ISSN 2347 - 3983
Volume 10. No.8, August 2022
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter021082022.pdf
https://doi.org/10.30534/ijeter/2022/021082022

Effects of collaboration on students' learning using Intelligent Tutoring System

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Received Date : July 4 , 2022 Accepted Date : July 22, 2022 Published Date : August 07, 2022

ABSTRACT

Computer-based learning tools called Intelligent Tutoring Systems (ITS) assist students to become better learners by simulating human tutors using Artificial Intelligence (AI) approaches. Students can interact using collaborative ITSs from various locations to study, discuss, and articulate concepts relevant to a certain problem. This paper presents a collaborative ITS to teach UML that is built to enable students to effectively communicate and share each other's mistakes. The ITS is capable of detecting and identifying student errors and offers students suggestions during the problem-solving stage, giving them guidance on how to proceed. The ITS also determines a student's current level of thinking and intellect in order to assign them activities that need more attention. The evaluations conducted for this study revealed that the experimental group had considerably more learning gains (81% scores on the posttest) than the control group, where students only showed a very low significant change in their learning with posttest scores of 46%.

Key words: Artificial Intelligence, Collaborative Intelligent tutoring system, Unified Modeling Language.

1. INTRODUCTION

An effective, efficient, and high-quality education in the present day should not be constrained by geographical limits, which is why it should be built on e-educational systems. A computer or other electronic device can be used to access e-learning, a sort of online learning. Online education or online learning are other names for it. The letter "E" in "E-learning" stands for "Electronic." The term "Electronic learning" was consequently created. One of such systems is called the Intelligent Tutoring System (ITS) [1]. It imparts knowledge in an interactive manner without the need of books or a conventional setting. Making students learn by doing is ITSs' main goal. The students are given a task or problem to complete within a particular subject area (such as mathematics, physics, or UML diagrams), along with a workspace. Students complete a task in the form of a solution, which is subsequently assessed by an intelligent tutoring system. ITS seeks to determine both the accuracy of students' responses and their level of understanding [2].

Support for collaboration is crucial in this situation since e-learning is currently a popular educational paradigm for working and geographically dispersed persons interested in pursuing higher education [3]. The learning environment provided by ITS is appealing and the learning process is tailored to the requirements and interests of the students. Academic studies dating back more than 20 years show that group learning is superior to solitary learning [4]. In intelligent tutoring systems, collaborative learning enables students to learn through a variety of tasks, such as developing, clarifying, and sharing ideas as well as asking questions of fellow students. The responses from fellow students, in addition to system feedback, are crucial in enhancing students' ability to learn. When students collaborate, they ask questions, describe problems, and discuss about solutions. There are many collaborative ITSs that allow students to communicate through different means. Students can use the agreement/disagreement buttons in CirCLE [5] to indicate their agreement or disagreement with another student's response. Students can only provide feedback using specified choices in the Collab-ChiQat interface [6], which is used to offer advice on solutions. Students can communicate through audio chats and have limited access to feedback using collaborative CTAT [7]. Students in ITSCL [8] [9] can converse in chat rooms and provide comments on one other's responses. The earlier systems had limited features and only offer a few or restricted opportunities for students to make feedback. Considering the importance of students' collaboration, this research offers a UML-ITS (Unified Modeling Language - Intelligent Tutoring System) with an efficient method of collaboration. The ITS approach that is being presented not only allow students to communicate through text messages, but it provides rich workspace where students can effectively assess each other's mistakes and provide feedback on solutions.

In the remainder of this paper, section 2 describes the UML-ITS architecture and collaboration techniques. Experimental design is presented in Section 3, and Results are presented in Section 4. Discussions are described in section 5 preceding the findings stated in section 6.

2. SYSTEM DESCRIPTION

2.1 Architecture

In the UML-ITS environment, students work together to create a UML class diagram based on predetermined specifications. A network-based system called UML-ITS gives student's feedback as they go through a particular problem by means of hints. The interaction between students begins by entering their names first, which is how UML-ITS generates sessions between two students. Through the session manager, each action taken by the student is logged in a log file. The pedagogical model, which is linked to all the other components, also receives the activities. The pedagogical model determines how additional components are activated based on the student's activities. For instance, if a student submits the answer to the present problem, the model for that student is updated, the answer is assessed, and the assessment results are once more given to the pedagogical model. The pedagogical model presents a new issue if the solution is accurate. However, it generates the proper feedback if the solution has problems, such as missing classes, characteristics, or incorrect relationships. The student's response is compared to the sample/ideal solution, which is the correct answer kept in ITS's knowledge base. Figure 1 shows the overall architecture of UML-ITS. Furthermore, the detailed architecture of UML-ITS can be found in [10].

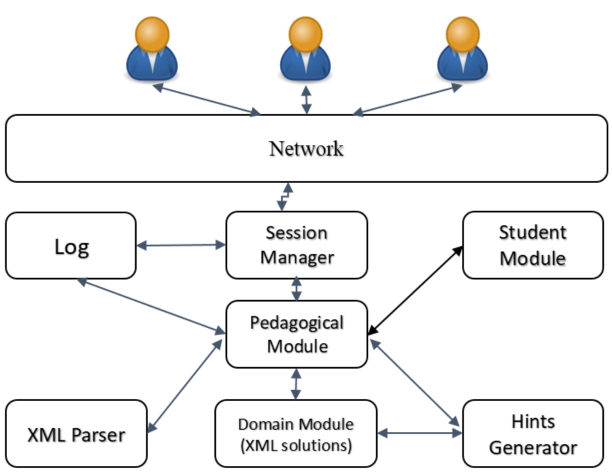

Figure 1: UML-ITS Architecture

2.2 Collaboration methods

UML-ITS interface provides different features through which students interact with the system and receive a response. Every student's top panel displays the problem that has to be solved (two students collaborate in this case). Students can create UML diagrams using the workspace for UML modelling provided by the central panel. On the right side, the system provides comments and suggestions to both students. Using the panel at the bottom of the screen, the students may also chat with one another. The type of error in the solution can be indicated by the student using several buttons. Buttons such as Suggest Missing, Select Error, and Delete can be utilized to add missing, or identify incorrect and additional components respectively. When the Select Error button is activated, the tutor can point out any mistakes the student detects in the diagram. To highlight a mistake, the student can only click on a particular diagram element. The color of the chosen component is changed to red, and other student may see this change. Additionally, a message that is created automatically and sent to the student with information about the problem is displayed in the UML hints section of the screen. The UML-ITS screen is shown in Figure 2, demonstrating different ways of collaboration.

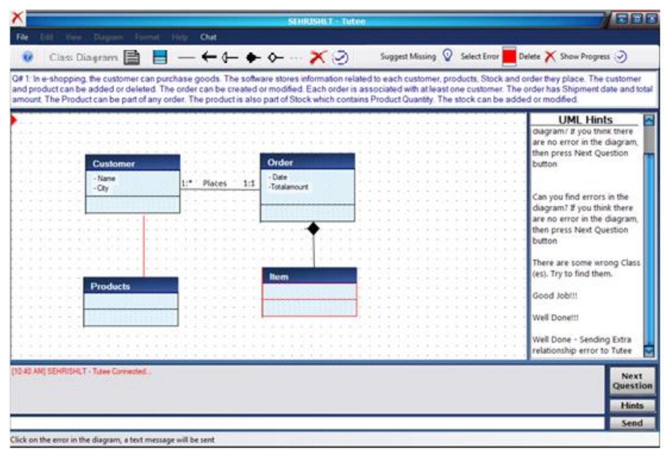

Figure 2: Students' collaboration using UML-ITS [10]

3. EVALUATIONS

The evaluation research included undergraduates from several universities. All of the students were enrolled in computer science or software engineering programs.

3.1 Experimental Design

Students were divided into 2 groups for the experimental study, one for the control group (individual participation) and the other for the experimental group (pair participation). Students were paired off at random. Over the course of two weeks, students in both groups had the same amount of time (three hours) for evaluative study, each week for one group. Both groups received a pretest to complete two days before to their experimental session at the start of each week. After that, the students were introduced to UML-ITS by explaining all functions and their usage, and were allowed to use it for 20 minutes to get themselves familiar with its interface. The students used UML-ITS in three hours of laboratory session and were supposed to complete up to 9 UML class diagram problem scenarios. The students in the experimental group were seated on separate sides of the same lab and were only permitted to communicate with one another indirectly using a chat tool. Students were invited to attempt a posttest following three hours of laboratory experiments. Each of these two tests contained a total of 8 questions with 22 total marks. 50 students from each group made up the total 100 participants in the experiment. The results of the pretest and posttest were utilized to assess the performance of the students. The mean and standard deviation were computed to monitor progress between the pretest and posttest.

4. RESULTS

4.1 Learning

The development of students' domain knowledge is the most significant indicator of ITS effectiveness [11][12]. Independent sample t-test was used to examine any differences between pretest and posttest outcomes across both conditions (Control group, Experimental group). The pretest and posttest findings for the control group did not significantly change (t = 1.596, p = 0.114), showing that the average scores on the pretest and posttest were not different. Inversely, the experimental group's pretest and posttest scores showed a significant difference (t = 7.644, p = 0.000). Pretest and posttest results are described in Table 1. The variation in the two groups' pretest and posttest results is shown in Figure 3. The students in the control group had the lowest average when compared to the other group, as can be observed. Hence, it reveals that the student's domain learning was effected when they worked in collaboration.

Table 1: Pretest and Posttest scores in both groups

Test Data	Mean	S.D.	Statistical Test	t-value	Sig p value
	Control Group				
Pretest	9.11	3.2	Independent Sample t-test	1.596	0.114
Posttest	10.18	3.3			
	Experimental Group				
Pretest	9.1	4.3	Independent Sample t-test	7.644	0.000
Posttest	18.2	2.8			

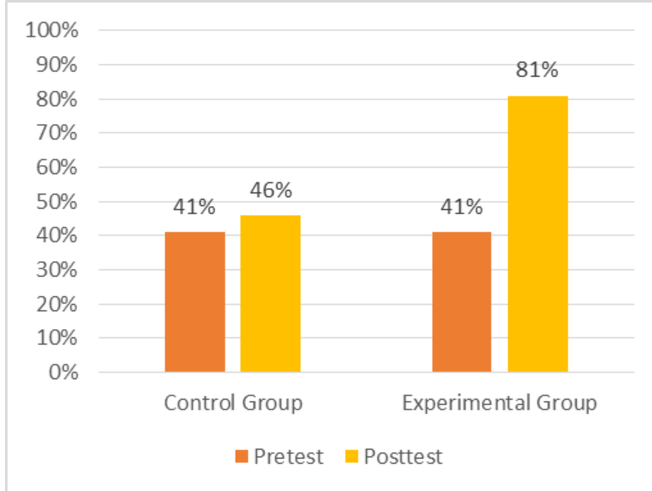

Figure 3: Pretest and Posttest average scores in both groups

4.2 Effects of collaboration

Given the encouraging results that students in experimental group leant more, the support that students received from ITS and peer student was further evaluated. As already mentioned, the students in control group did not collaborate and solved problems individually, due to which they scored lower in their posttests. By comparing the overall number of questions completed throughout the experimental session, the routes students followed during the intervention were further investigated. One may anticipate that students in each situation would solve problems at about the same rate. Students in the experimental group solved more problems (avg: 7.26 or 80 percent) than those in the control group (avg: 2.28 or 25%), despite the control group's lack of collaborative help. The average of total questions completed is shown in Table 2 and their percentages in Figure 4.

Table 2: Average problem scenarios completed in both groups

Test Data	Mean	S.D.
Control Group	2.28	0.82
Experimental Group	7.26	1.29

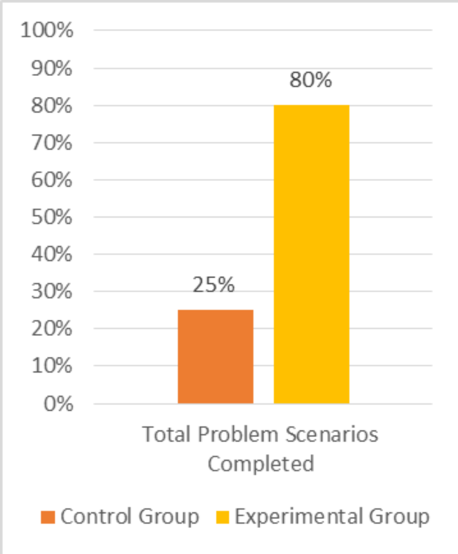

Figure 4: Average percentage of problems completed for both groups

5. DISCUSSION

This study examines the benefits of using a collaborative ITS on students' learning. It was predicted that students who work independently will learn less and perform worse as compared to those who study in groups. Results show that students in the experimental group performed better on their posttest than those in the control group. This was a result of the experimental pathways students took as well as specific design features that had different effects on students' learning in the two situations. For instance, the collaborative capabilities of UML-ITS did not assist students in the control group. Because of this, they performed lower on their posttest than the other group and committed more errors. Students in the experimental group, on the other hand, saw a substantial improvement in their posttest scores as a result of getting and sending domain-related feedback from fellow students while working together. Again, this was made possible by the UML-appropriate ITS's collaboration assistance. Peer students gave feedback and UML-ITS created hints when students were unable to identify the errors in their own solutions, encouraging them to reconsider and go over the solutions once more. Furthermore, the students in experimental groups were able to solve more problem scenarios as compared to control group due to the way students worked together. However, based on the finding of this study, it seems that the benefits of collaboration will grow as its quality improves.

6. CONCLUSION

Computerized systems called intelligent tutoring systems assist students in studying a variety of courses. These systems are becoming more and more popular since they are always accessible and simple to use. In this study, UML-ITS, an intelligent tutoring system with collaborative support, was introduced. To determine how ITS affected students' learning, an empirical research including control and experimental groups was conducted. The experimental group received assistance from UML-ITS while it was being taught how to construct UML class diagrams. The students were successful in working together to solve the provided problem. In other words, the experimental group's students improved their domain knowledge and considerably outperformed the control group's students on the posttest following the UML-ITS session, demonstrating that they had learned more. Hence, it can be concluded that collaborative ITS appears to be a promising advancement and should be implemented with enhancements in future ITS tools.

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