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Research Article

Intelligent Tutoring System: Learning Math for 6th-Grade Primary School Students

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This paper proposes a web-based application designed to help elementary school students who have difficulty learning online independently and also their parents who are currently having difficulty teaching their children to study at home online, especially at this time of difficulty with a pandemic outbreak like COVID-19; this time does not allow for physical meetings for the learning process in primary schools. In this paper, we only focus on mathematics because based on several other studies, it is very difficult and important to learn mathematics at the beginning of educational activities such as at the elementary school level. In this paper, the system is modeled using the Unified Modeling Language (UML) tool in the form of a use case diagram which is used to describe the proposed business process and uses class diagrams to describe the database model diagram. In this case, the class diagram is used to describe the data in the class diagram where each class refers to a table in the database. The web-based application user interface is shown at the end to show the communication between users and applications, where this web-based application is implemented using Personal Home Pages (PHP) as server programming and using MySQL to store database model designs. Moreover, for the Intelligent Tutoring System (ITS), content was created using the Cognitive Tutor Authoring Tools (CTAT) which is an authoring tool for learning mathematics created by Carnegie Mellon University. In the end, this web-based application is expected to be used and support teachers as a complement to online mathematics learning, especially during difficult times such as during the COVID-19 pandemic.

1. Introduction

A virus outbreak called COVID-19 occurred in Indonesia in March 2020. This affected many sectors in Indonesia, and one of the clearest impacts is on Indonesia's education. The government decided to minimize educational activities across the country by changing the learning method into an online learning system or daring with the hope to prevent or diminish the spread of COVID-19 [1]. The research found that this will highly affect education institutions that are not ready to embrace the new learning system. Some problems need to be anticipated not only by education institutions but also the government while implementing the new learning system such as Internet connection, devices needed, and many more [2].

Students become one of the main victims of the new learning system. The research found that COVID-19 has hugely affected students' psychology. Some students show signs or symptoms of having an anxiety disorder. This research also shows that the learnings are not optimal without the guidance of an expert. In this situation, students' only goal is to stay present in attendance. Lack of independent learning by students is one of the biggest causes that make students demotivate in the learning process [3]. With the

necessity of students learning online, parents tend to be involved. This can result in a positive or negative effect, and the research shows that parents who have a high level of education are mostly more confident in being involved in the education of their children than parents with a low level of education [4]. According to research, students' prior knowledge, in this case, primary school, is important and should be taken into consideration because it helps dictate students' knowledge in the future and will influence students' achievement.

Especially about the mathematic story case or word problem case, research was conducted and compared a high school student who was more native in English in terms of reading or writing with a primary student who was still in the learning stage of English. Furthermore, when the English word was combined or matched with mathematic operation, students from both sides performed worse on the story case with more text [5].

In facing problems that were mentioned before, this research proposes a method of teaching which will be focused on mathematics as it is one of the hardest primary school subjects which is caused by the lack of understanding of related concepts and the use of mathematical terminology [6]. The method of teaching that is proposed by this research can be achieved by the implementation of an Intelligent Tutoring System. An alternative method of teaching should be taken into consideration as it will help in boosting students' participation and learning progress, which becomes one of the main difficulties faced by Indonesian teachers while teaching online [7]. The research was conducted to measure the effectiveness of using an intelligent tutoring system and was concluded with an astonishing result that shows students who received this method of learning can outperform the other students [8]. Teachers have also shown signs of interest in the usage of the intelligent tutoring system because not only does it help in keeping students motivated but also helps in increasing students' problem-solving skills. In addition, step-by-step problem solving made by the intelligent tutoring system can easily be monitored by both teachers and students [9].

2. Current and Previous Research

In this section, we will elaborate the papers that we have collected for our reference to complete this paper; as we know, our title is about an intelligent tutoring system for mathematics; some of the students said that it is easier to learn mathematics after trying the intelligent tutoring system because of the efficiency in material and in nowadays' terms of teaching [10], many students find that mathematics is hard to learn but all of that depend on the Working Memory (WM) from the students themselves; in this context, students' working memory was identified as the important thing in learning performance, so solving the problem in mathematics too is an essential part of the student working memory [11].

With the implementation of an online learning system, the emergence of a new method of learning is unavoidable. One of the methods of learning is by implementing an Intelligent Tutoring System, and it was proven to be more effective in helping students develop more learning methods while, at the same time, becomes an alternative solution for the problems that students faced while using traditional learning methods [12]. Implementation of an intelligent tutoring system has been on the surface for years and was surveyed to be around 55 by the end of 2017 and does not close the possibility of being more than that [13].

There are some positive psychological effects of using the ITS as a learning system. Research on the web-based intelligent tutoring system said that the ITS does not significantly affect students' retention levels on the given subject, but it does help students to get greater academic achievement [14]. Another research also states that, aside from higher academic achievement, the use of the ITS also improves students' motivation, as concluded from their survey [15].

In a paper about ITS survey from 2000 and until the end of 2018, most ITSs usually have four parts, namely, the knowledge model which is used to model knowledge, the student model which is used to model students, the pedagogic model which is used to model the pedagogy, and finally, the user interface model used to model the User Interface (UI) as an application display that is used for communication between users and applications. The knowledge model serves as a place where all the actual teaching materials are found. The student model saves and collects data about students' habits and behaviors, individual data for each student. The pedagogical model will then use the teaching materials and the data collected about each student to control teaching experience, including, but not limited to, adjusting speed, picking the right tutoring strategy, and giving feedback to students. Finally, the user interface model, or what is sometimes referred to as a communication model, functions as a liaison between students and the system [16].

Making an ITS was originally only available to programmers. However, from time to time, research emerged to ease the making of the ITS. Nonprogrammers nowadays can also create their own ITS using available authoring tools. People do not need to code for their ITS; they only need to perform a model tracing or an example tracing on the authoring tools [17]. One of the most recent studies in this year even pushed forward a way to ease ITS making, saying that people can create the ITS faster, rather than using model tracing or an example tracing, with the help of machine teaching [18].

While interests were built upon all the positive effects of using an intelligent tutoring system, negative ones seem to be undeniable too. Some of the effects are the cost of implementation by researchers, users become socially isolated, lack of communication skills by users, the exposure of users to harmful contents, and many more [19]. This is also supported by other research which stated that developing an intelligent tutoring system is not an easy task and can only be possible with lots of authoring guidelines, feedbacks, and a good team of researchers and developers surrounding the creation of an intelligent tutoring system and serves as its main resource [20].

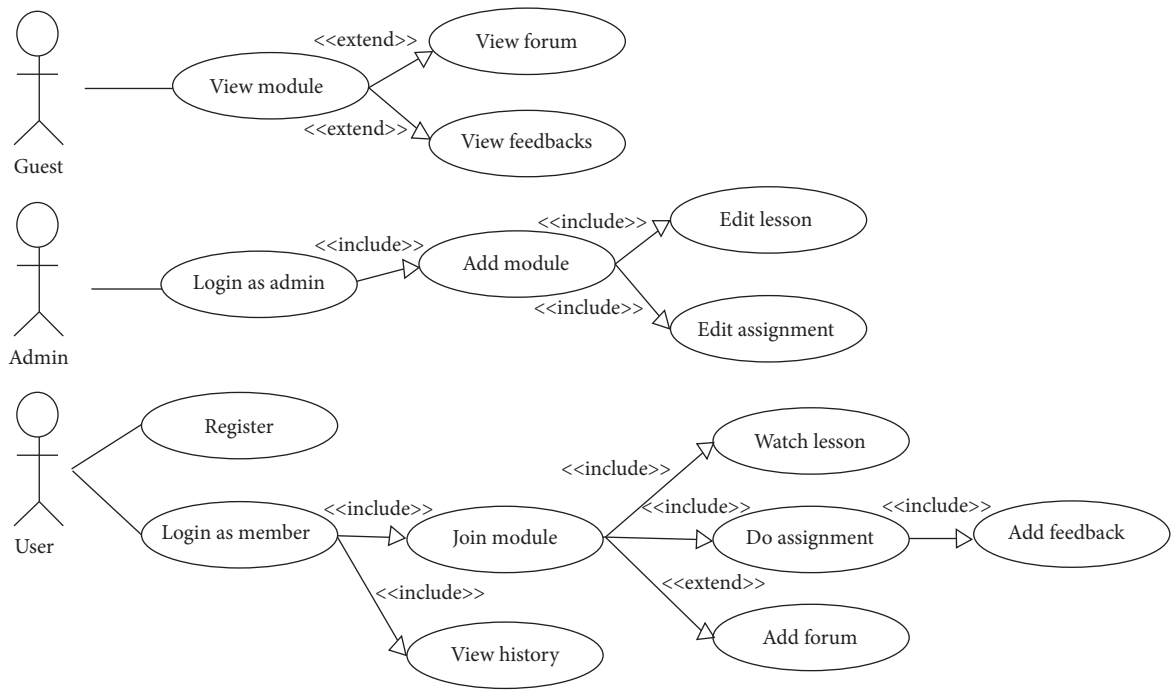


Figure 1: Use case diagram of the proposed model system.

3. Proposed Idea

3.1. Method of Creation. The idea is to create an ITS using the Cognitive Tutor Authoring Tools (CTAT) which is an authoring tool for learning mathematics in grade-6 elementary schools. The reasons are to have a faster developing time and ease of making. Also, CTAT is free to use for research and academic purposes.

The first step to build the ITS is to make an HTML for the student interface. In the beginning, this paper makes use of the drag-and-drop method to make the HTML using CTAT HTML editor available online from Carnegie Mellon University. We also specify some components as variables to make multiple similar questions with a slight difference in numbers or texts, the value which would then be specified in a spreadsheet editor (Microsoft Excel). The file should be saved in a Google Drive folder synced to one of our PCs. After that, we would like to modify the HTML by hand coding for additional aesthetics, adding some CSS and JavaScript.

Inside the authoring tools installed in our PC, we specify an example-tracing tutor as our chosen type to build the tutor. The example-tracing tutor works by defining an initial state (creating the first node in the behavior graph), and then, we use a behavior recorder to have a CTAT record our actions each as a step while demonstrating problem solving in the student interface. We can also demonstrate alternative steps to solve the problem, which is also valid but not preferred. Then, we set groups for the steps and make some steps done by the student to be ordered or unordered to be recognized as true.

After demonstrating the correct steps to solve the problem, we then demonstrate some incorrect steps. The engine defines all unrecognized input by the student as wrong answers automatically. The reason we demonstrate some incorrect steps are to place hint messages on some specific false step done by the student, which the text will prompt inside a hint widget of the CTAT HTML component. We also write some hints in the correct step.

The last thing to do inside the authoring tools is to create skill labels. We attach it to the graph, and then, it will be used by the system for knowledge tracing. The skill name or label would also be visible to the student when we put a skilled window (a CTAT HTML component) on the HTML. All things set in the authoring tools are saved as a BRD file. Since we do not use any Learning Management System (LMS), we do hardcode to connect every HTML to their respective BRD files. All project files will be saved in a folder inside the server, and we will save the HTML file path on the database.

3.2. Diagrams. We use the Unified Modeling Language (UML) tool such as use case diagram and class diagram, where the use case diagram is used to design the proposed business process while the class diagram is used to model the database model design where each class in the class diagram is represented as a table in the database. The use case diagram in Figure 1 shows the business process in the proposed ITS which includes three actors as a guest, admin, and user.

The guest could access the viewing module section and could separately view the forum and viewing feedback, the admin actor has the privilege to add the module, edit a lesson, and edit the assignment, and the admin actor must access the view module section for viewing the forum and viewing the feedback. Moreover, the third actor is the user, where the user could also access the view module section and

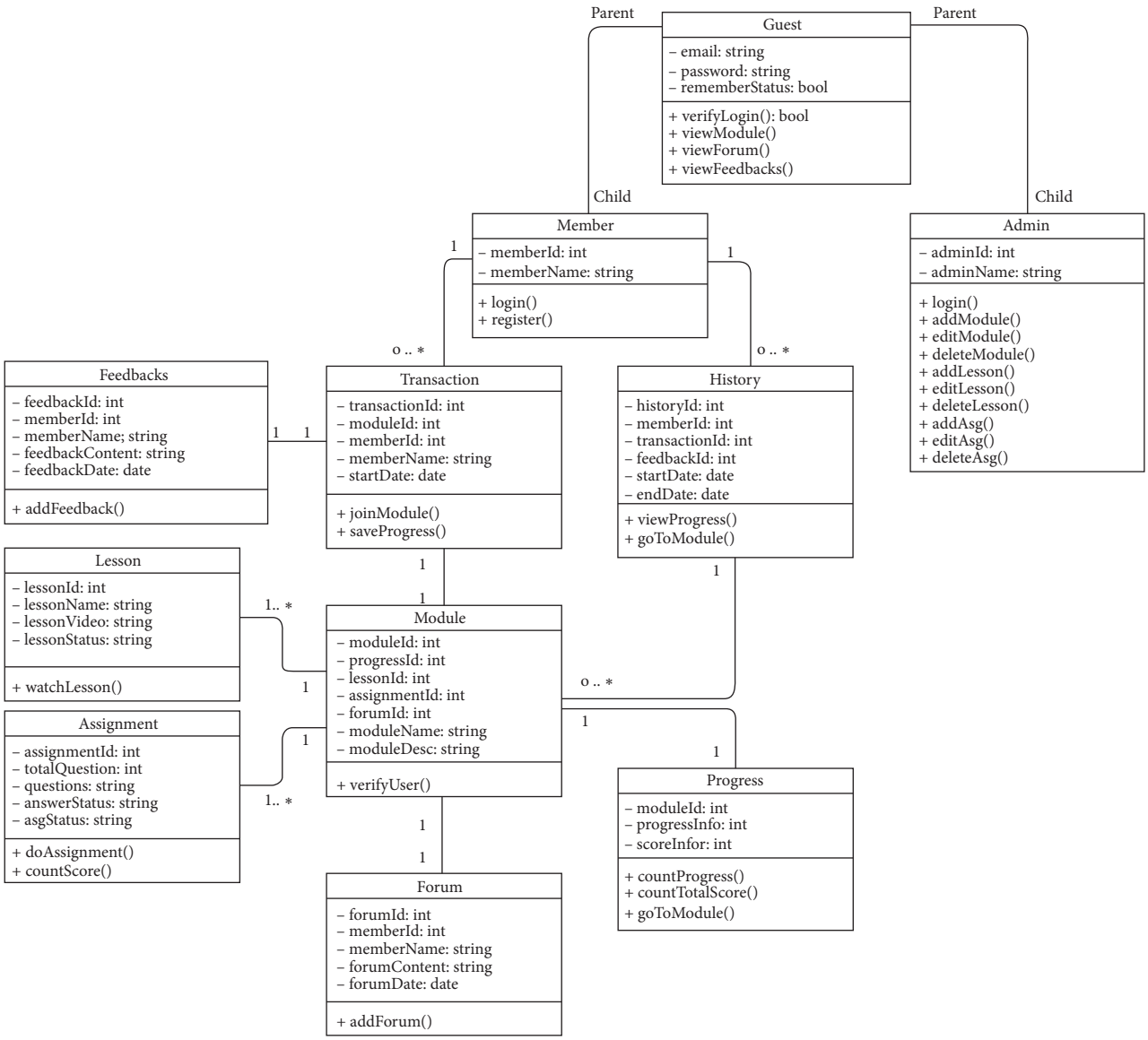


Figure 2: Class diagram.

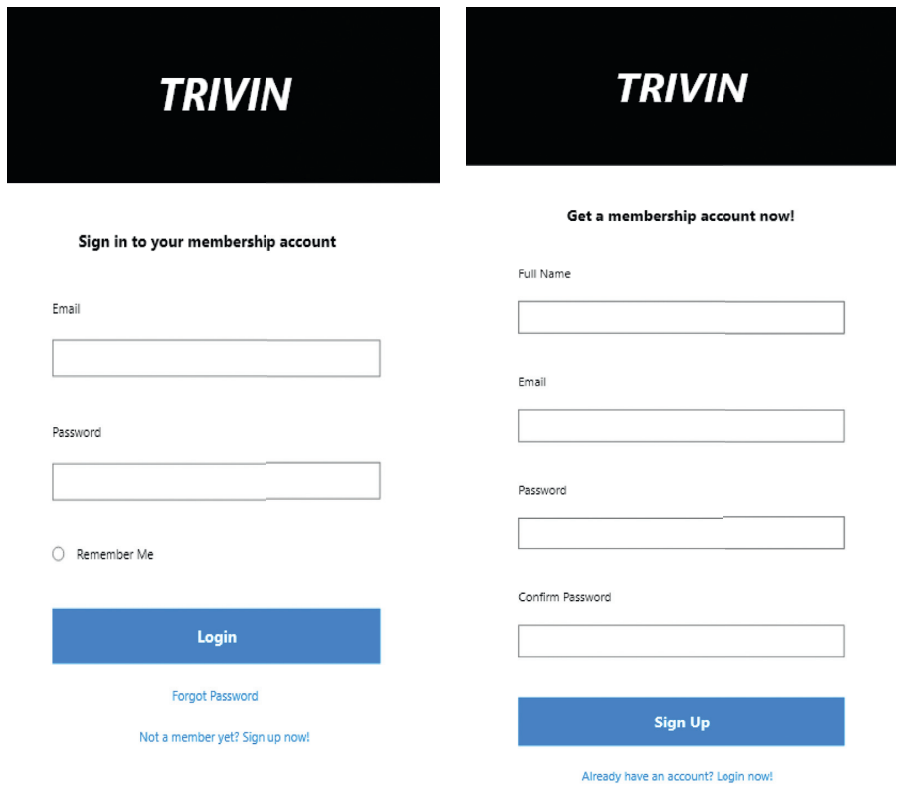
the user could freely view the forum and the feedbacks; the users could register their account and can log in as a member to have more privilege such as joining a module and viewing progress. After joining the module, the user may view the lesson, do the assignment, and add a forum; after doing the assignment, the user can add feedback to the assignment.

Figure 2 shows the class diagram for ITS math for the sixth grade. This diagram contains 11 classes that will correlate in a way with one another. The first class is the guest class, acting as a parent class that will inherit attributes such as e-mail, password, and rememberStatus. All attributes are private. This class will also have public methods such as verifyLogin() to see user status, viewModule(), viewForum(), and viewFeedbacks() which are the privileges that can be obtained by being a Guest user.

The next class is the member, which is a child of the guest class and will get all the attributes and methods available in the guest class. In this class, there are private attributes such as memberId and memberName. There are also public methods such as login() and register(). This class will contain zero or any transaction(s) and zero or many histories.

The next class is the admin class, which is a child of the guest class and will get all attributes and methods available in the guest class. In this class, there are private attributes such as adminId and adminName. There are also public methods that an admin can do which is login(), addModule(), editModule(), deleteModule(), addLesson(), editLesson(), deleteLesson(), addAsg() (Asg = assignment), editAsg(), and deleteAsg().

The next class is the transaction class which contains private attributes such as transactionId, moduleId. memberId, memberName, and startDate. In this class, there are public methods such as joinModule() and saveProgress(). This class belongs to one member class and can give one feedback for each transaction made.



(a) (b)

Figure 3: (a) Login page user interface and (b) register page user interface.

The next class is the history class which contains private attributes such as historyId, memberId, transactionId, feedbackId, startDate, and endDate. In this class, there are public methods such as viewProgress () and goToModule (). This class belongs to one member and has zero or many modules.

The next class is the feedbacks class which contains private attributes such as feedbackId, memberId, memberName, feedbackContent, and feedbackDate. In this class, there is a public method which is addFeedback (). This class belongs to one transaction.

The next class is the module class which contains private attributes such as moduleId, progressId, lessonId, assignmentId, forumId, moduleName, and moduleDesc. In this class, there is a public method which is verifyUser () to see if a user is logged in. This class has at least one lesson and one assignment. This class belongs to one history and has one progress and one forum.

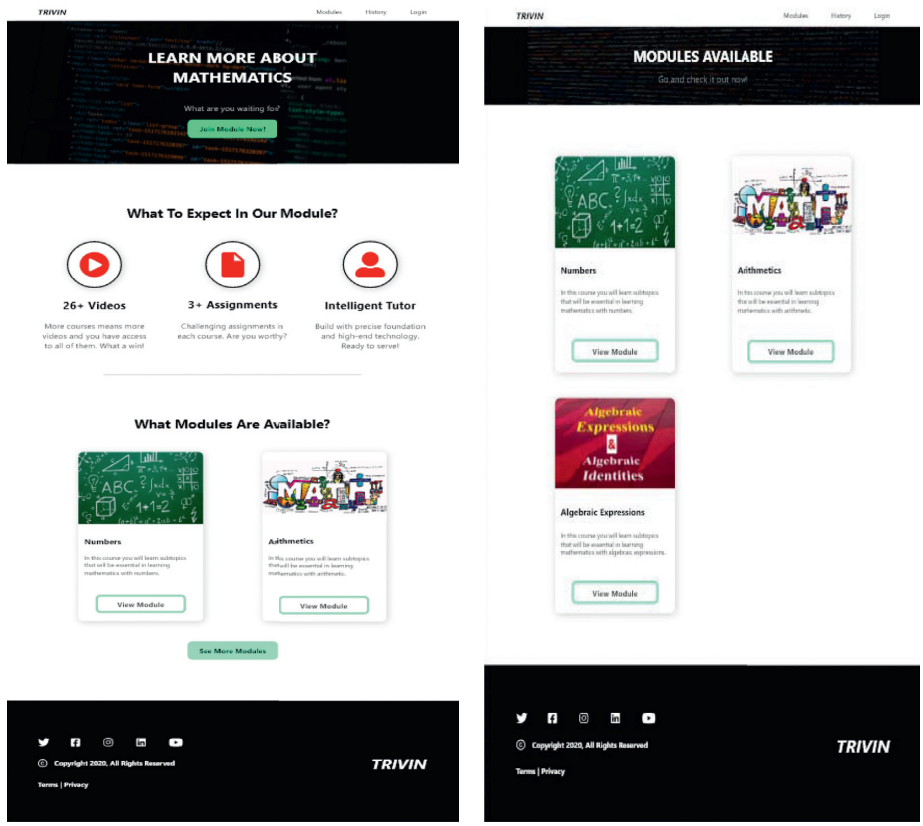
The next class is the lessons class which contains private attributes such as lessonId, lessonName, lessonVideo, and lessonStatus. In this class, there is a public method which is watchLesson (). This class belongs to one module.

The next class is the assignment class which contains private attributes such as assignmentId, totalQuestion, questions, answerStatus, and asgStatus. In this class, there are public methods which are doAssignment () and countScore (). This class belongs to one module.

The next class is the forum class which contains private attributes such as forumId, memberId, memberName, forumContent, and forumDate. In this class, there is a public method which is addForum (). This class belongs to one module.

The last class is the progress class which contains private attributes such as moduleId, progressInfo, and scoreInfo. In this class, there are public methods which are countProgress (), countTotalScore (), and goToModule (). This class belongs to one module.

3.3. User Interface. In Figure 3(a), the page shows that users can log into their perspective account. If the user logs in as an admin, then the user will be given the privilege and access of an admin. An admin account is already created in the database by developers. If the user logs in as a member, then the user will be given the privilege and access of a member. When logging in, the user must fill in some mandatory information such as e-mail and password. The user is also given an option of remember me where if the user agrees, their account will be saved in a cookie. After pressing the login button, the system will validate if the account exists in the database. Users can access forgot password to change their old password. Verification will be sent to their e-mail. If the user does not have an existing account, then the user can access the not a member yet? Sign up now! link. The user will then be redirected to the register page.



(a) (b)

Figure 4: (a) Home page user interface and (b) module page user interface.

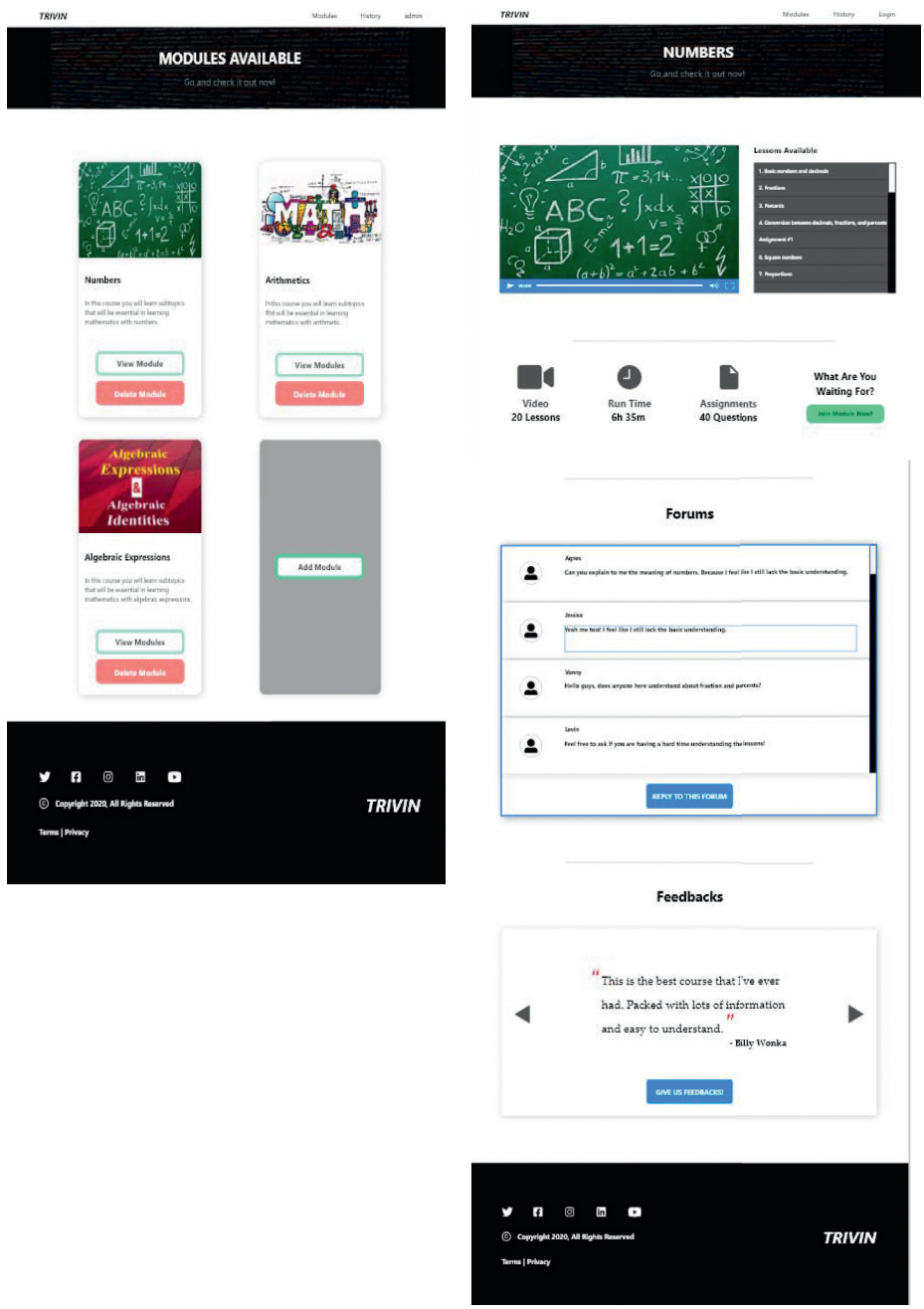
As shown in Figure 3(b), the users can create and register a new membership account. To be able to create a new account, the user must first fill in some mandatory information such as full name, e-mail, password, and confirm password. A verification link will then be sent to the user's e-mail account. After verifying the account, the user will then be redirected to the login page and can log in to their existing account. Users can also access the already have an account? Login now! link to get redirected to the login page.

When the user first accesses the website, this home page will be displayed. On this page, as shown in Figure 4(a), there are three menus that users can access. The first menu is the module, which will redirect the user to the module page. The second menu is history, which will redirect the user to the history page. The last menu, login, will redirect the user to the login page. Users can also have a preview of what to expect in our modules and what modules are available. A footer which contains information that allows user to connect with us will also be displayed throughout our website.

Figure 4(b) shows that the user will be able to view all available modules. In each module will be prescribed a title of the module and a brief description of what the module is about. If the user wants to view the full information of the module, the user can press the wiew module button and the user will then be redirected to the module's page.

Figure 5(a) will be displayed if the user is authenticated as an admin where the user has all the features a member has but with some additional privilege. An admin can delete an existing module and also add a new module. If an admin adds a module, then the admin will be redirected to the module detail page for admin. As shown in Figure 5(b), the website will be displaying a module detail page that was previously accessed by the user. The user will be able to see what and how many lessons are available in this module, what is the total run time of this module, how many questions are tasked to the user, all the discussions from the participants of this module in a forum, and all the feedback from the participants that have completed this module. Users can only join the module if they have successfully logged into their existing accounts and authenticated as a member. Features such as watch lessons, do assignments, reply the forum, and give feedbacks can only be accessed if the user has joined the module. Progress of the user that has joined the module will be saved and can be accessed in the history menu.

This page, as shown in Figure 6(a), can only be accessed by the admin when the admin wants to add a new module. There is some information needed before the admin can add a new module. First, the admin needs to upload a photo, title, and description that will be used to display the new module in the module page to enable other users other

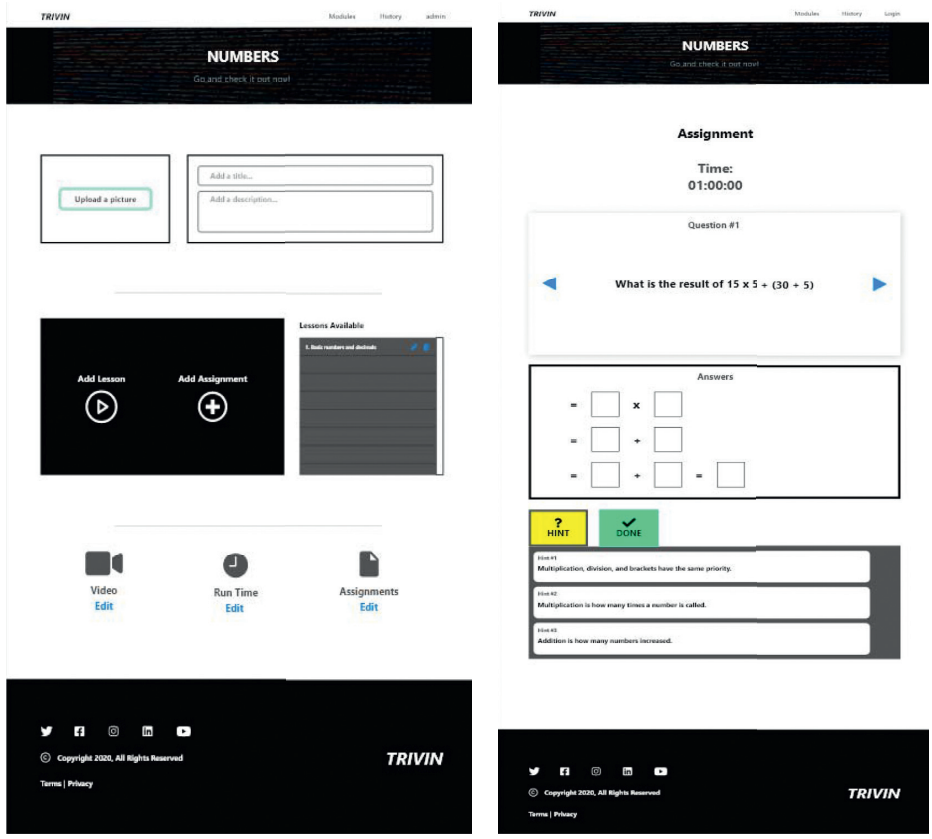


(a) (b)

Figure 5: (a) Module page for admin UI and (b) module detail page UI cont.

than the admin to view or join the module. Next, the admin can add lessons that users will learn upon joining this module. The lessons can also be edited or removed depending on the admin's desire. The admin can also add assignments where the admin will be redirected to CTAT and start building questions with an intelligent tutoring system. Additional pieces of information of the module detail can also be edited by the admin such as the number of videos available, overall run time, and amount of questions the user will have to do.

Moreover, after the user joined the module and has reached the assignment section, this page, as shown in Figure 6(b), will be displayed. Users will be given a limited time to do all the available questions. For this feature, an intelligent tutoring system is applied to help the users learn while doing their assignment. The time and number of questions vary based on the module. After finishing the assignment, the user will be redirected to the history page and the result will be saved and can be accessed on this page for future reference.



(a) (b)

Figure 6: (a) Module detail page for admin UI and (b) module detail assignment page UI.

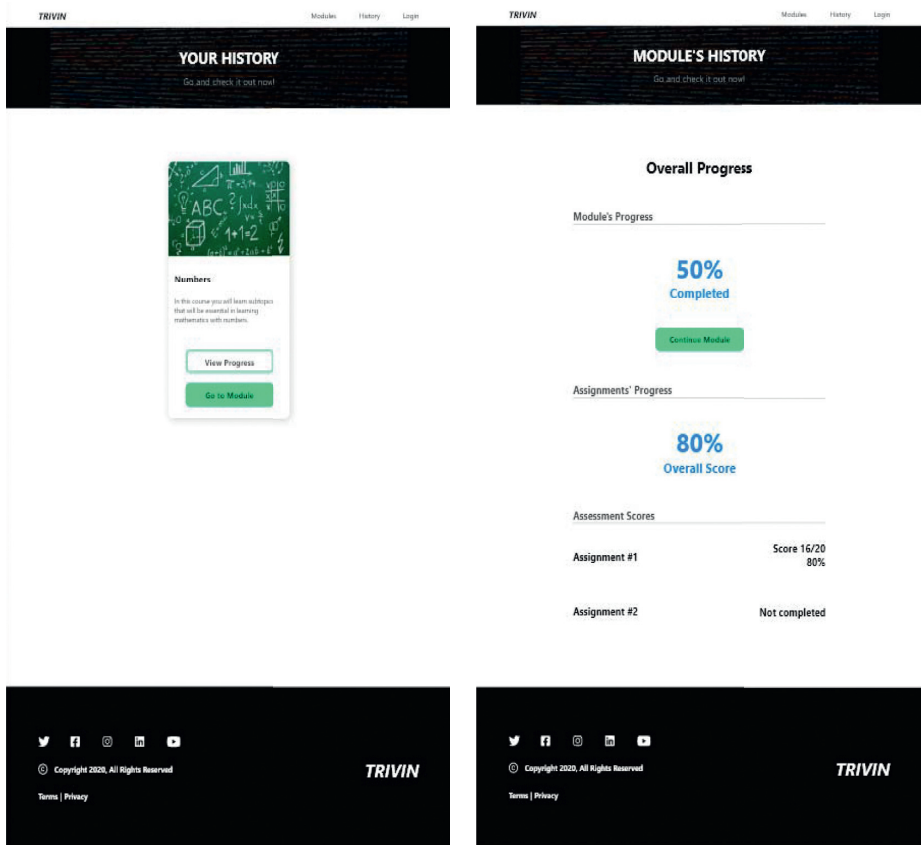
On this page, as shown in Figure 7(a), the users will be able to see all of the modules that they have joined. In every module, there are two buttons available. The first is view progress, where the user will be redirected to the view progress page. The second is go to module, where the user will be redirected to the module detail page.

On this page, as shown in Figure 7(b), the user will be able to see all the progress of the module that the user is currently on. The module's progress will display the percentage of lessons that the user has done. If it is not 100%, then a button will be available for the user to immediately get redirected to the respective module detail. The assignment's progress will show the overall score in percentage gained by the user. The users can also view their scores in each assignment.

We did not perform a full experiment on the writing of this paper. We tried some aspects of CTAT (using CTAT HTML Editor) and concepts to write this paper. No implemented function was tried. In this paper, we only apply the analysis, design, and implementation process where one more stage in the software development stage, namely, the testing phase, is not carried out considering that the ITS application built is still in the refinement stage. It is hoped that ITS implementation will not stop here but will be expanded by applying Artificial Intelligence (AI) technology such as the Recommender System (RS) where the RS can help actors such as tutors or teachers including students and their parents to get recommendations from the system according to their needs.

Meanwhile, other extension implementations will be implemented to, for example, handle forum data as unstructured communication data between actors that can be used to apply other AI technologies such as sentiment analysis or opinion mining including topic classification or topic mining. Sentiment analysis or opinion mining is applied to capture the sentiments or emotions of the actors which can be extracted from the communication of the actors involved in the forum facilities in their application and classify sentiments as positive, neutral, or negative.

Meanwhile, for now, the student assessment process still uses multiple-choice questions because it is very easy and automatic to assess student answers, but it is different from essay questions as unstructured data where it is necessary to assess essay questions that are done by students which are done manually. In overcoming the problem of assessing this test, an automatic essay assessment can be applied where the system will automatically assess the essay questions done by students. In addition, to complete the ITS application, a dialogue system or chat agent or chatbots will be implemented where the system will automatically handle user



(a) (b)

Figure 7: (a) History page UI and (b) view progress page UI.

problems by machine and the system will continue to learn when there are new questions and the labeling process will be carried out for these new questions.

We will apply all of these AI implementations for testing purposes where we will test all ITS applications that have been completed, and the testing process will be carried out by implementing user acceptance tests as an example. This testing process is a valuable stage where the shortcomings of the ITS being built can be seen, and it is hoped that by capturing signals from users, ITS application users will be fulfilled and to successfully apply the concept of software engineering in successfully building the software according to the wishes of the user. In the future, a separate research paper will be created that explains what approach was used to carry out the test and displays data and graphs from the results of the testing phase.

4. Conclusions

After all the research, this paper has come up with the conclusion that the COVID-19 pandemic hugely affected education. Students find it hard to learn and understand using this new online learning method. Alongside this new online learning method, the presence and guidance of parents are necessary, which can have both positive and negative effects.

In solving this problem, researchers have come up with an idea and have successfully designed a web-based online learning course that focuses on sixth-grade primary school mathematics with the implementation of an intelligent tutoring system made using Cognitive Tutor Authoring Tools (CTAT), which speeded up and simplified the making of an ITS. Also, the usage of an ITS is proven to improve students' self-learning and understanding experience according to the previous and current research. With the realization of this paper, researchers hope to bring a huge and positive impact globally.

This paper does not close the possibility of further research and improvement in the future. There are many possibilities yet to be researched from this topic. Research can be conducted to further enhance the user experience from the standpoint of the students, impact the relationship between the school's teachers and the students, and more.

Data Availability

The data are included in this paper.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] A. Azmil, R. M. Simamora, D. Fehabutar, and L. Mutakinati, "The impact of covid-19 to Indonesian education and its relation to the philosophy of "merdeka belajar"" *Studies in Philosophy of Science and Education*, vol. 1, no. 1, pp. 38–49, 2020.

[2] Z. Zaharah, G. I. Kirilova, and A. Windarti, "Impact of corona virus outbreak towards teaching and learning activities in Indonesia," *SALAM: Jurnal Sosial Dan Budaya Syar-I*, vol. 7, no. 3, pp. 269–282, 2020.

[3] A. Purwanto, M. Fahlevi, B. P. Santoso, A. S. Radyawanto, and C. Anwar, "Exploring the covid-19 pandemic impact on the Indonesian students performance," *Journal of Critical Reviews*, vol. 7, no. 15, pp. 1973–1980, 2020.

[4] K. Yulianti, E. Denessen, and M. Droop, "Indonesian parents' involvement in their children's education: a study in elementary schools in urban and rural java, Indonesia," *School Community Journal*, vol. 29, no. 1, pp. 253–278, 2019.

[5] F. C. Galan and C. R. Beal, "Math word problem solving by English learners and English primary students in an intelligent tutoring system," *International Journal of Learning Technology*, vol. 10, no. 102, pp. 170–184, 2015.

[6] C. E. Mulwa, "Difficulties encountered by students in the learning and usage of mathematical terminology: a critical literature review," *Journal of Education and Practice*, vol. 6, no. 13, pp. 2222–1735, 2015.

[7] R. Rasmitadila, R. R. Aliyyah, R. Rachmadtullah et al., "The perceptions of primary school teachers of online learning during the COVID-19 pandemic period: a case study in Indonesia," *Journal of Ethnic and Cultural Studies*, vol. 7, no. 2, pp. 90–109, 2020.

[8] J. A. Kulik and J. D. Fletcher, "Effectiveness of intelligent tutoring systems," *Review of Educational Research*, vol. 86, no. 1, pp. 42–78, 2016.

[9] A. K. Erümit, V. Nabiyev, and V. V. Nabiyev, "Teachers' opinions about intelligent tutoring system prepared for improving problem solving skills of students," *Participatory Educational Research*, vol. 2, no. 5, pp. 84–98, 2015.

[10] N. N. AbuEloun and S. S. A. Naser, "Mathematics intelligent tutoring system," *International Journal of Advanced Scientific Research*, vol. 2, no. 1, pp. 11–16, 2017.

[11] B. E. Mamoun, M. Erradi, and A. E. Mhouti, "Using an intelligent tutoring system to support learners' WMC in e-learning: application in mathematics learning," *International Journal of Emerging Technologies in Learning*, vol. 13, no. 12, pp. 142–156, 2018.

[12] A. T. Q. Al-aqbi, A. Y. Falih, B. J. Saleh, N. M. Al-juaifari, and L. Abdulhassan, "The effect of the intelligent tutoring systems on the education," *Journal of Intelligence Research (JIR)*, vol. 10, no. 27, pp. 683–698, 2019.

[13] A. N. Akkila, A. Almasri, A. Ahmed et al., "Survey of intelligent tutoring systems up to the end of 2017," *International Journal of Academic Information Systems Research*, vol. 3, no. 4, pp. 36–49, 2019.

[14] A. Karacı, H. İ. Akyüz, G. Bilgici, and N. Arıcı, "Effects on web-based intelligent tutoring systems on academic achievement and retention," *International Journal of Computer Applications*, vol. 181, no. 16, pp. 34–41, 2018.

[15] R. Çakir, "Effect of web-based intelligence tutoring system on students' achievement and motivation," *Malaysian Online Journal of Educational Technology*, vol. 7, no. 4, pp. 45–59, 2019.

[16] A. Almasri, A. Ahmed, N. Al-Masri et al., "Intelligent tutoring systems survey for the period 2000-2018," *International Journal of Academic Engineering Research*, vol. 3, no. 5, pp. 21–37, 2019.

[17] D. Dermeval, R. Paiva, I. I. Bittencourt, J. Vassileva, and D. B. F. da Silva, "Authoring tools for designing intelligent TutoringSystems: a systematic review of the literature," *International Artificial Intelligence in Education Society*, vol. 28, no. 6, pp. 336–384, 2017.

[18] K. R. Koedinger, E. Harpstead, and D. Weitekamp, "An interaction design for machine teaching to develop AI tutors," in *Proceedings of the CHI '20: CHI Conference on Human Factors in Computing Systems*, pp. 1–11, Honolulu, HI, USA, April 2020.

[19] Y. Akyuz, "Effects of intelligent tutoring systems (ITS) on personalized learning (PL)," *Creative Education*, vol. 11, no. 6, pp. 953–978, 2020.

[20] D. Bonner, S. Gilbert, M. C. Dorneich et al., "The challenges of building intelligent tutoring systems for teams," *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 60, no. 1, pp. 1981–1985, 2016.