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Empowering elementary students' higher-order thinking and creativity: the role of a problem-solving learning model with mentimeter integration in social sciences

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Abstrak

The present study explores the role of problem-solving learning models integrated with Mentimeter media in empowering higher-order thinking skills (HOTS) and creativity in social sciences learning at the elementary school level. A quasi-experimental, non-equivalent control-group design was used, involving two classes purposively selected. A total of 70 students were enrolled, 34 in the experimental class and 36 in the control class. Data were collected using essay tests that measured students' HOTS and creativity, then analysed using MANOVA after meeting the assumptions of normality and homogeneity. The results yielded a significant difference between the experimental class, taught using the problem-solving model with Mentimeter integration, and the control class, taught using the conventional teaching model, both in HOTS ($p < 0.001$) and in creativity ($p < 0.001$). These findings confirm the importance of combining problem-solving pedagogy with interactive technology tools in empowering elementary school students' cognitive and creative skills in social sciences learning.

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1. Introduction

Entering the 21st century, advancements in science and technology have brought profound transformations to various aspects of human life. Unlimited access to information and seamless communication through digital platforms have compelled countries, including Indonesia, to enhance their global competitiveness by developing high-quality human resources (Sare et al., 2024; Đurić et al., 2021). Education plays a pivotal role in this transformation, particularly at the elementary level, where the foundation of students' character, knowledge, and skills is built (Marleni & Mustoip, 2024).

Social Sciences (IPS) is a strategic subject that equips students with the social, cultural, and humanitarian competencies needed to face global challenges (Aslamiah et al., 2021). Beyond transferring factual knowledge, the Social Sciences aim to nurture students' ability to think critically, solve problems, and act creatively to address real-world issues. These objectives align closely with the goals of 21st-century education, which emphasise the cultivation of 4C skills, creativity, collaboration, communication, and critical thinking, where Higher-Order Thinking Skills (HOTS) serve as a central indicator of educational quality (Boemiya et al., 2023). Within the Social Sciences curriculum, HOTS and creativity are particularly essential for analysing social issues, evaluating diverse perspectives, and generating innovative solutions that support democratic citizenship and sustainable development.

However, implementing these competencies in Indonesian elementary schools remains a challenge. National assessment data and research indicate that Indonesian students still demonstrate limited higher-order cognitive performance, especially in problem-solving and reasoning (Kemendikbudristek, 2013; OECD, 2019). For instance, Indonesia's average score in the PISA 2022 assessment for creative thinking and problem-solving remains below the OECD average, suggesting that students often rely on rote memorisation rather than analytical reasoning. These findings indicate that fostering HOTS and creativity is not confined to a single school but is a broader national issue in elementary education.

Preliminary observations and interviews conducted with the principal and fifth-grade teacher at SDN 09 Rawang Air Putih revealed similar conditions at the local level. The average student score in Social Sciences during the previous semester was 68.5, below the school's minimum competency criterion (KKM) of 75. Students had difficulty identifying social issues, connecting concepts to real-life contexts, and proposing alternative solutions. Their creativity also remained underdeveloped, as reflected in the limited originality of ideas and passive classroom participation. Social Sciences learning was still dominated by teacher-centred instruction and minimal use of interactive learning tools, which hindered the cultivation of higher-order thinking and creativity.

The problem-solving learning model has been widely recognised for its potential to improve students' analytical and creative abilities by engaging them in real-world problem analysis and solution generation (Uge et al., 2019; Phungsuk et al., 2017). Meanwhile, Mentimeter, an interactive web-based learning platform, facilitates active engagement, real-time feedback, and gamified participation that enhance student motivation and collaboration (Wulan & Sulisworo, 2023; Nurhasnawati et al., 2023). Despite the growing use of both strategies independently, few studies have examined their integration within elementary Social Science learning, especially in the Indonesian context.

The research novelty lies in integrating the problem-solving learning model with Mentimeter technology to create an interactive, inquiry-based learning environment that encourages active participation and deep thinking. This combination is expected to bridge the gap between pedagogical innovation and technological engagement, both of which are crucial for empowering students' HOTS and creativity.

Based on this background, the study aims to: (1) investigate significant differences in HOTS between students in the experimental class taught using the problem-solving learning model with Mentimeter assistance and students in the control class taught through conventional instruction; (2) examine significant differences in creativity between the two groups; and (3) analyse simultaneous differences in HOTS and creativity between students exposed to the problem-solving model with Mentimeter integration and those receiving conventional teaching.

2. Literature Review

2.1 Higher-order thinking skills (HOTS)

Higher-Order Thinking Skills (HOTS) have emerged as a key indicator of 21st-century education quality, including at the elementary school level (Boemiya et al., 2023; Suharsiwi et al., 2023). Recent studies reveal that the implementation of HOTS in Indonesian elementary schools remains limited, particularly in terms of selecting appropriate instructional models, learning media, and assessment strategies to foster higher-order thinking (Shalikhah & Nugroho, 2023). Maspiroh et al., (2025) further, the majority of pre-service elementary school teachers demonstrated low HOTS levels (77%), with only a small proportion classified as high (22%). These findings underscore the urgent need for innovative instructional models that can effectively enhance higher-order thinking skills from the early years of schooling. In the context of Social Sciences education, HOTS are particularly essential because this subject emphasises inquiry into real-world social, cultural, and environmental issues. Through HOTS, students are expected to analyse social phenomena, evaluate multiple perspectives, and construct reasoned conclusions based on evidence. Hence, developing HOTS in Social Sciences is not only about cognitive sophistication but also about empowering students to become reflective and responsible citizens capable of addressing societal problems critically and creatively.

2.2 Creativity

Creativity is another fundamental competency that enables students to generate novel ideas and produce innovative solutions to social and civic challenges (Pebriana & Disman., 2017). However, several studies have highlighted that creativity among elementary students remains underdeveloped (Sudarmiani et al., 2021). In the context of Social Sciences, creativity supports students in designing alternative solutions to real-life community issues, developing social empathy, and expressing ideas through collaborative projects. Nursyaida & Samad, (2024), demonstrated that the use of interactive, game-based learning media can significantly increase students' motivation, engagement, and creativity, reinforcing the need to integrate technology-driven approaches into classroom practices to foster creative and participatory learning.

2.3 Problem-solving learning

Problem-solving learning models have long been recognised as effective in developing critical and creative thinking skills through real-world problem-solving experience (Uge et al., 2019; Phungsuk et al., 2017). A recent study by Anggriani et al. (2022), showed that integrating Problem-Based Learning (PBL) with interactive media can significantly enhance elementary students' critical thinking and collaboration skills. However, most previous research has focused on science education or general learning contexts, with limited applications specifically in elementary Social Sciences instruction. In Social Sciences, the problem-solving model is particularly relevant because it mirrors the analytical process of understanding social issues, identifying a problem, gathering relevant data, proposing alternative solutions, and evaluating outcomes. By positioning students as active investigators of social phenomena, this model encourages not only knowledge construction but also civic reasoning and innovation.

2.4 Mentimeter

Mentimeter, a technology-based interactive learning platform, has been shown to enhance classroom interaction and student engagement by enabling features such as quizzes, polls, word clouds, and open-ended responses (Retno Wulan & Sulisworo, 2023). Nurhasnawati et al. (2023), found that Mentimeter significantly improved student participation and comprehension, while these features allow teachers to gauge students' understanding in real time and stimulate discussion around social issues, making learning more dynamic and inclusive (Sare et al, 2024). For instance, in the problem-identification stage, a teacher may use a 'word cloud' in Mentimeter

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to visualise students' perceptions of a particular social problem. During the brainstorming stage, polling or open-ended response activities can help students generate and compare possible solutions collaboratively. Finally, during the evaluation stage, interactive quizzes or ranking polls can facilitate reflection and decision-making through collective reasoning.

This alignment between the stages of the problem-solving model and the interactive features of Mentimeter demonstrates their strong pedagogical aspects. The problem-solving model provides the cognitive framework for analytical and creative inquiry, while Mentimeter offers technological scaffolding that increases participation, feedback, and motivation. Together, they create an integrated learning environment that is student-centred, inquiry-driven, and collaborative, key conditions for fostering HOTS and creativity in Social Science classrooms.

Although previous studies have explored the separate impacts of problem-solving models and Mentimeter in enhancing students' higher-order thinking and creativity (Anggriani et al., 2022; Nursyaida & Samad, 2024), few have examined their combined effects within the context of elementary-level Social Sciences learning in Indonesia. This research gap constitutes the novelty of the present study, which seeks to design and evaluate an innovative, interactive, and contextually relevant instructional model to strengthen both HOTS and creativity among elementary school students.

3. Method

This study employed a quasi-experimental research design, specifically utilising a Pre-test-Post-test Control Group Design involving both experimental and control classes. The research population comprised all fifth-grade students from four parallel courses at a public elementary school in Pekanbaru, Indonesia. The sampling process was conducted in two stages. First, purposive sampling was used to select the school based on preliminary observations showing that students' Higher-Order Thinking Skills (HOTS) were relatively low. Second, cluster random sampling was applied to pick two of the four fifth-grade classes to participate in the study. The selected classes comprised 34 students in the experimental group (Class A) and 36 in the control group (Class B). Class A (experimental group) received instruction through the problem-solving learning model integrated with Mentimeter media, while Class B (control group) was taught using the Direct Instruction model.

The data were collected using two main instruments, a HOTS test and a creativity essay test.

3.1 HOTS test

The test consisted of 10 essay questions developed based on Anderson and Krathwohl's revision of Bloom's Taxonomy, targeting the cognitive levels of analysing (C4), evaluating (C5), and creating (C6). The test's content validity was assessed by three experts in mathematics education and educational evaluation, with an average content validity index (CVI) of 0.89, indicating high validity. Reliability testing was conducted using Cronbach's Alpha, yielding a coefficient of 0.86, indicating a high level of internal consistency.

3.2 Creativity of essay test

This instrument aimed to measure students' creative thinking in solving mathematical problems. It was developed based on the Torrance framework of fluency, flexibility, originality, and elaboration. The test's validity was confirmed through expert judgment (CVI = 0.91), and its reliability was 0.83.

Before implementation, both instruments were piloted on a group of students from a different fifth-grade class to ensure clarity and reliability. The pre-test and post-test were administered under similar conditions for both groups; Mentimeter was used only during the intervention phase in the experimental class.

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Data analysis was conducted using Multivariate Analysis of Variance (MANOVA) to test the research hypotheses. Before hypothesis testing, two assumptions were verified by (1) normality of data distribution and (2) homogeneity of variances. The normality test was performed using the Shapiro–Wilk statistical test in SPSS 28.00 for Windows at a 0.05 significance level. Homogeneity was examined through Levene's Test of Equality of Error Variances and Box's M test.

Hypothesis testing was subsequently conducted via MANOVA. Hypotheses 1 and 2 were tested using F-variance analysis under the Test of Between-Subjects Effects, with a 5% significance level. Hypothesis 3 was analysed using multivariate tests, Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root, at the same significance threshold ($p < 0.05$). If the computed F significance value was less than 0.05, the null hypothesis (H_0) was rejected, indicating support for the alternative hypothesis (H_1).

4. Results

This section presents the study's findings based on data collected from both the experimental and control classes. The analysis is organised into two main parts: (1) the results of descriptive statistical analysis, which include the mean and standard deviation of students' Higher-Order Thinking Skills (HOTS) and creativity scores, and (2) the results of inferential statistical tests, including the prerequisite analyses (normality and homogeneity tests) and the MANOVA hypothesis testing. The purpose of these analyses is to determine whether applying the problem-solving learning model, integrated with Mentimeter media, produces significant improvements in students' cognitive and creative learning outcomes compared to the conventional teaching model.

Following the implementation of instruction in both the experimental and control classes using different learning models, the findings revealed that the problem-solving learning model integrated with Mentimeter media had a significant impact on students' Higher-Order Thinking Skills (HOTS) and creativity. The average HOTS score in the experimental class, which used the problem-solving model with Mentimeter support, was 87.88, while the average HOTS score in the control class, taught through direct instruction, was 66.08.

Similarly, the students' average creativity score in the experimental class reached 92.00, compared to 83.02 in the control class. These results demonstrate that the problem-solving learning model integrated with Mentimeter media effectively outperformed direct instruction in enhancing elementary students' HOTS and creativity. A comparative analysis of the mean scores between the two classes is illustrated in the following bar chart:

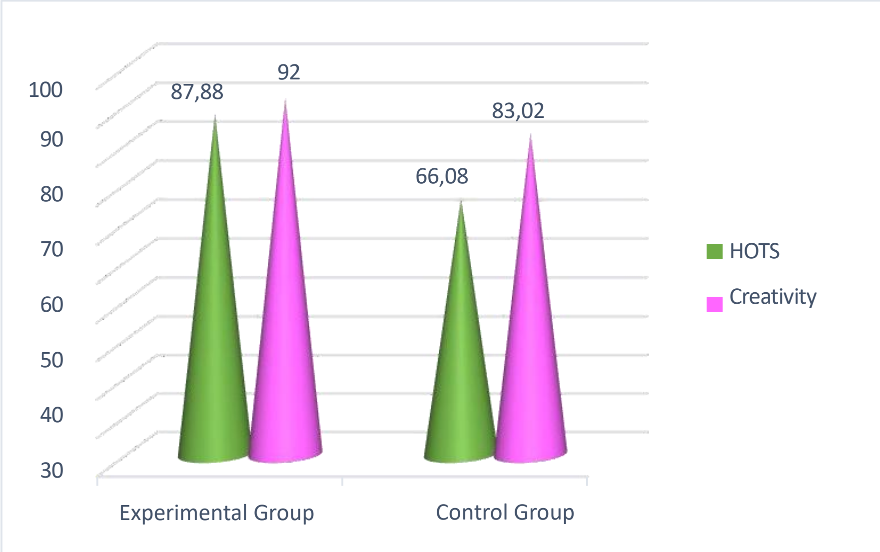

Figure 1. Comparison of students' average learning outcomes

Before testing the research hypotheses, prerequisite analyses are conducted on the Higher-Order Thinking Skills (HOTS) and creativity scores, namely the normality test and homogeneity test. Once all the data are collected, the next step is data analysis. The first step is to perform a normality test to assess whether the data followed a normal distribution, which is essential for applying parametric statistical analysis. The Shapiro-Wilk test is employed, examining both the Shapiro-Wilk statistic and the Asymp—sig value. The decision criterion for normality is set if the p-value exceeds α = 0.05; the data are considered normally distributed. Otherwise, they are considered not normally distributed. The summary of the normality test results is presented in Table 1 below.

Table 1. Results of the normality test

Tests of Normality

Variables	Classes	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
HOTS	Experimental Group	.149	34	.052	.954	34	.164
	Control Group	.133	36	.105	.962	36	.245
Creativity	Experimental Group	.135	34	.122	.951	34	.135
	Control Group	.143	36	.059	.957	36	.178

Regarding Table 1, the significance value for the HOTS data in the experimental group is 0.164, while in the control group it is 0.245. Furthermore, the significance value of the creativity data in the experimental group is 0.135, and in the control group, it is 0.178. Since all obtained significance values are greater than α = 0.05, it can be concluded that the data for both the experimental and control groups are normally distributed.

In addition, a homogeneity of variance test was conducted to determine whether the variances between the experimental and control groups were homogeneous. The test was carried out using Levene's Test of Equality of Error Variances, supported by SPSS software through Box's M test. The complete results of the homogeneity of variance analysis are presented in Table 2 below:

Table 2. Results of the homogeneity of variance test

Box's test of equality of covariance matrices[a]	
Box's M	1.780
F	.574
df1	3
df2	933697.455
Sig.	.632

Based on Table 2, the calculated Box's M value is 1.780 with a significance level of p = 0.632, where 0.632 > 0.05. This result indicates that the covariance matrices across groups are assumed to be equal (homogeneous).

Derived from the results of the data prerequisite tests, the post-test data for both the experimental and control groups were normally distributed and homogeneous. Following the confirmation of these assumptions, hypothesis testing was conducted.

The hypothesis tests for H1 and H2 were carried out using F-tests of variance through MANOVA analysis with the Test of Between-Subject Effects. The decision criterion was a significance level of F = 5%. If the obtained p-value is less than 0.05, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. The detailed results of these tests are presented in Table 3 below:

Table 3. Results of F-tests of variance

Sources	**Dependent Variables**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	HOTS	6090.667[a]	1	6090.667	72.418	.000	.516
	Creativity	1072.495[b]	1	1072.495	33.504	.000	.330
Intercept	HOTS	378,975.238	1	378,975.238	4506.005	.000	.985
	Creativity	536,170.210	1	536,170.210	16,749.345	.000	.996
Class	HOTS	6090.667	1	6090.667	72.418	.000	.516
	Creativity	1072.495	1	1072.495	33.504	.000	.330
Error	HOTS	5719.105	68	84.104			
	Creativity	2176.776	68	32.011			
Total	HOTS	388,352.000	70				
	Creativity	538,487.000	70				
Corrected Total	HOTS	11,809.771	69				
	Creativity	3249.271	69				

Based on the data analysis results presented in Table 3, the findings can be described as follows:

First Hypothesis (H_1) is that the calculated F-value is 72.418 with df = 1 and a significance level of p = 0.000. Since $p < 0.05$, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. This indicates a significant difference in Higher-Order Thinking Skills (HOTS) between students in the experimental class, taught using the problem-solving learning model integrated with Mentimeter media, and students in the control class, taught using direct instruction. Theoretically, these results demonstrate that the problem-solving model assisted by Mentimeter media is more effective in improving students' HOTS during the learning process.

Second Hypothesis (H_2) is that the analysis yields an F-value of 33.504 (df = 1, p = 0.000). Since $p < 0.05$, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. This finding indicates a significant difference in creativity between students in the experimental class, taught using the problem-solving learning model integrated with Mentimeter, and students in the control class, taught using direct instruction. Theoretically, this demonstrates that the problem-solving model supported by Mentimeter media is more effective in enhancing students' creativity during the learning process.

Third Hypothesis (H_3) is tested using the F-test based on analyses of Pillai's Trace, Wilk's Lambda, Hotelling's Trace, and Roy's Largest Root. The decision criterion is set at a 5% significance level ($p < 0.05$). If the calculated p-value is less than 0.05, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. The detailed results of this test are presented in Table 4 below:

Table 4. Results of multivariate tests for hots and creativity

Effect		Value	F	Hypothesis Df	Error df	Sig.	Partial Eta Squared
Class	Pillai's Trace	.591	48.480[b]	2.000	67.000	.000	.591
	Wilks' Lambda	.409	48.480[b]	2.000	67.000	.000	.591
	Hotelling's Trace	1.447	48.480[b]	2.000	67.000	.000	.591
	Roy's Largest Root	1.447	48.480[b]	2.000	67.000	.000	.591

Based on the results presented in Table 4, the analysis indicates that the calculated F-values for Pillai's Trace ($F = 48.480$), Wilk's Lambda ($F = 48.480$), Hotelling's Trace ($F = 48.480$), and Roy's Largest Root ($F = 48.480$) all have a significance value of $0.000 < 0.05$. Therefore, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted.

These findings confirm that there is a significant difference in Higher-Order Thinking Skills (HOTS) and creativity between students in the experimental class, taught using the problem-solving learning model supported by Mentimeter media, and those in the control class, taught through direct instruction.

In light of a theoretical perspective, these results demonstrate that integrating a problem-solving approach with interactive Mentimeter media is more effective in fostering HOTS and creativity during the learning process. This integration successfully creates a more active, collaborative, and engaging classroom environment, encouraging students to think critically, generate innovative ideas, and actively participate in social science learning at the elementary school level.

5. Discussion

According to this study's findings, several key results were obtained. First, there is a significant difference in Higher-Order Thinking Skills (HOTS) between students in the experimental class, which used the problem-solving learning model assisted by Mentimeter media, and those in the control class, which used direct instruction. The data indicate that the Mentimeter-supported problem-solving model is more effective at improving students' HOTS during the learning process. This finding aligns with Awang et al. (2022), who highlighted that problem-solving learning can enhance higher-order thinking skills such as critical and creative thinking. When students are confronted with questions or problems, they engage in reasoning and problem-solving processes that stimulate their cognitive development. Rather than relying solely on rote memorisation, students are trained to analyse the issues and spontaneously develop solutions, thereby expanding their thinking processes (Yuliya & Christina, 2021). Several other studies also confirm that HOTS can be improved through problem-based learning approaches (Maiti et al., 2023). Additionally, the use of Mentimeter media led to significant improvements in students' learning outcomes, as learners provided accurate answers, reflecting improved understanding after implementing Mentimeter as a learning tool (Nuzliah, 2016).

Beyond confirming the consistency of the findings with previous studies, it is crucial to understand why the problem-solving model integrated with Mentimeter proved effective. Mentimeter's interactive features, such as live polling, open-ended responses, and instant feedback, directly support the core stages of the problem-solving process. In the problem identification stages, Mentimeter encourages active participation through brainstorming polls that help students collectively recognise and define key issues in the lesson. During the exploration and idea-generation stages, students use Mentimeter to share multiple perspectives anonymously, reducing anxiety and fostering a more open exchange of ideas. This process cultivates divergent thinking, an essential component of HOTS and the development of creativity. In the evaluation and reflection stages, real-time feedback visualisations allow students to compare reasoning, evaluate various alternatives, and refine their problem-solving strategies collaboratively. These interactions build a metacognitive awareness that is rarely achieved in conventional classroom discussions.

Furthermore, implementing the problem-solving model with Mentimeter integration proved more effective at enhancing elementary school students' creativity. This finding supports the research of Nurhasanah et al. (2024), which reported a positive association between problem-solving approaches and students' creativity in learning. Similarly, Suryaningsih & Ainun Nisa, (2021) emphasised that problem-solving activities help students develop creative thinking skills and prepare them to face real-life problems. Ahmad & Wilujeng (2018) also revealed that problem-solving learning had a greater effect on students' creativity, as indicated by higher average scores in the experimental class than in the control class. The observed increase in creativity can be attributed to the open-ended, exploratory nature of the tasks facilitated by Mentimeter, which encourages learners to propose, test, and revise their own ideas freely. Verbal creativity, for instance, was stimulated when students used Mentimeter to generate unique responses, synthesise multiple viewpoints, and construct novel solutions in real-time collaborative discussions (Dan & Komunikasi, 2015).

Mentimeter's design as an interactive presentation tool plays a crucial mediating role in this process. It transforms passive classroom settings into dynamic, student-centred environments that stimulate curiosity and engagement (Faturohman & Afriansyah, 2020). Through visual and immediate feedback mechanisms, students can see how their peers think differently, which enhances critical comparison and deepens understanding. Such active learning conditions are essential for developing not only HOTS but also creative dispositions such as flexibility, originality, and elaboration, key indicators of creativity in education (Torrance, 1974). The digital interactivity also aligns with Vygotsky's social constructivist theory, which holds that learning occurs through social interaction and collaborative meaning-making. Mentimeter is a digital scaffolding tool that extends the zone of proximal development (ZPD) by enabling real-time cognitive collaboration among students.

Overall, the research findings suggest that combining a problem-solving learning model with Mentimeter media is highly effective in improving both HOTS and creativity among students. This conclusion aligns with Mohin et al. (2022), who stated that problem-solving learning helps students become more adept and intelligent at addressing problems after repeated practice. Problem-solving is understood as a high-level cognitive process involving systematic observation and critical thinking to find solutions and achieve specific goals (Md, 2019). It has been defined as a cognitive process requiring modulation and control beyond routine skills or basic competencies. Therefore, this learning model can significantly enhance students' HOTS. Moreover, problem-solving activities train students to generate ideas, apply them effectively, and identify appropriate solutions, making creativity an essential skill to be developed among learners. Based on participant performance and surveys, the majority reported understanding how to use Mentimeter and expressed their willingness to apply it to support future classroom learning (Gomez, 2013).

Despite these promising findings, this study has several limitations. The research was conducted in a single elementary school with a relatively small number of participants (36 students in the control class and 34 in the experimental class), which may limit the generalizability of the results. Additionally, the study did not account for external factors such as prior teacher experience with educational technology or students' digital literacy levels, which might have influenced the learning outcomes. Future research should increase sample size, include diverse school contexts, and examine the long-term effects of integrating Mentimeter into problem-solving learning. Furthermore, qualitative investigations, such as classroom observations or interviews, could provide deeper insights into how specific Mentimeter features facilitate cognitive and creative engagement during the learning process.

6. Conclusion and implications

Derived from the findings of hypothesis testing and the discussion, the conclusions can be drawn that 1) significant differences in Higher-Order Thinking Skills (HOTS) were observed between students taught using the problem-solving learning model assisted by Mentimeter media and those taught using the direct instruction model. The students' average HOTS scores in the problem-solving with Mentimeter group were higher than those of students in the direct instruction group. 2) Significant differences in creativity were found between students taught using the problem-solving learning model assisted by Mentimeter media and those taught using the direct instruction model. The students' average creativity scores in the problem-solving with Mentimeter group were higher than those of students in the direct instruction group. 3) Significant differences in HOTS and creativity combined were identified between students taught using the problem-solving learning model with Mentimeter integration and students taught using the direct instruction model. Overall, these findings demonstrate that integrating the problem-solving learning model with Mentimeter media positively influences both HOTS and creativity in elementary students' social science learning.

This study offers valuable contributions to the development of social science instruction at the elementary level. Teachers are encouraged to integrate problem-solving learning models, supported by interactive tools such as Mentimeter, to create more participatory, innovative, and cognitively stimulating classroom environments. Schools can utilise these findings as a basis for designing professional development programs that enhance teachers' ability to leverage interactive technologies effectively. However, this study has certain limitations. It was conducted in a single school with a limited sample size and a relatively short intervention period, which may restrict the generalisability of the results. Future research should involve larger, more diverse samples, extend the implementation period, and explore the mechanisms by which Mentimeter supports students' engagement and learning outcomes across different subjects and educational contexts.

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