Problem-Solving Acceleration via MagicSchool AI in Makerspace-Based STEM: Evidence from a Randomized Trial

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Abstract: - This research examines how adding an AI tool "MagicSchool" to a makerspace STEM program affects elementary students' ability to solve problems. Three cognitive subdomains—strategic planning, creative ideation, and iterative perseverance—were examined using a true experimental, post-test-only control-group design with 60 sixth graders (ages 11–12) from two public schools in Jerusalem; students were randomly assigned equally to experimental (AI-supported makerspace) and to control (makerspace-only) group. For 12 sessions both groups completed 15 engineering challenges. The effects of the intervention were assessed after its completion by employing the validated Elementary Problem-Solving Inventory (EPSI). Statistical analysis involved a multivariate analysis of variance (MANOVA) which subsequently followed by univariate analyses of variance (ANOVAs) with effect sizes also being reported. MANOVA resulted a significant multivariate effect of instructional condition on problem-solving variables Wilks' $\Lambda = 0.624$, $F(3, 56) = 11.26$, $p < .001$, $\eta^2_p = 0.376$. The ANOVAs indicated substantial improvements for the AI group in strategic planning ($p < .001$, $\eta^2_p = 0.198$) creative ideation ($p = .003$, $\eta^2_p = .143$), and iterative perseverance ($p = 0.011$, $\eta^2_p = 0.106$). Integrating MagicSchool AI significantly improved elementary students' problem-solving competence across all measured domains. These findings offer causal evidence supporting AI scaffolding in hands-on, constructionist learning environments and inform curriculum and teacher support in primary STEM education.

Key-Words: - MagicSchool AI, makerspace, problem-solving, strategic planning, creative thinking, iterative learning, stem education, elementary school, experimental design.

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1 Introduction

Problem-solving competence is now regarded by global benchmarks such as PISA 2022 creative thinking as a "gateway" capability, that enables young learners to transfer knowledge across unfamiliar contexts and to navigate uncertainty in an AI-saturated society, [1]. National curricula from Finland to Singapore front-load the skill as early as Grade 3, yet international trend data show wide variance in elementary learners' ability to strategies, iterate, and reflect—especially in economically disadvantaged schools. Makerspaces have emerged as one of the most promising environments for cultivating such higher-order skills because they situate learning in iterative cycles of design–make–test–redesign. A study in Hong Kong kindergartens found that children who took part in a makerspace program for twelve weeks did well with STEM habits of mind. This makerspace program was very helpful to the children. The children in the Hong Kong kindergartens learned a lot from the makerspace program, [2]. Also, some researchers talked to teachers in school makerspaces. The teachers said they helped children solve problems in a way. The teachers did this by working with the children thinking about what they did and getting better at using technology. The teachers and the children worked on these skills in the makerspace program. The makerspace program was good, for the children and the teachers, [3]. When people work on fabrication projects these fabrication projects can really help them learn and grow. Making something is not easy because there are a lot of things to think about when you're making something. The fact is, making something from scratch can be very confusing, for beginners who are working on these fabrication projects. These fabrication projects are like a test, for people. They can be really hard to do. People can learn a lot from these fabrication projects. They can help them become cleverer. People who are new, to making things often get stuck when they have an idea but do not know how to turn it into something they can actually build. Artificial intelligence makers and teachers have been thought of as a way to help people when they are stuck. These artificial intelligence makers and teachers can give people hints. Show them pictures or pieces of code when they need it to help them keep going with their maker tasks. A 2024 Scientific Reports survey of Chinese secondary schools, for example, concluded that embedding AI analytic dashboards into maker lessons significantly improved students' learning attitudes and transfer of knowledge, [4]. Parallel policy briefs from the U.S. NSF's CADRE network argue that generative AI can personalize feedback loops in STEM, provided ethical safeguards are in place, [5], [6], [7]. Yet to date, most evidence remains correlational; rigorous trials in elementary settings are virtually absent. Enter MagicSchool AI—a platform offering more than 80 educator-designed tools (e.g., idea visualizers, rubric builders, block-code generators) and already deployed in over 13,000 school districts worldwide, [8]. Early user analytics on G2 rate the system 4.5/5 for "time saved" and "lesson-planning quality," but no peer-reviewed studies have examined its learning impact, let alone within the high-cognitive-demand context of makerspaces, [9]. Building on the dual promise of makerspaces and AI-driven scaffolding the current research conducts the first randomized controlled trial to test whether integrating MagicSchool AI into makerspace-based STEM challenges accelerates elementary students' problem-solving growth. Grounded in Constructionism and Banduras self-efficacy theory we think that tools with AI that help with ideas and reflection will help people in ways. These tools will make it easier for people to handle the effort needed during design cycles. They will also help people plan better and keep going even when things get tough. Additionally these tools will improve people's problem-solving skills. The study tries to find out how much an AI layer adds to a makerspace curriculum. The curriculum without the AI layer is the same as the one with it. The study wants to provide evidence, about how AI can help with maker learning. It also aims to give advice for teachers who want to give students the right amount of support. Lastly it wants to inform policies about using learning environments in primary education.

The study question is**: Can using MagicSchool AI tool with the teaching plans that are already used in makerspaces really help elementary students get better at solving problems faster than just doing hands-on projects by themselves?** We need to answer this question because teachers need to decide if they should use their limited resources to add MagicSchool AI to their classes and because people who make rules need to figure out how to use intelligence in a way that helps kids learn science and math in elementary school. MagicSchool AI is a tool that can be used in makerspaces to help elementary students learn. The question is can MagicSchool AI really make a difference, in how fast elementary students learn to solve problems when it is used with the makerspace teaching plans.

2 Literature Review

2.1 Makerspace Learning Environments and Problem-Solving Development

Makerspaces are really popular today. They are places where people can learn and think carefully. They help people work together and design things in a way. People can come up with ideas and make them happen in makerspaces. These spaces help people be creative and try things. Makerspaces are great, for people who want to learn and make things. You can try things out. Then make changes as you go along. This is a lot like what happens in the world. Makerspaces give students tasks to do that are not straightforward. That require them to figure things out for themselves. This means that students are actually creating their knowledge rather than just being told what to do. Makerspaces are about letting students be, in charge of their own learning, which is a really powerful thing, [10]. From a pedagogical standpoint, makerspaces foster **problem-solving skills** by requiring learners to identify challenges, design potential solutions, test prototypes, and revise designs based on performance outcomes, [11]. Problem-solving, in this context, refers to the learner's ability to employ **strategic planning**, **creative ideation**, and **iterative perseverance**—three interrelated cognitive-behavioral dimensions, [12]. Studies involving primary school students have reported statistically significant gains in these domains following structured makerspace interventions. For example, [13] found that kindergarten students involved in a 12-week STEM-based makerspace program exhibited substantial improvements in problem-solving performance (d = 0.50), particularly in strategic task execution and design creativity.

2.2 Challenges in Makerspace-Based Problem-Solving

Despite these benefits, research indicates that the open-ended nature of makerspace tasks can overwhelm younger or novice learners, leading to what [14] refer to as "cognitive stall-out." These things happen when students do not have the skills to think about their learning or the technical skills to move past the idea stage. When teachers are not available to help students away especially in classrooms with few resources or a lot of students it can be hard for students to make progress on solving problems and it can make the makerspace model not work as well. In these situations teachers need to provide support. Not to help students, with the work but also to help them feel confident and want to keep trying. Makerspace model is important and scaffolding is necessary for the makerspace model to work, [15]. When this happens the framework is really important. It is not about helping with the content but it is also about helping people feel confident and stay interested, in the framework for a long time. The framework plays a role in this and that is why the framework is so essential.

2.3 The Role of Artificial Intelligence in Educational Platform

New things are happening with intelligence. This is helping teachers support students better when they need it. Artificial intelligence tools are good at making learning personal giving feedback and helping students with changing content. Some artificial intelligence systems are really good at giving students hints at the time showing them pictures to help or suggesting code when they need it. These systems are working well for kids who are learning languages, math and science. Artificial intelligence is helping because it can take care of tasks that're too much for students. This means students can think about the picture and learn more. Artificial intelligence is doing this in a lot of subjects and it is making a big difference. The idea, behind this is that artificial intelligence can help with the things so students can focus on the important stuff. This is based on something called cognitive load theory. Artificial intelligence is making it possible for students to learn in a way, [16], [17]. The theoretical rationale stems from cognitive load theory suggesting that AI can offload routine or overwhelming tasks allowing learners to focus on higher-order thinking processes.

2.4 MagicSchool AI as a Pedagogical Tool

MagicSchool AI is a newly developed platform offering over 80 instructional tools designed for K–12 teachers and students. These include lesson plan generators, idea visualizers', flowchart builders, rubric assistants, and adaptive questioning prompts, [18]. The platform is increasingly being used in classrooms to support project-based learning and design thinking. Despite its wide adoption in over 13,000 school districts, [19], there is currently no peer-reviewed empirical evidence evaluating its impact on students' cognitive development or problem-solving performance. Given its capabilities, MagicSchool AI is theoretically well-positioned to enhance problem-solving skills within makerspace environments by offering learners immediate scaffolding during the design and iteration phases. The platform's tools could reduce cognitive stall-outs by enabling students to visualize their design plans, structure their thoughts, and access templates or exemplars for solution development—all of which are directly related to strategic planning, ideation, and perseverance.

2.5 Integration and Research Gap

The integration of AI scaffolding (MagicSchool AI) within a makerspace-based learning environment introduces a novel instructional combination with potential synergistic effects on elementary students' problem-solving competence. While prior research has examined the independent effects of makerspaces [20] and AI scaffolding tools [21], no controlled experimental study has evaluated their combined impact. Moreover, no study to date has examined whether the layering of MagicSchool AI over traditional makerspace curricula produces significantly greater gains in strategic planning, creative ideation, and iterative perseverance than hands-on fabrication alone. This study addresses this gap by employing a true experimental design to isolate the causal effect of MagicSchool AI on problem-solving skills within a controlled makerspace intervention.

3 Method

3.1 Research Design

A true experimental, post-test–only control group design was employed. It is widely recognised as one of the most rigorous models for establishing causal inference in classroom-based educational research, [22]. By randomly assigning participants to either an experimental or control condition, the design aimed to isolate the effect of the MagicSchool AI–augmented makerspace experience on students' problem-solving abilities, independent of prior performance or extraneous variables.

3.2 Participants

60 elementary students (ages 11–12) drawn from two public schools in Jerusalem that operate makerspace laboratories aligned with national STEM curriculum standards were selected. A group of 60 students who had permission from their parents and had never used intelligence tools before. These students were then picked at random to be, in one of the following groups:

- **Experimental Group (n = 30)**
- **Control Group (n = 30)**

All the students took part in the study in an after-school hours.

3.3 Intervention Procedure

The program had 12 sessions that were 90 minutes long. These sessions took place over six weeks. The Ministry of Educations STEM Challenge Workshop Manual was used for this. Both groups worked on 15 engineering design challenges from the Ministry of Educations STEM Challenge Workshop Manual (2022). They made things like bridges, lifting devices and wheeled vehicles with a set of materials. The main difference between groups was the help they got. Students in one group used some tools from the MagicSchool AI platform. Idea visualizer, flowchart assistant, step-by-step prompt generator during planning and building. These tools helped with problem-solving: Strategic Planning, Ideation, Iterative Perseverance. The other group got help from teachers with printed worksheets and verbal instructions only no technology. All sessions were in the makerspace, with the same materials and prompts.

3.4 Instruments

The study employed a modified version of the Elementary Problem-Solving Inventory (EPSI), originally developed and validated by [23] and subsequently adapted to Arabic by a panel of three bilingual experts. The inventory consists of 18 items across three subscales—planning, ideation, and perseverance—scored on a 5-point Likert scale. Content validity was confirmed via expert review (CVI = .89), and the Arabic version demonstrated high internal consistency (Cronbach's $\alpha = .84$). In addition, an observational rubric was used by two trained raters during three randomly selected sessions to ensure behavioral triangulation. Interrater reliability was established at Cohen's $\kappa = .87$.

3.5 Ethical Considerations

Ethical approval was issued from the Institutional Review Board of An-Najah National University. In addition, a written informed consent was secured from all participants' legal guardians. Students were informed of their right to withdraw at any time without penalty, and no personally identifiable data were collected or reported.

4 Result

A Multivariate Analysis of Variance (MANOVA) test was conducted. The independent variable was group condition (AI-supported vs. non-AI-supported), and the three dependent variables were strategic planning, creative ideation, and iterative perseverance, measured by the adapted Elementary Problem-Solving Inventory (EPSI).

4.1 Preliminary Assumptions

Box's M test was non-significant, $F(6, 11252.14) = 1.42$, $p = .202$, indicating that the assumption of homogeneity of variance-covariance matrices was met. Levene's tests for each dependent variable were also non-significant ($p > .05$), supporting homogeneity of error variances.

4.2 Multivariate Effects

The skewness values ranged from −0.41 to 0.36 and kurtosis values ranged from −0.62 to 0.58, which fall within commonly accepted thresholds (±1.0) for approximate normal distribution in educational research, [22]. These results support the appropriateness of applying parametric statistical procedures such as MANOVA, ANOVA, and *t*-tests. The MANOVA revealed a statistically significant multivariate effect of instructional condition on the combined problem-solving dimensions: Wilks' Λ=.624,F(3,56)=11.26,p<0.001, η^2 =0.376. This suggests that approximately 37.6% of the variance in the combined dependent variables is attributable to the experimental manipulation.

4.3 Univariate Effects

Follow-up one-way ANOVAs were conducted to examine the effect of condition on each dependent variable individually. Results are presented in Table 1 (Appendix).

These findings support the hypothesis that embedding MagicSchool AI within a makerspace curriculum significantly enhances students' problem-solving competence. Particularly in the domain of strategic planning. Lesser extent in ideation and perseverance. The effect sizes reported using partial eta squared (η^2_p) were interpreted according to Cohen's (1988) conventions, where values of .01 represent small effects, .06 represent medium effects, and .14 or greater represent large effects. Based on these benchmarks, the effect of MagicSchool AI on strategic planning (η^2_p = .198) can be considered large, while the effects on creative ideation (η^2_p = .143) and iterative perseverance (η^2_p = .106) fall within the medium-to-large range. These effect sizes indicate that the intervention produced not only statistically significant but also educationally meaningful improvements in students' problem-solving competence.

To further strengthen the analytical robustness and improve interpretability, independent-samples *t*-tests were conducted for each subscale. The results are presented in Table 2 (Appendix).

These results reinforce the robustness of the findings, demonstrating that the integration of MagicSchool AI significantly enhanced students' problem-solving performance across all measured domains. The largest effect was observed for strategic planning, suggesting that AI-supported visualization and planning tools played a particularly important role in helping students' structure complex design processes.

These results are illustrated in Figure 1 (Appendix), which presents the group-wise post-test means and standard deviations across all three subscales. The visual representation highlights the consistent performance advantage of the AI-supported group, particularly in strategic planning, where the gap between conditions was most pronounced.

4.4 Chi-Square Analysis Section

To analyze the data, we split performance into three levels: low (< 3.00), medium (3.01–3.75), and high (>3.75). The results for strategic planning were significant, X^2(2, N = 60) = 10.84, p = .004; while the control group sat mostly in the low-to-mid range, the AI-supported group saw a much higher concentration of top-tier performers. We saw a nearly identical pattern in creative ideation, $\chi^2(2, N = 60) = 7.96, p = .019, where MagicSchool AI users were significantly more likely to demonstrate high-level ideation. Iterative perseverance also showed a notable gap between groups, X^2(2, N = 60) = 6.21, p = .045. Taken together, these chi-square tests reinforce the parametric data: MagicSchool AI doesn't just raise the "floor" of student performance, it effectively raises the "ceiling".

5 Discussion

We set out to see if MagicSchool AI could actually improve problem-solving in a STEM makerspace compared to a standard hands-on approach. Our findings suggest that it can, specifically by supporting strategic planning, creative ideation, and iterative perseverance. The data shows that students using MagicSchool AI generators and builders made significant leaps forward. For example, the effect on strategic planning was particularly strong (η^2_p = .198), explaining nearly a fifth of the variance in how well students organized their tasks. Practically speaking, these students were better equipped to plan for design challenges before they happened. This supports the idea that novice makers need these kinds of "thinking tools" to succeed in open-ended environments, [2], [16]. The AI also acted as a catalyst for creativity (η^2_p = .143) helping students overcome the initial "blank page" problem, [9]. Perhaps most importantly, the AI scaffolds helped students push through the frustration of the redesign phase, improving iterative perseverance (η^2_p = .106) indicates that AI scaffolds helped students sustain engagement during repeated testing and redesign cycles, a central feature of maker-based learning and a known challenge for younger learners, [17]. These results offer two key contributions: they provide rare causal evidence for AI in makerspaces and back up the theory that generative AI can empower young learners when used within a solid pedagogical framework, [1].

6 Limitations

Despite the statistical strength of these findings, the study has limitations that should be considered. One primary constraint is the post-test–only design; while it clearly showed the effect of the AI intervention, it couldn't map how students actually progressed from their baseline skills. A longitudinal approach in future studies would likely reveal more about these learning patterns. Additionally, the relatively small sample (n = 60) limits our ability to apply these findings broadly across different types of classrooms. Finally, we treated MagicSchool AI as a single intervention, meaning we didn't differentiate between the impact of the flowchart builder and the prompt generator. Future work should look closer at usage frequency and specific tool interactions to better understand why and how the AI support is working.

7 Implications for Practice

The data shows that thoughtfully integrating AI into makerspace environments can lead to significant gains in how students solve problems. In high-ratio classrooms where teachers are stretched thin, AI tools that assist with planning and visual organization can act as a vital "second set of hands" for students. Furthermore, the fact that this program required minimal training suggests it is highly scalable. Schools can implement these tools quickly, providing students with advanced cognitive scaffolding without the need for extensive—and often expensive—teacher preparation.

8 Future Research

We still need to figure out which specific parts of MagicSchool AI are doing the heavy lifting. Is it the flowchart builder that helps most, or the prompt generator? It’s also worth looking at how these tools land with kids of different ages or those who haven't spent much time with technology. Moving forward, I’d like to see more mixed-methods studies. Combining hard numbers with 'think-aloud' sessions or screen recordings would show us exactly what’s happening in a student’s head while they use the AI. Finally, as this tech keeps evolving, we can't ignore the ethical and emotional side of bringing AI into early childhood classrooms.

9 Conclusion

I set out to see if MagicSchool AI could actually make a difference in a STEM makerspace, and the data from this experiment says yes. Students who had the AI tools didn't just edge out the others—they were significantly better at planning their projects, coming up with ideas, and sticking with them when things got tough. This gives us some of the first real, causal evidence that AI has a place in hands-on, elementary-level learning. The biggest win was in strategic planning. It seems AI is great at acting as a sort of 'thinking partner' for kids, helping them map out complex tasks that might otherwise feel overwhelming. But it went deeper than just following steps; we saw real growth in creativity and persistence, too. For teachers, this is a big deal because it shows that AI can be a simple, scalable way to support kids in a busy classroom. For researchers, it’s a clear signal that we need to look closer at how these specific tools impact long-term development. As AI becomes a staple in schools, the goal should be to pair smart tech with human-centered teaching to make learning more inclusive and, ultimately, more effective.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

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Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethics approval and consent to participate

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APPENDIX

Table 1. Means, Standard Deviations, and ANOVA Results for Problem-Solving Subscales by Group

Subscale	Group	M	SD	F	p	η²
Strategic Planning	Experimental (AI)	4.21	0.51	14.35	<.001	0.198
	Control (No AI)	3.62	0.57			
Creative Ideation	Experimental (AI)	4.07	0.55	9.72	0.003	0.143
	Control (No AI)	3.54	0.59			
Iterative Perseverance	Experimental (AI)	3.88	0.49	6.89	0.011	0.106
	Control (No AI)	3.42	0.61			

Source: Created by the author

Table 2. Independent-Samples t-Test Results for Problem-Solving Subscales

Subscale	Group Mean (AI)	Group Mean (Control)	t	df	p	95% CI Mean Difference	Cohen's d
Strategic Planning	4.21	3.62	4.05	58	< .001	[0.30, 0.88]	1.05
Creative Ideation	4.07	3.54	3.24	58	.002	[0.20, 0.85]	0.84
Iterative Perseverance	3.88	3.42	2.63	58	.011	[0.11, 0.81]	0.68

Source: Created by the author

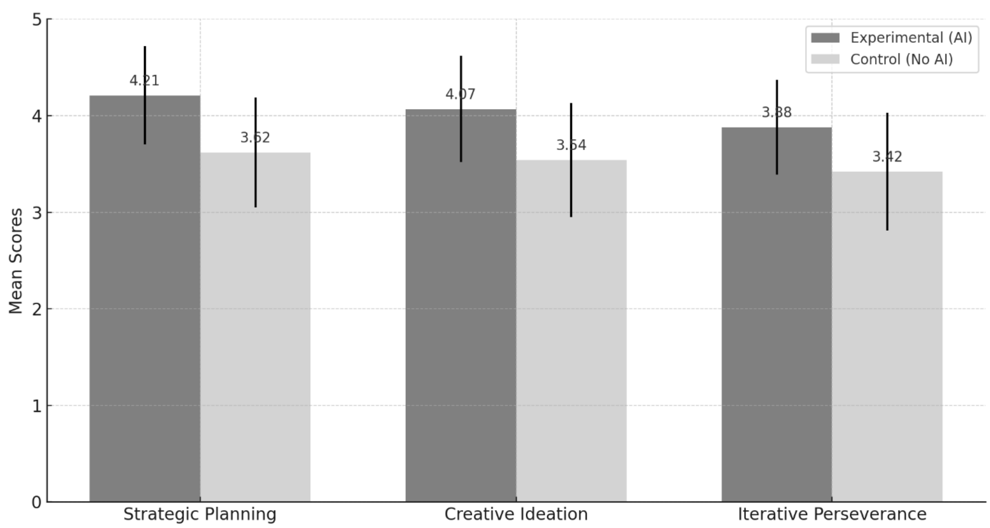

Fig. 1: Mean Post-Test Scores on Problem- Solving Subscales by Instructional Group(N=60)
Source: Created by the author