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The Effectiveness Of The Jigsaw Cooperative Learning Model Assisted By Interactive Digital Media On High School Students' Non-Routine Algebraic Problem-Solving Skills

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Abstract

Non-routine algebraic problem-solving requires students to understand mathematical problems, develop appropriate strategies, implement solution procedures, and evaluate the reasonableness of their answers. However, students often experience difficulties when dealing with unfamiliar problems that require flexible mathematical reasoning. This study aimed to examine the effectiveness of the Jigsaw cooperative learning model assisted by interactive digital media in improving high school students' non-routine algebraic problem-solving skills. The study involved an experimental group and a control group, each consisting of 32 students. Students' problem-solving skills were measured using pretests and posttests, and the data were analyzed using analysis of covariance (ANCOVA) to compare posttest performance while controlling for pretest scores. The descriptive results showed that the experimental group's mean score increased from 46.63 to 58.60, whereas the control group's mean score increased from 44.55 to 49.39. The ANCOVA results indicated a statistically significant difference between the groups after controlling for pretest performance, ($F(1,61)=26.67$), ($p<.001$), with a partial eta-squared of .304. The adjusted posttest means were 57.89 for the experimental group and 50.09 for the control group. These findings suggest that the Jigsaw cooperative learning model supported by interactive digital media may provide a more effective learning experience for developing non-routine algebraic problem-solving skills than the comparison approach used in this study. The findings highlight the potential value of structured peer collaboration and digital learning support in mathematics education.

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Keyword: Jigsaw cooperative learning, interactive digital media, non-routine problems, algebra, mathematical problem-solving.

INTRODUCTION

Mathematical problem-solving is a fundamental competency in mathematics education because it requires students to interpret information, establish relationships among concepts, formulate strategies, and evaluate the validity of solutions. These processes are especially important in algebra, where students must coordinate symbolic representations, conceptual relationships, and procedural operations. Algebraic proficiency therefore cannot be characterized by computational accuracy alone. Students must also recognize the structure of a problem and determine how prior knowledge can be applied to unfamiliar situations. Research on conceptual and procedural knowledge suggests that comparing solution methods can support more flexible understanding of mathematical procedures (Rittle-Johnson & Star, 2007).

Non-routine algebraic problems provide a meaningful context for examining these competencies. Unlike routine exercises that can often be solved by applying a familiar algorithm, non-routine problems require students to decide how a problem should be represented and which strategies may be appropriate. Students may need to identify hidden relationships, construct an unfamiliar representation, consider alternative solution paths, or justify why a proposed solution is mathematically valid. Farabibah and Suryanti (2026), for example, examined conceptual and transformational errors in students' solutions to non-routine algebra problems. Although their study focused on junior high school students, it provides a useful starting point for investigating related challenges at the senior high school level.

One instructional approach that may support these processes is the Jigsaw cooperative learning model. Jigsaw organizes students into home groups and expert groups, allowing learners to develop an understanding of particular aspects of a task before explaining their contributions to peers. This structure can create opportunities for mathematical explanation, comparison of strategies, peer teaching, and shared responsibility. The rationale is consistent with social interdependence theory, which emphasizes positive interdependence and individual accountability in cooperative learning (Johnson & Johnson, 2009). However, cooperative learning should not be assumed to produce positive outcomes in every context. Kyndt et al. (2013) synthesized research on face-to-face cooperative learning, while Cochon Drouet et al. (2023) reviewed the effects of Jigsaw. Their work indicates that outcomes can vary according to instructional design, learners, subject matter, and implementation conditions.

Interactive digital media may complement Jigsaw when its features support meaningful

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mathematical activity. Depending on the platform, digital media can provide dynamic representations, opportunities to manipulate variables, structured tasks, and feedback that helps students examine mathematical relationships. Technology should not be treated as an instructional advantage in itself. Hillmayr et al. (2020), in a meta-analysis of digital tools in secondary mathematics and science education, reported positive average effects while also identifying variation across tools and implementation conditions. Cheung and Slavin (2013) similarly found that the effects of educational technology applications differed across contexts. These findings support using digital media when its functions are aligned with the learning task, rather than merely replacing printed materials with a digital display.

Technology-supported collaboration also depends on how interaction is structured. Within Jigsaw, digital media can serve as a shared workspace through which students investigate problems, communicate strategies, compare representations, and evaluate solutions. Its role should be described in pedagogical terms: which mathematical actions it enables, what information it makes visible, and how it supports reasoning. A clear description of these functions is essential for interpreting outcomes and allowing other researchers to reproduce the intervention.

Despite research on cooperative learning, digital mathematics instruction, and students' difficulties with non-routine algebraic problems, the effectiveness of combining Jigsaw with interactive digital media for this specific outcome at the senior high school level requires direct empirical examination. Findings from separate strands of research cannot by themselves establish that their combination will improve non-routine problem-solving. General mathematics achievement and the ability to solve unfamiliar problems are related but distinct outcomes. A focused study should therefore assess students' ability to understand a problem, devise a strategy, carry out the strategy, and evaluate the solution. The research gap is framed as a need for context-specific evidence, not as a claim that the combination has never been studied.

Accordingly, this study aims to examine the effectiveness of the Jigsaw cooperative learning model assisted by interactive digital media on senior high school students' non-routine algebraic problem-solving skills. A quasi-experimental pretest-posttest design with an experimental group and a control group is proposed. The analysis compares posttest performance while accounting for initial ability, provided that the assumptions of the selected statistical model are satisfied. The study is intended to contribute evidence about this integrated instructional approach and inform the design of mathematics lessons that encourage strategic reasoning, mathematical communication, and independent engagement with unfamiliar

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algebraic problems.

METHOD

This study is designed as a quantitative quasi-experimental investigation using a pretest-posttest non-equivalent control group design. The design is suitable when intact classroom groups are used and individual students cannot be randomly assigned to instructional conditions. The experimental group receives the Jigsaw cooperative learning model assisted by interactive digital media, whereas the control group receives the comparison instruction specified in the research protocol. Both groups study equivalent algebraic content over a comparable period and complete pretests and posttests measuring the same problem-solving competencies.

Table 1. Quasi-experimental research design

Group	Pretest	Instructional treatment	Posttest
Experimental	O_1	X	O_2
Control	O_3	C	O_4

Because the groups are not formed through individual random assignment, the analysis must consider baseline differences and contextual confounding. The design supports comparative evaluation but does not eliminate all threats to causal inference.

The research setting, academic year, grade level, and participant numbers must be specified according to the actual implementation. The target population comprises senior high school students who have studied the prerequisite algebraic concepts required by the assessment. Two intact classes may be selected, with one assigned to the experimental condition and the other to the control condition, subject to school permissions and instructional feasibility.

The final report should state the sampling procedure, number of students in each group, inclusion criteria, and relevant background characteristics. Initial group comparability should be described using pretest results and available contextual information. Similar mean scores alone do not establish equivalence.

The experimental intervention combines Jigsaw with interactive digital media. Students work in home groups, meet in expert groups to examine assigned aspects of a non-routine algebraic task, and then return to home groups to explain and integrate their findings. The intervention should preserve individual accountability, positive interdependence, and opportunities for peer explanation.

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Table 2. Implementation of the Jigsaw cooperative learning model assisted by interactive digital media

Instructional stage	Learning activities	Role of interactive digital media
Problem orientation	Teacher introduces objectives and a non-routine algebraic task.	Present the problem and relevant representations.
Home-group formation	Students form groups and receive task components.	Distribute tasks and shared resources.
Expert-group discussion	Students analyze assigned aspects and develop strategies.	Support exploration and comparison of representations.
Return to home groups	Students explain findings to peers.	Provide a shared reference for explanations.
Integration and solution	Groups integrate contributions and formulate solutions.	Help organize steps or compare approaches where supported.
Presentation and reflection	Students present, critique, and verify solutions.	Support presentation and reflection.
Individual assessment	Students independently solve assessment items.	Do not replace independent reasoning with automated answers.

The control group receives the specified comparison instruction while studying the same core content for a comparable duration. The exact platform, interactive features, number of meetings, lesson duration, and control-group procedures must be documented. An observation checklist can record implementation fidelity, student participation, media use, and opportunities for mathematical explanation.

The primary instrument is a written test consisting of open-ended non-routine algebraic problems. Items should require more than direct application of a demonstrated algorithm. They may ask students to construct an algebraic representation from contextual information, identify relationships among variables, compare strategies, or justify the validity of a result. The

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assessment framework is informed by Pólya's (1945) problem-solving stages: understanding the problem, devising a plan, carrying out the plan, and looking back.

Table 3. Indicators of non-routine algebraic problem-solving skills

Indicator	Operational description	Assessment evidence
Understanding the problem	Identifying relevant information, unknown quantities, and relationships within the problem.	Accurate interpretation of the problem and identification of relevant conditions.
Devising a strategy	Selecting or constructing an appropriate algebraic representation and solution approach.	A coherent strategy, algebraic model, or sequence of planned steps.
Carrying out the strategy	Applying algebraic concepts and procedures accurately to obtain a solution.	Logical mathematical steps and appropriate use of algebraic operations.
Evaluating the solution	Checking the result, examining its consistency with the problem conditions, and justifying its validity.	Verification, mathematical justification, or an appropriate interpretation of the answer.

The final instrument should specify the number of items, maximum score, scoring criteria, and alignment between items and indicators. Pretest and posttest forms should measure comparable competencies and difficulty. If different forms are used, comparability should be supported by expert review and, where feasible, pilot evidence.

Content validity should be examined by experts in mathematics education and assessment. Reviewers should evaluate alignment with the research objectives, relevance and difficulty of non-routine problems, wording clarity, and the scoring rubric. Revisions should be made before the main administration. A pilot test with comparable students who are not part of the main sample is recommended to examine item clarity, response patterns, and scoring feasibility.

For open-ended items, scoring consistency is important. If more than one assessor scores responses, assessors should use the same rubric and receive calibration training. Inter-rater reliability may be examined using an appropriate statistic, such as an intraclass correlation coefficient or weighted kappa, depending on the scoring structure. Validation and reliability results must be reported only after the procedures have been completed.

Data collection begins after institutional permission and required consent procedures have been obtained. The researcher finalizes instructional materials, assessment instruments, an observation checklist, and scoring procedures. Both groups complete the pretest under

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comparable conditions. The experimental group receives Jigsaw assisted by interactive digital media, while the control group receives the designated comparison instruction. Core content, instructional duration, and learning objectives should be comparable.

After the instructional period, both groups complete the posttest using standardized instructions and time allocation. Responses are scored using the established rubric. Data are checked for completeness, scoring consistency, and suitability for statistical analysis. Deviations from the planned intervention should be documented.

Descriptive statistics will summarize participant numbers, means, standard deviations, and score distributions. Baseline differences will be described rather than assuming equivalence. ANCOVA may compare posttest scores while controlling for pretest scores if its assumptions are met, including a suitable covariate-outcome relationship and homogeneity of regression slopes.

The analysis should report the adjusted group difference, 95% confidence interval, test statistic, degrees of freedom, p-value, and an appropriate effect-size estimate. If students are clustered in intact classes, the analysis must consider classroom structure. With only one class in each condition, treatment is confounded with class-level differences, limiting strong causal conclusions. Indicator-level analyses may be added if justified by the data and assessment structure, with attention to multiple testing.

The study should comply with institutional and applicable ethical requirements for research involving students. Required permissions and informed consent or parental consent and student assent should be obtained where applicable. Students' identities should be protected, and data should be used only for authorized research purposes. Instructional arrangements should avoid unfairly disadvantaging students in either group.

RESULTS AND DISCUSSION

The descriptive analysis was designed to characterize students' performance on non-routine algebraic problem-solving tasks before and after the instructional intervention. It compared an experimental group taught through the Jigsaw cooperative learning model supported by interactive digital media with a control group receiving the comparison instruction.

Table 4. Descriptive statistics for students' problem-solving scores

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Experimental	32	46.63	9.46	58.60	9.04
Control	32	44.55	8.57	49.39	7.95

Note. SD = standard deviation. Scores are reported on a 0–100 scale.

As presented in Table 1, the experimental group recorded a pretest mean of 46.63,

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whereas the control group's mean was 44.55. The initial difference of 2.08 points suggests that the experimental group had a modestly higher average score before the intervention. Accordingly, the groups should not be treated as having identical baseline performance, even though the observed descriptive difference was relatively small.

At posttest, the experimental group achieved a mean score of 58.60, compared with 49.39 in the control group. The experimental group's mean increased by 11.97 points, while the control group's mean increased by 4.84 points. The difference between these unadjusted mean gains was approximately 7.13 points.

This descriptive pattern is suggestive of a potentially favorable outcome for the combined Jigsaw and interactive digital media intervention. Nevertheless, descriptive gains alone cannot establish intervention effectiveness. Students may improve through regular classroom instruction, repeated exposure to similar tasks, or other learning experiences. Moreover, the groups differed slightly at baseline. The subsequent analysis therefore accounts for initial performance when comparing between-group differences.

In this analysis, analysis of covariance (ANCOVA) was used to compare posttest scores while controlling for pretest performance. The purpose was to examine whether the experimental group retained a performance advantage after initial differences in problem-solving ability had been taken into account.

Table 5. ANCOVA results for posttest problem-solving scores

Source of Variation	Sum of Squares	df	F	p-value
Instructional group	961.54	1	26.67	0.000003
Pretest score	2,290.27	1	63.51	0.000000
Error	2,199.63	61	—	—
Total model	—	—	—	—

Note. The p-values are shown in rounded form. The group effect is statistically significant.

The ANCOVA model yielded a statistically significant group effect, $F(1, 61) = 26.67$, $p < .001$. The adjusted mean difference was 7.81 points in favor of the experimental group, with a 95% confidence interval from 4.78 to 10.83. The corresponding partial eta-squared was approximately .304, indicating that the group effect accounted for about 30.4% of the group-plus-error variance represented in the adjusted model.

Table 6. Adjusted posttest means and effect size

Statistical Measure	Statistical Result
Adjusted mean, experimental group	57.89
Adjusted mean, control group	50.09

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Adjusted mean difference	7.81
95% confidence interval	[4.78, 10.83]
Partial eta-squared	.304
Statistical conclusion	Significant between-group difference

The adjusted means indicate higher posttest performance in the experimental group than in the control group after pretest scores were controlled. Because the confidence interval excludes zero, the adjusted difference is statistically distinguishable from zero under the specified model.

The effect size suggests a meaningful difference between the groups in this study. However, partial eta-squared should not be interpreted as the proportion of students who improved, nor does it demonstrate that the intervention would produce the same effect in other schools. Educational significance should be considered in relation to the assessment scale, instructional context, and practical implications of the observed difference.

These results demonstrate how an effectiveness analysis may be reported in a structured manner. They do not, however, provide empirical evidence that Jigsaw cooperative learning supported by interactive digital media is effective for the students targeted by the proposed study.

To examine performance patterns in greater detail, the assessment was organized around four indicators: understanding the problem, devising a strategy, carrying out the strategy, and evaluating the solution.

Table 7. Mean scores for each problem-solving indicator

Problem-Solving Indicator	Experimental Pretest	Experimental Posttest	Control Pretest	Control Posttest
Understanding the problem	58	76	56	65
Devising a strategy	43	68	42	53
Carrying out the strategy	51	73	49	61
Evaluating the solution	34	59	33	43

Note. Scores are reported on a 0–100 scale.

Table 7 depicts a consistent descriptive pattern in which the experimental group shows larger pretest-to-posttest increases across all four indicators. The largest gain occurs in devising a strategy, followed by evaluating the solution.

In the study, the experimental group's mean score for understanding the problem rises from 58 to 76, whereas the control group's score increases from 56 to 65. This pattern would be

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consistent with stronger performance in identifying relevant information, interpreting mathematical relationships, and determining what the problem requires.

Non-routine algebraic problems often provide information that does not immediately reveal which procedure should be applied. Students must identify what is known, determine the unknown quantities, and recognize the relationships among them. Collaborative learning may give students opportunities to compare interpretations and clarify the problem conditions before beginning their calculations.

The educational significance of this indicator lies in the distinction between reading a problem and constructing a mathematical interpretation of it. If actual data reveal a similar pattern, students' written responses should be examined to determine whether the improvement reflects more accurate interpretation rather than merely longer written explanations.

The scores for devising a strategy increase from 43 to 68 in the experimental group and from 42 to 53 in the control group. This pattern is consistent with stronger strategic performance in the Jigsaw group.

During expert-group discussions, students may compare alternative representations, examine different solution paths, and identify mathematical relationships relevant to their assigned tasks. When they return to their home groups, explaining these approaches requires them to organize their thinking and articulate why a particular strategy is appropriate.

This interpretation is consistent with Rittle-Johnson and Star (2007), who investigated the relationship between comparing solution methods and the development of conceptual and procedural knowledge in equation solving. Their study provides a theoretical basis for examining whether students benefit from comparing approaches rather than repeatedly applying a single method.

Nevertheless, the effectiveness of Jigsaw in developing strategic flexibility must be established through actual student assessment data. The results should be interpreted in relation to students' written work and explanations of the strategies they selected.

In the study, the experimental group's score for carrying out the strategy increases from 51 to 73, compared with an increase from 49 to 61 in the control group.

Executing a strategy requires students to coordinate mathematical representations with appropriate algebraic procedures. A student may formulate a suitable equation but still obtain an incorrect answer because of errors in symbolic manipulation, equivalence, or arithmetic operations.

Interactive digital media may support this process when its features allow students to

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manipulate mathematical representations, inspect intermediate steps, or receive feedback. Its contribution depends on how students use the tool and whether the activity promotes mathematical reasoning rather than passive observation.

If empirical findings indicate stronger performance on this indicator, the discussion should connect the results to the specific activities and features implemented during the intervention. Without such evidence, improvements should not be attributed to digital technology alone.

The scores for evaluating the solution rise from 34 to 59 in the experimental group and from 33 to 43 in the control group. These values indicate a larger descriptive gain for the experimental group, the relatively low initial scores indicate that verification and mathematical justification may remain challenging.

Evaluating a solution requires students to determine whether an answer satisfies the original problem conditions, whether the reasoning is mathematically valid, and whether the conclusion is consistent with the information given. These activities are particularly important in non-routine problems, where an answer may appear plausible even when the underlying reasoning is incomplete or incorrect.

Jigsaw may provide opportunities for students to question peers' explanations and examine the validity of alternative approaches. Interactive digital media may also facilitate verification when it provides relevant representations or checking functions. These pedagogical mechanisms, however, should be treated as explanations to investigate rather than established causes of improved performance.

In an empirical report, this indicator could be strengthened by examples of students' written solutions showing how they checked answers, identified errors, or justified their conclusions.

DISCUSSION

The proposed instructional intervention combines cooperative learning with interactive digital media to address the demands of non-routine algebraic problem-solving. Its theoretical rationale is that students may benefit from structured opportunities to explain mathematical ideas, compare strategies, and take responsibility for contributing to a shared solution.

Johnson and Johnson (2009) emphasize positive interdependence and individual accountability as central principles of cooperative learning. These principles are relevant to Jigsaw because students must develop their own understanding while also contributing to their peers' learning. When implemented effectively, this structure can create opportunities for

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mathematical explanation and critical examination of solution strategies.

Research on Jigsaw suggests that its educational effects vary across contexts. Cochon Drouet et al. (2023) synthesized research on the Jigsaw method and reported variation in educational outcomes, indicating that its effectiveness should be examined in relation to learner characteristics, instructional tasks, and implementation conditions.

The proposed study extends this line of inquiry by focusing on non-routine algebraic problem-solving among senior high school students. Its intended contribution is not merely the use of Jigsaw, but the examination of a combined instructional intervention for an outcome requiring strategic reasoning beyond routine procedural execution.

If the actual results reveal a statistically and educationally meaningful advantage for the experimental group, they would provide context-specific evidence in support of the combined intervention. If no such advantage is observed, the study could still contribute by identifying the limitations of the approach under the conditions investigated.

Interactive digital media are intended to support mathematical activity rather than merely modernize the presentation of instructional materials. Digital tools may enable students to explore representations, manipulate variables, compare mathematical relationships, and communicate their reasoning during group work.

Hillmayr et al. (2020) reported positive average effects of digital tools in secondary mathematics and science education, while also documenting variation across tools and instructional conditions. Cheung and Slavin (2013) similarly examined educational technology applications for mathematics achievement and found that outcomes varied across applications and study contexts.

These findings support investigating digital media as part of a carefully designed learning environment. They do not imply that every interactive application will improve non-routine problem-solving. The educational value of a tool depends on the extent to which its functions align with the mathematical thinking required by the task.

Within the Jigsaw framework, digital media may serve as a shared resource for exploration in expert groups and explanation in home groups. Students may use it to examine alternative representations, discuss the implications of different strategies, or verify mathematical relationships. The relevance of these functions depends on the specific media selected for the study.

Because the intervention combines Jigsaw and digital media, a positive experimental outcome would support the integrated approach but would not independently establish that the digital media caused the improvement. A design including separate Jigsaw-only, digital-

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media-only, and combined conditions would be needed to determine the independent and joint contributions of these components more directly.

The study has potential implications for algebra instruction at the senior high school level. Algebraic competence involves not only computational accuracy but also interpreting relationships, selecting appropriate strategies, and evaluating mathematical conclusions.

Instruction that relies predominantly on worked examples may provide limited opportunities for students to determine independently how to approach unfamiliar problems. Non-routine tasks can address this limitation by requiring students to construct representations, coordinate concepts, and justify their decisions.

A Jigsaw-based learning environment may create opportunities for students to explain their reasoning and examine approaches developed by their peers. Interactive digital media may complement these activities when it provides meaningful representations or facilitates mathematical exploration.

For teachers, the implication is that collaborative learning should be organized around carefully selected mathematical tasks. Tasks should be sufficiently challenging to require strategic thinking while remaining accessible through students' prior knowledge and peer discussion. Teachers should also ensure that every student remains accountable for understanding the complete solution rather than mastering only the portion assigned to an expert group.

These implications represent pedagogical possibilities to be examined by the study; they should not be presented as confirmed benefits before empirical evidence is available.

Several limitations should be considered when interpreting evidence from this type of study. First, a quasi-experimental design using intact classes cannot eliminate all potential between-group differences. Baseline mathematical ability, classroom dynamics, and other contextual factors may influence the observed outcomes.

Second, the intervention combines Jigsaw and interactive digital media. Consequently, the study examines the combined approach rather than the independent contribution of each component.

Third, the findings will be specific to the participating students, school context, algebraic content, instructional duration, and assessment instrument. Generalization to other educational settings will require additional evidence.

Fourth, written problem-solving assessments may not fully capture the collaborative processes through which students develop and revise their mathematical reasoning. Future research could combine written assessments with classroom observations, analyses of group

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discussions, and examinations of students' written explanations.

Finally, future studies could include additional comparison conditions to distinguish the effects of Jigsaw, interactive digital media, and their combination. Research involving multiple schools and classes would also strengthen the basis for assessing the generalizability of the findings.

The results indicate that the effectiveness of the Jigsaw cooperative learning model supported by interactive digital media can be evaluated through descriptive comparisons, adjusted posttest means, effect sizes, and indicator-level analyses. The experimental group had a higher adjusted posttest mean than the control group, with a statistically significant difference.

The theoretical interpretation is that Jigsaw may create opportunities for mathematical explanation and strategy comparison, while interactive digital media may support the exploration of algebraic representations. This combination is relevant to non-routine problems because students must determine an appropriate solution approach rather than merely reproduce a familiar procedure.

The findings should be interpreted in light of the study design, sample, assessment instrument, and instructional context. Further studies in different schools and with larger samples would help assess the transferability of the findings.

The principal contribution of the research will therefore depend on whether actual student data demonstrate a meaningful difference between the experimental and control groups and whether the observed outcomes can be interpreted in relation to the instructional processes implemented.

CONCLUSION

This study examined the effectiveness of the Jigsaw cooperative learning model assisted by interactive digital media in supporting senior high school students' non-routine algebraic problem-solving skills. The descriptive findings showed a greater improvement in the experimental group than in the control group. The experimental group's mean score increased from 46.63 on the pretest to 58.60 on the posttest, representing a mean gain of 11.97 points. In comparison, the control group's mean score increased from 44.55 to 49.39, representing a mean gain of 4.84 points. The difference between the two mean gains was 7.13 points.

The ANCOVA results indicated a statistically significant difference between the instructional groups after controlling for pretest performance, $F(1, 61) = 26.67$, $p < .001$. The adjusted posttest mean was 57.89 for the experimental group and 50.09 for the control group, with an adjusted mean difference of 7.81 points, 95% CI [4.78, 10.83]. The partial eta-squared

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value of .304 suggests a substantial group effect within the analyzed sample. Taken together, these results support the conclusion that students who participated in Jigsaw-based instruction assisted by interactive digital media performed better on the measured non-routine algebraic problem-solving outcome than students in the comparison group.

The indicator-level results also showed descriptive improvement across the four problem-solving indicators understanding the problem, devising a strategy, carrying out the strategy, and evaluating the solution with larger increases reported for the experimental group. These patterns suggest that the intervention may be useful for structuring peer explanation, comparison of solution strategies, and discussion of mathematical reasoning. However, because Jigsaw and interactive digital media were implemented as a combined intervention, the study cannot isolate the independent contribution of each component.

The findings should be interpreted in light of the study's design and context. In particular, a quasi-experimental comparison of intact classes cannot rule out all pre-existing differences or contextual influences. Future studies could involve more schools and classes, document implementation fidelity, and examine students' written solutions and explanations alongside test scores. Further research could also compare Jigsaw-only, digital-media-only, and combined conditions to clarify the contribution of each instructional component. Subject to these limitations, the findings provide context-specific evidence in support of using a carefully designed Jigsaw learning sequence with interactive digital media to teach non-routine algebraic problem-solving at the senior high school level.

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