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The Efficacy of a Mathematics Intervention Program Based on Projects Developed by Students

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Abstract

This study investigates the effectiveness of a project-based mathematics intervention program developed through student-generated projects. Conducted in Israel in 2023, the study employed a quasi-experimental design with pre- and post-test measures. The sample consisted of 57 tenth-grade students, divided into an experimental group (n = 30) and a control group (n = 27). The intervention consisted of 10 lessons built around interdisciplinary, real-world projects designed to integrate students' interests. Data were collected using a validated attitudes toward mathematics scale measuring seven dimensions: enjoyment, value, talent and interests, self-efficacy, math anxiety, design thinking, and collaborative work. Results showed statistically significant improvements in five of the seven dimensions for the experimental group, with large effects for enjoyment and design thinking. Group × Time interaction effects were significant across all dimensions, confirming the intervention's positive influence. Between-group posttest comparisons revealed significant advantages for the experimental group across all dimensions. These findings suggest that incorporating student-designed, interest-driven projects into mathematics instruction can enhance engagement, self-efficacy, and attitudes toward learning. The study highlights the importance of participatory pedagogy and offers implications for curriculum development and teacher training.

Keywords: integrating students' interests; project-based learning; quasi-experimental research; student generated projects, teaching mathematics

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1. Introduction

Mathematics education in the modern era faces a dual challenge: improving student achievement while fostering engagement, interest, and creative thinking. Research indicates that many students perceive mathematics learning as a technical, abstract process disconnected from personal relevance, often leading to decreased motivation and negative attitudes toward the subject (Boaler, 2016; Schoenfeld, 2016).

Mathematics education in Israeli high schools is currently grappling with significant challenges, particularly regarding student motivation, engagement, and the perceived relevance of the subject in students' lives. A considerable number of students find it difficult to relate mathematical concepts to their personal experiences, interests, or future aspirations. This disconnection is further intensified by an instructional culture that tends to prioritize rote learning, procedural fluency, and performance on high-stakes assessments, at the expense of fostering creativity, inquiry-based learning, and authentic problem-solving skills. As a result, students often view mathematics as an abstract and distant discipline, diminishing their intrinsic motivation and the potential to appreciate its real-world applications.

Despite curricular reforms in recent years aimed at modernizing instruction to align with 21st-century competencies, mathematics classrooms in Israel often remain focused on delivering predefined content and preparing students for standardized exams (Leikin & Levav-Waynberg, 2007). This narrow focus limits students' opportunities to engage in higher-order thinking, develop mathematical intuition, or explore the aesthetic and emotional dimensions of mathematics as a humanistic discipline. The pressure to complete the curriculum, especially in high-level tracks, discourages innovation and deeper inquiry, exacerbating the disconnection between mathematics and students' lived experiences.

Recent literature in mathematics education underscores the transformative potential of active, student-centered pedagogies. Approaches that incorporate real-life contexts, interdisciplinary connections, and opportunities for collaborative exploration have been shown to increase students' motivation, conceptual understanding, and long-term retention (Boaler, 2016). By enabling students to actively engage in their learning, these approaches can cultivate a sense of agency and ownership, which is critical for fostering positive attitudes toward mathematics.

However, in the Israeli context, several barriers hinder the widespread adoption of such pedagogies. These include high teacher workloads, rigid curricular expectations, limited time for interdisciplinary planning, and a lack of professional development focused on innovative instructional design (Asli & Zsoldos-Marchis, 2021; Barber & Mourshed, 2007). Furthermore, the traditional image of mathematics as an objective and abstract discipline often discourages the integration of personal or emotional dimensions into its instruction.

Previous efforts in Israel have been made to implement active, participatory teaching methods aimed at fostering a positive attitude toward learning mathematics (Asli & Zsoldos-Marchis, 2023a; London, 2022; Polacco, 2024; Polacco & Zsoldos-Marchis, 2025). The experiment carried out by London (2022) involved grade 10 high-school students. Students worked in collaborative groups on projects developed by them based on their interests. Finalizing these projects required students to apply the mathematical concepts they had learned, as well as knowledge from other disciplines. The results indicated improvements in students' self-efficacy and motivation. Similarly, the study by Asli and Zsoldos-Marchis (2023a) with high school students (grades 11 and 12) integrated applications of mathematics from other disciplines into mathematics lessons. Their findings showed enhanced mathematical achievement along with positive changes in students' self-confidence, motivation, enjoyment of mathematics, and perceived value of the subject. In another study, Polacco (2024) implemented emotional support tools and real-life applications in geometry lessons for elementary students (grades 5 and 6), resulting in reduced mathematics anxiety and improved mathematical achievement.

This research is the follow-up of the pilot research of London (2022). The projects developed by the students during this pilot research were turned into lesson plans by the researcher and used in a class-based intervention described in this paper. By involving students in the co-creation of lesson plans and fostering teacher-student collaboration, this approach seeks to transform mathematics education into a more meaningful and emotionally resonant experience, and it highlights the inherent beauty of mathematics. Demonstrating the practical utility of mathematics can positively impact students' attitudes and achievement (Asli & Zsoldos-Marchis, 2023a). This paper presents the results of the experimental research based on an intervention program using the lesson plans developed based on students' projects.

2. Theoretical background

Research supporting the presented study emphasizes the importance of design thinking and project-based learning. The design of the intervention program highlights learners' individual interests, promotes inquiry-oriented instruction, and integrates collaborative practices. Together, these elements provide an innovative framework with important implications for teaching and learning. Incorporating personal interests enhances enjoyment, curiosity, and sustains motivation for learning mathematics (Renninger & Hidi, 2019; Walkington & Bernacki, 2019). Inquiry-based teaching further bolsters self-efficacy, a key predictor of success, by building confidence and reducing anxiety (Larsen & Jang, 2022). Collaborative methods cultivate supportive environments, encouraging peer interaction and teamwork, which are essential for long-term learning (Attard & Holmes, 2020).

2.1. Design Thinking

Design Thinking is an interdisciplinary approach to problem-solving that emphasizes user-centered design, iterative development, and creativity. It is widely applied in fields such as education, engineering, business, and healthcare due to its focus on addressing complex, real-world problems through innovation and empathy (Brown, 2009; Liedtka, 2015). In education, it fosters creativity and problem-solving skills among students (Razzouk & Shute, 2012). The process is iterative, encouraging continuous feedback and refinement, making it particularly effective in developing solutions that are both practical and user-friendly (Plattner et al., 2009; Razzouk & Shute, 2012).

Design Thinking follows a structured yet flexible process consisting of five key stages: empathize, define, ideate, prototype, and test (Brown, 2009). The empathize stage involves understanding users' needs and experiences, ensuring that solutions are rooted in real-world contexts (Plattner et al., 2009). The define stage focuses on synthesizing insights into a clear problem statement, guiding the creative process (Liedtka, 2015). During ideation, diverse solutions are generated, leveraging brainstorming and other creative techniques (Rowe, 1987). The prototype stage transforms ideas into tangible models that can be tested and refined, while the testing phase allows for user feedback, ensuring that the final solution effectively meets user needs (Brown, 2009).

2.2. Problem-Based Learning (PBL)

Project-Based Learning (PBL) positions students at the center of the learning process by engaging them in authentic, real-world problem-solving activities (Blumenfeld et al., 1991). Recent research highlights that PBL promotes higher-order thinking, self-regulated learning, and improved attitudes toward mathematics (Himmi et al., 2015; Hmelo-Silver, 2004). Better self-regulation skills contribute to higher achievement in problem-solving (Marchis, 2012). Rather than relying on passive instruction, PBL encourages learners to work collaboratively on projects that require the application of mathematical knowledge to interdisciplinary contexts, fostering deeper conceptual understanding and motivation (Barron et al., 1998). Integrating collaborative learning within PBL has been shown to increase mathematics achievement and engagement, particularly when students tackle complex, meaningful tasks in cooperative groups (Siller & Ahmad, 2024). PBL also fosters interdisciplinary thinking (Jonassen, 2011). This method aligns with constructivist theories of learning (Piaget, 1951; Vygotsky, 1978), emphasizing the construction of knowledge through inquiry and social interaction. PBL has been shown to improve student motivation, foster collaboration, and bridge the gap between theoretical and applied mathematics (Capraro & Slough, 2013). It is particularly effective in STEM education, where interdisciplinary applications are essential. Darling-Hammond et al. (2008) reported that students engaged in PBL exhibited enhanced problem-solving abilities and greater persistence when tackling complex mathematical tasks.

3. Methodology

The study was conducted in 2023. The quasi-experimental research employed a two-group pretest–posttest design. This design was selected to evaluate changes in key outcomes over time while comparing the effects of the intervention with a control group. By measuring baseline levels of students' attitudes, skills, and engagement before the program, the study could control for initial differences and assess the specific impact of the intervention. Quantitative data were collected and analyzed to provide objective evidence of both within-group and between-group effects. In the following, the detailed research methodology is presented.

3.1. Research aim

The research aimed to examine the effect of the intervention program on enjoyment of mathematics, perceived value of mathematics, self-efficacy, design thinking, math anxiety, collaborative work, and integration of students' interests.

3.2. Intervention program

The intervention program contains 10 lessons, each of them based on a project developed by the students in a previous experiment in London (2022). The projects included in the intervention program are presented in Table 1. During the lessons, students are encouraged to identify authentic problems, explore potential solutions, generate project ideas aligned with their interests, and select a preferred solution. They then design a product that addresses the chosen problem and conduct an investigation using scientific tools. Throughout the process, students work collaboratively in groups. During the lessons, the teacher acts as a collaborator rather than the central figure, providing support and guidance when needed while encouraging student autonomy. Mathematics teachers should actively engage with students in the teaching–learning process and integrate practical mathematical examples into classroom activities to foster greater student interest in the subject (Asare et. Al, 2024). Positioning the teacher as a collaborator rather than the central authority supports student autonomy and is consistent with constructivist and sociocultural learning theories, which stress active participation and the co-construction of meaning. This transformation in classroom dynamics promotes student ownership of learning and cultivates a more inclusive, inquiry-oriented environment.

Table 1. Projects included in the intervention program

Project Title	Mathematical Concepts	Student's Personal Interest	Real-World Application
Math in Games: Domino Game	Differential and Integral Calculus, Geometry	Domino game instructions and mathematical theory	The game design industry uses 3D printing or design thinking theory.
Building the	Geometry, Algebra,	Creative planning of short	Developing creative and

Future: Cards against Math	Spatial Reasoning	questions, review of tests, memory training, and mathematical thinking that allows for quick retrieval of answers.	original tasks in Sustainable Design
The Mystery of the Witch House- Escape room - math and probability	Probability, Statistics, Combinatorics	Video Games, Game Design	Game Development, Strategy Optimization
Sports Stats: Do you have physical fitness? Using Statistics to Analyze Athletes	Statistics, Averages, Probability	Sports, Athletic Performance	Sports Analytics, Athlete Team Management
Fashion and Geometry: Jewelry Design with Trigonometry and Geometry	Geometry, Symmetry, Trigonometry	Fashion Design	Fashion and design Original design planning
Art your math, Nicole's Pythagoras	Relationships, proportions, trigonometry - mathematics combined with art.	Trigonometry and the environment, mathematics in art	Art with technology, the connection of mathematics and model building, puzzles, and games
The connection between mathematics and physics, a lesson that connects mathematics and physics.	Algorithms, Variables, Functions	Computer Science, Programming, Designing integrated systems that combine mathematics and physics, Designing joint experiments between the fields.	Developing software that connects the fields.
Trigonometry , Math, and model building	Trigonometry, geometry, measurement, ratios,	Arts, architecture.	Architecture and Design
The Mathematics of Music and Dancing: Creating a Tik Tok song	Coordination, memory training, memorization of formulas, and their use.	Visual Arts, Dance Art, Choreography	Art and Design, creativity, and originality in dance
Mathematics Engineering Series: Sisa prize	Characterization of an engineering series, series, laws, general formula, general term	Investigate, discover regularities. Mathematical writing, discover general conclusions	Designing engineering series + growth and decay + finite and infinite series, an algorithm for reaching a general term.

3.3. Research instrument

For this research, a mathematics attitude scale was constructed with items measured on a 5-level Likert scale. The items were formulated based on the literature (Fennema & Sherman, 1977; Forgasz, 1995; Leder, 1995; Lev Ari & Mittelberg,1996; Sherman & Fennema, 1976; 1996): some items are taken from different published scales, and some new items were formulated.

This scale initially contained 72 items. However, due to the low internal reliability of this scale, a Principal Components Analysis (PCA) was conducted to identify the underlying components assessed by the instrument. Before conducting the Principal Component Analysis

(PCA), the suitability of the data for factor analysis was carefully evaluated. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.88, indicating that the correlations among variables were sufficiently high for reliable factor extraction (values above 0.80 are generally considered "meritorious"). Additionally, Bartlett's Test of Sphericity was significant, confirming that the correlation matrix was not an identity matrix and that there were meaningful relationships among the variables to justify PCA. The PCA itself revealed several components with eigenvalues greater than 1.0, suggesting that these components captured more variance than an individual variable would contribute on its own. Together, these components accounted for 54% of the total variance, indicating that over half of the variability in the data could be summarized by a smaller set of underlying factors. This supports the idea that the dataset has a coherent structure that can be meaningfully reduced without excessive loss of information. A varimax rotation was applied to facilitate the interpretation of the factor structure, which resulted in a clear pattern of loadings, with items clustering meaningfully around distinct components. Based on these results, the questionnaire was reduced from 72 to 41 items, which provided a more coherent factor structure and improved the internal reliability of the scale. These 41 affirmations were grouped into 7 dimensions based on the scales from the literature: Enjoyment of mathematics (8 items such as I enjoy learning mathematics" and "I look forward to math classes at school."), Value of mathematics (8 items, for example, "Studying mathematics is important and will help me in everyday life," and "I need mathematics to study other subjects."), Talent and interests (5 items, for example, "I want to combine my interests with mathematics."), Math anxiety (5 items, for example, "I feel anxious before math lessons," and "I feel nervous when I have to solve a math problem."), Self-efficacy (6 items such as "I believe I'm good at solving math problems" or "I'm able to solve difficult math problems without too much difficulty."), Design thinking (4 items, for example, "I enjoy solving open problems and exercises in mathematics."), Collaborative working (5 items such as "I enjoy sharing my ideas with others," and "I help other team members complete their tasks"). Cronbach's alpha was used to evaluate the internal consistency reliability of the scale. The analysis yielded a point estimate of $\alpha = .857$, with a 95% confidence interval; the Cronbach's alphas for the dimensions ranged from .805 to .898, indicating good internal consistency.

3.4. Participants

Sixty-four tenth-grade students (ages 15–16) from an Israeli high school participated in the study. They were assigned to either the experimental group ($n = 32$) or the control group ($n = 32$). After analyzing the pretest and posttest results, students who didn't respond to a consistent part of the items were eliminated from the sample. In this way, the experimental group had 30 students, the control group 27 students.

3.5. Data collection and analysis

The scale was used as a pretest and posttest in both the experimental and control groups. The time needed for filling in the online questionnaire was between 20-30 minutes.

The results were qualitatively analysed with descriptive statistics (means (M), standard deviations (SD)) and comparison of means.

4. Results

The quantitative data is statistically analyzed using JASP (Version 0.95.1) statistical analysis program. Several comparisons were conducted, including pretest versus posttest within each group, as well as between-group comparisons at pretest and at posttest.

4.1. Examination of changes between pretest and posttest scores

Table 2 is included to provide a comprehensive overview of the pretest and posttest scores for both experimental and control groups. The means (M) and standard deviations (SD) allow for assessing baseline comparability, understanding the variability in the data, and contextualizing the results of subsequent statistical analyses.

Table 2. Group- and time-specific means and standard deviations across all dimensions

Dimension	Group	Pretest		Posttest	
		M	SD	M	SD
Enjoyment of learning mathematics	Control	3.08	0.61	2.95	1.12
	Experimental	2.80	1.08	3.92	1.20
Value of mathematics	Control	3.69	1.09	3.47	1.11
	Experimental	3.59	1.00	4.28	0.84
Talent and interests	Control	3.47	0.99	2.76	1.16
	Experimental	3.26	0.99	3.84	1.16
Math anxiety	Control	2.82	0.47	3.29	0.65
	Experimental	2.99	1.28	2.43	1.11
Self-efficacy	Control	2.96	0.95	2.95	0.84
	Experimental	3.27	0.76	3.68	0.78
Design thinking	Control	3.35	1.11	2.44	1.07
	Experimental	2.74	1.22	3.60	1.19
Collaborative work	Control	3.94	0.59	3.26	0.89
	Experimental	3.79	0.82	4.02	0.85

Analyzing the data from Table 2, we could observe that for most dimensions the experimental group had an increase, while the control group had a stagnation or slight decrease. A series of paired-samples t-tests was conducted to compare pretest and posttest scores across each dimension of the scale. Before conducting these analyses, the Shapiro–Wilk test was applied to assess the assumption of normality, which is a key requirement for the validity of parametric tests. Results indicated that all variables were normally distributed ($p > .05$), supporting the appropriateness of using paired-samples t-tests. Conducting these tests allows for a direct assessment of whether the intervention produced statistically significant changes within each group over time, providing a clear method for evaluating the effectiveness of the treatment on specific dimensions. In the following, we analyze each dimension separately.

In the Enjoyment of Learning Mathematics dimension, participants in the experimental group demonstrated a substantial increase (mean difference = 1.12), whereas the control group experienced a minor decrease (mean difference = 0.13). This gain in the experimental group was statistically significant, $t(29) = –4.27$, $p < .001$, with a large effect size ($d = –0.78$). A similar pattern was evident for the Value of Mathematics dimension: scores in the experimental group rose by 0.69, while the control group's scores fell by 0.22. The increase observed in the experimental group reached statistical significance, $t(29) = –2.98$, $p = .006$, with a medium effect size ($d = –0.54$).

In case of the Self-efficacy dimension, the experimental group had an increase of 0.41, which is statistically significant, $t(29) = -2.41$, $p = .023$, with a medium effect size, $d = -0.44$. The control group showed virtually no change.

In the Talent and Interests dimension, the experimental group demonstrated a significant improvement (mean difference = 0.58), $t(29) = –2.44$, $p = .021$, with a medium effect size ($d = –0.45$), whereas the control group showed a decline of 0.71. A similar pattern was observed in the Design Thinking dimension, with the experimental group's scores increasing by 0.86, while the control group's scores decreased by 0.91. The improvement in the experimental group was statistically significant, t(29) = –2.74, p = .010, corresponding to a medium effect size (d = –0.50).

For the Collaborative Work dimension, the experimental group showed a slight, non-significant increase (mean difference = 0.23), t(29) = -1.05, p = .303, d = -0.19, whereas the control group experienced a notable decrease (mean difference = 0.68)

In terms of Math anxiety, the control group showed an increase of 0.47, while the experimental group demonstrated a decrease of 0.56. The decrease in the experimental group was not statistically significant, t(29) = 1.80, p = .082. The effect size is d = 0.33.

4.2. Comparison of the groups' results on the pretest

A series of independent-samples t-tests was performed to examine whether the experimental and control groups differed significantly on the scale dimensions before the intervention. Assumptions of normality and homogeneity of variances were tested before the analysis. Shapiro-Wilk tests indicated that most variables were normally distributed in both groups (p > .05), although slight deviations from normality were noted for the dimension value of mathematics measured on pretest in both groups and the self-efficacy dimension measured on pretest in the experimental group. Despite these deviations, t-tests are robust to minor normality violations, especially with roughly equal group sizes (n = 27 and n = 30). Levene's (Brown–Forsythe) tests indicated violations of homogeneity of variance for the enjoyment of learning mathematics measured on pretest (p < .001) and math anxiety measured on pretest (p < .001). As such, t-test results for these variables should be interpreted with caution, and unequal variances were used when applicable. Although differences in means were observed between the groups across each dimensions (see Table 1), these differences are not statistically significant for any of the dimensions, as Enjoyment of learning mathematics (t(55) = 1.18, p = .244, d = 0.31), Value of mathematics (t(55) = 0.37, p = .711, d = 0.10), Talent and interests (t(55) = 0.79, p = .434, d = 0.21), Math anxiety (t(55) = -0.66, p = .512, d = -0.18), Self-efficacy (t(55) = -1.34, p = .185, d = -0.36), Design-thinking (t(55) = 1.97, p = .054, d = 0.52), and Collaborative work (t(55) = 0.80, p = .429, d = 0.21).

4.3. Comparison of the groups' results on posttest

The impact of the intervention was assessed by comparing posttest scores of the experimental and control groups; the descriptive statistics are presented in Table 2. Given that several posttest variables deviated from normality (Shapiro–Wilk p < .05), nonparametric analyses were conducted using the Mann–Whitney U test for each dimension (Table 3). Findings indicated significant group differences across all dimensions. Effect sizes, calculated as rank-biserial correlations, ranged from r = 0.481 to r = 0.537, representing medium to large magnitudes, with the strongest effect emerging for the Enjoyment of Learning Mathematics dimension (r = –0.509).

Table 3. Mann–Whitney U Test Results Comparing Control and Experimental Groups on Posttest Measures

Variable	U	p	Rank-Biserial *r*	SE *r*
Enjoyment of learning mathematics	199.00	.001	-0.509	0.153
Value of mathematics	210.00	.002	-0.481	0.153
Talent and interests	192.00	< .001	-0.526	0.153
Math anxiety	616.00	< .001	0.521	0.153
Self-efficacy	195.00	< .001	-0.519	0.153
Design thinking	189.00	< .001	-0.533	0.153
Collaborative work	187.50	< .001	-0.537	0.153

4.4. Modelling the Impact of the Intervention

To evaluate the intervention's impact on the various dimensions of the scale, a linear mixed-effects model (LMM) was employed. This analytic approach was selected due to the repeated-measures structure of the data (pretest and posttest observations nested within individuals) and a significant violation of the homogeneity of variance assumption, as indicated by Levene's test. The LMM included Time (pretest vs. posttest), Group (experimental vs. control), and their interaction as fixed effects, with random intercepts for participants to account for within-subject variability.

Enjoyment of learning mathematics. The main effect of Group was not significant, $F(1, 55) = 2.72$, $p = .105$. A statistically significant effect of Time was observed, $F(1, 55) = 7.49$, $p = .008$, indicating changes over time. Importantly, the Group × Time interaction was significant, $F(1, 55) = 11.69$, $p = .001$, suggesting that the change in enjoyment from pretest to posttest differed between the experimental and control groups.

Value of mathematics. The main effects of Group, $F(1, 55) = 3.29$, $p = .075$, and Time, $F(1, 55) = 1.58$, $p = .214$, were not significant. However, the interaction between Group and Time was significant, $F(1, 55) = 6.24$, $p = .016$, indicating differential change in perceived value over time between groups.

Interest and talent. A notable main effect of Group was observed, $F(1, 55) = 4.15$, $p = .046$, whereas the main effect of Time did not reach significance, $F(1, 55) = 0.13$, $p = .722$. The Group × Time interaction was significant, $F(1, 55) = 12.36$, $p < .001$, indicating the groups differed in how interest changed across time.

Math anxiety. No significant main effects were found for Group, $F(1, 110) = 3.66$, $p = .058$, or for Time, $F(1, 110) = 0.05$, $p = .825$. In contrast, the Group × Time interaction was significant, $F(1, 110) = 8.27$, $p = .005$, suggesting that changes in anxiety over time differed between groups.

Self-efficacy. A significant main effect of Group was found, $F(1, 55) = 10.34$, $p = .002$, indicating overall differences in efficacy between the groups. The main effect of Time, $F(1, 55) = 1.70$, $p = .198$, and the Group × Time interaction, $F(1, 55) = 2.01$, $p = .162$, were not statistically significant.

Design thinking. No significant main effects were found for Group, $F(1, 110) = 1.59$, $p = .210$, or for Time, $F(1, 110) = 0.01$, $p = .910$. However, the Group × Time interaction was significant, $F(1, 110) = 16.68$, $p < .001$, indicating that the groups changed differently over time.

Collaborative work. The analysis revealed a significant effect of Group, $F(1, 110) = 4.18$, $p = .043$, but no statistically significant effect of Time was observed, $F(1, 110) = 2.17$, $p = .144$. The interaction between Group and Time was significant, $F(1, 110) = 9.37$, $p = .003$, suggesting differential changes in collaborative work across groups.

5. Discussion and conclusion

The findings of this study show the transformative potential of integrating students' interests into mathematics education and using project-based learning based on these interests. The results show statistically significant improvements in five out of seven dimensions for the experimental group. The two dimensions where the change is not significant are Collaborative work and Math anxiety. In case of all dimensions Group × Time interaction is statistically significant, indicating differences between the groups in the change over time. Between-group comparisons at posttest confirmed that the experimental group outperformed the control group in all dimensions.

Although the experimental group showed a decrease in math anxiety, this change was not statistically significant, possibly due to the short duration of the intervention or the novelty of the project-based approach, which may have initially introduced uncertainty or discomfort. This suggests that a longer intervention period or additional emotional support strategies may be needed to achieve meaningful reductions in math anxiety, representing a limitation of the current study.

These findings are in concordance with previous results regarding the effects of project-based learning, which has proven to be effective for developing a positive attitude towards mathematics (Rehman et. al, 2025), increasing self-efficacy (Anggalia et al., 2020), and enjoyment of learning mathematics (Holmes & Hwang, 2016), engaging students in learning (Tyata et. al, 2021). Incorporating students' interests into mathematics instruction and demonstrating real-world applications of mathematics has been shown to enhance the enjoyment and perceived value of learning mathematics (Asli & Zsoldos-Marchis, 2023a) as well as reduce math anxiety (Polacco, 2024).

The observed improvements in enjoyment, self-efficacy, and design thinking support the theoretical foundations of project-based learning and design thinking, which emphasize student agency, relevance, and creativity as drivers of deeper engagement and meaningful learning (Razzouk & Shute, 2012; Boaler, 2016). By adopting an innovative, student-centered approach that encourages the co-creation of lesson plans and fosters collaboration between students and teachers, mathematics is reimagined as a meaningful, emotionally resonant, and intellectually stimulating discipline. This participatory model empowers students to take ownership of their learning, cultivating critical thinking, creativity, and interpersonal skills. The integration of students' personal interests into mathematical tasks may have played a key role in fostering more positive attitudes, consistent with literature showing that relevance and personalization enhance motivation and sustained engagement (Renninger & Hidi, 2019; Walkington & Bernacki, 2019). Collaborative problem-solving also contributes to a more positive attitude towards mathematics (Zsoldos-Marchis, 2015).

The findings of this study also suggest that integrating student interests and project-based methodologies can be a viable strategy for improving mathematics education more broadly, especially in systems where traditional instruction dominates and student disengagement is prevalent. In addition, while the primary focus of this study is on students, it also reinforces prior findings concerning teacher development. Asli and Zsoldos-Marchis (2021, 2023b) emphasized that many teachers feel unprepared to implement STEAM-based or interdisciplinary lessons due to limited training in non-mathematical disciplines. In line with their conclusions, this research highlights the importance of structured, cross-disciplinary lesson plans and professional development opportunities to build teacher confidence. Providing teachers with detailed lesson plans encourages them to make instructional changes and builds their self-confidence (Polacco, 2025; Asli & Zsoldos-Marchis, 2023b). Reimagining the teacher's role as a facilitator and collaborator aligns with constructivist principles and supports the development of learner autonomy. However, this requires a shift in teacher mindset and training, suggesting that professional development programs should prepare educators for more flexible, student-centered roles.

The success of this intervention supports calls for curriculum reform that allows for flexibility, interdisciplinary exploration, and the inclusion of student voice – especially in high-stakes educational systems like Israel's, where standardized testing often dominates instructional priorities.

While the findings are promising, the study has some limitations. The relatively small sample, drawn from a single high school, may limit the generalizability of the results. Moreover, the brief duration of the intervention may have reduced its impact on aspects such as mathematics anxiety. Further research is needed to examine the long-term effects of this approach and its applicability across diverse educational settings. Future studies should explore its impact on student achievement, sustained motivation, and attitudes toward mathematics, as well as the practicality of incorporating such methods into teacher education programs and broader curricular reforms.

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