengths.
- Outputs are visualizing of bars splicing and development length of bars which are actually hooks in beam and column bars.
- It contains C# coding for every step which includes code for camera movement, code for splicing, code for lengths and diameter fixing which are discussed below;

3.2.1 Camera movement

Figure 3.4 shows that the pseudo code for cam movement according to each selected bars of beam and column

Start

- Set the variable count to 0.
- **IF** count is greater than or equal to 1 **Then**

  Move the camera gradually towards the end position based on movement speed and time

- **IF** the camera reaches the end position **Then**

  Reset count to 0.

  Enable the canvas.

- **Exit loop**

  Rotate the camera gradually towards the end rotation based on movement speed and time

- **If** the camera reaches the **end** rotation:

  Reset **count** to 0.

  Enable the canvas.

End

Figure 3.4: Code for camera movement

3.2.2 Beam length setting

Figure 3.5 shows pseudo code for setting length of bars in beam. y and y2 shows red and blue bars in top section of beam which are spliced together. Similarly ya and ya2 denotes red and blue bars in bottom section of beam. While, z,z2,za and za2 denotes diameter of bars.

```
Start
    • Calculate the dimensions for the red and blue bars
        • y = barRedText * 0.00798  // y represents length of top red bar & the constant multiplied with y is for adjusting its size for visual clarity
        • z = diamRedText * 0.25  // z represents bar No of top red bar & the constant multiplied with z is for adjusting its size for visual clarity
        • y2 = barBlueText * 0.00798  // y2 represents length of top blue bar & the constant multiplied with y2 is for adjusting its size for visual clarity
        • z2 = diamBlueText * 0.25 // z2 represents bar NO of top blue bar & the constant multiplied with z2 is for adjusting its size for visual clarity
        • ya = barRedText * (1 / 39) // ya represents length of bottom red bar & the constant multiplied with ya is for adjusting its size for visual clarity
        • za = diamRedText * 0.25 // za represents bar No of bottom red bar & the constant multiplied with za is for adjusting its size for visual clarity
        • ya2 = barBlueText * (1 / 211.5) // ya2 represents length of bottom blue bar & the constant multiplied with ya2 is for adjusting its size for visual clarity
        • za2 = diamBlueText * 0.25 // za2 represents bar No of bottom blue bar & the constant multiplied with za2 is for adjusting its size for visual clarity
End
```

Figure 3.5: Code for Beam length setting

3.2.3 Column length setting

Figure 3.6 shows pseudo code for setting length of bars in column. c_y and cy2 shows red and blue bars in corner of column which are spliced together. Similarly cya and cya2 denotes red and blue bars in interior section of column. While, cz,cz2,cza and cza2 denotes diameter of bars.

```
Start
    • Calculate dimensions for red and blue columns
        • cy = barRedText * 0.025 // cy represents length of red corner bar & the constant multiplied with cy is for adjusting its size for visual clarity
        • cz = diamRedText * 0.25 // cz represents bar No of red corner  bar & the constant multiplied with cz is for adjusting its size for visual clarity
        • cy2 = barBlueText * 0.0222 // cy2 represents length of blue corner bar & the constant multiplied with cy2 is for adjusting its size for visual clarity
        • cz2 = diamBlueText * 0.25 // cz2 represents bar No of blue corner bar & the constant multiplied with cz2 is for adjusting its size for visual clarity
        • cya = barRedText * 0.0311 // cya represents length of red middle bar & the constant multiplied with cya is for adjusting its size for visual clarity
        • cza = diamRedText * 0.25 // cza represents bar No of red middle bar & the constant multiplied with cza is for adjusting its size for visual clarity
        • cya2 = barBlueText * 0.025 // cya2 represents length of blue middle bar & the constant multiplied with cya2 is for adjusting its size for visual clarity
        • cza2 = diamBlueText * 0.25 // cza2 represents bar No of blue middle bar & the constant multiplied with cza2 is for adjusting its size for visual clarity r
End
```

Figure 3.6: Code for Column length setting

3.2.4 Splicing of bars

Figure 3.7 shows pseudo code for splicing of bars in beam and column and for providing hooks. The code indicates the necessity of inserting a bar, and it emphasizes that the splicing should be prohibited for bar no greater than 11.

```
Start
    Check if both the parsed values of diaR and diaB are less than 11.01.  // diaB & diaR represents bar No
        • If true
            • Disable the warningMessage
            • Enable otherContent
        • Else
            • Enable the warningMessage
            • Disable otherContent
End
```

Figure 3.7: Code for splicing of bars And Hooks

- Process can be explained as first of all we have to enter length for each bar. In game red and blue bar names are used for easy understanding. After lengths we have to enter diameter for each bar and press enter. After this we have to enter splicing length for which we have to know development length

  Splicing length = 1.3 * dl

- Then we have to enter hook length for each beam and column bars from figure 3.3 and we will get final visuals of beam and column bars splicing and hooks as shown in Figure 3.9, Figure 3.10 and Figure 3.11

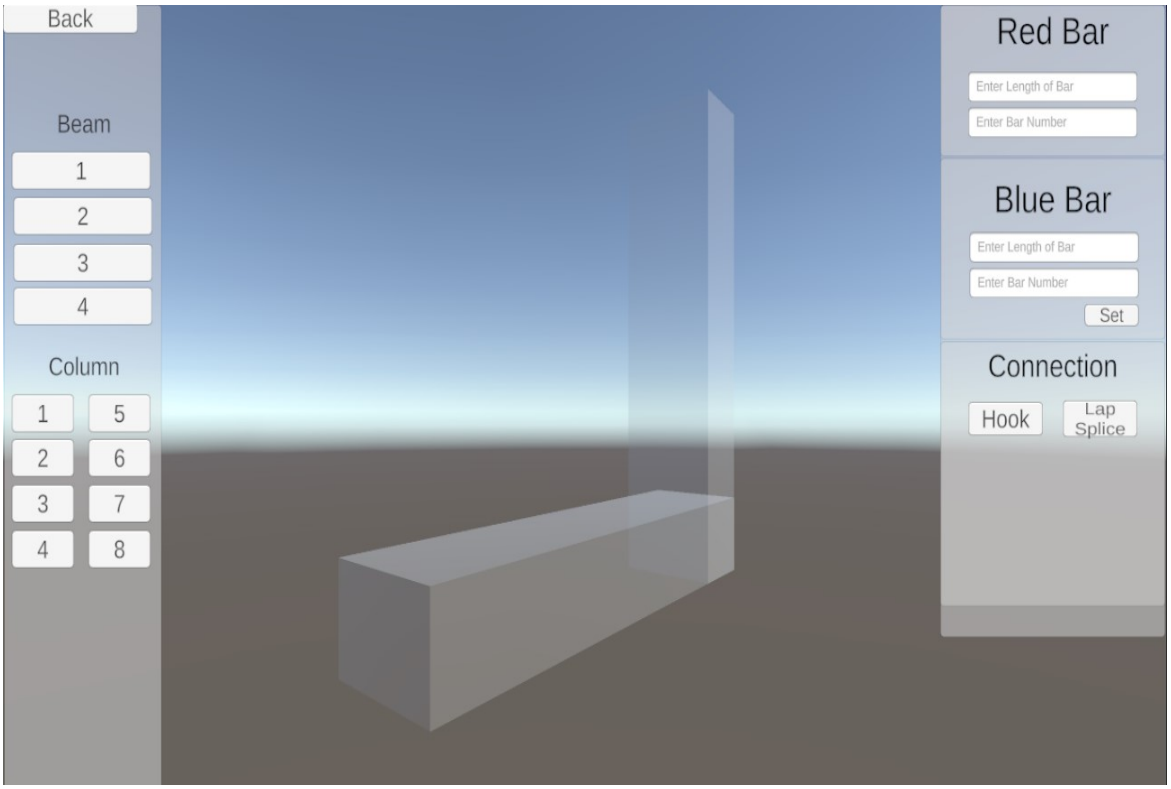

Figure 3.8: Game interface

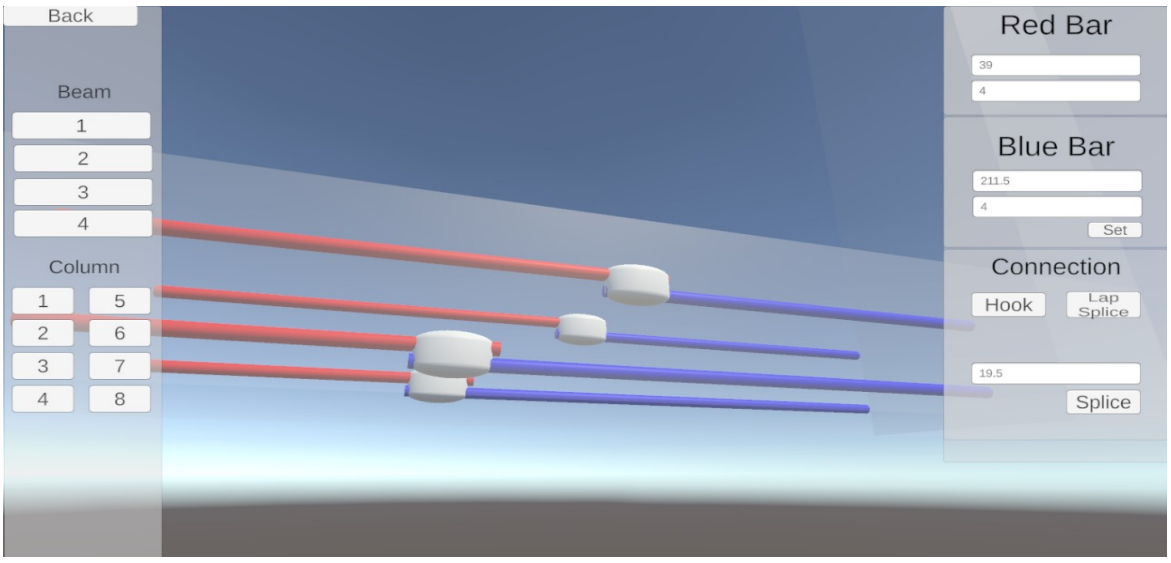

Figure 3.9: Splicing of bars in beam

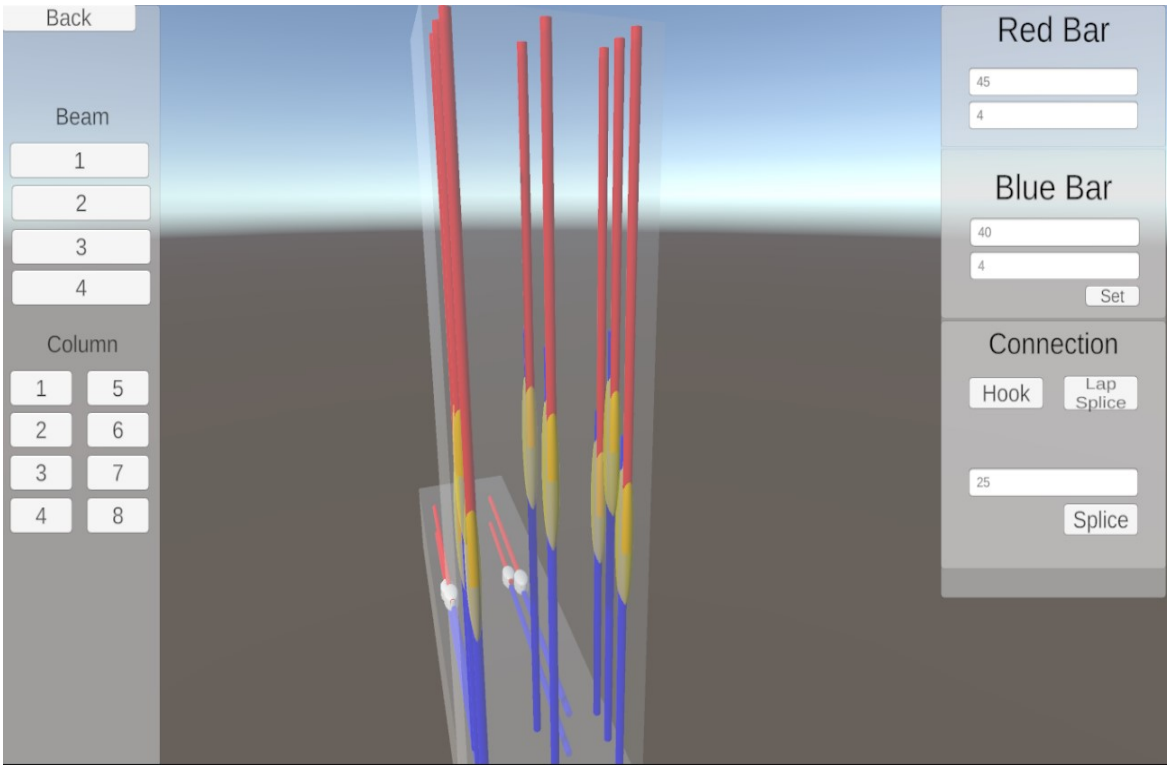

Figure 3.10: Splicing of bars in column

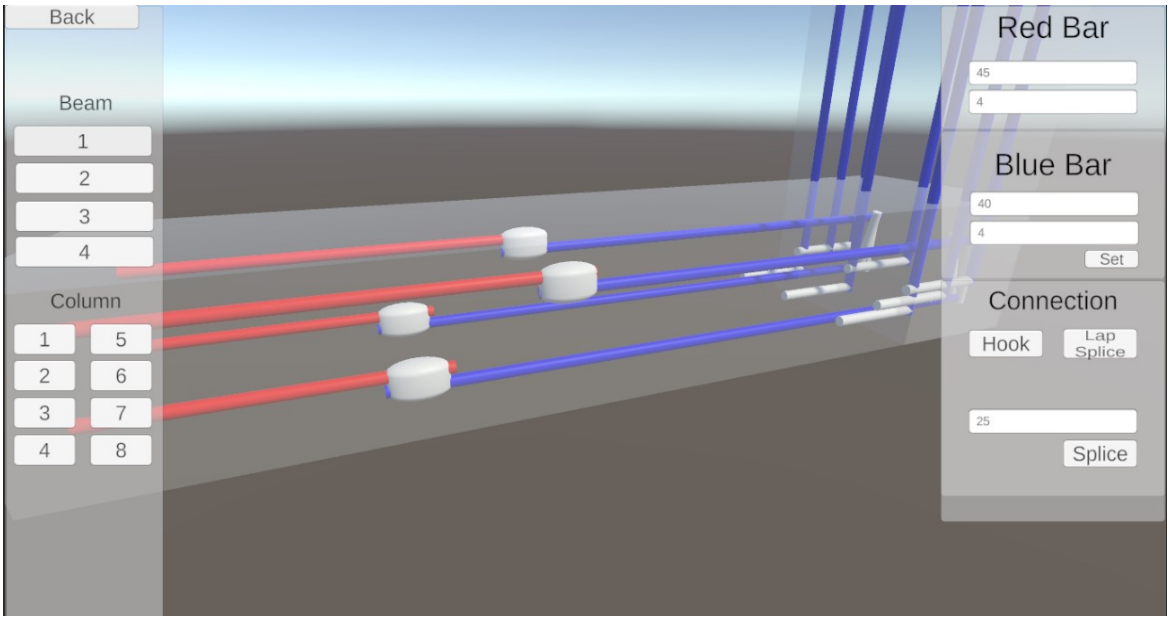

Figure 3.11: Hooks development length

3.3 Validation of Game:

After the game development, game was validated from game experts to check any room for improvement in the game to make it more interesting for students.

3.4 Survey

After the finalization of game, survey was conducted. Students were first treated as a controlled group so they were exposed to traditional teaching method and were taught these topics and then they were treated as an experimental group and were exposed to game and at the end to collect their views survey was conducted. Questionnaire was developed from validated scales on a likert scale 1 to 5.

3.5 Measures:

To get students response on both the methods survey was collected in classroom face to face from both controlled group and intervention group. A five point likert scale was used for measuring characteristics like entertainment (Jesionkowska, Wild et al. 2020), engagement (Hamari, Shernoff et al. 2016), and difficult level of both techniques to understand (Kim and Ruipérez-Valiente 2020) and a binary scale of Yes/No was used for knowing about method helpful in reinforcing concepts (Kazemiroodsari and Folajimi 2022) and motivation to use this method for learning in future (Felicia 2012).

3.6Sample size determination

For intervention studies, minimum sample size requirement is **30** (Sekaran and Bougie 2016). This study collected data from **92** participant's studies, which fulfill the sample size requirement. Similarly, from past literature **50** (Shatri 2020) & **50** (Law 2019).

CHAPTER 4 RESULTS AND ANALYSIS

4.1 General

This chapter describes the process of data analysis. Analysis of data will help us in knowing the effectiveness of gaming as an active learning technique used by civil engineering students in Pakistan and how can we further improve it for increasing its effectiveness. So, after the game development it was tested by students in classroom. A total of 46 students were present in classroom which consisted of 5 female students and 41 male students. At the end their views were collected by conducting survey which is discussed in this chapter.

4.2 Discussion on Survey Results:

The survey results and its main points are discussed below;

4.2.1 Demographic Analysis:

Game was tested by and then survey results were collected from students studying in seventh semester of civil engineering. Survey was collected from 46 students having 41 male students and 5 female students. Survey was collected from 46 students having 41 male students and 5 female students. The results obtained from survey were analyzed through independent T-test in Statistical Package for the Social Sciences (SPSS) which are shown below in table 4.1:

Table 4.1: Independent T-test results

Factors	**Mean (Gaming)**	**Mean (Traditional Method)**	**Mean difference**	**Significance**
Entertainment	4.13	3.72	0.41	0.56
Difficulty Level	2.65	2.72	-0.07	0.68
Reinforcing Concept	0.85	0.67	0.18	0.05
Motivation	4.65	2.89	1.76	0.00
Interesting	0.93	0.41	0.52	0.00

4.2.2 Key findings

- Figure 4.1 and Figure 4.2 shows the comparison between traditional teaching method and gaming technique for entertainment purpose. 91% students find this gaming technique entertaining while less than 2% students find this game boring. On other hand 58% students find traditional teaching method entertaining while 22% students find it boring. So, total of 33% increase in entertainment by switching from Traditional teaching method to Gaming technique. Also we can see through independent T-test that for entertainment the mean **4.13** through game is higher than mean **3.72** through traditional teaching method as shown in Table 4.1 which confirms that students were more entertained through game as compared to traditional teaching method. While Entertainment is an activity which captures attention (Moss 2010).

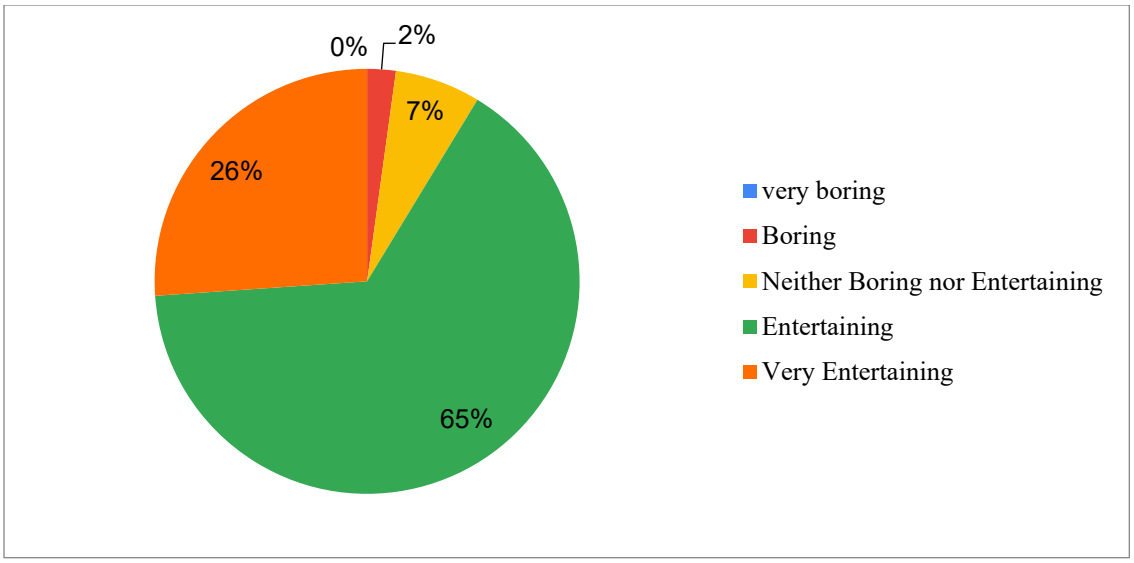

Figure 4.1: Game for entertainment

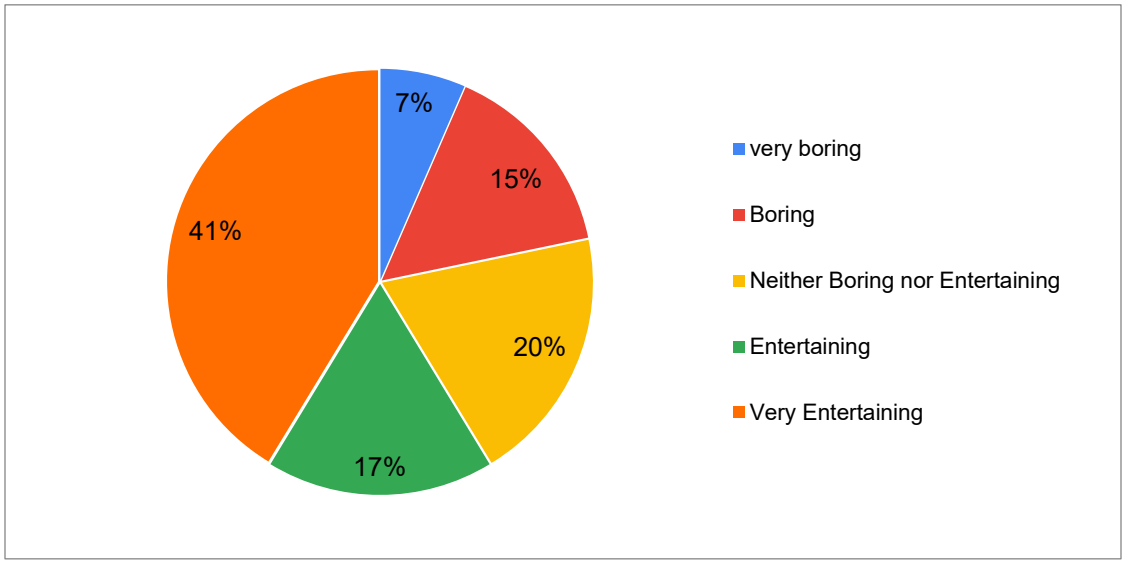

Figure 4.2: Traditional method for entertainment

- Figure 4.3 and Figure 4.4 shows the comparison between traditional teaching method and gaming technique for engaging purpose. 96% students find this gaming technique engaging while less than 5% students find this game less engaging. On other hand 57% students find traditional teaching method engaging while 43% students find it less engaging. So, total of 39% increase in engagement by switching from Traditional teaching method to Gaming technique. Also we can see through independent T-test that for engagement the mean **0.93** through game is higher than mean **0.41** through traditional teaching method as shown in Table 4.1 which confirms that students were more engaged through game as compared to traditional teaching method. The term Engaging can be defined as increasing interest to add new ideas to already available knowledge (Nunez-Eddy, Wang et al. 2018)

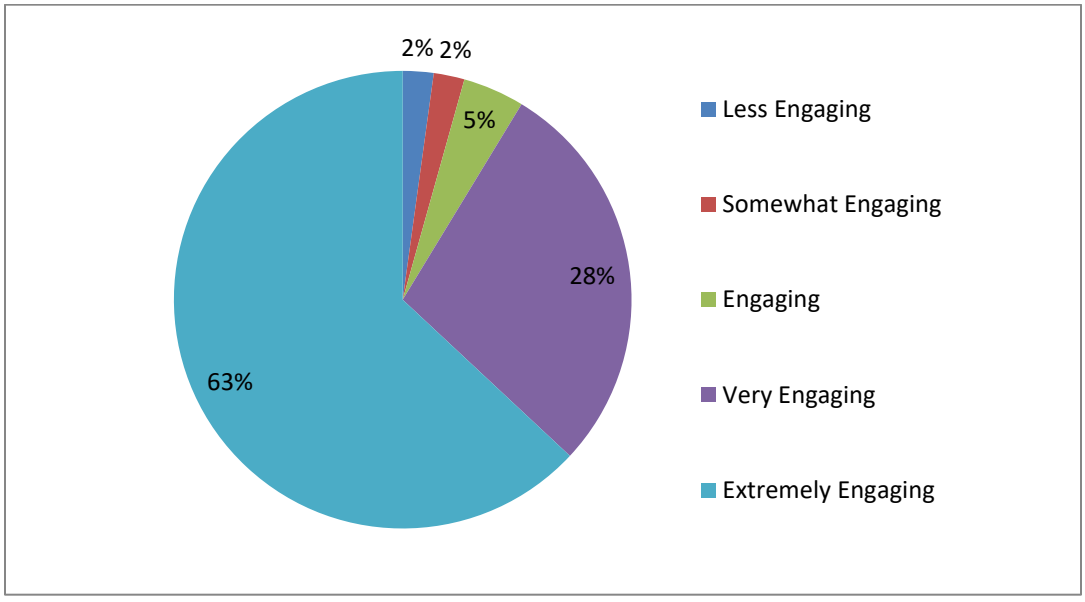

Figure 4.3: Traditional method for engagement

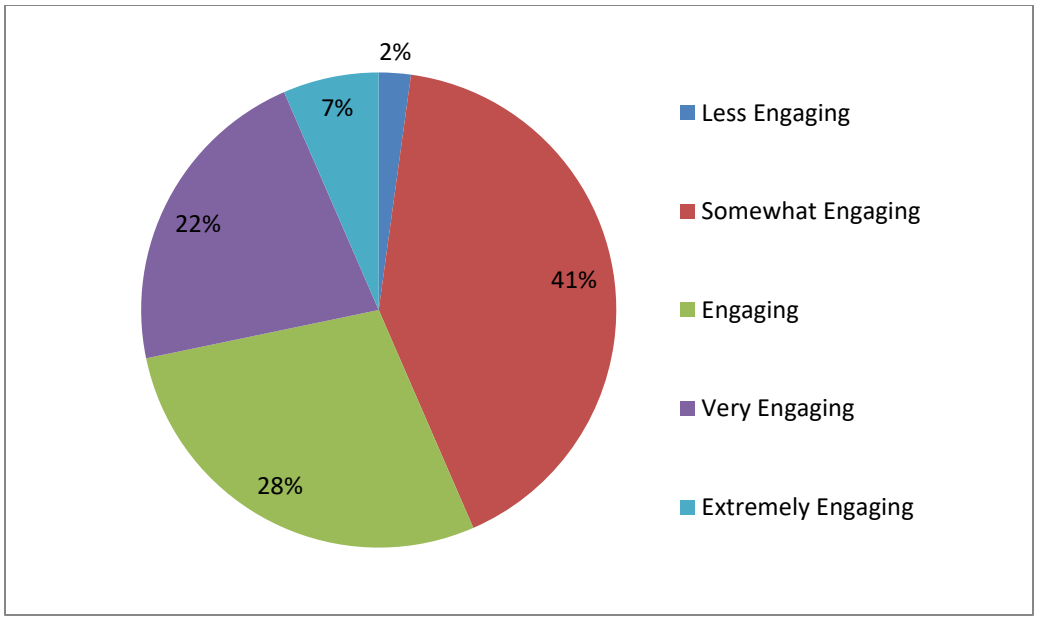

Figure 4.4: Game for engagement

- In response to the difficulty level of game one section of students found the game easy, and the other section of students found it difficult. 56% students found the game easy and helpful in understanding topic while 44% students found it difficult, very difficult or extremely difficult to understand as shown in Figure 4.5 while in traditional teaching method 69% students find it difficult or very difficult to understand as shown in Figure 4.6. Also we can see through independent T-test that for difficulty level the mean **2.65** through game is lower than mean **2.72** through traditional teaching method as shown in Table 4.1 which confirms that students faced less difficulty to understanding topic through game as compare to traditional teaching. Difficulty level includes efforts to solve the required problem.

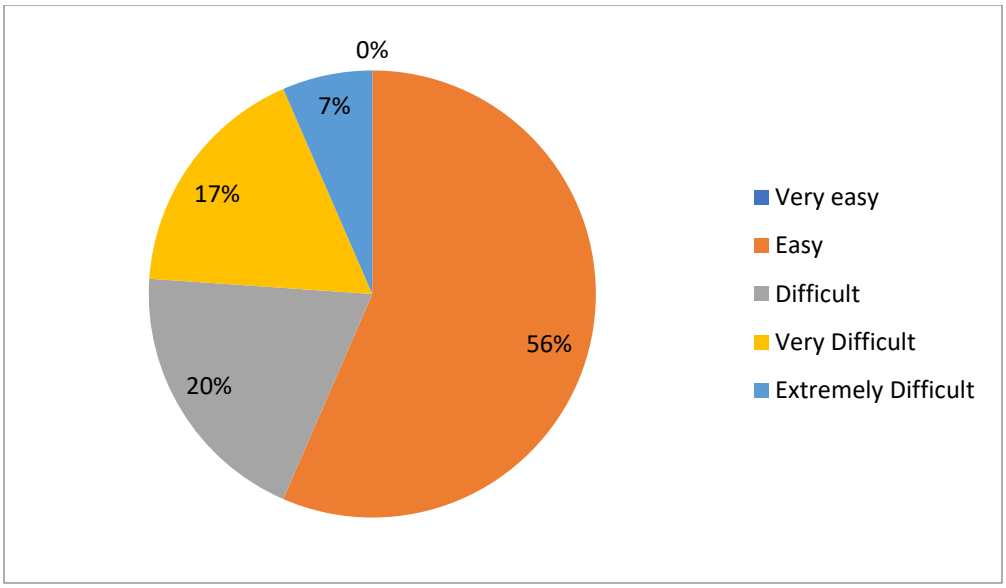

Figure 4.5: Gaming Difficulty Level

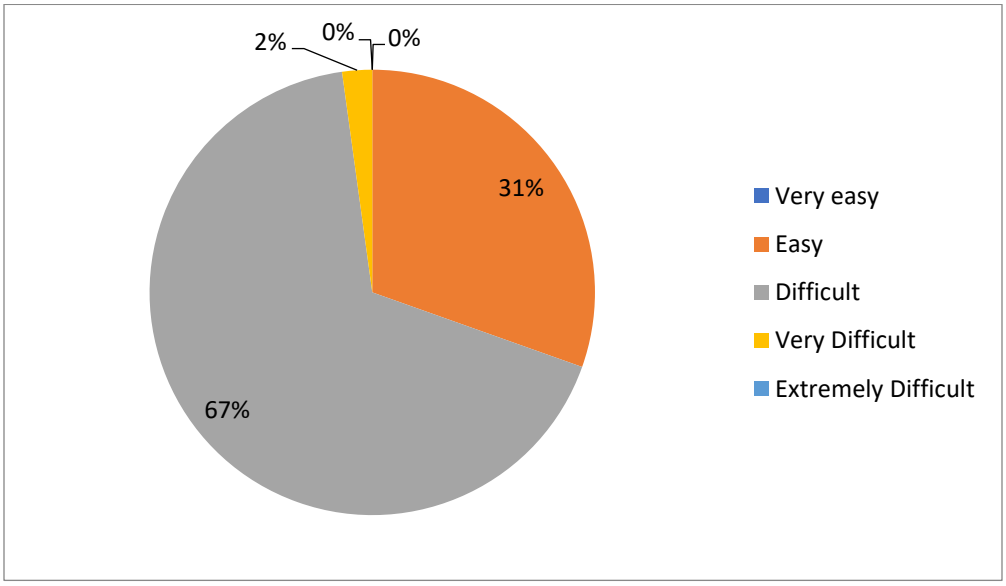

Figure 4.6: Difficulty level of Traditional method

- Figure 4.7 and Figure 4.8 shows the comparison between traditional teaching method and gaming technique for helping in reinforcing concepts. 85% students find this gaming technique helpful in reinforcing concepts while 67% students find traditional teaching method as helpful in reinforcing concepts. So total of 18% students were of the view that Game helped more in Reinforcing concepts as compare to Traditional teaching method. Also we can see through independent T-test that for reinforcing concepts the mean 0.85 through game is higher than mean 0.67 through traditional teaching method as shown in Table 4.1.

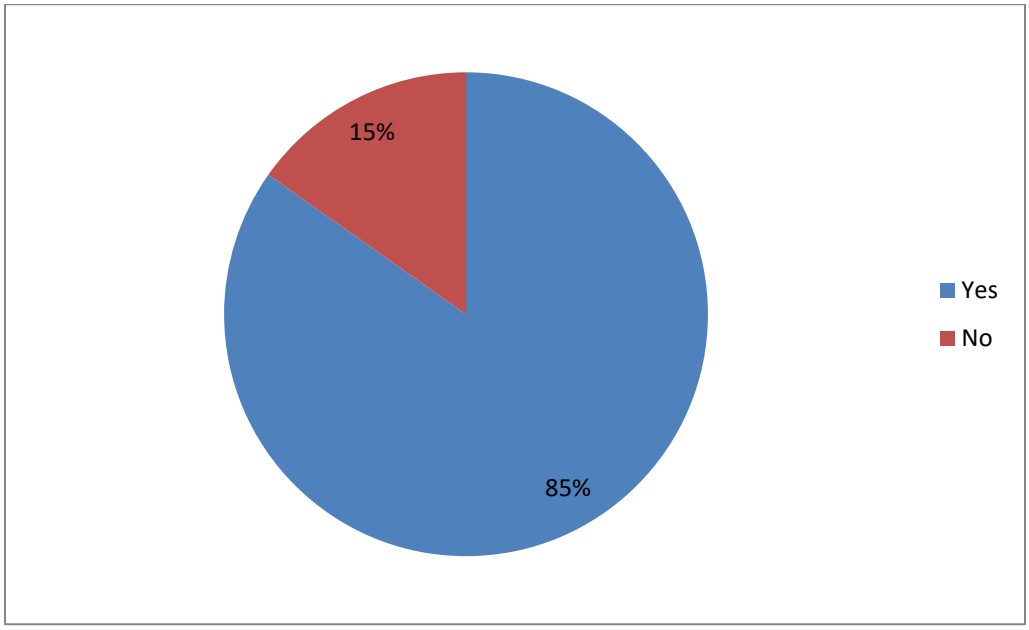

Figure 4.7: Game for Reinforcing Concepts

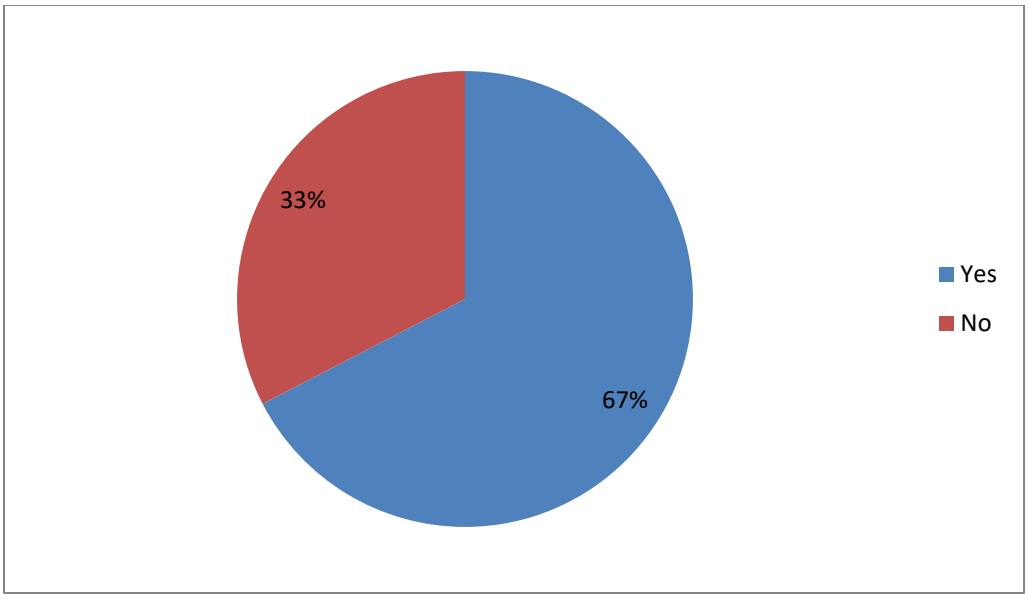

Figure 4.8: Traditional method for Reinforcing Concepts

- Figure 4.9 and Figure 4.10 shows the comparison for motivation level to learn in future using traditional teaching method and gaming technique. 87% students were motivated to use gaming technique for educational purpose in future while only 41% students were motivated to use traditional teaching method in future. Also, we can see through independent T-test that for motivation to learn further through game the mean **4.65** is higher as compare to mean **2.89** through traditional teaching method as shown in Table 4.1

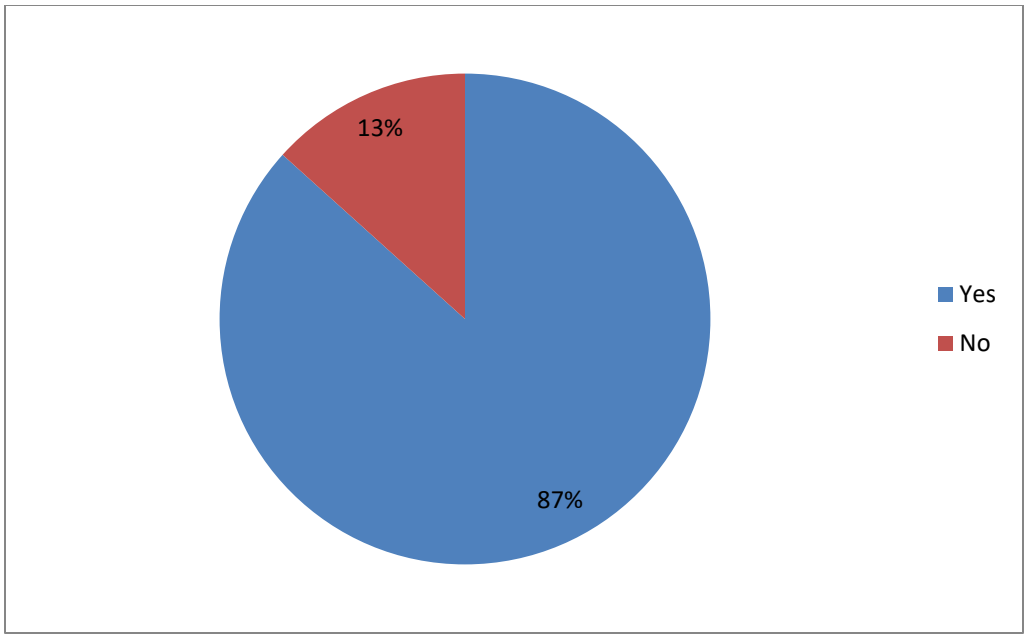

Figure 4.9: Motivation by using game

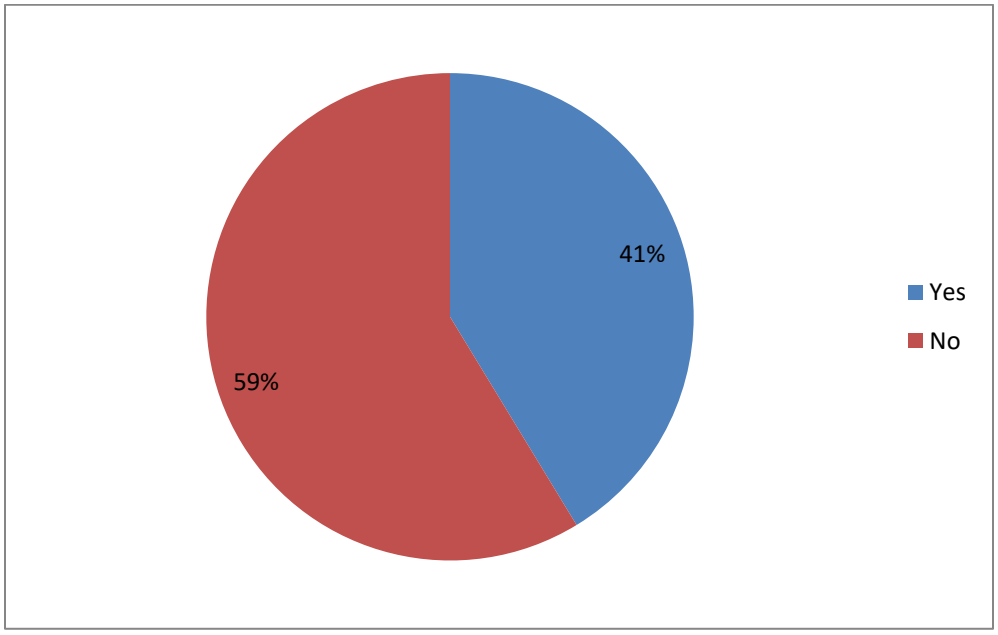

Figure 4.10: Motivation by Traditional method

Apart from comparison some extra features of game were also asked from students. When asked about having played a simulation game for educational purposes before so majority of them answered no and most of them were playing a simulation game for educational purpose for the first time. 87 percent of students were playing a simulation game used for educational purpose for the first time as shown in Figure 4.11. Similarly most of the students played this game multiple times in practice session which were 65 percent which was indeed a positive sign as shown Figure 4.12. Also students were extremely satisfied with its technicalities and found no bugs while playing the game.

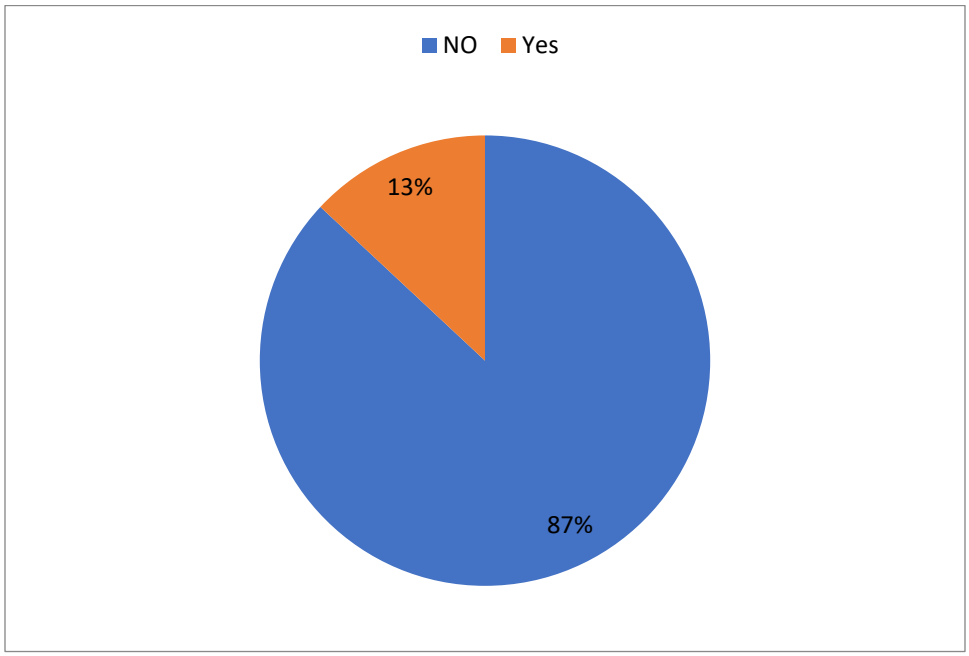

Figure 4.11: played simulation game before

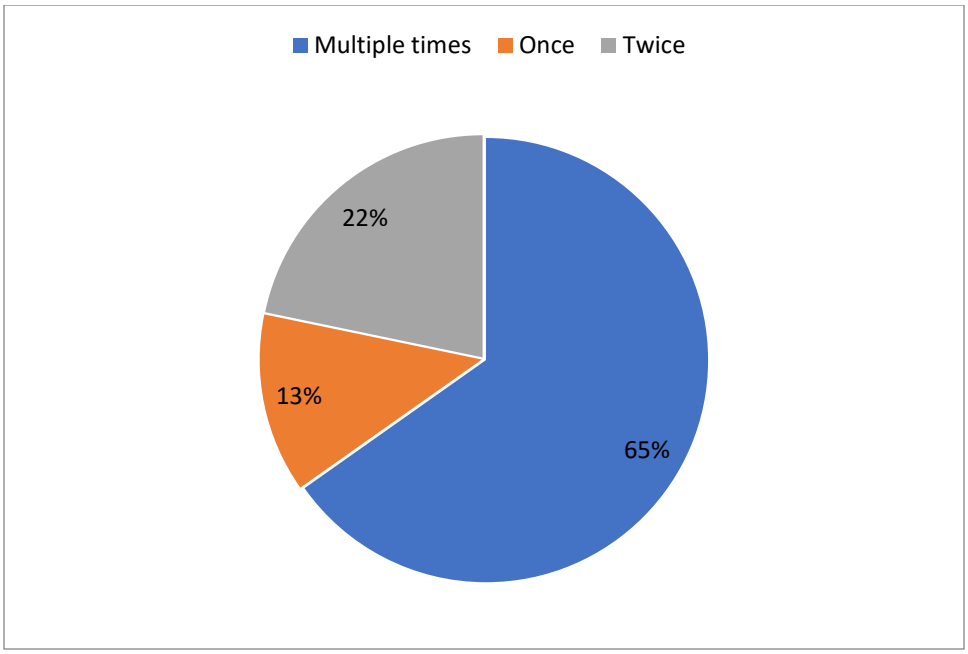

Figure 4.12: No of times played game

Students were also asked about the time taken by them to complete the game in which 87 percent of students were able to complete between 5-10 minutes while only 4 percent of students took more than 10 minutes and 9percent of students took less than 5 minutes as shown in Figure 4.13

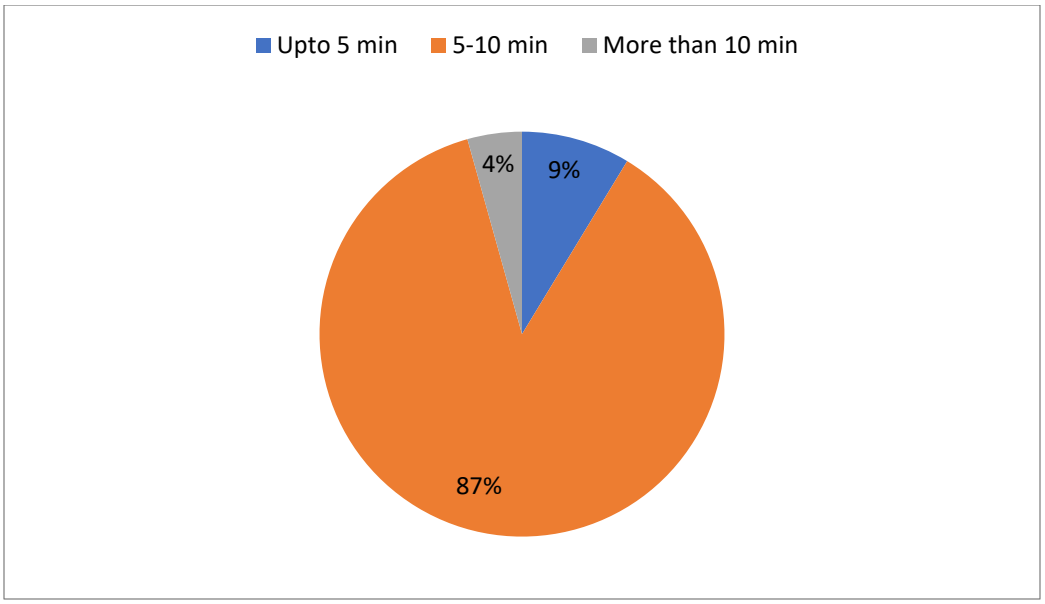

Figure 4.13: Time taken for completing game

SUMMARY OF RESEARCH WORK

To increase learning of students different active learning techniques are used worldwide. In this research i studied different active learning techniques used previously and then selected the technique of gaming for increasing interest of students in learning. This research had three main objectives which are achieved here. The first one was to investigate all conventional teaching methods applied in classrooms which were achieved by attending sessions in classrooms and observing the way of teaching of courses in classrooms.

The second one was to devise a pathway to translate these concepts taught in classroom to an interactive game which was achieved by studying literature and observe different active learning techniques used previously. After that selecting the active learning technique of gaming for translating the concepts taught in classroom. So for this game was developed through unity 3D which contained all the animations and were controlled with the C# code and it addressed all the concepts taught in classroom with animations.

The last objective was to validate the enhancement of students learning through this proposed game which was achieved by testing the game in classroom by students. First they were taught selected topics in traditional way by using whiteboard and then were taught these topics by using game and then they were given time for practicing the game and at the end survey was collected from them to observe their response.

The views of students were very positive and encouraging. They encouraged the proposed technique of game for enhancing their learning and they further emphasized on

improving the game by including more and more topics in future. This technique surely enhanced the learning of students. As compare to traditional teaching methods this technique is more preferable because;

- Students are the leading players of the learning process.
- It increases engagement of students
- learner is motivated to participate actively in class activities
- It includes learners work which is built on learning objectives
- Understanding of students is increased because all the efforts are applied by the learner.

CONCLUSION

To conclude this research, it had three main objectives which are achieved here. The first one was to investigate all conventional teaching methods which was achieved by attending sessions in classrooms and observe the way of teaching and the second one was to devise a pathway to translate these concepts taught in classroom to an interactive game which was achieved by studying literature and observe different active learning techniques used and then selecting the technique of gaming for translating the concepts taught in classroom. So for this game was developed through unity 3D and it addressed all the concepts taught in classroom and the last one was to validate the enhancement of students learning through this proposed game which was achieved by testing the game in classroom by students. First they were taught this game and then they were given time for practicing the game and at the end survey was collected from them. The views of students were very positive and encouraging.

FUTURE RECOMMENDATIONS

This research covered Simulation game for Structural engineering topic. In future more topics can be covered through simulation games and it can also be enhanced to different civil engineering fields like geotechnical engineering and transportation engineering. As for game is concerned so multiple players can be included in the game for making game more interesting and more variables and parameters can be included in the game.

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