The Effect of SRL Strategy with Cloud-Based-Blended Approach on Undergraduate Students' Mathematical Reasoning Ability

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***Abstract*—Mathematical reasoning is one of the key competencies for learning mathematics. In this study a Self-Regulated Learning (SRL) strategy using the cloud-based blended approach was proposed to investigate its effects on undergraduate students' mathematical reasoning ability. A quasi-experimental method with a control group pre-test-post-test design was employed. The sample was selected by simple random sampling and comprised a total of sixty undergraduate students, equally divided into experimental and control groups. The experimental group learned using a SRL strategy with a cloud-based blended approach, while the conventional learning group acted as the control group. The research instrument was a mathematical reasoning test. The data were analyzed using descriptive statistics, n-gain, and a t-test. The findings revealed that the experimental group had a high level of improvement in mathematical reasoning ability, and the control group had a moderate level. The experimental group performed statistically significantly higher at the 0.05 level in terms of the mean score with regard to the post-test of mathematical reasoning ability than the control group. The findings underscore the significance of incorporating a SRL strategy and a cloud-based blended approach to support students' performance and to meet the potentially-changing educational context.**

***Keywords*—blended approach, cloud technology, mathematical reasoning, self-regulated learning, undergraduate students**

I. Introduction

The pandemic situation and natural disasters have both had economic and social impacts. This meant that education has undergone pivotal changes in terms of teaching and learning theories applicable to mathematics learning environments [1, 2]. Mathematical reasoning ability is the ability to analyze cause and effect relationships, think logically, summarize ideas and extend principles to other problems [3, 4]. A learning environment that allows students to practice mathematical reasoning alongside the use of technological tools and resources will engage them more, and make them more able to analyze knowledge in different situations [5]. Analytical, inductive, and deductive reasoning are characteristics of higher-order cognitive thinking [6, 7]. As mathematics and reasoning are related, an effective classroom learning strategy would be an approach which improves proficiency with regard to mathematical reasoning.

The COVID-19 pandemic was an opportunity for practitioners at all education levels to look at the potential of digital technology in mathematics education as the new normal-behavioral approaches including pedagogical adjustments by incorporating more technology to allow educational institutions to cope with similar situations should they arise [8]. Restrictions resulting from the pandemic on the exchange of knowledge resulted in an adjustment of the educational paradigm towards digital learning [9, 10] to offer instructors and students an alternative to conventional classroom learning [11, 12]. Mathematics is one of several areas of knowledge that can be presented effectively by an online approach [13]. In these circumstances, blended learning or what may be called hybrid learning, is an approach that combines face-to-face (classroom) and virtual (online) activities, and positively contributes to learning performance [1, 2, 4, 14].

The possibility of using cloud services in mathematics education to augment digital technology opens possible avenues for enhancing student-centered mathematics activities [15]. The cloud Learning Management System (LMS) has an essential role to play and has attracted the interest of educational institutes as it reduces costs, increases budget flexibility, and helps organize distance education via the internet. The cloud encourages a more flexible learning environment, and it can support the concept and development of online social networks, making management more convenient, accessing information thoroughly, and responding to a learning society [1, 16–18]. Importantly, social influence is positively correlated with undergraduate students' behavioral intentions and LMS use [19]. Some educators have met the challenge by implementing a learning approach involving blended LMS, such as the preparation of instructional materials or videos that provide effective learning strategies [20]. However, if there is no appropriate advice or assistance, many students may exhibit low behavioral self-regulation, and may lack responsibility during virtual learning activities [21]. However, in the event of a lack of SRL, many students may fail to browse and understand teaching materials by themselves outside of the classroom. Consequently, instructors are invited to develop student learning experiences with regard to mathematics in a digital environment. One of the most-accessible cloud tools that facilitates education is Google Classroom [1, 22].

It has been demonstrated that students who are more responsible and regulated in their own learning are more likely to succeed compared with those who rely only on guidance and information from their instructors [23, 24]. To respond to such conditions and achieve learning success, various methods have been suggested to assist students by encouraging them to become responsible for their own

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learning. These methods have received increasing attention, leading to the study of SRL strategies [17, 25–27]. The academic philosophy underpinning mathematics education nowadays has altered from solely emphasizing course content to determining how students acquire mathematics skills most effectively [27]. Studies have shown that training students in the employment of cognitive SRL strategies improves their learning performance [20, 28, 29]. In this framework, students are the ones who plan and monitor their learning. This requires analytical, synthetic, reflective and critical thinking skills which are consistent with the characteristics of mathematical reasoning.

Previous studies have highlighted the implementation of blended learning to develop students' thinking skills by combining teaching techniques [30] and digital platforms [1, 18]. In terms of using LMS, for example, Edmodo was used to improve learning motivation and the scientific critical thinking skills of junior high school students [4], the use of a flipped classroom with Google Classroom was used to promote digital literacy and academic achievement for vocational certificate students [31], as was the implementation of Google Classroom using a cultural theme in learning mathematics [1]. However, there is a gap regarding the application of the concept of SRL, and how to associate it with cloud technology blended learning with regard to undergraduate students in the context of mathematics. In an attempt to close this gap, the educational cloud was leveraged in an SRL situation to support the learning process in order to enhance mathematical reasoning ability. The significance of this study lies in its remarkable contribution to the use of SRL strategy with a cloud-based blended approach and being conducted in a higher education mathematics course context. The study aimed to determine its impact on undergraduates' mathematical reasoning ability.

We addressed the following research questions: firstly, does the proposed approach improve the mathematical reasoning ability of undergraduate students? Secondly, are there differences in the mathematical reasoning ability between groups using the SRL strategy with a cloud-based approach as part of a blended approach and a conventional approach?

II. Literature Review

A. Mathematical Reasoning

Mathematical reasoning refers to a students' ability to arrive at reasonable conclusions from the given information, an ability which cannot be developed without training [6, 32]. Mathematical thinking involves four steps: recall thinking, basic thinking, critical thinking, and creative thinking [32]. Regarding mathematical reasoning, it is considered to take the form of mathematical thinking that is more advanced than the recall stage. That is, reasoning involves basic, critical, and creative thinking. The author of [33] had a similar view with regard to mathematical reasoning to that of [32], who believed that reasoning is a part of mathematical thinking that involves creating principles, summarizing ideas that make sense, and finding relationships between concepts. Following [34], mathematical reasoning is defined as a process of arriving at logical mathematical conclusions based on facts and related sources that are expected to be true. Students can demonstrate reasoning if they are able to use their reasoning skills in determining patterns and attributes, and dealing with mathematical situations in such a way as to summarize or explain mathematical concepts and statements. Mathematical reasoning also involves other skills such as plausibility analysis, reflecting on whether information corresponds to previous knowledge and drawing reasonable conclusions [35].

The enhancement of mathematical reasoning ability requires practice involving various experiences in a particular classroom atmosphere that encourages explanation and the exchange of ideas, together with reasoning and solving problems [36, 37]. Following The National Council of Teachers of Mathematics [38], standards for teaching mathematics regarding mathematical reasoning are as follows: create and verify mathematical predictions, and develop and evaluate mathematical arguments and proofs. Learning activities should be organized in such a way as to allow students to participate with one another and show appropriate behavior in terms of making predictions, searching for methods of proof, observing patterns, and clarifying reasons for ideas by explaining patterns [4, 39]. Some studies have found that learning strategies involving problem-solving are more effective than the scientific method for enhancing students' mathematical outcomes in terms of problem solving and mathematical reasoning [40]. For the reasoning process, learning strategy and many aspects of thinking such as analyzing, synthesizing, reflecting, and the application of critical thinking are required to derive appropriate conclusions [6, 32, 38, 39].

From the analysis of the various concepts involved, mathematical reasoning is an expression of an idea based on factual knowledge. It also involves analysis of the relationships of data to arrive at a reasonable conclusion according to that idea.

B. Cloud Technology

Cloud technology is a technology that improves the efficiency of access and use of educational resources at different levels by combining university and other learning resources [41]. Educational cloud service models take three main forms [42]: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). Cloud-based tools used in education in particular support blended learning. These tools can be divided into three categories depending on their application: synchronization, Learning Management System (LMS), and social network [43, 44].

LMS based on cloud technology is a system that provides content presentation, content reuse, management, and content improvement to ensure greater efficiency [12, 22]. Also known as e-learning, it facilitates both instructors and students with regard to online aspects, including communication between students and instructors and among class members, and in organizing related learning activities including administering quizzes and surveying student opinion [9]. In addition, it can be used to support collaborative learning among students at a low cost [45]. Examples of popular LMS based on SaaS, include Google Classroom, Moodle, Edmodo, Schoology, and Blackboard. As LMS has been developed to support online learning, cloud–based education is therefore an aid when it comes to helping students store files, lesson or work materials conveniently [41, 44]. In terms of content preparation, instructors have to prepare various examples of information that contain the principles and concepts that are related to the desired topic [45]. Instructors may use the features of LMS to adapt them to teaching methods in many ways. For example, Riyanti [46] employed Google Classroom in blended learning to improve the logical thinking ability of students. As described in [30], undergraduates' critical thinking abilities were enhanced using a flipped classroom model with self-directed learning. Schoology-based blended learning media was implemented for a Basic Physics I course and it was found that the use of LMS was beneficial in developing conceptual understanding and problem solving [18].

Google Classroom, launched in 2014, is a learning platform that supports interactive courses that can be accessed on digital devices and through mobile applications [31, 47]. In terms of learning organization, Google Classroom includes many working tools such as Assignment, Web board, and Course Portfolios, that support the learning process. The advantages of using these to support teaching and learning can be summarized as follows: it relieves instructors of the burden of evaluating students, gives opportunities for students to monitor their learning in terms of lessons or assignments, makes classes more active as it provides instructors and students with the opportunity for interactivity through learning lessons and activities, it is easy to use, it offers free online access for smartphones and mobile devices in terms of learning lesson content, as well as details of tasks. It is independent of time and location because it can be accessed anywhere and at any time, and promotes collaboration in virtual environments [1, 31, 46, 48]. In summary, the outstanding features are that Google Classroom is easy to use, and connects other Google App services.

C. *SRL Strategy in Cloud-Based Blended Approach*

SRL is a concept that promotes life-long learning, and is very suitable for preparing students for a future world in which information will be changing rapidly [25, 28]. It can be interpreted as an active process by which students set goals for their own learning as well as monitoring, controlling, and regulating their perceptions, motivations, and behaviors [49]. Following [23], SRL has been determined as the ability of an individual to self-modify behavior in such a way as to achieve a specific goal. It can be viewed as the process by which students adjust engagement with regard to functional skills in academic use. These advantages are especially to be found in online learning which is under the students' control [50]. The application of SRL techniques requires motivating students to maintain their interest and participation in learning [51].

There are three main strategies related to SRL that students can be trained to use: cognitive, metacognitive, and motivational strategies [13, 49]. As stated by [52], the constructive management of learning time is the chief component of self-regulation. Self-regulated students set relevant goals for themselves, and choose the appropriate task-related strategy. They then monitor themselves during the learning process. The framework of cognitive strategy involved in SRL has been applied to the teaching of various subjects over the past decades, including mathematics [53]. Other studies have suggested that SRL is significantly associated with mathematical problem-solving and reasoning abilities [25, 54]. The process of SRL suggested by [50] which was applied in this study consists of three phases: the forethought phase, the performance phase, and the self-reflection phase.

A blended approach or blended learning is a mode of learning that incorporates face-to-face classroom learning or offline meetings with online learning [18, 48]. The advantages of the blended learning model are as follows [1, 4, 14, 18, 55]: (1) It is a method for providing materials and ensuring learning communication. Both the preparation of the learning content and mathematics education take place online, (2) Traditional learning is not replaced by blended learning. Rather, it strengthens traditional learning methods by adding value to teaching materials and the use of educational technology, (3) The teaching materials used are independent of the classroom since instructors and students can access them anywhere, anytime.

As the online mode was one key environment for blended learning, LMS plays an important role in the quality of the blended approach as a source of learning, and the practice activities that should be available for students use [16, 56, 57]. In this view, Google Classroom and blended learning should therefore be able to be reciprocally favorable [22, 58].

For this study, a hybrid learning model and a SRL strategy were incorporated, with Google Classroom being used to support each main component of the learning process. The instructional component of Google Classroom [1, 59] incorporated SRL which served as framework in this study. Details are presented in Table 1.

Table 1. Google classroom based blended approach with SRL

Component	Subcomponent available for use	Aspects consistent with SRL
Stream	Site page, course information, link for meetings - the course features/course materials - learning resources	The forethought phase
Class work	- work creation - assignment - quiz	The performance phase
Person	Online student members - invitation to students to join the class Online instructor member - instructor invitation to join the class	The forethought phase
Scores	Select display of scores sorted by name or surname Viewing each assignment's score against the full score	The self-reflection phase

III. Materials and Methods

A. *The Research Design*

A quantitative approach was adopted in this study. The research design was quasi-experimental, using a pre-test-post-test control group design. The experimental group received a SRL cloud-based strategy as part of a blended approach. The control group were provided with a conventional face-to-face classroom approach.

B. Sample

The sample in this study comprised a total of 60 third year students who were enrolled in a Number Theory course at a public university in Thailand. They were selected using a random sampling technique. Both the experimental and the control group consisted of 30 students.

C. Procedure and Implementation

1) Procedure

A SRL strategy in a blended cloud-based approach was developed in terms of the following steps: (1) The study of the process of SRL, (2) Analysis and design of learning activities in line with the SRL phase according to [50], (3) Analysis of blended learning components, (4) Review of LMS, including analysis of the features and tools that are consistent with the designed learning activities, (5) Analysis of the concordance between the elements of LMS and SRL, and (6) Implementation of SRL strategy in a blended cloud-based approach through a selected LMS.

The LMS platform used in this study was Google Classroom. The preparation initially involved creating a classroom, done by considering the media and methods to be used in the blended model. The course materials (clips, videos, power point presentations, PDF documents, and additional learning resources or websites) were provided and uploaded. Fig. 1 shows an overview of an SRL strategy with a cloud-based blended approach.

2) Implementation of Google Classroom with an SRL approach

The instructional approach intervention used in each lesson was developed by merging the concept of a SRL strategy and LMS using Google Classroom-based blended learning. For this study, blended approach rotation models were employed. Enriched learning was included in the model, both face-to-face, and in terms of online materials. Online sessions were supported by course materials and asynchronous activities utilizing Google Classroom.

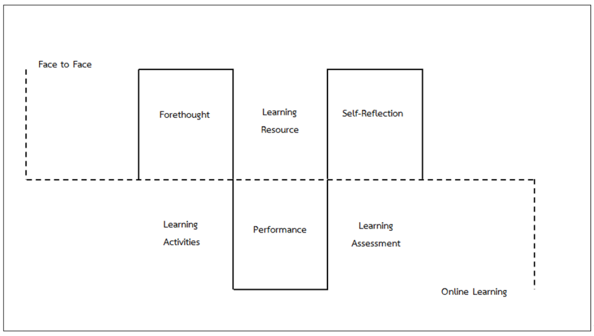

Fig. 1. Conceptual framework of a SRL strategy with a cloud-based blended approach.

The implementation of the SRL strategy in a cloud-based blended approach is presented in Table 2.

An entire semester was devoted to the experiment. At the beginning of the semester, the participants were given a pre-test of mathematical reasoning ability. The SRL process in a blended approach through Google Classroom was used in the case of the experimental class (see Table 2). Meanwhile, the control group received information in a conventional manner in the face-to-face classroom, with emphasis on the explanation of materials based on the textbook as well as exercises. In this approach, students do not practice finding their own ideas and they are less trained in reasoning. After completing the course, both groups were given the same post-test to evaluate their mathematical reasoning.

Table 2. The syntax of the SRL process in a cloud-based blended approach

Stage	Mode	Learning strategies and activities	Related tools based on the cloud
Forethought	Face-to-face mode	Planning - Worksheets are distributed for students to practice SRL. - Students set their own learning goals (sub-goals and final goals).	- Course Calendar - Worksheets - Learning resources
	Online mode	- Stimulating previous knowledge - Seeking information	- Link for meeting online through Google Classroom
Performance	Face-to-face mode	Implementation of the plan with class work - Analyze and create problem representatives - Formation and organizing learned things - Monitoring progress of plan. - Monitoring suitability and reasonableness of method used.	Performance support tools - Course portfolios
	Online mode	- Determine whether to proceed with solving problem or change to a new approach. - Presentation of students' viewpoints and implications of the outcomes.	Presentation tools
Self-Reflection	Online mode	- Determine whether there are other methods available and how different they are. - Evaluation of the correctness and how sensible the solution and implementation are.	Communication tools - Web board
	Face-to-face mode	- Reflecting and concluding.	Collaboration tools

D. Research Instrument

The instrument used for data collection were mathematical reasoning tests (pre and post-test) created by the authors. The topics assessed by these tests were included in the Number Theory course content. The test was subjective with a total of six items based on the following aspects: ability to analyze and identify relationships between data, draw conclusions or make predictions, together with the ability to reasonably confirm conclusions and forecast statements. The tests were revised based on the recommendations of education experts before being used on the sample. The item score for each aspect was 5, and the full score was 90. The tests were quality checked by using a difficulty level in the range of 0.38 to 0.80. The discriminative coefficient was in the range of 0.78 to 0.98, and a McDonald's omega reliability coefficient of 0.83 was obtained. Based on these results, the research instrument met the requirements.

E. Data Analysis

The scores obtained from the test of mathematical reasoning were computed by using descriptive statistics in the form of means and Standard Deviation (S.D.). In order to investigate whether there was an improvement in the students' mathematical reasoning ability, the average of the normalized gain (n-gain) score was calculated using the formula [60]: n-gain = (post-test score – pre-test score)/(maximum score – pre-test score). The criteria for interpretation of n-gain level are: n-gain < 0.3 – low, 0.3 ≤ n-gain ≤ 0.7 – moderate, and n-gain > 0.7 – high. To determine whether there are differences in the mathematical reasoning ability between the two groups, the authors compared their post-test scores using an independent t-test. The effect size was determined using Cohen's d [61].

To examine the significance of the findings, the prerequisites with regard to mathematical reasoning abilities were performed. The testing of normality was done using the Kolmogorov-Smirnov test, and homogeneity involved the use of Levene's test. The significance level (α) for hypothesis testing in the normal distribution and homogeneity test was 0.05.

The normality test of mathematical reasoning ability using the Kolmogorov-Smirnov test is shown in Table 3.

Table 3. The normality test of mathematical reasoning ability

Test	Group	Kolmogorov-Smirnov		
		Statistic	N	Critical value
Pre-test	Experiment	0.121	30	0.242
	Control	0.115	30	0.242
Post-test	Experiment	0.101	30	0.242
	Control	0.130	30	0.242

Table 3 presents the analysis of the Kolmogorov-Smirnov test for the pre-test, post-test for mathematical reasoning ability with regard to the experimental group and the control group. At the significance level of 0.05, there is not enough evidence to conclude that the distribution of scores is not normal. All the values of Kolmogorov-Sminov statistic of both groups are less than the critical value. Hence, the data used were deemed to be normally distributed.

The homogeneity test of mathematical reasoning ability was performed using Levene's test. The results are presented in Table 4.

Table 4. The homogeneity test of mathematical reasoning ability

Test	Levene statistic	df1	df2	Sig.
Pre-test	0.187	1	58	0.667
Post-test	0.086	1	58	0.771

Based on Levene's test, it was found that the significant values of 0.667 and 0.771 were obtained for pre-test and post-test, respectively, and both were above 0.05. Thus, the equality of variances met the assumption.

To verify the equality of the two groups, an independent sample t-test was deployed and the results are given in Table 5.

Table 5. The analysis of pre-test data for two independent groups

Group	N	Mean	S.D.	t	df	Sig.
Experimental	30	20.86	5.35	1.724	58	0.09
Control	30	18.57	4.93			

In Table 5, the differences between the mean scores for the pre-test of the experimental group and the control group are presented. The mean pre-test score of the experimental group was 20.86 while it was 18.57 for the control group. Based on the independent sample t-test, a t value of 1.724 was obtained, and the significance value was found to be 0.09 which exceeded the threshold (0.05). This implies that there is no significant difference between the mean scores of mathematical reasoning ability for both groups on the pre-test. That is, there was an equivalence in terms of the students in the two groups before the experiment. Random selection was at the class level, one class was selected as the experimental group and another one was selected as the control group.

IV. Results

The obtained data were analyzed to determine the impact of the SRL strategy with cloud-based blended approach among undergraduates in terms of mathematical reasoning ability.

A. Findings with Regard to Improvement of Undergraduate Students' Mathematical Reasoning Ability Using the SRL Strategy with a Cloud-Based Blended Approach

The analysis of the improvement level in terms of mathematical reasoning ability for the experimental group and the control group are presented in Table 6.

Table 6. N-gain score of students' mathematical reasoning ability according to learning approaches

Group	N	Mean	S.D.	Std. error mean	Interpretation
Experimental	30	0.75	0.10	1.36	High
Control	30	0.68	0.10	1.28	Moderate

The mean n-gain scores with regard to the experimental group and the control group were 0.75 and 0.68, respectively. Accordingly, the results indicate that the SRL strategy with a cloud-based blended approach improved the mathematical reasoning ability to a high level, whereas the conventional approach enhanced the mathematical reasoning ability to only a moderate level.

B. Findings with Regard to Differences in Mathematical Reasoning Ability between Groups

The differences between the post-test scores of the two groups were assessed by an independent sample t-test and are as shown in Table 7.

Table 7. The analysis of the mean scores with regard to mathematical reasoning ability for the post-test scores of the experimental and control groups

Group	N	Mean	S.D.	t	df	Sig.	Effect size
Exp.	30	64.20	6.95	2.567	58	0.013*	1.29
Cont.	30	59.56	6.02				

Note: $*p < 0.05$

Table 7 presents a comparison of the two groups in terms of the mean score for the post-test using an independent sample t-test. It was found that the experimental group's mean post-test score was 64.20, while that of the control group was 59.56. The t value is equal to 2.567. The significant value was 0.013 < 0.05. This indicates that there was a statistical difference in the mean post-test scores between the experimental and the control groups at the 0.05 level. The effect size measured by Cohen's d was 1.29, which indicates a big difference. Consequently, it was considered that the students in the experimental group had significantly higher mathematical reasoning ability than those in the control group. The proposed intervention is likely to indicate an enhancement of mathematical reasoning ability on the part of the experimental group.

V. Discussion

Using a SRL strategy involving a cloud-based blended approach, the mathematical reasoning ability of undergraduate students was investigated in terms of both pre- and post-testing. The study showed that an improvement of mathematical reasoning ability on the part of students who used a SRL strategy involving a cloud-based blended approach was at a high level, whereas the control group improved only moderately. This is in accordance with the findings of [46] in terms the availability of online learning facilitates, the ability of students to survey information, analyze different perspectives with regard to mathematical situations or issues, confirm their findings based on supporting theories, mathematical definitions, rules and principles in such a way as to arrive at appropriate conclusions [28, 40]. In the initial phase of learning, the previous knowledge of the students was explored. Preparation involved the studying of various pieces of information related to the content of the lesson in order to create solutions to problems or situations that they received. Moreover, presenting a clear conclusion to a mathematical problem requires a causal interpretation [35]. Regarding the role of LMS, another study revealed that the development of learning skills results from the application of flipped model supported by Google Classroom [31]. The finding also corresponds to those of [4], who found that learning motivation and scientific critical thinking skills were improved by a blended learning model using Edmodo. The finding implies that LMS can serve as a cloud material resource to give assistance to students when it comes to employing their experiences in terms of practicing reasoning skills in interesting and unfamiliar situations [45]. Chances for practicing reasoning in mathematics are also provided [13]. The findings imply that incorporating an SRL strategy supported by the cloud as part of a blended approach helps students to improve their mathematical reasoning ability.

From the analysis and interpretation of the results, there was a significant difference in students' mean post-test scores with regard to mathematical reasoning ability in the experimental group using an SRL strategy with a cloud-based blended approach and a control group using conventional learning. The enhancement of students' mathematical reasoning abilities following the intervention was shown to be better, with a large effect size. We account for this finding for the following reasons. The employment of appropriate learning materials as part of the learning strategy and process is an approach that can enhance students' reasoning abilities [6]. Not all educational media or learning technologies can be utilized to increase students' mathematical reasoning abilities, but activities that support cooperative learning must be used. When students organize their learning in this way, they will create a deeper understanding of the mathematical content, in terms of reasoning as well as demonstrating improved achievement [27].

In this study, using a blended cloud-based approach in a Number Theory course that focused on proving related theories, involving activities in which students encountered problems in a SRL environment. The ease of the utilization of Google Classroom for students' presentations helped facilitate the students' learning process [1]. The presentation of perspectives with regard to problems that require interpretation that must be supported by definitions, principles and reasons, had the effect of increasing students' reasoning abilities [16]. In addition, allowing them to express their ability to identify relationships among relevant concepts associated with the problem was an indicator of their ability to reason and to relate such reasoning to the knowledge contained in the cognitive structure in such a way as to allow them to arrive at a conclusive solution. This will help to increase the self-confidence of students when it comes to developing their ability in terms of mathematical reasoning [6]. Based on the analysis, the blended learning model using an SRL strategy in a cloud learning platform can be used to create a learning environment that encourages students to actively think logically in mathematical terms something that is not necessarily the case using a conventional approach. This finding is consistent with those of previous studies [27–31].

This study suggests that using a SRL strategy with a cloud-based blended approach encourages student engagement and enhances their mathematical reasoning ability. It was observed that the online learning mode involving a blended approach may not be suitable for some students who are unfamiliar with the use of educational technology tools. However, the study was limited to a study of third-year mathematics students and a particular context.

VI. Conclusion

In this study, the use of SRL with cloud facilities involving a blended learning was proposed. An experiment was carried out to gauge the performance of the proposed approach in terms of enhancing students' mathematical reasoning. Overall, the proposed approach had a positive effect on students' mathematical reasoning ability.

The findings endorse the use of mathematics instruction adapted for cloud matching in preference to the cognitive process. From all the findings we conclude that leveraging the available resources with regard to cloud services within the mathematics learning community enriches students' learning experiences. Rather than simply providing information to students through passive teaching, instructors are now encouraged to act as facilitators in order to assist students' SRL. Interested educators may apply the results of the analysis to develop an approach to promote the quality of mathematical reasoning in the context of higher education. They may be used in future research as a guideline for similar studies in other subjects involving the use of self-regulated strategies combined with other LMS, as well as the development of tools to measure mathematical reasoning ability. Future studies, possibly qualitative in nature, on the level of student satisfaction in the experimental group and the control group may be included. The analysis of special scores for students who can analyze the missed problems and link to the lecture part, and who are able to create a new problem similar the one that was missed on the exam and solve it, may also be considered.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

BC conceptualized the study, conducted the research, collected and analyzed crucial data, and wrote the paper; AA drafted the literature review, validated data accuracy, designed conceptual visualization, revised and edited the manuscript. All authors had approved the final version.

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