



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 8, August 2025

Effect of E-Learning and Blended Learning on the Content Knowledge and Problem-Solving Skills in Mathematics

Leal, Jonathan P.¹, Parce, Susan O.²

Dean, College of Teacher Education, Filamer Christian University, Inc. Roxas City, Capiz, Philippines¹

Department Head, Secondary Education, Filamer Christian University, Inc. Roxas City, Capiz, Philippines²

ABSTRACT: The integration of e-learning tools and blended learning in mathematics education was especially advantageous for students during the pandemic. These approaches were used together to support preservice teachers in grasping mathematical concepts and honing their problem-solving abilities. This quasi-experimental research design aimed to determine the effect of e-learning and blended learning on the content knowledge and problem-solving skills in mathematics of preservice teachers for the 2021-2022 school year. The study involved 33 college students assigned to the experimental group and 22 college students placed in the control group. Data were collected using researcher-made content knowledge and problem-solving tests. The findings revealed that the experimental group began with very low pretest scores but showed significant improvement in both content knowledge (moving from very low to low) and problem-solving skills (moving to average). Similarly, the control group started with very low scores but showed even greater progress, reaching an average level of content knowledge and a high level of problem-solving skills. No noticeable difference was found in content knowledge in the pretests of the experimental and control groups. Additionally, no significant difference was observed in problem-solving skills between the two groups. There were no significant differences in post-test content knowledge or problem-solving skills between the experimental and control groups. However, significant differences were found between the pretest and posttest results of both the experimental and control groups in terms of content knowledge and problem-solving skills in mathematics. There was a very large negative effect size, indicating a significant difference between the two groups, suggesting that the blended learning group demonstrated considerably higher content knowledge and improved problem-solving skills compared to the e-learning group.

KEYWORDS: E-Learning, Blended Learning, Content Knowledge, Problem-Solving Skills

I. INTRODUCTION

The COVID-19 pandemic greatly impacted education, shifting teaching to remote learning through digital platforms. E-learning, as defined by [1], is an online practice utilizing the internet and technology for synchronous or asynchronous learning, accessible from anywhere. This approach supports learner-centered, interactive, and well-designed environments, promoting flexible learning opportunities [2]. Blended learning, which combines traditional face-to-face instruction with online learning, also enhances teaching by allowing teachers to present more content and improve student engagement [3] and [4].

In mathematics education, which is critical for national development, e-learning and blended learning were particularly beneficial during the pandemic. These methods helped preservice teachers better understand mathematical concepts and develop problem-solving skills. Effective teaching, which depends on both content knowledge and pedagogical skills, was shown to have a greater impact on student performance than prior academic records [5]. Teachers with strong content knowledge and the ability to use diverse teaching methods contributed more to student success [6] and [7].

Despite mastering mathematical concepts, students faced difficulties in problem-solving, particularly with multi-step and word problems. Challenges such as misconceptions, poor procedural skills, and trouble translating problems into mathematical terms led to incorrect answers [8] and [9]. The real value of mathematics lies in its application, requiring critical thinking and problem-solving skills, which students struggled to develop.

This study was designed to investigate the effect of e-learning and blended learning on the content knowledge and problem-solving skills in mathematics of college students for the school year 2021-2022. Specifically, the study sought to answer the following questions:

1. What is the level of content knowledge and problem-solving skills in mathematics in the pretest and posttest of the control and experimental groups?
2. Are there significant differences in the content knowledge and problem-solving skills in mathematics in the pretests of the control and experimental groups?
3. Are there significant differences in the content knowledge and problem-solving skills in mathematics in the posttests of the control and experimental groups?
4. Are there significant differences in the content knowledge and problem-solving skills in mathematics in the pretests and posttests of the control and experimental groups?
5. What is the effect size of e-learning and blended learning on the content knowledge and problem-solving skills in mathematics?

II. RELATED LITERATURE

E-learning, using ICT like websites and mobile devices, enhances education by offering flexible, student-centered learning, breaking down barriers and allowing self-paced learning, especially in developing countries. It has been shown to improve teaching quality and student performance, with digital methods often outperforming traditional approaches [10] and [11]. Many higher education institutions are adopting e-learning, though unequal access to technology remains a challenge [12]. When implemented well, e-learning boosts engagement and prepares students for a globalized world [13].

Blended learning combines traditional teaching with e-learning, offering flexibility, reducing costs, and enhancing access to updated content. It requires diverse teaching methods and teacher expertise but faces challenges such as a lack of computer skills, inconsistent tech access, and a shortage of qualified staff. Despite these, studies show blended learning improves student achievement in subjects like biology, English, and science [14] and [15].

In math education, teachers' content and pedagogical knowledge (TCK & TPK) significantly affect student performance. Effective teachers with strong knowledge and teaching skills can close achievement gaps, and teacher quality is a greater determinant of student success than prior knowledge or the school attended [5]. However, many math classrooms remain teacher-centered, limiting critical thinking and engagement [16]. Despite its importance, research on the direct link between teacher knowledge and student performance in math is limited [7].

Problem-solving, a key cognitive skill, involves both computational abilities and metacognitive strategies. Many students struggle with applying math concepts in real-world scenarios, particularly word problems, due to language comprehension issues, poor procedural skills, and misconceptions [17] and [8]. To improve, students should be encouraged to tackle non-routine problems and follow structured problem-solving strategies. However, teaching these skills is time-consuming for educators, and students often lack interest in problem-solving, indicating a need for improved instruction [18] and [19].

III. METHODOLOGY

The study employed a quasi-experimental research design. The participants were categorized into control and experimental groups. A total of 33 college students were assigned to the experimental group (use e-learning), while 22 college students were placed in the control group (employ blended learning). To ensure valid comparisons between the groups, the participants were matched based on their general weighted average grades from the first semester. The data collection was carried out in three phases. In the pre-investigation phase, the researcher developed learning tasks and modules on topics such as interest, central tendency, and sampling procedures. Content knowledge and problem-solving tests were created, pilot-tested, and revised, then administered through Google Forms. Random groupings were also prepared at this stage. During the investigation phase, the experimental group was exposed to e-learning, while the control group used blended learning. Both groups were oriented and took a pretest. The control group used a module with online teacher support, while the experimental group worked with online tasks without a module. After completing the tasks, both groups took a posttest. In the post-investigation phase, the pretest and posttest data were entered into SPSS for analysis. Inferential statistical tools were applied to examine the differences in the results,

addressing the study's research questions and hypotheses, with the findings presented in tables and text for interpretation.

IV. RESULTS AND DISCUSSION

A. Content Knowledge and Problem-Solving Skills in Mathematics Based on the Pretest and Posttest of the Control and Experimental Groups

The level of content knowledge and problem-solving skills in mathematics, based on the pretest and posttest of the control and experimental groups, is shown in Table 1.

The pretest of the experimental group started with a very low level of content knowledge in mathematics ($M = 4.54$), with relatively high variability ($SD = 3.10$). The posttest shows a substantial increase ($M = 19.48$), moving from a very low level to a low level of content knowledge. The standard deviation is slightly lower than the pretest ($SD = 3.02$), indicating a slight reduction in score variability, but it remains relatively high, suggesting that there is still some variation in how participants performed.

Like the experimental group, the control group started with a very low level of content knowledge ($M = 4.86$), with a slightly higher variability in the scores compared to the experimental group ($SD = 3.53$). The control group also showed significant improvement, with the posttest mean ($M = 25.09$), moving from very low to average. The SD is similar to the experimental group ($SD = 3.02$), suggesting that although scores increased, there is still substantial variation in performance.

In the problem-solving skills, the experimental group began with a very low level of problem-solving skills ($M = 2.96$), and the SD of 1.61 shows moderate variation in how participants scored. After the treatment, the experimental group showed a large increase in problem-solving skills ($M = 28.75$), classified as average. The SD increased slightly ($SD = 3.27$), suggesting more variation in performance after the intervention, though still within the "average" range.

Similarly, in the experimental group, the control group had a very low initial score in problem-solving ($M = 2.45$), with a relatively low SD ($SD = 1.59$), indicating a more consistent performance among the participants. The control group showed a significant improvement in problem-solving skills ($M = 37.22$), which is classified as high. The SD is also relatively large ($SD = 3.02$), indicating considerable variation in performance.

Table 1: Mean and Standard Deviation of Content Knowledge and Problem-Solving Skills in Mathematics Based on the Pretest and Posttest of the Control and Experimental Groups

Content Knowledge	Pretest				Posttest			
Group	Mean	Desc.	SD	N	Mean	Desc.	SD	N
Experimental	4.54	Very Low	3.10	33	19.48	Low	3.02	33
Control	4.86	Very Low	3.53	22	25.09	Average	3.37	22
Problem-Solving Skills	Pretest				Posttest			
Group	Mean	Desc.	SD	N	Mean	Desc.	SD	N
Experimental	2.96	Very Low	1.61	33	28.75	Average	3.27	33
Control	2.45	Very Low	1.59	22	37.22	High	3.02	22

Note Interval. 40.01 – 50.00 Very High:30.01 – 40.00 High:20.01 – 30.00 Average:10.01 – 20.00 Low:0.00 – 10.00
Very Low

The study found significant improvements in both content knowledge and problem-solving skills in both the experimental and control groups. The experimental group, likely using e-learning, saw improvements from very low to low in content knowledge and from very low to average in problem-solving skills, though with high variability in individual progress. The control group, using blended learning, showed more notable progress, with content knowledge improving from very low to average and problem-solving skills rising from very low to high. Despite similar variability in both groups, the control group had larger gains in problem-solving skills.

The results suggest that both e-learning and blended learning positively impacted students, but blended learning appeared more effective. This could be due to the increased face-to-face interaction and immediate feedback in the blended learning environment, which may have supported collaborative learning and better problem-solving. On the other hand, the e-learning platform might have lacked sufficient interactivity or engagement, leading to less dramatic improvements in the experimental group. The flexibility of e-learning, while beneficial for some students, may have hindered others who needed more structure or guidance.

B. Differences in the Content Knowledge and Problem-Solving Skills in Mathematics in the Pretests of the Control and Experimental Groups

The significant differences in content knowledge and problem-solving skills as indicated in the pretests of the control and experimental groups are shown in Table 2.

Data show statistically that there is no significant difference in content knowledge between the experimental and control groups, as the p-value (0.726) is greater than the significance threshold of 0.05. Moreover, there is also no significant difference in problem-solving skills between the experimental and control groups, as the p-value (0.249) is greater than the significance threshold of 0.05. Therefore, the hypothesis that states no significant differences in content knowledge and problem-solving skills based on the pretest scores of the experimental and control groups is accepted.

Table 2: T-test in the Content Knowledge and Problem-Solving Skills in Mathematics Based on the Pretests of the Experimental and Control Groups

Group	Mean	SD	t-value	df	Sig.(2-tailed)
Content Knowledge					
Experimental	4.54	3.10			
Control	4.86	3.53	-.352 ^{ns}	53	0.726
Problem-Solving Skills					
Experimental	2.96	1.61			
Control	2.45	1.59	1.167 ^{ns}	53	0.249

^{ns}p > .05 – not significant at 5% level

The p-values of 0.726 for content knowledge and 0.249 for problem-solving skills indicate that the differences between the experimental and control groups were not statistically significant. This suggests that the experimental intervention did not lead to notable improvements in either content knowledge or problem-solving skills compared to the control group. The lack of significant results could imply that the intervention was either ineffective or insufficient in terms of design, intensity, or duration. Additionally, factors like prior knowledge, time spent on tasks, or individual learning styles could have influenced the results, introducing potential confounding variables.

C. Differences in the Content Knowledge and Problem-Solving Skills in Mathematics in the Posttests of the Control and Experimental Groups

The significant differences in content knowledge and problem-solving skills as indicated in the posttests of the control and experimental groups are shown in Table 3.

Data show that the negative t-value (t-6.428) indicates that the control group performed better on the content knowledge post-test than the experimental group. The p-value is 0.000, which is statistically significant. This suggests a significant difference in content knowledge between the two groups, with the control group outperforming the experimental group.

Furthermore, the negative t-value (t-9.667) again shows that the control group had significantly higher problem-solving skills than the experimental group. The p-value of 0.000 is statistically significant, indicating a significant difference in problem-solving skills between the two groups, with the control group outperforming the experimental group.

This means that both tests in content knowledge and problem-solving skills show that the control group had significantly higher scores than the experimental group. The p-values of 0.000 for both tests indicate that these differences are statistically significant, meaning the observed differences are unlikely to have occurred by chance. Therefore, the hypothesis that states no significant differences in content knowledge and problem-solving skills based on the post-test scores of the experimental and control groups is rejected.

Table 3: T-test in the Content Knowledge and Problem-Solving Skills in Mathematics Based on the Posttests of the Experimental and Control Groups

Group	Mean	SD	t-value	df	Sig.(2-tailed)
Content Knowledge					
Experimental	19.48	3.02			
Control	25.09	3.37	-6.428*	53	0.000
Problem-Solving Skills					
Experimental	28.75	3.27			
Control	37.22	3.02	-9.667*	53	0.000

*p < .05 – significant at 5% level

The control group outperformed the experimental group, suggesting that the experimental intervention may not have been effective in improving the tested skills. The control group likely benefited from blended learning, which may have provided better resources, materials, and a more supportive learning environment. In contrast, the experimental group might have been less motivated or engaged, which could have negatively affected their learning and post-test performance. Factors like the perceived value of the intervention, the novelty of the approach, or fatigue could have influenced the experimental group's results.

D. Differences in the Content Knowledge and Problem-Solving Skills in Mathematics in the Pretests and Posttests of the Control and Experimental Groups

The significant differences in content knowledge and problem-solving skills in mathematics, as shown in the pretests and posttests of the control and experimental groups, are shown in Table 4.

The result shows that the experimental group showed a significant improvement in content knowledge from the pretest (M = 4.54) to the posttest (M = 19.48), with a large difference of -14.93. The paired t-value of -28.319 is very large, indicating a substantial difference between pretest and posttest scores. The p-value of 0.000 suggests the improvement is statistically significant, meaning it is unlikely to be due to chance.

The control group also showed a significant improvement, with the mean increasing from 4.86 (pretest) to 25.09 (posttest), a difference of -20.22. The paired t-value of -28.43 is slightly larger than that of the experimental group, indicating a highly significant improvement. The p-value of 0.000 also indicates a statistically significant change in the control group's content knowledge.

Moreover, the result reveals that the experimental group demonstrated a significant improvement in problem-solving skills from the pretest (M = 2.96) to the posttest (M = 28.75), with a large difference of -25.78. The paired t-value of -36.766 is very large, indicating a strong and significant improvement. The p-value of 0.000 shows that this improvement is statistically significant.

The control group showed a significant improvement in problem-solving skills, with the mean increasing from 2.45 (pretest) to 37.22 (posttest), a difference of -34.77. The paired t-value of -42.597 is even higher than the experimental group's, suggesting a very strong improvement. The p-value of 0.000 indicates this improvement is statistically significant.

This means in both areas, the experimental and control groups showed significant improvements, but the control group consistently showed larger gains. Both groups' improvements are statistically significant. This suggests strong and meaningful changes in both content knowledge and problem-solving skills for both groups, with the control group

outperforming the experimental group in both areas. Therefore, the hypothesis that states no significant differences in the content knowledge and problem-solving skills in mathematics based on the pretest and posttest of the experimental group and the control group is rejected.

Table 4: T-test in the Content Knowledge and Problem-Solving Skills in Mathematics Based on the Pretest and Posttests of the Experimental and Control Groups

Group	Mean	SD	Paired Difference	t-value	df	Sig.(2-tailed)
Content Knowledge						
Experimental						
Pretest	4.54	3.10				
Posttest	19.48	3.02	-14.93	-28.319*	32	.000
Control						
Pretest	4.86	3.53				
Posttest	25.09	3.37	-20.22	-28.43*	21	.000
Problem-Solving Skills						
Experimental						
Pretest	2.96	1.61				
Posttest	28.75	3.27	-25.78	-36.766*	32	.000
Control						
Pretest	2.45	1.59				
Posttest	37.22	3.02	-34.77	-42.597*	32	.000

* $p < .05$ – significant at 5% level

Both the experimental and control groups showed significant improvements in content knowledge and problem-solving skills from the pretest to the posttest. However, the control group exhibited larger increases, suggesting that the methods used in their learning (blended learning) were more effective. The improvements in both groups were likely due to factors such as effective teaching, motivation, exposure to learning materials, and the benefits of practice. While both groups showed substantial growth, the control group's greater progress indicates the potential effectiveness of their learning approach.

E. Effect Size of e-Learning and Blended Learning on the Content Knowledge and Problem-Solving Skills in Mathematics

The effect size of e-learning and blended learning on the content knowledge and problem-solving skills in mathematics is shown in Table 5.

The result shows that Cohen's d of -1.753 is a very large negative effect size, indicating a significant difference between the two groups' means in content knowledge. The large magnitude of the negative value suggests that the e-learning group performed significantly lower than the blended-learning group. The Effect Size of -0.659 indicates that the size of the difference between the groups is large, which reinforces that the blended learning group had much higher content knowledge compared to the e-learning group.

Similarly, the blended learning group showed substantially better performance in problem-solving skills, with a very large negative Cohen's d value of -2.691 and a large effect size of -0.802, indicating that blended learning was more effective than e-learning for enhancing problem-solving abilities.

Table 5: *Cohen's d on the Effect Size of e-Learning and Blended Learning on the Content Knowledge and Problem-Solving Skills in Mathematics*

Group	Mean	SD	Cohen's d	Effect Size	Desc.
Content Knowledge					
e-Learning	19.48	3.02	-1.753	-0.659	Large
Blended Learning	25.09	3.37			
Problem-Solving Skills					
e-Learning	28.75	3.27	-2.691	-0.802	Large
Blended Learning	37.22	3.02			

Cohen's d and Effect Size: 0.01-Very Small: 0.2-Small: 0.5-Medium: 0.8-Large: 1.2-Very Large: 2-Huge

Blended learning had a more significant positive impact on both content knowledge and problem-solving skills than e-learning. The large effect sizes and Cohen's d values indicate that blended learning was the more effective approach. The combination of online learning with face-to-face instruction likely provided a more comprehensive and supportive environment, offering social interaction, immediate feedback, and active learning. In contrast, more self-directed e-learning may have been less effective for students, particularly in areas requiring problem-solving and personalized support. The higher self-regulation needed in e-learning could explain why some students struggled compared to those in the blended learning group.

V. CONCLUSIONS

Both the experimental and control groups showed significant improvements in content knowledge and problem-solving skills, with the control group demonstrating slightly larger gains. This suggests that the control group's learning environment or method had a stronger impact, though both interventions were effective. The results imply that factors beyond the specific intervention—such as instructional quality, student engagement, or teaching strategies—may have contributed to the observed improvements. Interestingly, the interventions in both groups had similar effects, with no significant differences between them, which suggests that the specific methods used may not have been as critical as other factors like student motivation or the classroom environment. Both groups achieved comparable outcomes on the post-test, further suggesting that various teaching strategies can be successful if implemented effectively.

However, when comparing the effectiveness of the teaching methods, blended learning emerged as the more impactful approach, leading to larger improvements in both content knowledge and problem-solving skills. This highlights the benefits of combining in-person and online instruction, offering a more comprehensive learning experience. In contrast, e-learning alone appeared less effective, suggesting that a more balanced integration of teaching methods is essential to optimize student learning outcomes. The findings call for further research to explore which aspects of blended learning contributed most to these improvements, emphasizing the need for a mixed approach that incorporates both digital and face-to-face elements.

REFERENCES

- [1] Cole, M.T.; Swartz, L.B.; Shelley, D.J. Threaded Discussion: The Role It Plays in E-Learning. *Int. J. Inf. Commun. Technol. Educ.* 2020, 16, 16–29.
- [2] Ayanda, D., Eludiora, S., Amassoma, D., & Ashiru, M. (2011). Towards a model of e-learning in Nigerian higher institutions: An evolutionary software modelling approach. *Information and Knowledge Management*, 1(1), 31–39. Retrieved May 9, 2014, from <http://www.iiste.org>.
- [3] Wang, S. (2011). Benefits and challenges of e-learning: University students' perspectives. Retrieved July 3, 2013 from <http://www.igi-global.com/chapter/benefits-challenges-learning/53285?camid=4v1>.
- [4] Umoh, U.J. and Akpa, E.T. (2014). Challenges of Blended E-Learning Tools in Mathematics: Students' Perspectives, University of Uyo. *Journal of Education and Learning*; Vol. 3, No. 4; 2014 ISSN 1927-5250 E-ISSN 1927-5269.

- [5] Ishola, A. A. and Udofia, I. G. R. (2017). Effect of Demographic Factors and Teachers' Mastery of Instructional Designs as Predictors of Pupils' Achievement in Mathematics. *Journal of Educational Research and Development*. 15(1) 10-24.
- [6] Ma'rufi, I., Budayasa, K., and Juniati, D. (2017). Pedagogical content knowledge: Knowledge of pedagogy for novice teachers in mathematics learning on limit algebraic functions. *AIP Conference Proceedings* 1813, 050003 (2017); <https://doi.org/10.1063/1.4975975>.
- [7] Tchoshanov, M. et al. (2017). *The Journal of Mathematical Behavior*. 4754. <https://www.sciencedirect.com/science/article/abs/pii/S0732312316301195>.
- [8] Phonapichat, P., Wongwanich, S., & Sujiva, S. (2014). An analysis of elementary school students' difficulties in mathematical problem-solving. *Procedia – Social and Behavioral Sciences*, 116, 3169-3174.
- [9] Dela Cruz, J. K., & Lapinid, M. R. (2014). Students' difficulties in translating worded problems into mathematical symbols. Paper presented at the De La Salle University Research Congress, 2014, Manila. http://www.dlsu.edu.ph/conferences/dlsu_research_congress/2014/_pdf/proceedings/LLI-I-009-FT.pdf.
- [10] Soleymanpour, J. et al. (2010). *Iranian Journal of Information and Communications Technology in Education Sciences* 1(2), 77-91.
- [11] Ushakov, D. et al. (2013). *Actual Problems of Economics* 2(3), 38-46.
- [12] Mahdinejad, V. & Amoui, M. (2011). *Iranian Journal of Higher Education* 16(4), 102-117.
- [13] Holley, D. (2012). *Education and Training* 44(3), 112-121.
- [14] Maccoun, Hussein Salem. (2016). The Effect of Using Blended Learning on the Achievement of Students and Information Retention of Fifth Graders in the Biology Course, *Faculty of Education Journal*, 22 (95) 209-240.
- [15] Al-Rimawi, Firas Tharwat. (2016). The Effect of Using Blended Learning in Teaching English Language on the Direct and Delayed Achievement among the Sixth Graders, Unpublished Master Thesis, Faculty of Educational Sciences, Middle East University, Jordan.
- [16] Sidhu, G. K., Fook, C. Y. & Kaur, S. (2011). Assessing ESL teacher trainees' content, pedagogical, and professional knowledge base. *The Assessment Books*, 4(2), 3-18.
- [17] Angateeah, K. S. (2017). An investigation of students' difficulties in solving non-routine word problems at the lower secondary. *International Journal of Learning and Teaching*, 3(1), 46–50.
- [18] Kim, M. C., & Hannafin, M. J. (2011). Scaffolding problem solving in technology-enhanced learning environments (TELEs): Bridging research and theory with practice. *Computers & Education*, 56(2), 403-417.
- [19] Simamora, R. E., Sidabutar, D. R., & Surya, E. (2017). Improving Learning Activity and Students' Problem-Solving Skill through Problem-Based Learning (PBL) In Junior High School. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*, 33(2), 321–331.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details