NEW USER INTERACTION DESIGNS FOR PEER TEACHING AND
COOPERATIVE LEARNING USING MOBILE AUGMENTED REALITY

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ABSTRACT

Most faculties rely on teaching their students about knowledge rather than guiding students to learn on their own. This creates a passive learning environment where students' knowledge is based on whatever knowledge given to them. Learning should be active and constructive process where the role of faculties is to guide the students toward learning not pouring the knowledge to their students. The use of collaborative learning approach is suitable in learning environment where the center of learning is on the students' exploration not simply the teacher's presentation. Faculty of Electronic and Computer Engineering at Universiti Teknikal Malaysia Melaka has implemented collaborative learning activity and problems faced by faculty are students still difficult to understand certain concept. We believed that the failure is due to learning-teaching style mismatch and collaborative learning can improve students' performance both group and individual when students' learning style is considered in the learning instrument. In order to prove the hypothesis, this study carried out preliminary analysis at the first phase. At the second phase, design and development of learning instrument based on preliminary analysis results was conducted. The third phase is experimental and data analysis. From the experimental results, the analysis shows that the implementation of learning style in collaborative learning improve students' and groups' performance. This conclusion is based on the significant difference on groups' and individual achievement between control and experimental group and students' performance in experimental group is higher. The analysis also shows that the implementation of learning style brings effect in satisfaction thus performance is increased. There is correlation between satisfaction and learning performance and students with higher satisfaction gain higher performance. The implementation of learning style also improved motivation. This was shown by the result that motivation level in experimental group is higher than control group. The result also shows that students with higher motivation gain higher performance.

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CHAPTER 1

INTRODUCTION

1.1 Overview

Popular usage of mobile devices among students might create distractions for their learning experience. It is because functions and features offered by their mobile devices are more appealing than the learning itself. This condition becomes even worse with the rapid developments of mobile devices technologies with its ability to do many things like people do with their personal computer. It makes people rely on it in everyday life and creates a situation where mobile device is a window to infinite space hence for student it creates more distraction in learning experience. But there is a time when students use some function in mobile device to help them catch up with their learning for examples they use SMS to ask colleagues for assignments or schedule changes, and use mobile instant messenger as a medium for discussion.

This situation encourage many studies on mobile and learning in order to enhance learning outcomes and it created new learning term called mobile learning. Litchfield et al.
(2007) studied that the use of mobile devices can enhance learning experience and learning outcomes because of its ability to change the approach of learning and learning perceptions. The way mobile learning combine technology and learning context is a new approach which aims does not substitute the traditional learning environment, but to give new feeling hence can increase learning interests, learning experiences, and learning outcomes. Current study about mobile learning is focused on how to use mobile devices to interact students in collaborative learning environment such as using notification (Nakahara, Hisamatsu, Yaegashi, & Yamauchi, 2005), using game approach (J. S. Cabrera, et al., 2005), involving multiple users (Lyons, Lee, Quintana, & Soloway, 2006), and designing interaction interface (Black & Hawkes, 2006).

It is said that collaborative learning able to enhance students’ performance because it promotes active learning among students (Smith & MacGregor, 1992). Therefore many studies was conducted on collaborative learning approach because of its effectiveness in engaging active learning hence critical thinking among students is developed. Nevertheless, there are heterogeneous finding towards the use of technology for collaborative learning activity. Some studies showed significant result towards students’ performance (A. F. Cabrera, et al., 2002; Prince, 2004; Rao, Collins, & DiCarlo, 2002) and some studies were not (Hanze & Berger, 2007; Messeguer, Navarro, Damian-Reyes, & Favela, 2010). From those studies, the implementation of collaborative learning seems to bring effect only on group academic performance. Collaborative learning effects indirectly to individual performance such as increase students’ interest towards learned subject and makes students more actively participate in discussion. This is supported by Yazici (2005) who said that collaborative learning is only a method for teaching in order to supplement individual students needs. This means, not all students feel comfortable in collaborative
environment because every student in different discipline possess different learning preferences. This early investigation directs us to make assumption that collaborative learning can improve students’ performance both group and individual when students’ learning style is considered in the learning tool.

Our Faculty of Computer and Electrical Engineering in Univeristi Teknikal Malaysia Melaka has implemented collaborative learning activity and problems faced by faculty are students still difficult to understand certain concept. We believed that the implementation of collaborative learning can enhance students understanding and performance and the failure is due to learning-teaching style mismatch. From preliminary analysis, it was known that engineering students’ learning style is active, sensory, visual, and sequential but the current implemented learning instrument is lack of visual explanation. For example, when students are explained about generator, their own understanding will visualize how generator works which some students make correct assumption some are not. Some teachers using graphics to explain more but it is more understandable to use moving images since students have different level of understanding. The use of augmented reality can solve this problem because augmented reality can extends the physical environment by adding more information on it.

1.2 Augmented Reality

Superimposing virtual information on the real environment is the characteristic of augmented reality. The ability to blur the line between what’s real and what’s computer-generated can extends the ability to increase possibility of doing things that are impossible.
The word augmented reality is close to virtual reality where both share almost all characteristics except for the environment. In virtual reality, a set of devices usually used to let the virtual world being seen in which a person will not aware of the real world around him. These devices include display, haptic device, audio generator and some have scent generator such as Sensorama build by Morton Heilig 1962. In some activity, the immersion of virtual reality brings limitation of its usage since this system does not allow of seeing anything but the virtual world and does not allowed to do interaction and activity other than those available in that world. This kind of immersion creates a gap to the learning process where student does not aware of other student’s existence hence cannot communicate with them. A term of Mix Reality (MR) and taxonomy of virtual display proposed by Milgram et al. (1994) put this system into category augmented reality.

![Figure 1: RV Continuum (Milgram, et al., 1994)](image)

Augmented reality is a term in which virtual object is imposed to real world so a person will see a virtual world as well as a real world. This characteristic brings interest to many researchers to explore its capability, supported technologies, and potential applications. Currently, augmented reality has been put to use in a number of applications such as medical, manufacturing and repair, annotation and visualization, robot path planning, entertainment, military aircraft (Azuma, 1997), and education. By applying augmented reality, resources could be provided to a level where content could really transfers a lot of information in a very visual, easy-to-understand way since a person can
see a virtual object or information being added in front of him without reduces the awareness of real world around.

The ability to put virtual object into the real environment makes augmented reality system suitable to be used in mobile condition. With the improvement of technology on mobile devices that allow the use of camera, augmented reality system is able to be implemented in it. But of course the user interface and interaction will be different when using mobile devices compared with the one using HMD. User Interface design needs to concern on the limitation of mobile device's screen size in order to let users interact with the virtual object more effective. In augmented reality system, users might face difficulty to differentiate between the virtual and real object, it is a user interface design which gives a clue in order to avoid this ambiguity.

1.3 Collaborative Learning

Collaboration has became interesting topic since '80s, it is because its flexibility and adaptability to any discipline. Since learning is an active and constructive process, collaborative learning approach is suitable to be used in learning environment where the center of learning is on the students’ exploration not simply the teacher’s presentation. Basically, the emergence of collaborative learning does create major changes in learning style. Traditional learning style which always focuses on teacher’s role in classroom is being substitute with collaborative learning where teacher assists student in learning material. In traditional learning style, students learn in a passive environment. They are being forced to accept all materials their teacher gave and questioning is forbidden. This
situation brings negative impact on students’ life which they will only response what people gives them in other word, their critical thinking ability is not develop. Collaborative learning style changes the way educators see learning activity in classroom. Learning environment changes from passive to active activities and teacher helps students to develop their knowledge and critical thinking skills. The subject in learning activity is students whereas teachers are a mentor to direct students to the correct path.

In collaborative learning activity, knowledge is coming from the communication with others instead of an individual mind. With doing interaction and communication with others, students may sharing their opinion and develop their own understanding from the combination between their internal knowledge and external knowledge and came up with factual knowledge. Applying collaborative learning in classroom, Gokhale (1995) stated that students’ performance become higher compared to them who learn individually because there are activities involving active learning which are exchanging ideas with peers, analyzing other opinions, and synthesizing their understanding so that they are able to explain and justify opinions to others. This is how the knowledge grows in line with collaborative activity. Students from different level of learning performance work together. This situation creates an environment where all students can get same level of understanding where discussion does not continue when there is misunderstanding between teammates.

Collaborative learning has been applied in many years and there are many approaches have been created such as seminars, peer teaching, cooperative learning, reciprocal teaching, etc. All those approaches have the same characteristic which is based on students' active learning. Nevertheless, this study focuses on cooperative because the
center of cooperative approach emphasized on each member and all member achievement (Olivares, 2007).

1.4 Interface Design

Based on (Barfield, 1993), user interface is a combination between a system, users, and methods of communicating between one to the other. Wilbert (Galitz, 2002) determines user interface as part of human-computer interaction (HCI) which consist of two elements, input and output. He also stated that good interface design could satisfy users’ need, enhance their capabilities, and cover their limitation in the most effective way. Susan, Pamela, and Sarah (1997) said that intelligent interface “allows user to perform a task in the way that makes the most sense to them, rather than having to adjust to the software”. A design should be based on the users, reduce error and training time, make users more productive, and support how the users need to work. There are three elements should be considered in interface design which are users, tasks, and context (Parsons, Ryu, & Cranshaw, 2007). Users are important factor because each user possessed different habit, preferences, needs, etc toward interface whereas tasks and contexts determine tasks users need to do by the help of interface and the environmental context in order to finish the task.

1.5 Learning Style

User is one of elements of user interface. In learning, users possessed different learning preferences. According to Johnston and Orwig (1998), learning style is a unique
characteristic of individual skills and preferences which affect how a student receives, collects, and processes the learning material. Learning styles by Fleming (2001) are individual characteristics and preferred ways of gathering, organizing and thinking about learning material. His idea of learning style is more to instructional preferences because it deals with perceptual modes whereas Felder (Richard M. Felder & Silverman, 1988) defined learning styles as characteristics and preferences of an individual to take, process, and understand information. Therefore learning style is preferences towards information perception, retrieval, processing, and understanding that each individual possess differently.

In engineering disciplines, Felder (1996) summarized four learning style models that have been used effectively which are Myers-Briggs Type Indicator (MBTI), Kolb’s Learning Style Model (KLSM), Herrmann Brain Dominance Instrument (HBDI), and Felder-Silverman Learning Style Model (FLSM). This research uses Felder Learning Silverman because FLSM is equipped with free instrument called Index Learning Style (ILS) (Soloman & Felder, 1997). Besides, FLSM dimensions address cognitive style and social interaction (Tobar, Luis, & 2004), and Kirkham, Farkas, and Lidstrom (2006) found that FLSM result can be easily translated to a specific design.

FLSM consists of four dimensions and 2 elements for each dimension. Every person tends to have one of the two elements for each dimension and it will be their dominant learning style, but it is also possible that a person sometime shows characteristic of the other element. For example, before a person act (active), he should reflect (reflective) the action to have it mature and better rather than act right away. There are perception dimension which determines type of information student prefers to perceive
whereas he prefers intuitive (internal; e.g. using imagination) or sensory (external; e.g. through observation); Input dimension which determines through which sensory channel information being easily received and consists of visual (prefer picture) or auditory (prefer words); processing dimension which determines how student process information whereas he prefers actively process the information (do it) or passively process the information (think it); understanding dimension which determines how student progresses toward information whereas he prefers sequentially (in chronological order) or globally (in large gap order).

1.6 Research Question

This research aims to answer the following questions:

**RQ1:** What are interface design considerations for effective collaborative learning?

**RQ2:** How to implement learning preference in user interface for effective collaborative learning activity?

**RQ3:** Is the implementation of learning style in collaborative learning which related to performance differs between expert evaluation, tutored evaluation, and group evaluation.

**RQ4:** Is performance affected by individual satisfaction?
1.7 Research Objectives

The objective of this thesis is to create a possible interface design of mobile learning which is suitable for engineering students and support for collaborative learning environment and augmented reality which provides students a rich learning material hence can help enhancing students’ understanding. It aims to support students with easy to understand interface to let students comfortable to acquire knowledge, easy to do interaction with virtual object and do collaboration effectively.

The statement of this study can be summarized as follows:

OB1: To investigate engineering students’ learning preference based on learning style model for engineering field in order to create effective collaborative learning activity.

OB2: To design and develop a prototype that implements engineering students’ learning preferences to support collaborative learning activity.

OB3: To assess students’ performance and prototype usability.

1.8 Overview of the Thesis

The rest of this thesis is organized as follows.

Chapter 2 Literature Review: This section opens with an overview of main elements of this study which are augmented reality, collaborative learning, learning styles, and interface design, and. In augmented reality section, history of augmented reality is
reviewed, augmented reality architecture design is discussed, input output device needed for augmented reality application is reviewed and interaction design is discussed. In Collaborative learning section, the definition of collaborative learning is described in more detail and the characteristic of collaborative learning is discussed. In learning styles section, learning styles based on Felder Silverman Model is reviewed, the learning styles assessment is discussed and the reason of choosing presentation learning preference in the interface design process is discuss. In interface design section, usability requirements are reviewed and usability principles are discussed.

**Chapter 3 Design and Research Methodology:** This chapter starts from mobile augmented reality architecture design implemented for this study. Then it shows and explains in detail about the proposed interface design. This section also discusses research methodology, research design, research framework, and research procedure.

**Chapter 4 Evaluation and Discussion:** The achievement of this research will be discussed here which shows evaluation results from usability testing of the proposed interface design and also results from Inventory Learning Style which was done in the earlier stage to ensure learning style of engineering students. This is followed with diagram from the gathered data for each evaluation. The evaluation result will be discussed and description of possible further improvements accompanies the discussion.

**Chapter 5 Conclusion:** The final section contains a summary of the work covered and conclusions reached.
CHAPTER 2

LITERATURE REVIEW

2.1 Augmented Reality

2.1.1 History of AR

Augmented reality is not a new technology. Its appearance started when Morton Heilig created Sensorama Simulator (1962), a cinematographer machine which has capability to immerse user in their visual, sound, vibration, and smell sensory. He then realized the need of head-mounted television and his initial work of Head Mounted Display (HMD) was continued by Ivan Sutherland (1968). Later, the work continued by Thomas Caudell and David Mizell (1992) and they coined the term "augmented reality" to refer to overlaying computer-presented material on top of the real world. They combined head position sensing and a real world registration system to create a system which augments user’s visual field with necessary information. From this study, it was known that AR
system require less processing power since less objects have to be rendered and registration process was needed in order to align real and virtual object.

The relation of virtual reality and augmented reality brings interest for many researchers until now. In 1994, Paul Milgram, and his colleagues described the position of augmented reality in reality-virtuality continuum (1994), and in 1997, Ronald Azuma published “a survey on augmented reality” (1997) which was being cited by many other researcher. Augmented reality for handheld devices is introduced by Jun Rekimoto and Katashi Nagao by created the NaviCam (1995). The NaviCam was connected to a workstation with a camera mounted on the mobile screen that is used for optical tracking. The computer detects color-coded markers in the live camera image and displays context sensitive information directly on top of the video feed in a see-through. Their study proposed human-real world interaction using computer augmented environments. One year after, Jun Rekimoto (1996) came with 2D matrix markers (square shaped barcodes), one of the first marker systems to allow camera tracking with six degrees of freedom, and his paper publish on 1998 (Jun Rekimoto, 1998).

Augmented Reality usage has been expanded to be available to outdoor environments. Steven Feiner with his colleagues created Mobile Augmented Reality System (MARS) which combined AR with mobile user interface by see-through displays and 3D graphics without assuming precise registration (1997) to provide University information based on physical world. This works was extend by Bruce Thomas, et al (1998) who investigated see-through display, digital compass, and GPS to provide outdoor AR system using terrestrial navigation.
2.1.2 AR Architecture

Commonly, augmented reality application consists of tracking image, application control, and rendering. Figure 2 is the AR application architecture. Camera by using video capturing mode, capture a marker which has a unique id and it is compared with id in database to generate certain virtual objects. AR toolkit is used to recognize a marker by detecting the corners of the square marker and use it to calculate the position and orientation of the camera in a coordinate system centered on the square. Later, the marker-id will be compared with database. The database stores XML file which contains geometric information of an object such as ventricles and surfaces, and AR-toolkit-marker. Once tracker finds the match id, corresponding data is sent to the application to be rendered by scene generator, OpenGL, the most used 2D and 3D API (Application Programming Interface) applicable for variety of platform, with position based on position and orientation of the camera in marker coordinate.

![Figure 2: AR Application Architecture](image)
Figure 3: Transformation from the Camera Plane to a Local Coordinate System

(Wagner & Schmalstieg, 2007)

Each pattern of the marker has different identity which is inscribed inside the square. It is better to use id-markers over template-marker because no image matching is required hence it will produce faster tracking process (Wagner & Schmalstieg, 2007). AR toolkit provides marker images from a fixed set of 4096 patterns which means developers do not have to create marker images by themselves.

2.1.3 Virtual Objects

The virtual object used for augmented reality is usually in the form of 2D or 3D object. In order to render this object into augmented reality application, FLARToolKit using papervision3D which needs the objects to be in dae format. This can be accomplished by exporting the objects from 3D modeler (e.g. blender) using Collada plug-in (.dae).
Figure 4: Exporting Object from 3D Modeler

By default, there is no plug-in in 3D modeler that support Collada file format. In order to be able to export 3D object into Collada format (.dae), a plugin needs to be downloaded and installed to 3D modeler. In this case, Blender is used as 3D modeler and the corresponding plug-in can be found in Collada-blender website (colladablender.illusoft.com). All the virtual objects will be stored in the database based on the corresponding matrix id. When the tracking process found identical pose (object geometry or matrix id) from the database, the correspondence object information is called to be rendered using papervision3D library.

In order to develop an AR system, it is a must to consider about the way virtual object will be augment to the real world. There are two categories of augmented reality displays. They are monitor-based AR display and see-through AR display. See-trough display is characterized by the ability of users to see through the display medium directly to the real world using optical or video technology and the virtual images are drawn on the medium based on users head position whereas in monitor-based, video camera is placed at different location with users and users see virtual object taken by the video camera through monitor.
Figure 5: Optical See-Through Conceptual Diagram (Azuma, 1997)

In optical see-through, optical combiner is placed in front of user eyes through which user will see the world surround him with virtual images added in the combiner. This optical combiner acts like half silver mirrors, which users can see directly through them to see the real world and control the light come from the real world to make virtual images can be seen clearly. This technology brings issues which include low latency in registering geometric calibration and combiner and it also brings problem in displaying real scene resolution since the system do not has access to both real scene and virtual images. The created virtual objects are displayed ghost-like and transparently since light is coming from both virtual and real world and it is difficult to shut the light from real world.

The limitation of optical see-through can be replaced by using video see-through display. It allows manipulation on how to add virtual image into real scene because the system access both virtual images and real scene before being displayed in the monitor in front of user. It also enables real world to be delayed to match the virtual image because sometimes there is mismatch between the real and virtual images and it is difficult to use optical display which real world is being seen directly. The video camera provides users
with the real world views and video compositor will combine these views with graphic images created by scene generator. Later on, the combined video will be sent to monitors in front of users.

![Figure 6: Video See-Through Conceptual Diagram (Azuma, 1997)](image)

AR system can also be build using monitor-based configuration. Monitor-based is same with video see-through in term of real-virtual world combination. In this case, a camera is placed together with tracker in a moving object, different location between users and video camera and user will see real world scene in a monitor, like in video see-through, that display a scene after combined with virtual images.
Figure 7: Monitor-Based Conceptual Diagram (Azuma, 1997)

Screen as monitor to display real-virtual world.

The phone itself acts as trackers, from which the position of virtual object will be determined.

Figure 8: Mobile Devices Are Categorized As Video See-Through Display

(Wagner, Pintaric, & Schmalstieg, 2004)

Mobile devices are categorized in video see-through display in which users and video camera are located in the same place hence users can also see real world with or without monitor. Devices' screen acts as monitor that display real-virtual objects whereas
devices' camera takes real world scene in the form of video. The phone itself acts as trackers, from which the position of virtual object will be determined.

2.1.4 Tracking Technique

The usage of tracking in AR system is very important. It provides a system with data that will be use to measure position of real world scene and virtual images in order to align those positions before displayed to users. There are many ways to track real world scene for AR system which are using sensor-based, vision-based, or hybrid technique. This prototype implements vision-based tracking technique. This is using marker tracking which is easier to use, increase the robustness, computational efficiency, and inexpensive.

2.1.4.1 Sensor-based Tracking Technique

This tracking uses sensors such as magnetic, acoustic, inertial, optical, and mechanical sensors. They all have its advantages and disadvantages. GPS and accelerometer are examples of sensor-based tracking techniques that commonly used for AR system. GPS (Global Positioning System) determine some position with GPS receiver attaches in it. The system responds by display virtual object based on user's position supplied by GPS. GPS is using satellite which data position will be delivered to GPS receiver, on in this case, within handheld devices. This characteristic allows collaboration among multiple users by which location of each user can be detected by AR system hence action might be triggered based on that. The usage of GPS is based on the need of AR system. The example usage of GPS in AR system is to calculate distance between users, to show user's position in a map. In learning, GPS can be very useful because there is no limitation on user's position. The system can be used everywhere as long as the position is
registered within the system. Whereas accelerometer measures acceleration to which it is attached. Acceleration is used as input to interact with virtual object, for example, camera gesture gives command to zoom in and out an object, and shake the device gives command to display next or previous object.

2.1.4.2 Vision-based Tracking technique

It uses image processing methods to calculate camera pose relative to real world object. There are two categories in vision-based tracking which are feature-based (natural feature) and model-based tracking (marker tracking).

Natural feature tracking is a method for a system to recognize natural feature in the real world such as edges and textures. This is done by comparing objects to known shapes, colors, or texture. The main problem with natural feature is it requires a lot of processing power hence it is not suitable for handheld device usage.

Figure 9: Natural Feature Tracking (Hagbi, et al., 2009)
Another way is using marker tracking or it is also called fiducial marker. It is easily recognized object within real world since the shape is designed in such way to be found and identified easily. The pattern represents an ID number which is completely unique. It is the best solution for mobile AR since it is faster and easier determining user’s pose. The use of fiducial marker will increase the robustness, computational efficiency, and inexpensive.

![Figure 10: Marker/ Fiducial Marker Tracking (Rösler, 2009)](image)

### 2.1.4.3 Hybrid tracking Technique

Every tracking technique has advantages and disadvantages. The use of hybrid technology can overcome the limitation of some technique by exposing the plus value of other technique. There is not a mistake to combine more than one technique used for AR system such as using GPS and fiducial marker in game application (Rösler, 2009).

### 2.1.5 Interaction Techniques

How users can easily manipulate the virtual object is depend on the interaction technique selected for AR system. At first, development of AR system within handheld devices focused more on tracking technique. This offers virtual objects being seen from
handheld device through real-time video camera. In the next development stage, the need of interaction with virtual objects in AR system was felt very important because it gives users experience even more. This interaction technique consists of tangible AR, collaborative AR, and hybrid AR. This project implements tangible AR.

2.1.5.1 Tangible AR for Object Manipulation

Object manipulation will provide strong impression to users after using a system. In AR system, manipulation to the virtual object is done with the same technique used in VR system. In educational aspect, manipulation can support constructivism learning theory where students will do something to an object hence maximized learning transfer process. Kaufmann (2003) develop a learning environment called construct3D. His system was build based on AR where students can learn mathematic and geometric easier because it allows selection, construction, and modification directly in a 3D space. All construction and manipulation are carried out by using tangible AR which is stylus with 6 Degree of Freedom (6DOF).

Figure 11: Schema of Augmented Classroom Setup (Kaufmann & Schmalstieg, 2002)
Students carry a backpack computer which has wireless LAN card to allow communications between devices hence support team collaboration. Using HMD they may see 3Dimensional content and also interact with it without reducing the awareness of surround environment. Direct manipulation is using pinch gloves/stylus with 6DOF tracker. A camera will track a marker which the view will be sent to a projection and let other students, who are not using HMD, see the virtual content being manipulated. To get 3Dimensional experiences, a classroom need to have HMDs and devices to handle the AR process. Those devices are quite expensive which restrict the use of the system in large group collaboration hence this limitation may be handled to use cheaper and simpler AR learning tool by porting the system into mobile devices such as laptop. Students are able to purchase a mobile device that makes 3Dimensional experiences can be felt by each of them. With this, each student will get the same opportunity to feel the AR system. Difference in how users interact with virtual object will emerge between HMD usage and mobile device usage. This creates a problem in designing usable interface to handle interaction and creation in mobile device such as the limited view in handheld device do not allow all information displayed at once since it uses one camera and facing on one direction. The use of internal camera found in most of mobile devices is occupied although more than one camera can be used to track the marker or movement. It is because of the need to keep the application affordable for student.

In construct3D, student sees an object overlaid to his surround environment and he can do some selection, intersection, operations, take measurement, object modification, etc. Every object (points, lines, planes, cubes, sphere, cylinders, and cones) has their own corresponding button by which students can create their own object. To create a point, point mode should be on, and using stylus student click at the location in 3D space where
the point should appear. This interaction technique supports user’s mobility around 3D space provided by HMD. The ability to move freely may support learning flexibility among students and teachers. Another advantage by using HMD in AR system is to make the way users manipulate virtual objects becomes easier. It allows user’s both hand to interact, of course equipped with input device such as gloves or stylus.

While Construct3D use stylus and glove for interaction, Fjeld et al. (2003) studied the use of tangible interface for their Augmented Chemistry (CA) project which interaction is done using markers. It is to allow students to interact with the 3D molecule in a direct way.

![Image](image)

**Figure 12:** Tangible Input Used in Augmented Chemistry

Student is given a booklet which shows element by printed picture and a name, and there is a marker in every page. Using a gripper, a picker with marker on top of it, student can pick element in the booklet to be combine with molecule holds by a platform. There is a cube with different marker in each side which is used to know where and how the element shall be connected to molecule.
Figure 13: The Use of Booklet, Gripper, Platform, and Cube to Handle Object Selection and Manipulation

Their study proved the effectiveness of AR system in helping delivering a learning process but there is a need of simpler interface to access all functions offered by the learning application. In Construct3D, students will use personal interaction panel (PIP) with lots of button to interact, select, or manipulate objects whereas Augmented Chemistry uses lot of cards with different marker to interact, select or manipulate objects or to use function provided by the learning application. It will troublesome the student, at some point, to recognize all the buttons, and remember the entire marker with corresponding to its function.

Compared with mLAR, this is developed for mobile devices with using only one camera to track markers and a single marker, this project implements the use of mouse for object manipulation and function selection. The use of mouse is chosen because student can directly select the object by moving the mouse without the need to remember navigating through keyboard, buttons, or marker cards in order to select some objects.
2.1.5.2 Collaborative AR

The first augmented reality only supports for single augmented reality application. The collaborative augmented reality for handheld devices was introduced by Wagner et al. (2004) and Henrysson et al. (2005). The use of collaborative augmented reality allows for applications to share same virtual information through devices' communication, commonly via Bluetooth and TCP/IP hence users can see at the same times the other users and virtual information they are interacting with.

The research conducted by Henrysson et al. (2005) make use of Bluetooth available by the phone device to establish communication between devices. This communication creates client-server application where one phone becomes the server that opens the connection and a client. The direction and position of the virtual objects are sent over to the other phone as a synchronization process between applications to precede its function.

2.2 Learning Style

Learning consists of two processes that involve information retrieval and processing. The development of knowledge comes from external and internal information (inductive and deductive) and a person will retrieve this information. Some information will be processed and the rest is ignored. The processing step involves memorization, information organization (inductive deductive), interaction with others, and the outcome is either the information is learned or not learned.
According to Johnston and Orwig (1998), learning style is a unique characteristic of individual skills and preferences which affect on how a student receives, collects, and process the learning material. Learning styles by Fleming (2001) is an individual characteristic and preferred ways of gathering, organizing and thinking about learning material which is more to instructional preferences because it deals with perceptual modes. Felder and Silverman (1988) defined learning style as individual preferences to receive and process information.

There are many studies regarding learning style models such as Felder and Silverman (1988), Montgomery and Grouat (1998), and Fleming (2001). The reasons of using Felder Silverman are:

- There is a free instrument for Felder Silverman learning style model, ILS (Soloman & Felder, 1997) and some researchers have found the effectiveness of using ILS (Graf, Viola, Kinshuk, & Leo, 2006; Kinshuk, 2004; Kirkham, et al., 2006; Kolomos & Holgaard, 2008; Viola, Graf, Kinshuk, & Leo, 2006).

- The objective of Index Learning Style questionnaire by Felder and Soloman is to determine dominant learning style of each student and intended for engineering education.(Richard M. Felder & silverman, 1988).

- This model represents the characteristic of cognitive style and social interaction (Tobar, et al., 2004).

- Felder Silverman model is appropriate to diagnose an individual learning style and the ILS result can be linked directly to automatic adaptive environment.
ILS data is informative and easy to be translated into specific design guidance (Kirkham, et al., 2006).

### 2.2.1 Felder and Silverman Learning Style

This was developed by Richard Felder and Linda Silverman in 1980s. Their learning style models are based on students’ preferences on perception, retrieval, process, and understand information. FLSM consists of two component styles and four dimension that a person tend to possess one style in every dimension. FLSM characterized learner based on four dimensions: active learners learn by doing things and prefer to do within a group whereas reflective learners learn by introspecting the material and prefer to do individually or in pair. Sensing learners obtain data via senses (observation) and learn concrete material (facts and data) whereas intuitive learners obtain data from symbol and learn abstract material (principles and theory). Visual learners remember best what they see (picture, diagram, demonstration) whereas verbal prefer discussion either spoken or written. Sequential learners learn in sequential manner, mastering the material as it is presented whereas global learners learn in large gaps. From above, it can be summarized as Table 1.
Table 1: Characteristic of Learning Preference and its Corresponding Teaching Style

<table>
<thead>
<tr>
<th>Learning Preferences</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory Perception</td>
<td>Practical and observing&lt;br&gt;PREFER concrete: facts and data&lt;br&gt;PREFER repetition&lt;br&gt;Dislike surprises&lt;br&gt;Patient with detail&lt;br&gt;Do not like complication&lt;br&gt;Good at memorizing facts&lt;br&gt;Careful but slow&lt;br&gt;Imaginative and interpretive&lt;br&gt;PREFER abstract: theory and principle&lt;br&gt;PREFER variation&lt;br&gt;Like innovation&lt;br&gt;Good at grasping new concept&lt;br&gt;Quick but careless&lt;br&gt;Comfortable with symbol</td>
</tr>
<tr>
<td>Intuitive Input</td>
<td>Prefer picture and diagram&lt;br&gt;Show me how&lt;br&gt;Remember best what they see (picture, diagram, flowchart, film, demo)</td>
</tr>
<tr>
<td>Visual Verbal</td>
<td>Prefer written and spoken explanation&lt;br&gt;Tell me how&lt;br&gt;Remember best what they hear (discussion, verbal explanation)</td>
</tr>
</tbody>
</table>

Teaching Style

- Concrete
- Abstract
- Visual
- Verbal
- Presentation
<table>
<thead>
<tr>
<th>Active</th>
<th>Processing</th>
<th>Passive</th>
<th>Reflective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Let’s try it out (Do it)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process information by physical activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learn by working with others</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discuss, explain or test the information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“The ones who evaluate the ideas, design and carry out the experiments, and find the solutions that work, the organizers, the decision-makers” (Richard M. Felder &amp; Silverman, 1988)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Let’s think it through</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process information introspectively</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learn by working alone or in pairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examine or manipulate the information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“The theoreticians, the mathematical modelers, the ones who can define the problems and propose possible solutions” (Richard M. Felder &amp; Silverman, 1988)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequential</td>
<td>Understanding</td>
<td>Sequential</td>
<td>Perspective</td>
</tr>
<tr>
<td>Sequential</td>
<td>Perspective</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global</td>
<td>Understanding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand in continual and increment steps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear reasoning process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convergent thinking and analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand in large leaps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tactic reasoning process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System thinking and synthesis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 shows the characteristic of teaching styles which are based on learning preferences.
<table>
<thead>
<tr>
<th>Teaching Style</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| Concrete       | Example first and followed by the exposition  
|                | Hand-on work, such as practicing in the  
|                | applying environment  
|                | Provide concrete information (facts, data,  
|                | experiment’s result)  
| Abstract       | Exposition first and followed by the example  
|                | More concept and abstract (principles,  
|                | theories)  
| Visual         | More picture, graphs, diagram  
|                | Animation demonstration  
|                | Color important concepts  
| Verbal         | Text  
|                | Audio  
| Active         | Providing discussion area  
|                | Reminding student to guess several possible  
|                | questions  
|                | Emphasizes on problem-solving method  
| Passive        | Think before going ahead  
|                | Stop periodically to review what have been  
|                | learning  
|                | Writing summaries  
|                | Emphasizes on fundamental understanding  
| Sequential     | Step by step to present material  
|                | Constrict links  
| Global         | Give big picture of the course  
|                | Provide all the links  

It is known from (Richard M. Felder & Silverman, 1988; Mumford & Honey, 1992; Provitera & Esendal, 2008) that learning and teaching style is mismatched. Many students received low grade, have difficulties in understanding lectures or even drop out. It is time to synchronize between learning and teaching style. The concept of synchronization proposed by (Richard M. Felder & Silverman, 1988) is by combining two attributes in one dimension of FLSM for the teaching styles. For example gives pauses to lectures for thought (aim for reflective learner) and discussion (aim for active learner). We believe when these two attributes (active/reflective) are balanced, a person should reflect before act...
Researchers in education believed that collaborative learning is the best learning approach can be used for classroom activity. Collaborative learning restructures the traditional classroom into small group work concentrated on communication between students and teachers. This communication creates a situation where students can actively exchange ideas which increase interest on the learning and promote critical thinking (Coleman, Gallagher, & Nelson, 1993; Gokhale, 1995; Smith & MacGregor, 1992).

Figure 14 is a graphic representation of traditional learning activity where students learn in a passive environment. The whole knowledge is given just like that without letting the students questioning the content in other word student are being forced to accept all knowledge without ability to express their opinion and develop their critical thinking.

![Diagram of traditional learning](image)

**Figure 14: Traditional Learning (McInerney & Roberts, 2004)**

Student level of understanding is higher and information retain longer when students work on collaboratively compared to them who work individually. This is because students interact with each other, exchange idea, synthesize their understanding, explain and justify their opinion.
giving information one way to their students. The metaphor of knowledge flows for traditional learning is changed when collaborative learning being introduced where there is a shared knowledge between students or students and teachers. Through communication, information will be added continuously where each individual contribute their own knowledge.

- Students work in a group of two or more where social interdependence is created. Activities are designed so that each student contributes to collaborative task. Each student sets the same goal and he/she communicates with others in order to achieve this goal. The contribution given by each group member effect the success of the group.

- Learning activities centered on student’s exploration not simply the teacher presentation. Learning should be an active and constructive process. In active learning, student not simply taking new knowledge but they create new knowledge from their internal knowledge combine with external knowledge. This is achieved through communication and interaction between students and teachers.

- Activities frequently begin with problems for which student must solve problem with what they already know. This is achieved by establish and maintain a shared understanding of meanings within the group. They do not simply taking new ideas but from communicating, they form something new from it. Students take turn questioning, clarify and comment others’ idea to ensure their own understanding and build knowledge.

- Every student has their own learning style, preference, level of understanding, ideas and opinion. When these students put into one group, they bring their
diversities (diverse learning styles, knowledge, experience, etc) where they must share what they have in mind and come out with an agreed-by-each-member idea.

- There are individual and group assessments. The assessment of collaborative learning is different with traditional work group. In traditional, all students will get the same mark whether they really work or not within the group. In collaborative, students will be assessed individually from their understanding of content and the group will be assessed from its achievement.

Characteristic of collaborative learning based on Soller et al (1998):

- Group success depends on each student’s participation. Through discussion, amount of information available to the group is increased. This will enhance their decision making and improve their quality of thought.

- Through communication, social grounding is established. It is when students establish and maintain shared understanding of meaning. Students take turn questioning, clarify and comment others’ idea to ensure their own understanding and build knowledge. It increases the probability that all students will learn the subject and no one left behind.

- In collaborative learning, students will increase their quality of their communication skills in collaborative group. Student will know when and how to question, inform, and motivate other students, know how to mediate and facilitate conversation, and know how to deal with conflicting opinions.
Table 4: Questions of Collaborative Dimension (Grasha & Riechmann, 1975), the functions and corresponding characteristic

<table>
<thead>
<tr>
<th>Questions in Collaborative Dimension</th>
<th>Functions</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working with other students on class projects is something I enjoy.</td>
<td>Working with other student</td>
<td>Social interdependence</td>
</tr>
<tr>
<td>I enjoy discussing my ideas about course content with others students.</td>
<td>Discussing</td>
<td>Communication</td>
</tr>
<tr>
<td>I enjoy hearing what other students think about issues raised in class.</td>
<td>Hearing</td>
<td>Communication</td>
</tr>
<tr>
<td>Students can learn more by sharing their ideas with each other.</td>
<td>Sharing ideas</td>
<td>Social interdependence</td>
</tr>
<tr>
<td>I like to study for test with other students.</td>
<td>Study with others</td>
<td>Communication</td>
</tr>
<tr>
<td>The ideas of other students help me to understand course material.</td>
<td>Get others’ help</td>
<td>Social interdependence</td>
</tr>
<tr>
<td>An important part of taking courses is learning to get along with other people.</td>
<td>Get along with people</td>
<td>Communication</td>
</tr>
<tr>
<td>Learning should be cooperative effort between students and faculty.</td>
<td>Cooperative effort between students and faculty</td>
<td>Learning style match with teaching style</td>
</tr>
<tr>
<td>I let other students borrow my notes when they asked for them.</td>
<td>Sharing notes</td>
<td>Social interdependence</td>
</tr>
<tr>
<td>Participating in small group activities in class is something I enjoy.</td>
<td>Participating</td>
<td>Participating</td>
</tr>
</tbody>
</table>

2.3.2 Collaborative Learning Design

Based on characteristic discussed in previous topic (collaborative learning characteristic), collaborative learning characteristics implemented for this study supports for these functions such as sharing, hearing, giving ideas, communicating, and participating. Students will be provided with these functions which are based on Grasha and Riechmann (1975) collaborative preference dimension.

Collaborative group consist of minima two students. Each student will be given different individual assignment. In order to solve individual assignment, they must collaborate by sharing ideas, discussing, sharing resources etc that the assignments are
tangible input such as gloves, head tracker, or/and intangible input. The way users interact with virtual image is through interface. The design of interface will affect the usability and functionality of a system.

The main issues for this project is to design an interface that is suitable for engineering students based on their learning style, an interface that can be used in synchronous collaborative learning environment, and also interface which support augmented reality view.

2.4.1 Usability Requirements

User requirement is very crucial to design user interface. The aim in designing user interface is to create an application that adapt to what users needs not vice versa. This is done by determine usability required by user in order to finish the task. Usability is multi-dimensional attributes of user interfaces which are determined by tasks, users, and environment. By this means, there are six attributes commonly used to measure usability of an interface which are (Jokela, Koivumaa, Pirkola, Salminen, & Kantola, 2006; Nielsen, 1993):

Learnability

User interface should be easy to learn. This can be done by designing an application which has familiar user interface as other application usually used by engineering students. The main purpose is to help students to do their tasks, hence it is very important to design user interfaces which allow student to easily understand and use the application. In other words, high learnability application allows students to start doing their task faster. It
Memorability

It is preferable to create an easy-to-remember interface design. By doing this, students can easily use the application again after some period of not using it. Designer can measure memorability by giving memory test to students after they finish using the application and ask them about several icons within the interface to be explained. But usually, memorability is rarely tested as in detail like the other attributes.

Few Errors

It measure number of errors students make when they use the application to finish given tasks and how well students can recover from those errors. Error is defined as actions which do not accomplish the desired goals, lead to wrong task completion, destroy students’ work and hard to recover from. It is not some actions that have affect other than slowing down students’ completion time because such errors are minor and it is already included in efficiency attribute.

Satisfaction

It refers to how students feel while and after using application. From each student’s perspective of the application, their replies can be count as subjective opinion, while when all students’ perspective gathered and averaged together, it will create objective measurement of students’ satisfactions. There are many instruments to assessed satisfaction. Tullis and Stetson (2004) compared these instruments in term of the accuracy on determining satisfaction level.
Figure 17: m-learning Framework

(Parsons, et al., 2007)

Properties within mobile environment issues do concern about user’s role and their profile, mobility, interface design, media types and communication support. Mobility is the advantages of mobile devices in educational environment that this is being seen as interesting feature to be used for education. Mobility itself can be conceptualized into users’, devices, and/or services mobility and this is supported with communication whereas it is between devices, applications, or device server. Users’ mobility is identified by ability on giving freedom to users, where learning application can be used collaboratively by users to access the learning content wherever and whenever they want. This concept is implemented for our prototype which can be used anywhere around campus. Devices mobility means the learning content have the ability to adapt in different mobile devices. By applying devices mobility to learning content, the coverage of users widens and not limited only to user with specific devices. This study does not utilized this concept, which want to focus more on establishing effective collaborative learning using mobile devices.
CHAPTER 3

DESIGN AND RESEARCH METHODOLOGY

3.1 Overview

The overall framework, Figure 18 - Figure 19, of this study consisted of three phases which are described as below:

Phase I: Analysis

In Phase I, critical research was done on main topics of this study which are user interface, collaborative learning, learning style, cognitive process, and augmented reality. Learning style test was conducted to users which are engineering students’ at Universiti Teknikal Malaysia Melaka to determine their preferred learning style. The result of this preliminary analysis was used in Phase II to provide content material which full fill students’ cognitive processes.
Figure 18: Research Framework: Phase I and II
Figure 19: Research Framework: Phase III
<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Research Objectives</th>
<th>Hypothesis</th>
<th>Activities</th>
<th>Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1: What are interface design considerations for effective collaborative learning?</td>
<td>To investigate engineering students' learning preference based on learning style model for engineering field in order to create effective collaborative learning activity.</td>
<td></td>
<td>Literature Review Learning Style Assessment</td>
<td>Preliminary Study: Engineering Students' Learning Preferences</td>
</tr>
<tr>
<td>RQ2: How to implement learning preference in user interface for effective collaborative learning activity?</td>
<td>To design and develop a prototype that implements engineering students' learning preferences to support collaborative learning activity.</td>
<td></td>
<td>Develop user interface</td>
<td>Prototype</td>
</tr>
</tbody>
</table>
| RQ3: Is the implementation of learning style in collaborative learning which related to performance differs between expert evaluation, tutored evaluation, and group evaluation. | To assess students' performance and prototype usability. | H1a: Groups' achievement will be same between two groups.  
H1b: Groups' achievement in experiment group will be higher than control group.  
H2a: Students' achievement on expert evaluation and tutored evaluation will be | Experiment | Students' performance |
<table>
<thead>
<tr>
<th>RQ4: Is performance affected by individual satisfaction?</th>
<th>H₃c: Students who satisfied with the interface gain the same achievement as them who are not satisfied.</th>
<th>H₃b: There is no correlation between satisfaction and learning performance.</th>
<th>Experiment</th>
<th>Students’ satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ5: Is there any significance correlation between students’ motivation and learning performance?</td>
<td>H₄: Motivation does not have significant relation to determine students’ performance.</td>
<td></td>
<td>Experiment</td>
<td>Students’ motivation and performance</td>
</tr>
</tbody>
</table>
3.2 Design and Production

3.2.1 System Architecture

Mobile devices (laptop and mobile phone) were used as implementation platform. Mobile phone was used to support collaborative learning whereas laptop was used to support all content about the corresponding subject. This architecture was chosen since interface for content and discussion cannot be at the same interface because it will create distraction for students. By separating the interfaces, student could take notes and do discussion while looking at the available content. Figure 20

![System Architecture Diagram]

**Figure 20:** System Architecture
Augmented reality was implemented using a toolkit called FLARTToolkit. This toolkit provides tracking library for augmented reality and papervision library for 3D object handler.

![AR Architecture Diagram](image)

**Figure 21:** AR Architecture

### 3.2.2 Content Model

#### 3.2.2.1 Learning Object

This project implemented for electrical engineering class which focus on AC and DC generators. Currently, this subject consists of seven learning objects which are:

- Able to differentiate between generator and motor
Table 7: User Interface to Support Cognitive Processes

<table>
<thead>
<tr>
<th>Cognitive Processes</th>
<th>User Interface Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct to Important Information</td>
<td>Highlight Important Information. Highlight Content Using Learning Map</td>
</tr>
<tr>
<td>Manage Cognitive Load</td>
<td>Content with picture is supported by text</td>
</tr>
<tr>
<td>Integrating Information in Working and</td>
<td>Unambiguous interface component (buttons looked like buttons)</td>
</tr>
<tr>
<td>Long Term Memory</td>
<td>Exercise with assessment for group and individual</td>
</tr>
<tr>
<td>Retrieval from long term memory and</td>
<td></td>
</tr>
<tr>
<td>Transfer to working memory</td>
<td></td>
</tr>
</tbody>
</table>
Next session is Expert session where student will form new group in accordance to the questions number given. During this Expert session, student has to utilize the courseware to get the answers. While for Traditional group, they have to use slides or book to find the answers. All of the group members should participate in the discussion and contribute their knowledge for the answers. Each of the answers and idea regarding the questions will be publish in the system that will enable lecturer to evaluate their participation in collaborative learning and discussion as shown in figure below.
Student still can add or update their idea towards the answers throughout the presentation session. The last session is Individual assessment. For Individual assessment, student will enter their answers through the courseware.

3.2.3 Experimental Design

3.2.3.1 Research Design

Figure 28: Expert session: Presentation

Figure 29: Research Design
The second session is expert session. At this session, students separated from their group to create a new group with other groups’ member who possessed the same questions (Figure 31).

![Figure 31: Group Assignment: Expert Session](image)

The third session is present session. At this session, students back to their original group to explain their new knowledge to other members (Figure 30).

3.2.3.4 Data Collection Instrument

**ILS (Index Learning Style)**

It is based on Felder-Silverman Learning Style Model. This model incorporates five dimensions of learning experience which are perception (sensing/intuitive), input (visual/verbal), organization (inductive/deductive), processing (active/passive), and understanding (sequential/ global). It is shown in Montgomery and Groat (1998) that engineering students tent to have active, sensing, verbal, and sequential learning style. ILS was developed by Felder and Soloman (1997) and used in most learning style research.
motivation section and (2) a learning strategies section. According to the MSLQ Manual: The motivation section consists of 31 items that assess students’ goals and value beliefs for a course, their beliefs about their skill to succeed in a course, and their anxiety about tests in a course. The learning strategy section includes 31 items regarding students’ use of different cognitive and metacognitive strategies. (Pintrich et al., 1991, p. 5). For this test, only 31 questions from motivation section were used for pre and post test. MSLQ consists of 15 sub-scales, six within the motivation section. MSLQ questionnaire can be found in Appendix F.

Scoring MSLQ

Students rate themselves on a 7-point Likert scale, from 1 (not at all true of me) to 7 (very true of me). Scores for the individual scales are computed by taking the mean of the items that make up the scale. For example, the test anxiety scale is composed of five items. Summing these five items and computing the mean would calculate a student’s score.

Components of the MSLQ

Table 8: MSLQ Component

<table>
<thead>
<tr>
<th>Motivation Scales</th>
<th># Of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Intrinsic Goal Orientation</td>
<td>4</td>
</tr>
<tr>
<td>2. Extrinsic Goal Orientation</td>
<td>4</td>
</tr>
<tr>
<td>3. Task Value</td>
<td>6</td>
</tr>
<tr>
<td>4. Control of Learning Beliefs</td>
<td>4</td>
</tr>
<tr>
<td>5. Self-Efficacy for Learning &amp; Performance</td>
<td>8</td>
</tr>
<tr>
<td>6. Test Anxiety</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total number of items</strong></td>
<td><strong>31</strong></td>
</tr>
</tbody>
</table>
experimental group, lecturer assessed the collaborative learning through system database. It is because all discussion activities were recorded by the interface. After completed all three sessions, students answered individual assessment. Students in control group used paper whereas in experimental group used the interface. Then, students asked to fill the last SUS questionnaires. Last but not least before experiment ended, students asked to fill Post-test for MSLQ. The summary of experimental procedure is shown by Figure 32.

![Figure 32: Experimental Procedure](image-url)
CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter displays results from learning style testing. It shows that engineering students' learning style is active, sensory, visual, and sequential. Besides, this chapter also discusses about experimental testing results and explains how the result can answer the research questions.

4.2 Learners: Learning Style

RQ1: What are interface design considerations for effective collaborative learning?

Based on Chapter 2: Literature Review, collaborative learning seems to improve group performance only which is not effective. An effective collaborative learning should
From the result, it can be seen that engineering students' learning style at Faculty of Electronic and Computer Engineering, Universiti Teknikal Malaysia Melaka, possessed active, sensory, visual, and sequential preferences towards learning. Therefore, we implement the corresponding teaching style based on students' learning style. The teaching
H₁₀: Groups’ achievement in experiment group will be higher than control group.

The result analysis also shows the difference of mean between control (58.91) and experimental group (82.78). Therefore we concluded that the implementation of learning style on students’ learning activity can increase groups’ achievement.

4.3.2 Learning Style on Individual’s Performance

H₂₀: Students’ achievement on expert evaluation and tutored evaluation will be same between two groups.

H₂₁: Students’ achievement on expert evaluation and tutored evaluation in experimental group will be higher.

Expert Evaluation

<table>
<thead>
<tr>
<th>Method</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>ExpertEval control group</td>
<td>12</td>
<td>68.9593</td>
<td>15.71979</td>
<td>4.53791</td>
</tr>
<tr>
<td>experimental group</td>
<td>12</td>
<td>88.8750</td>
<td>4.89956</td>
<td>1.41430</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Independent Samples Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

The result was analyzed using Independent T Test Analysis using SPSS. The result analysis shows the probability value (.001) is less than predetermined alpha value (α/2=.025), thus the null hypothesis was rejected. Therefore we concluded that students’ achievement on expert evaluation between control and experimental groups are not same. This conclusion is made at the significance level, α = 0.05.
The result also shows the significant difference in the mean score of expert evaluation score between control (μ=68.96) and experimental group (μ=86.88). Therefore we concluded that students’ achievement on experimental group is higher than control group. The results proved that the implementation of learning style on students’ learning activity can increase individual expert evaluation.

**Tutored Evaluation**

<table>
<thead>
<tr>
<th>Method</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutored Eval control</td>
<td>12</td>
<td>66.2242</td>
<td>13.27801</td>
<td>3.83303</td>
</tr>
<tr>
<td>experimental group</td>
<td>12</td>
<td>86.5708</td>
<td>13.94590</td>
<td>4.02584</td>
</tr>
</tbody>
</table>

The result was analyzed using Independent T Test Analysis using SPSS. The result analysis shows that the probability value (.005) is less than predetermined alpha value (α/2=.025), thus the null hypothesis was rejected. Therefore we concluded that students’ achievement on tutored evaluation between control and experimental groups are not same. This conclusion is made at the significance level, α = 0.05.

The result also shows the significant difference in the mean score of tutored evaluation score between control (μ=69.22) and experimental group (μ=86.57). Therefore we concluded that students’ achievement on experimental group is higher than control group. The results proved that the implementation of learning style on students’ learning activity can increase individual tutored evaluation.
The result was analyzed using Linear Regressing using SPSS. The result analysis shows that the probability value (.009) is less than predetermined alpha value (\(\alpha = .05\)), thus the null hypothesis was rejected. There exists adequate evidence to show that satisfaction level is significant predictor in estimating individual's performance (tutored evaluation). Satisfaction can explain 26.8% of the variance in students' individual performance scores. This conclusion is made at the significance level, \(\alpha = 0.05\). Therefore we concluded that students with higher satisfaction gain higher achievement.

From above analysis, we can conclude that satisfaction score is a significant predictor which can be use to estimate individual's performance score, both expert and tutored evaluation, in collaborative learning activity.
The result was analyzed using Bivariate Correlation using SPSS. The result shows that the probability value (.001) is less than predetermined alpha value (α=.05), thus the null hypothesis was rejected. There is correlation (.603) between satisfaction and learning performance. This conclusion is made at the significance level, \( \alpha = 0.05 \).

4.5 Students Motivation on Individual Performance

**RQ5:** Is there any significance correlation between students' motivation and learning performance?

**H0:** Motivation does not have significant relation to determine students' performance.

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Performance</td>
</tr>
<tr>
<td>Mean: 77.9071</td>
</tr>
<tr>
<td>Std. Deviation: 12.83525</td>
</tr>
<tr>
<td>N: 24</td>
</tr>
<tr>
<td>Motivation</td>
</tr>
<tr>
<td>Mean: 59.3888</td>
</tr>
<tr>
<td>Std. Deviation: 8.04770</td>
</tr>
<tr>
<td>N: 24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Pearson Correlation</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>Motivation Pearson Correlation</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
</tr>
<tr>
<td>N</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (1-tailed).

Since the probability value (.012) is less than predetermined alpha value (α=.05), thus the null hypothesis was rejected. There exists adequate evidence to show that
CHAPTER 5

CONCLUSION

5.1 Experimental Observation

5.1.1 Learning Style and User Interface

In learning activity, students' performance can be determined based on their intelligent, prior knowledge, learning style and cognitive processing. Past studies have proved the important of learning style to deliver the knowledge. By matching teaching style with learning style, students can learn in comfortable way that helps their cognitive processing. Based on our study, we found engineering students learning style at our university possessed active, sensory, visual, and sequential preferences towards learning. This means they will learn best when the learning environment is set corresponding to their learning style. To enhance students' cognitive processing and to also support visual learner needs, we implement augmented reality view in the interface. Augmented reality is a technology that has been proven able to improve students' motivation and satisfaction. But
that motivation level in experimental group is higher than control group. The result also
shows that students with higher motivation gain higher performance.

5.2 Observation on Weaknesses and Strength

5.2.1 Project Weaknesses

- Students are new to the use of computer supported technology for collaborative
  learning activity.
- Not all students understand the concept of collaborative learning jigsaw technique.
- Augmented reality object is slow to response since the device is not enough
  capabilities to support augmented reality views.

5.2.2 Project Strength

- The application is effective for collaborative learning. This is because learning style
  is implemented in collaborative learning activity. By matching teaching style with learning
  style, students can learn in comfortable way that helps their cognitive processing thus
  students exploit their learning ability. Collaborative learning activity improved students’
  individual performance and group performance.
- The application guide students to conduct collaborative learning activity jigsaw
  technique hence students can finish the activity faster. It also gives advantage to lecturer
  because all assessments are stored in database and can be accessed directly although the
  learning activity is not finished yet.
REFERENCES


Barfield, L. (1993). *The user interface: Concept and design* (illustrated, reprint ed.): Addison-Wesley Publisher Ltd.


Kinshuk, T. L. (2004). *Application of learning styles adaptivity in mobile learning environments*


