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The Integration of Web-Applications and Collaborative Learning in Mathematics for Grade Five Bhutanese Students

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Abstract: The purposes of this research are follows: (1) to assess the learning achievement in mathematics among Grade Five Bhutanese students using web-applications and collaborative learning; and (2) to examine the perception of Grade Five Bhutanese students towards web applications and collaborative learning in mathematics. The study was conducted in the 2022 academic year in a lower Secondary school in Bhutan. The population consisted of 31 Bhutanese students from one section of Class Five and they were selected using the cluster random sampling method. This paper presented a mixed-method study incorporating both qualitative and quantitative studies. The research instruments consisted of lesson plans, learning achievement tests (pretest and posttest) and semi- structured interviews. For the quantitative data, learning achievement tests (pretest and posttest) were used and further analyzed using a Paired Sample t-test. The analysis revealed that the mean score of the posttest (14.44) was higher than the mean score of the pretest (10.24) with a mean difference of 4.20. The significance value (p) was also revealed as .01, indicating a statistically significant rise in the posttest scores of the research participants over the pretest scores. Regarding the qualitative data, it was analyzed with semi- structured interviews and conducted on the sample group by dividing the students into six groups. The data collected from the interviews included enthusiastic and motivated responses from the students, revealing positive perception used by the researcher towards intervention in learning mathematics. Thus, all of these findings demonstrated how the integration of web-based applications and collaborative learning in mathematics improved the learning achievement and the perceptions of the students.

Keywords: Web applications, Collaborative learning, Learning achievement, Learner's perception

Introduction

Education is a top priority for all nations in the modern world in the twenty-first century, and Bhutan is no exception. Bhutan, despite having three key divisions in its educational system, namely (1) general education; (2) monastic education; and (3) non-formal education. General education is widely recognized as formal and the most important educational unit. His Majesty the Fifth King of Bhutan wants the children to receive a world-class education, which is both meaningful and supports getting better jobs for improved living (The Druk Gyalpo, 2021). The world has changed and so have the demands of the educational system. The education system today aims to keep up with technological advancements. There are many researchers studying how to improve education with technology for the benefit of students to learn and be capable of contributing towards the development and globalization of the country. According to Lhendup (2020), technology has the potential and opportunity to enhance access to quality education, created employment opportunities, supported good governance through effective and reliable service delivery, developed and strengthened the private sector, and improved accountability and transparency. As stated by the American University School of Education (2020), technology allows quick access to knowledge, rapid learning, and exciting opportunities to apply, and practice what has been learned. This is particularly true for STEM (Science, Technology, Engineering and Mathematics), as students can go deeper into challenging ideas and exploring a set of concepts and be able to acquire the 21st-century technical abilities required for future careers through its use, both inside and outside the classroom. This indicates that mathematics is also one of the most important subjects and can help to develop the skills of the students, which can be benefitting for their future careers.

In Bhutan, mathematics has always been one of the important subjects apart from Dzongkha (the national language of Bhutan) and English (Drukpa, 2015). According to the Importance of Mathematics (2015, as cited in the Role of Mathematics, n.d). Mathematics is an important component of human logic and intellect, which contributes to comprehending the world and ourselves. Thus, it makes learning mathematics a great approach to developing mental focus, logic, creativity, abstract or spatial thinking, critical thinking, problem-solving skills, and even effective communication. There are numerous other benefits of focusing on Mathematics in particular. The economic growth of the country along with computer programming and data analysis is also dependent on mathematical skills. If the educational sector is provided with an efficient teaching method by integrating technology in learning math, it will be a logical match given the importance of visuals and a quick response in the process of learning and strengthening the mathematical skills. Considering the significance of the subject and its ability, the students must enhance their mathematical skills because it indicates a greater influence on self-development as well as future employment. Despite the importance of the subject, an unfavorable emotional pattern is emerging among students regarding the unpopularity of mathematics (Gotz, 2012, as cited in Summer, 2020). This is in line with Dorji and Tshering (2020) stated that the tests conducted in Bhutan by the Program for International Student Assessment Development (PISA-D) and the Bhutan Council of Secondary Education (BCSEA) in 2017 and 2019 found that there was a poor performance in mathematics. It was also found that the curriculum was so restrictive that students from grades 4 to 12 shared their views on being unable to use a variety of methods to solve problems, which made the subject rigid and prescriptive. This also led them to believe that the curriculum was linked to assessments that are intended to admit students to higher grades or only to obtain a job.

According to Dolma (2016), after a review of the mathematics curriculum by a Bhutanese counterpart team and Canadian consultants, the Ministry of Education began to construct the new framework for the mathematics curriculum from grade PP to grade 12 in 2005. The Royal Education Council (REC) also revised the mathematics text books for Classes PP to VI with compliance to National Curriculum Conference 2016 (Cheki, 2018). The Department of Curriculum and Professional Development (DCPD, 2022), also had developed the new Mathematics curriculum Framework 2021 with the goal to encourage learners with a mathematical mind-set and skill-set, vital for the development of competent mathematician, statistician and data scientist citizens. Later, with the pandemic in progress, the Royal Education Council (REC, 2021) framed a New Normal Curriculum to create opportunities and learning experiences for students. With the new system in place, students and teachers were provided with a new platform of teaching and learning that encouraged them to learn and explore more about technology. Additionally, today's students are digital natives with a strong interest in technology, so if the lessons are taught using technology, it will result in more innovative approaches to teaching and learning. As claimed by Baleni (2016), students often utilized the internet, social media, and mobile technology, which indicated that the conventional teaching methods are almost obsolete and their expectations reflected the modern global needs of the students. Moreover, as stated by Tsuei (2012), the use of technology encourages interaction with virtual manipulation, which increased mathematical thinking by teaching students with the problem-solving process. Additionally, it has given the students a platform that allows them to feel more at ease, focus more clearly, have enough time to look for new ideas or solutions, and enhance the technological skills, showing that teaching mathematics through technology helps the students in maintaining motivation. As a result, the researcher has integrated web-applications and collaborative

learning in mathematics to investigate the efficacy of technology to improve the learning achievement of the students and fostering positive perception towards the use of the strategies and the subject. Specifically, the researcher used Google Slide and Slido as tools in collaborative learning. According to Ahmad, Hamzah and Rohanai (2020), Google Slide is a presentation program that offers engaging visual presentation and allows collaborative work on presentations. Slido is an online platform, which when linked with the Google Slide presentation, can make a lesson interactive through a live poll, a quiz poll and audience questions and answers (Holub, 2020). Google Slide allows an instant display of the responses submitted by participants through the Slido platform. Using this platform, the students can learn collaboratively and as a result they can discover an excitement in learning, which can build both their knowledge and confidence. The research objectives of the study were as follows: (1) to assess Grade Five Bhutanese students towards learning achievement in mathematics using web applications and collaborative learning; and (2) to examine the perception of Grade Five Bhutanese students towards web applications and collaborative learning in learning mathematics. Therefore, through the use of web applications and collaborative learning, the researcher was able to facilitate the students in acquiring content and learning information, including the delivery of various material contents, concentration, and management of learning experiences, which motivated students to improve their learning achievement and perception of a subject. Finally, given the efficiency and effectiveness of the strategy, teachers will also have a new alternative to improve the academic progress of students and fostering a positive attitude towards the subject.

Conceptual Framework of the Study

The researcher included independent and dependent variables. The independent variable in this study was the integration of web applications and collaborative learning, whereas the dependent variables were the learning achievement of students, as well as the perception of the students towards web applications and collaborative learning. Figure 1 shows the illustration of the conceptual framework of this study.

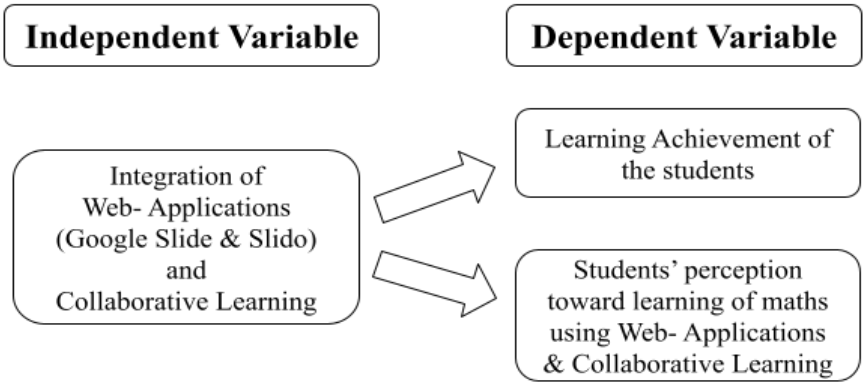

Figure 1 Illustration of the Independent and Dependent Variables

Teaching Framework of Web Applications and Collaborative Learning Setting

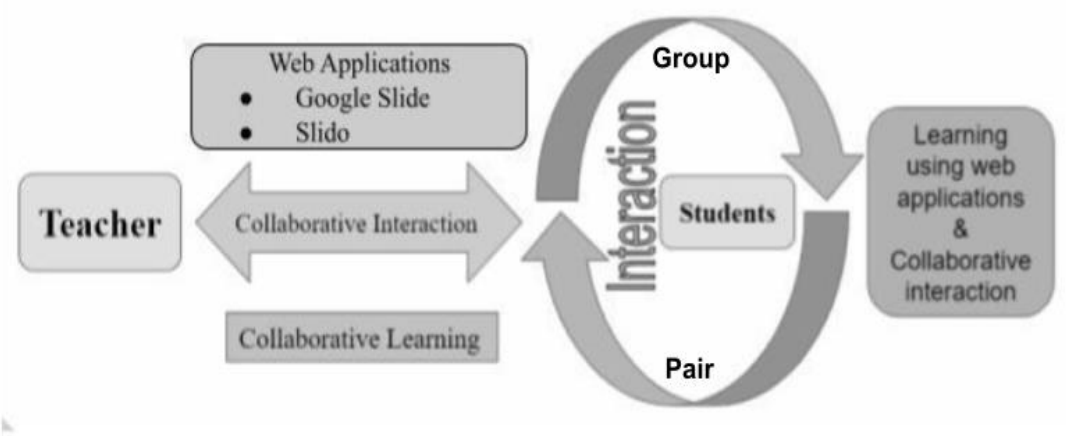

Figure 2 Framework of Web Applications and Collaborative Learning Supported Environment

Figure 2 illustrates the framework of teaching mathematics integrated with web applications and collaborative learning. The researcher used two web applications: (1) Google slides and (2) Slido, an interactive learning platform used for presentation, collecting responses and having students work collaboratively. According to Al-Samarraie and Saeed (2018), these platforms helped users to develop their competencies and improved perception of their ability to engage in collaborative activities. This was because Google Slide allowed users to work collaboratively through access to the same presentation slides, which made it highly effective for collaborative projects. Therefore, researchers of collaborative classroom setting presented lessons on the topic of decimal computation using Google Slide and made it interactive by posing questions and compiling responses through Slido. Slido was another platform that allowed users to instantly provide responses, and since it was linked to Google Slide presentations, the responses instantly displayed on presentation slides as anonymous responses. Furthermore, for improved learning and understanding of the concepts, the researcher also provided students with class activities and assignments either in groups or in pairs, which they were given to do in Google Slide.

Research methodology

This study was conducted using a mixed methodology that included both the qualitative and quantitative approach. According to Sahin and Ozturk (2019), a mixed method is used to investigate the gaps in the literature that cannot be answered by a single method and may provide a better understanding of the research problem. The researcher applied mixed methodology mainly to gather the in-depth findings on the information for the study. The research design of the study is illustrated in Figure 3 below.

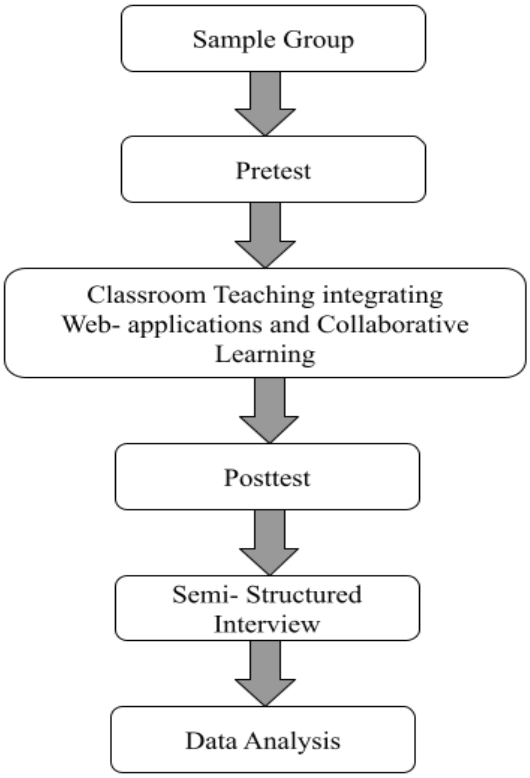

Figure 3 Illustration of the Research Design

Sampling: The study was carried out in a lower secondary school, which consisted of grades PP-VIII. The school was located in the southern foothills of Bhutan. There were four sections of grade five and one section was selected through a clustered random sampling method executed using the lucky dip method. The selected grade was 5 'B' consisting of 31 students, who were the research participants of the study. The students were of mixed ability, ranging from 10 to 12 years of age.

Research Instruments: The researcher used three different research instruments to collect the data. The instruments were four lesson plans, learning achievement tests and the semi-structured interview, which were used for both quantitative and quantitative data.

Lesson Plans: A total of four lesson plans were prepared by the researcher for the chapter 'Decimal Computation' in mathematics by integrating web applications (Google Slide and Slido) and collaborative learning. This chapter included four subtopics, and each lesson plan was designed to last for 90 minutes. However, each lesson plan was used for two sessions, and each session lasted for 45 minutes. Therefore, the researcher taught the lessons to the research participants in eight sessions and the study was completed in four weeks.

Learning Achievement Tests: The learning achievement test, developed as a pretest and posttest, were used to collect the quantitative data for the study. The mandates of Bhutan education framework, as described by the REC and the Bhutan Council for School Examination, served as the basis for developing the achievement test questions. The learning achievement tests consisted of 20 marks and the questions that were subdivided into 10 marks for the multiple-choice questions, five marks for the true/false questions and five marks for the short answer questions. The pretest was completed before the introduction and

implementation of lessons integrated with web applications and collaborative learning, whereas the posttest was completed following the implementation of the intervention. Both the tests were administered to the same set of participating students and compiled for further analysis.

Semi-structured interviews: A semi-structured interview was developed to gather qualitative data of the study. After the intervention, a face-to-face interview was conducted with the research participants in the groups. There were six groups formed by providing the numbers 1 to 6 randomly and grouping them by number. The purpose of this interview was to discover their thoughts, feelings and their beliefs about learning mathematics integrated with web applications and collaborative learning. Five questions were asked during the interview, and each group was provided with approximately 10 minutes to respond. The students had the choice of speaking in English or Dzongkha (their mother tongue), which was audio recorded by the researcher during the interview. The researcher later transcribed their responses and analyzed the data and using a process called thematic analysis.

Validity: The research instruments (lesson plans, learning achievement tests, and semi-structured interview questions) were validated by the three experts, including a professor from a university in Thailand and two experienced Mathematics teachers from Bhutan. Item Objective Congruence (IOC) was used to determine the validity of the instrument, which helped to determine whether the items were aligned with the research objectives. The accuracy and acceptability of the test item value was between 0.67 and 1.00, which was calculated using the statistical formula. All the instruments for this study were validated and rated +1, which indicated that the items were valid for the study.

Reliability: The reliability test was administered to Grade Six students studying in the same school. It was carried out to determine the reliability of learning achievement tests. There were 31 students and the questions consisted of 20 marks from the Grade Five mathematics chapter, ‘Decimal Computation’, which included 10 marks for the multiple-choice questions, five marks for the true/false questions and five marks for the short answer questions. The test was done prior to the experiment with the intervention and the data gathered from the learning achievement test was calculated using Kuder-Richardson formula (KR-20). The coefficient obtained for the test using KR-20 was 0.77, which was greater than 0.70. This result indicated that the test items were reliable.

Research Results

The lessons were developed for Grade Five students integrating web applications and collaborative learning in mathematics. The researcher taught one of the chapters on the topic of 'Decimal Computation' from a Grade Five mathematics textbook, which contained four subtopics. The lesson consisted of presentations, using Google Slides, interactive question-and-answer sessions, which they responded to individually, in pairs or in groups and using Slido. Also, there were other classroom activities and assignments set for students to be carried out in pairs or in groups using Google Slide. These activities were all prepared for online collaborative learning using the web applications. After integrating the intervention, the data were collected and analyzed under two categories:

1. Analyze the test scores of the research participants to examine the effect of using the web application and collaborative learning on student achievement in learning mathematics.

2. Thematic analysis of semi-structured interviews to examine and to determine the perception of students on the integration of web applications and collaborative learning in mathematics.

Data Analysis of the Learning Achievement Tests of the Students

The data provided in the pretest and posttest indicated that the posttest scores were comparatively higher than the pretest scores, which indicated that there was a significant improvement in the mathematical ability of students after integrating web applications and collaborative learning in mathematics. As per the data of the learning achievement test scores, the lowest and highest pretest scores were 4 and 17, respectively, whereas in the posttest, the lowest and highest scores were 8 and 19, respectively. Their pretest scores were comparatively low since they predominantly used the traditional method of learning mathematics, but following the intervention they were provided with greater opportunities allowing them to learn by exploring. Furthermore, the comparison between pretest and posttest scores also showed the highest difference of 13 points and the lowest of 1 point, which indicated improvement in learning achievement among students either way, due to the integration of web applications and collaborative learning in mathematics. It is further illustrated in the pie chart in Figure 4 by categorizing the students based on each score difference between the pretest and the posttest.

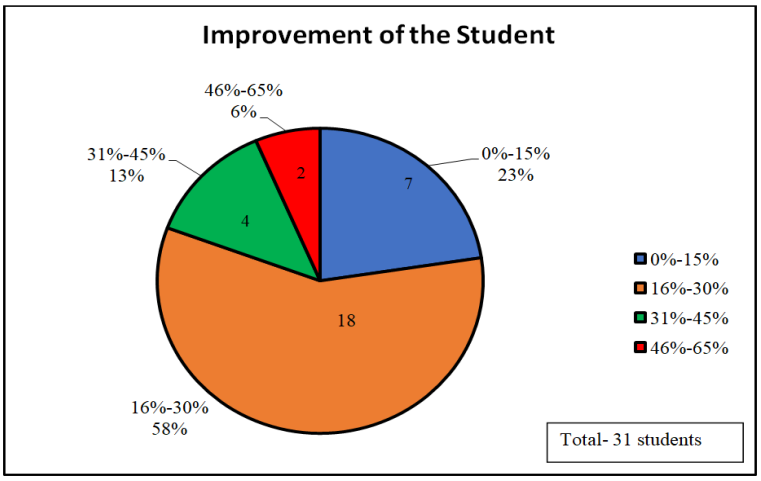

Figure 4 Number of Students and Score Difference

Figure 4 above demonstrated that among 31 students, seven students or 23% of the total number of students scored a difference of 0-15% in the posttest than the pretest, indicating the minimum increase of posttest score compared to other students. There were two students, equaling 6% of students, who secured 46%-65% more in the posttest than in the pretest, which showed the maximum increase of score in the posttest. Overall, the largest score difference between the pretest and the posttest was 65% increase secured by one student with the lowest of 5% increase in posttest secured by one student.

The learning achievement data were also further analyzed using a paired sample t-test to show the descriptive statistical analysis for the achievement test scores of the sample group, as presented in Table 1.

Table 1 Comparison between Pretest and Posttest in the Sample Group

Group	Pretest		Posttest		Mean Difference	t	P – value
	M	SD	M	SD			
Sample Group	10.24	3.04	14.44	3.15	4.20	-8.66	.01

According to Table 1, the mean score for the pretest and the posttest were 10.24 and 14.44, respectively. The data shown in the table clearly indicated that the posttest mean score of the sample group (M= 14.44) was higher compared to its pretest mean score (M = 10.24) and the mean difference was 4.20. Thus, the greater the mean score of the posttest and the pretest, and the integration of web applications and collaborative learning was efficient and effective. Additionally, the p-value shown was .01, which also indicated the significance of the test. The standard deviations of the pretest and posttest were 3.04 and 3.15, respectively.

Data Analysis of Semi-Structured Interviews

The interview was conducted on the research participants after the intervention. The main aim was to compile the information on the perceptions of students toward the use of web-applications and collaborative learning in mathematics. The data collected from the semi-structured interview were analyzed using thematic analysis with five themes: (1) Past Experiences; (2) Enjoyment; (3) Sense of Achievement in Learning Concepts; (4) Learning Experiences with Intervention; and (5) Interest and Motivation for Learning. According to the data, most of the students remarkably provided positive and satisfying responses.

Past Experiences: For students, learning was encouraged mostly in a classroom setting and most of the activities were too similar to conventional methods. The learning activities provided to the students were mostly individual and though there were activities given for cooperative learning, they mostly ended up providing little understanding of these concepts. Therefore, when the researcher used web applications and collaborative learning in a classroom setting, it was a new learning experience. One of the groups shared their past experiences:

"Our teacher mostly taught us using chalk and chalkboard, where he demonstrated with the examples for few times and then we were given to do the activity ourselves in the class or as homework." (Group 2)

"We have learnt by doing our activity using the cooperative method, but it was not online and we had to catch up with the group later after school hours. It was difficult since some of the members were living far from each other". (Group 6)

Enjoyment: When the web-applications and collaborative learning were integrated in their learning of mathematics, doing tasks collaboratively helped students build confidence and actively took part in the activities by being able to inquire about the lesson with their friends or the researcher. It also encouraged the students to connect with each other by learning to interact using the web applications, leading to better understanding of the concept and completion of the collaborative tasks. The students commented:

"We enjoyed the opportunity to digitally interact with our friends by doing the pair and group work. We are able to also do the edit and make the necessary corrections online together". (Group 2)

Sense of Achievement in Learning Concepts: Getting access to learn collaboratively using web applications provided them a platform to learn through interaction and helped them by being able to support each other for better understanding of the concept or the tasks. Some of the other groups said:

"The application helps us do the work faster and we get enough time to collaboratively do necessary editing and correction". (Group 3)

"As we use the applications online, even if we have any doubts, we feel comfortable to ask our friend since we get use to learn together by helping each other in groups or in pairs". (Group 4)

Learning Experiences with the intervention: Learning mathematics using web applications and collaborative learning was a new experience for the students. Using Slido to respond anonymously and with no worries of feeling low made them confident to actively participate. Moreover, using Google Slide helped them explore tasks collaboratively, which made it easier for them to understand their work and do the work comfortably. This was made possible because they can interact, update and also made the necessary corrections online.

"It seemed difficult at first but we got used to it and then our learning using it became simpler and easier. We were able to share our presentation with our friends and were able to help each other in the learning process". (Group 1)

Interest and motivation for Learning: Integrating web applications and collaborative learning in mathematics had created an excitement, which had motivated the students to learn mathematics. The data collected through the interviews showed how encouraged and attracted they were towards learning mathematics with the new intervention. Furthermore, it had also developed an interest among the students and motivated them for more learning.

"We would also want to learn other topics through the use of web applications and collaborative learning because it doesn't restrict us to learn alone but learn together by sharing and assessing our work together. (Group 2)

"Using these web applications can help us learn and understand the lessons better because if we face any doubts on any of the slides or topics in the presentation slides, then we can directly contact our friends or teachers online. Therefore, it made us like studying that lesson better". (Group 3)

Thus, analyzing the results from the learning achievement test and their interviews, the integration of web applications and collaborative learning in mathematics also had a positive impact on the learning achievement among Grade Five students, which also added to building positive perception towards the learning mathematics with integrated intervention.

Discussion

This research study aimed to investigate the learning achievement of students in mathematics along with their perception towards learning mathematics using web applications and collaborative learning. Accordingly, the findings of the study showed that this intervention had a positive impact on learning among students and were considered effective in developing a positive mindset towards the intervention and the subject. Moreover, by the end of learning mathematics with these new interventions, the students reported that they were able to understand the concept clearly and doing work collaboratively was also very easy, enjoyable and motivated for them to learn. They also appeared to have gained confidence in learning, whereby they were able to either seek help or provide support

to their peers, which further helped them in strengthening their knowledge. These findings were consistent with the previous study made by Edwards (2021), which stated that the integration of Slido into Google Slide presentations provided students with an opportunity to witness the immediate opinion or insights of the questions they responded to and also inspired interactive ideas, which motivated them to participate actively to completely understand the subject. In addition, as stated by Lin and Jou (2013), students had more in-depth discussion and insights during each learning activity (both before and after class) in a web-based learning environment, which effectively and efficiently led student learning levels and viewpoints, especially for the more introverted students. For further justification on the findings of the study on learning of mathematics integrated with web applications and collaborative learning, the advantages were broadly explained under the two following headings: the learning achievement and learning perceptions of students.

Student Learning Achievement

According to McLeod (2018), integrating web-based learning had a significant impact on the learning abilities of students because it was through learning strategies, group discussions and group interactions that students performed better academically. In this study, integrating web applications and collaborative learning also strengthened the learning achievement of Grade Five Bhutanese students because it fostered the stronger relationship and collaboration in the classroom due to a great level of connectedness, whereby students were able to learn the new subjects and communicate their ideas more swiftly. It was apparent that the students had improved their learning achievement. Their posttest result was significantly higher mean scores ($\bar{x}$ 14.44) than the pretest means scores ($\bar{x}$ 10.24) and the mean difference was 4.20. Then, the two-tailed significant value was .01, which indicated that the intervention was an effective approach to improve the learning achievement of students. This was due to the collaborative activities, they inculcated the skills to communicate and interact with their peers for learning, which was further attributed to instilling core skills, acquiring more knowledge and achieving goals indicating the effectiveness of integrating web applications and collaborative learning in mathematics.

Learning Perceptions of Students

The integration of web applications and collaborative learning in mathematics was perceived positively by the students as well as creating a sense of contentment. The data on this was collected by face-to-face interviews in groups and the students were given the opportunity to share their opinions in any language that they were comfortable with, which was then transcribed by the researcher for further analysis. The students reported that learning mathematics with these interventions was so engaging and motivating for them. They were also so excited to use the web applications and had exhibited interest in learning mathematics, which resulted in active engagement and a clear understanding of the concepts. It was found that the students had experienced this way of learning as motivating, since the use of the Google Slide has simplified their work because they could share their slides with anyone and could seek necessary help for better learning and achievement. This had also built a sense of confidence in students for their knowledge acquisition by working collaboratively with their peers and members. According to the Department of Professional and Curriculum Development (2022), web-based technology was able to improve the comprehension of the concept using the visuals, simulations, representation and further

progressed in knowledge building through communication and interactive learning with peers at their own pace. Additionally, the Ministry of Education et al. (2021) reported that 74.48% of the student respondents enjoyed and appreciated the effectiveness of being engaged in learning online. The positive reports from the research participants and the previous researchers indicates that the integration of web application and collaborative learning had a positive impact on both the learning achievement of the students as well as their perceptions towards the interventions and the subject.

Conclusion

The findings from the study on the integration of web applications and collaborative learning in mathematics for Grade Five Bhutanese students revealed a positive implication in its practice and learning for these students. Since these students were enthusiastic about the use of technology, they were likely to participate in an engaging learning environment, which directly provided them with more opportunities for communication and collaboration to apply their higher-order thinking skills and problem-solving skills in practical terms. Nevertheless, these inventions in practice for learning may lead to self- development and that of society in general. Also, in case of a pandemic and if schools have to close, education can be continued with online learning, then these web applications may provide a useful online learning platform for the teachers and students. Hence, due to the effectiveness of integrating these interventions, any interested teachers may provide a better learning environment according to the demands of the contemporary world and to enhance the learning achievement of the students in other aspects of mathematical content as well.

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