User Interface and Interaction Design Considerations for Collaborative Learning Using Augmented Reality Learning Object

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Abstract. Most education is too often about teaching and not enough about learning. It is because students are forced to take whatever it is given to them without considering what they think about it, in other words, they passively take the given knowledge. This paper presents early investigation about interface and interaction design considerations for effective collaborative learning by taking account individual learning preferences and collaborative learning characteristics of engineering students. In our investigation, we follow Felder Silverman Learning Style Model and conducted a test measured using Index Learning Style. As a result, we discovered that engineering students tend to be active, sensory, visual, and sequential. Therefore, we implement augmented reality views to satisfy students' learning preferences toward content presentation (visual learner). It is also because augmented reality can give rich information toward real objects/environment. For collaborative characteristics, we studied past research on collaborative learning regarding its characteristics that affects learning effectiveness. Besides, our proposed design also considered the user interface principle which provides a guidance to effectively implement our consideration into an interface.

Keywords: user interface, learning style, collaborative learning.

1 Introduction

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. Since learning is an active and constructive process, collaborative learning approach is suitable to be implemented in learning environment where the center of learning is on the students' exploration not simply the teacher's presentation [1]. By applying collaborative learning, students should exchange ideas with peers, analyze other opinions, and synthesize their understanding so that the knowledge is build from a combination of information they already had and information they get from communication with others. Furthermore, students' level of understanding are higher and information will

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retain longer when students work collaboratively compared to them who work individually [2].

There are several elements should be considered in designing collaborative learning application. First is diversity of students within a learning group which may lead to learning disturbance. There are many elements of diversities but the most important element is learning style [1]. Second is environment and tool that support students' exploration. This includes requirements supported for collaborative learning [3] and the way information should be delivered (interface design). Interface design principle is important as a guidance to implement our finding on engineering students' learning style and characteristic of collaborative learning at our university.

In current environment, which is in UTeM's engineering faculty, learning material is not supplemented with clear visual explanation and this, however, affects students' understanding. Based on engineering students' learning style, this study implements an augmented reality view which will satisfy visual students' needs. It also extends what students see in physical world and Kaufmann [4]found the usage of augmented reality in education is very powerful.

Our design will be implemented on mobile devices by seeing the fact that mobile devices are very popular among students and should be considered for a learning medium. Litchfield [5] found 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. This can give a new feeling to students, hence can increase their learning interests, learning experiences, and learning outcomes.

In the next section, we will talk about the learning style model called Felder Silverman Learning Style Model (FLSM) and collaborative learning characteristic and its elements. Next, we discussed about user interface and how the learning style and collaborative learning combined together to create a learning instrument. Finally, we summarize and conclude this paper.

2 Learning Styles

Learning style is a unique characteristic of individual skills and preferences which affect how a student receives, collects, and processes the learning material. There are many studies regarding learning style models. The reasons of using Felder Silverman are:

1. There is a free instrument for Felder Silverman learning style model called ILS [6],and some researchers have found the effectiveness of using ILS [7-11].
2. The objective of Index Learning Style questionnaire is to determine dominant learning styles of each student and intended for engineering education [12].
3. This model represents the characteristic of cognitive style and social interaction [13].
4. ILS data is informative and easy to be translated into specific design guidance [9].

FLSM is based on students' preferences on perception, retrieval, process, and understanding of information. FLSM characterized learners based on four dimensions: *active learners* prefer to learn within a group whereas *reflective learners* learn individually or in pair. *Sensing learners* easy to learn concrete material (facts and data) whereas *intuitive learners* easy to learn abstract material (principles and theory). *Visual learners* remember best what they see (picture, diagram, and demonstration) whereas *verbal learners* prefer discussions either spoken or written. *Sequential learners* learn in sequential manner, mastering the material as it is presented whereas *global learners* learn in large gaps. Table 1 shows students' learning preferences and its corresponding teaching styles.

Table 1. Learning Preferences and the Corresponding Teaching Styles

Learning Style		Teaching Style	
Processing		Student participation	
Active	Reflective	Active	Passive
- Let's try it out - Process information by physical activity - Learn by working with others	- Let's think it through - Process information introspectively - Learn by working alone or in pairs	- Providing discussion area - Reminding student to guess several possible questions - Emphasizes on problem-solving method	- Think before going ahead - Stop periodically to review what have been learning - Writing summaries - Emphasizes on fundamental understanding
Perception		Content	
Sensory	Intuitive	Concrete	Abstract
- Practical and observing - Prefer concrete: facts and data - Prefer repetition	- Imaginative and interpretive - Prefer abstract: theory and modeling - Prefer variation	- 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)	- Exposition first and followed by the example - More concept and abstract (principles, theories)
Input		Presentation	
Visual	Auditory	Visual	Verbal
- Prefer picture and diagram - Show me how	- Prefer written and spoken explanation - Tell me how	- More picture, graphs, diagram - Animation demonstration - Color important concepts	- Text - Audio
Understanding		Perspective	
Sequential	Global	Sequential	Global
- Understand in continual and increment steps - Linear reasoning process - Convergent thinking and analysis	- Understand in large leaps - Tactit reasoning process - System thinking and synthesis	- Step by step to present material - Constrict links	- Give big picture of the course - Provide all the links

We conducted preliminary analysis toward engineering students in our faculty using Index Learning Style (ILS). The ILS was given to 21 random students and results from our preliminary analysis shown that engineering students tend to be more active (19:90%) rather than reflective (2:10%), sensory (18:86%) rather than intuitive (3:14%), visual (15:71%) rather than verbal (6:29%), and sequential (12:57%) rather than global (9:43%). Figure 1 shows the results of our study.

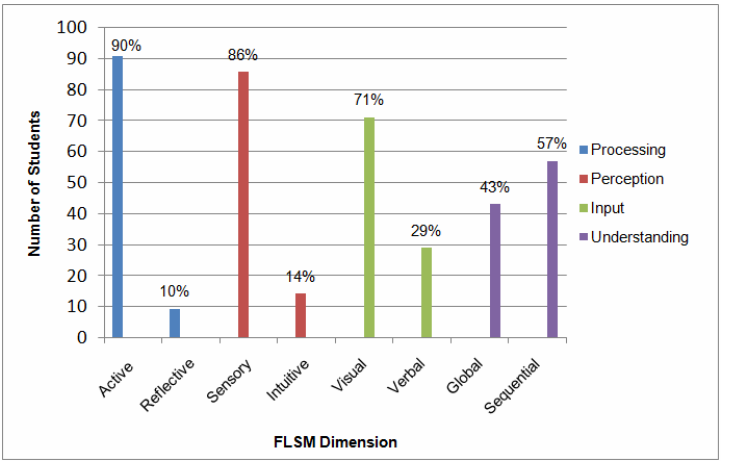

Fig. 1. Engineering Students' Learning Styles

3 Collaborative Learning

Collaborative learning is a situation in which students actively interact with each other to share knowledge and experiences in order to learn something together. Collaborative learning differs from traditional work group by the additional value within the group such as *interdependency* which is group success is based on everyone contribution; *accountability* which is every individual accountable to share his knowledge and group accountable to achieve its goal; and the development of *social skills* which every individual try to accept other's opinion, tolerate or resolve differences, make decision that agreed by all group members, and care what others doing. It is proved that student level of understanding is higher and information retain longer when students work on collaboratively compared to them who work individually [1-2, 14]. The characteristic of collaborative learning in a classroom based on Smith and MacGregor [1] and Soller et al. [15] are:(1)*communication* which is the way students share, exchange and grow the knowledge; (2)*social interdependence* which is students dependency toward each other to discover the knowledge and *participation* is important for every students; (3)students' *exploration* which is students' contribution to discover the knowledge not only depends on teacher's presentation; (4)*promote interaction* which can be done by *begin the activity with problems*; (5)*diversity between group* which means each group consist of different level of learning ability; (6)*assessment* which is not only based on group performance but also individual performance.

Table 2. Characteristics of Collaborative Learning

Collaborative Learning Characteristic
Communication
Social interdependence and participation
Students exploration
Promotive interaction
Diversity between group
Individual and group assessment

4 Interface Design

Interface design is a combination between system and users by providing interaction based on goals users trying to achieved, and tasks they should perform. User interface should concern about users, tasks, and context[16-17]. From preliminary analysis, we knew that the users characteristic are active, sensory, visual, and sequential. The context implemented in this study is collaborative learning environment whereas the tasks for students are to finish group and individual assessment. User interface was designed based on these three elements therefore the interface will implement augmented reality as learning instrument and functions to support collaborative learning. Table 3 shows the implementation of learning style consideration on user interface. Table 4 shows the implementation of collaborative learning characteristic in user interface.

Table 3. The Implementation of Learning Style in the Interface

Learning Style	User interface consideration	Explanation
Perception		
Sensory	Provide the overall pictures on generator and then determine each part and explain the functions.	Students tend to do observation and patient with details.
	Provide real usage of generator and motor.	Prefer facts.
	Provide animation to be played again and again.	Prefer repetition.
	Provide understandable marker for augmented reality	Dislike surprises and do not like complication.
Input		
Visual	Implement augmented reality.	Prefer picture and diagram because students remember best what they see
	Provides step by step explanation.	Show me how
Understanding		
Sequential	Provide step by step explanation.	Understand in sequential manner
Processing		
Active	Provide assessment to do.	Let's try it out (Do it)
	Support collaborative learning activity	Process information by physical activity and by working with others.

Table 4. The Implementation of Collaborative Characteristic in the Interface

Collaborative Characteristics	User interface consideration	Explanation
Communication Social interdependence Students' exploration Begin with problems	Provide group assignment	Group assignment allows students to take participation. It also acts as promotive interaction hence communication is irresistible.
Diversity between group Participation Promotive Interaction Performance analysis and group processing	Group and individual assessment	Group and individual assessment are different. Every student in a group will not get the same result. The result is not only from group performance but also individual understanding towards the assessment.

To cater sensory learner, interface provide "the big picture" to be observed. Animation is implemented to explain how things working which can be play over and over and brings advantage to them who like repetition. To cater visual learner, we implement augmented reality learning object. AR object allows students to make interaction with it in order to see the object clearly. To cater sequential learner, the interface provide sequential process in order to give clear explanation. To cater active learner, the interface provide assessments for individual and group. The interface also supports effective collaborative learning activity by providing centralized assessment. Through centralized assessment, students may submit their answers faster and lecturers can assess their assessment directly.

5 Augmented Reality Learning Object

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 advantages on learning to support visualization and collaborative activity. The way AR enables users to see both added information and real world brings advantages in collaborative learning environment. Students aware of others and communication happens without disruption [4, 18-19]. AR does able to added additional information into the real world. This gives advantage in learning because not all learning object can be display properly for example due to size (molecular object, big machine).

This study implemented augmented reality learning object to enhance students' visualization towards the learned material. The AR brings benefits not only for visual learner but also for active, sequential, and sensory learners. When the virtual object is displayed, sensory learner can explore and observe the objects' components. Sequential learners will also get the benefits because the virtual object can display a process of how something is done in a sequential manner in a form of animation and can be played over and over again.

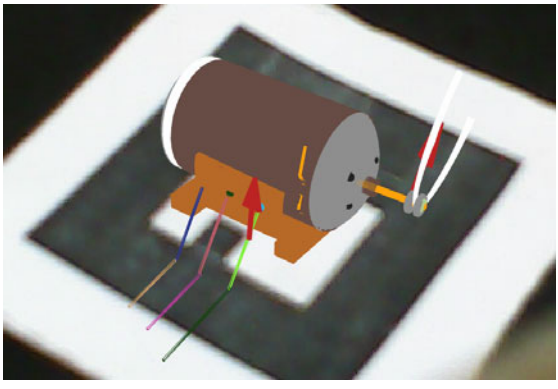

Fig. 2. The Implementation of Augmented Reality

6 Pilot Test

We conducted a pilot test to 24 engineering students. Students were asked to create a group of 3 students and they were assigned random questions. Then students had to separate from their group to meet students from other group who has the same questions. In the new group, students discuss about the given questions and create an artifact/document. After finished on this group, students were asked to back to their original group and presented the new knowledge to other group's member and created an artifact/document. Figure 3 shows group creation during pilot test. The artifact

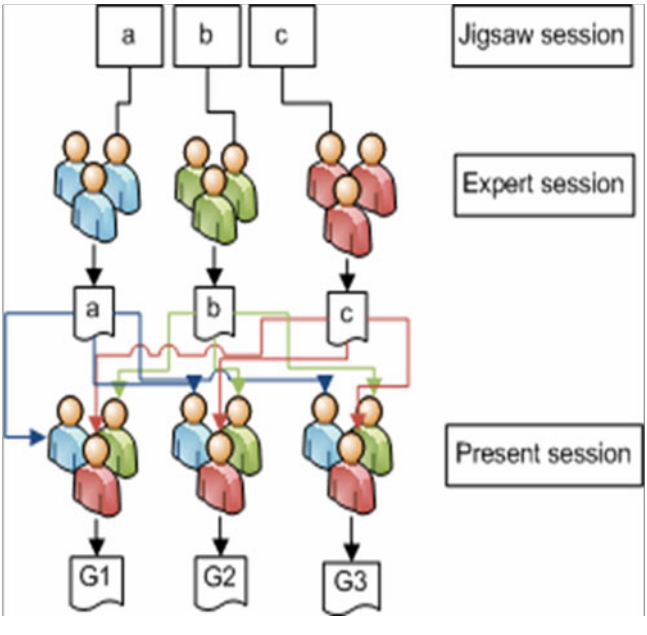

Fig. 3. Group Creation Based on Jigsaw Technique

created for each session were used to analyzed students' performance and satisfaction questionnaire were distributed to determine students' satisfaction towards the interface.

From this pilot test, the result shows that students who used the interface had higher performance compared to them who used traditional collaborative learning in expert session and present session. This was concluded based on the comparison on artifact/documents from expert session and present session between students who used the interface and them who used traditional collaborative learning. Students were satisfied with the interface in term of collaborative learning functions that it helped them to created and reused notes taken from other sessions. But there were negative comments on the interface regarding the redundant text and server connection. This was because the interface was not fully completed. For augmented reality display, students found it new and exciting thing but negative comments were received such as virtual object placement is not on its default view that students need to move and rotate the object to get the front view (correct view), it takes time to load the object because the objects contains too many meshes and object, unstable image tracking that sometimes virtual object was displayed and sometime was not.

7 Conclusion and Future Work

This paper presents early investigation about interface and interaction design considerations for effective collaborative learning by taking account individual learning preferences and collaborative learning characteristics of engineering students. In our investigation, we follow Felder Silverman Learning Style Model and we discovered that engineering students tend to be active, sensory, visual, and sequential hence in the interface, we implement centralized assessment for active learner and augmented reality views to cater visual learner. For collaborative characteristics, we studied past research on collaborative learning regarding its characteristics that affects learning effectiveness. Our next work is to assess the usability of interface on both collaborative functions and augmented reality view and conduct another test to assess students' performance after using the interface.

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