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Enhancing Motivation through Teacher-Driven Project-Based Learning

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Abstract. This study investigates a multi-tiered, teacher-driven Project-Based Learning (PBL) program implemented in Israeli middle schools, where academic staff mentored M.Ed. students who, in turn, collaborated with 90 in-service science teachers across 10 schools. Together, they co-designed and implemented PBL units that aimed to shift instructional practices from traditional, teacher-centered methods toward more active, student-centered learning. The research explores how teacher empowerment and direct involvement in the PBL design process influenced not only educators' instructional motivation, but also students' academic engagement, creativity, and learning outcomes. Findings revealed that general learner motivation after the PBL intervention was rated as high ($M = 4.08$, $SD = 0.80$). Significant gains were observed across behavioral, cognitive, emotional, and social domains of student motivation (all $p < .01$). For example, behavioral motivation rose from a mean of 1.74 ($SD = 0.86$) under traditional learning to 3.97 ($SD = 0.83$) with PBL, while emotional motivation increased from 2.12 ($SD = 0.96$) to 4.27 ($SD = 0.67$). Teachers also reported heightened motivation, professional growth, and a stronger sense of ownership over instructional practices. Beyond the classroom, this study introduces an innovative and scalable professional development model that can be adapted internationally to address persistent challenges in educational equity, teacher preparation, and STEM curriculum reform. By showing how PBL can be effectively implemented even in under-resourced schools through structured teacher collaboration, the study provides a replicable framework for sustainable educational innovation. Ultimately, these findings contribute to the broader discourse on teacher-led reforms and offer actionable recommendations for scaling PBL beyond individual classrooms into systemic change.

Keywords: Intervention program; motivation to learn; project-based learning (PBL); teachers' perceptions

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1. Introduction

In Israel, Science, Technology, Engineering and Mathematics (STEM) education serves as a catalyst for national innovation and economic advancement. The Ministry of Education emphasizes scientific literacy, inquiry-based learning, and the cultivation of skills such as problem-solving, collaboration, and creativity. These priorities align with the NRC Framework's global goals (NGSS Lead States, 2013; Schneider et al., 2022). Recent initiatives, such as Tomorrow 2028, seek to reform STEM education to meet international standards (Goldreich & Karashtranova, 2024). However, translating national visions into effective classroom practices requires innovative and scalable approaches to teacher training and curriculum design.

Israel ranks second among 72 nations in the correlation between inquiry-based science instruction and students' interest in scientific careers (Mostafa et al., 2018). This highlights the need for teaching strategies that merge inquiry-based learning with sustainable professional development. Addressing this challenge, the present study examines how a structured PBL training framework, linking academic staff, M.Ed. students, and in-service teachers, can cultivate a culture of innovation and motivation in STEM education. Similar multi-tiered PD models have been shown to strengthen both teacher and student outcomes in other contexts (Darling-Hammond & Hyster, 2022; Organisation for Economic Co-operation and Development [OECD], 2023).

This mixed-methods study focuses on socioeconomically disadvantaged schools in northern Israel, where the socioeconomic index is 4 out of 10 and only 60% of high-school graduates earn a matriculation certificate. Prior research has demonstrated that socioeconomic disadvantages are closely tied to reduced motivation, limited learning resources, and lower academic achievement (Sirin, 2005; OECD, 2018). More recent studies reinforce that equity-oriented PD interventions are crucial to addressing these persistent gaps (OECD, 2023; Schneider et al., 2022). By situating this intervention in low-SES schools, the study provides critical insights into how motivation operates in challenging contexts and how teacher-driven PBL can support equity in STEM education.

The study employed a mixed-methods intervention design to capture both the measurable effects of the PBL program on student motivation and the qualitative insights from teachers' experiences. Quantitative data from pre- and post-intervention surveys provided objective measures of changes across behavioural, cognitive, emotional, and social dimensions of motivation. Complementary qualitative data from interviews and classroom observations offered a contextual understanding of how teachers implemented PBL, perceived student engagement, and reflected on their professional growth. Integrating these methods strengthens the validity of the findings and provides a comprehensive perspective on the intervention's impact.

Accordingly, the study addresses the following research questions:

- How does participation in a teacher-driven, multi-tiered PBL program influence teachers' professional motivation, instructional practices, and sense of agency?
- How does the implementation of PBL affect students' behavioral, cognitive, emotional, and social motivation in socioeconomically disadvantaged schools?
- To what extent can the cascading mentorship model provide a scalable framework for teacher professional development in STEM education, both locally and internationally?

2. Literature Review

2.1 Science Education and Socioeconomic Context

Globally, science education has faced longstanding criticism for its limited capacity to equip students with the skills required to navigate contemporary social, environmental, and technological challenges. In Israel, these challenges are intensified by socioeconomic disparities, particularly among low-income, Arabic-speaking pupils, and children of Ethiopian immigrants. Motivation to learn is a cross-cutting issue across all socioeconomic groups, but its effects are especially pronounced among students from low socioeconomic status (SES) backgrounds, who often contend with compounding disadvantages.

Research shows that SES correlates with limited access to learning resources, lower levels of parental involvement, and reduced opportunities for extracurricular enrichment, all of which hinder the development of both intrinsic and extrinsic motivation (OECD, 2018; Sirin, 2005). Stress and instability further weaken these students' ability to engage fully in academic activities, perpetuating cycles of underachievement.

International assessments such as PISA and TIMSS continue to highlight achievement gaps linked to SES (Imran & Masood, 2020), underscoring the urgent need for pedagogical approaches that can strengthen equity in science education. Addressing these challenges requires targeted teacher preparation, encompassing both instructional strategies and greater awareness of systemic bias. Two theoretical lenses provide useful insight: Self-Determination Theory (SDT), which emphasizes autonomy, competence, and relatedness as drivers of intrinsic motivation (Deci & Ryan, 2000), and social cognitive theory (SCT), which foregrounds observational learning, self-efficacy, and the social environment (Bandura & Wessels, 1997). Project-Based Learning (PBL), by encouraging authentic inquiry, collaboration, and problem-solving, aligns closely with these frameworks.

2.1.1 Conceptualizing PBL

Rooted in constructivist pedagogy, PBL positions learners as active agents who explore real-world problems through sustained inquiry, teamwork, and iterative design (Thomas, 2000; Krajcik & Shin, 2014). Unlike traditional teacher-centered instruction, PBL emphasizes student autonomy and promotes the development of

higher-order cognitive skills such as critical thinking, creativity, and collaboration.

Structured models such as the Engineering Design Process provide a systematic framework for integrating PBL into science education, guiding learners through problem definition, research, brainstorming, prototyping, and communication of solutions. This process mirrors 21st-century demands, linking classroom content with authentic applications while also supporting metacognitive growth.

2.1.2 Evidence Supporting PBL's Effectiveness

A growing body of research highlights the benefits of PBL in improving student motivation, engagement, and achievement. PBL enables students to connect academic content with their lived experiences, thereby increasing persistence and performance (Bell, 2010; Deci & Ryan, 2000). Studies also show that PBL encourages ~~fosters~~ critical thinking, problem-solving, and collaborative skills, essential competencies for success in both higher education and the workforce (Barron & Darling-Hammond, 2008; Hmelo-Silver, 2004).

Empirical findings are particularly compelling in disadvantaged contexts. Bas (2011) and Rivera et al. (2015) documented increased engagement and equitable participation among marginalized groups. Similarly, Krajcik and Shin (2014) demonstrated how PBL supports deeper disciplinary understanding by requiring students to apply scientific knowledge to authentic challenges such as designing water filtration systems or addressing environmental sustainability. Recent reviews further confirm PBL's potential to narrow equity gaps, particularly when embedded within long-term curricula and supported by collaborative teacher networks (Chen & Yang, 2022; Chu et al., 2023).

2.1.3 Critiques and Limitations of PBL

Despite these strengths, PBL is not without challenges. Critics argue that its resource-intensive nature, requiring substantial investment in teacher training, planning time, materials, and infrastructure, makes it less feasible in under-resourced schools, where it may inadvertently widen rather than close achievement gaps (Glasner, 2014; Xie et al., 2022). Another limitation concerns assessment alignment. Standardized testing systems, which emphasize discrete knowledge acquisition, often conflict with the open-ended, inquiry-driven ethos of PBL. This tension raises questions about scalability in accountability-driven systems (Emin-Martínez et al., 2020).

Teacher capacity is another critical factor. Many educators report feeling underprepared to manage student-driven inquiry or to facilitate collaborative learning environments effectively. Without adequate professional development, PBL can devolve into loosely structured activities with limited educational value (Chiang & Lee, 2016; Krajcik, 2021). Furthermore, ~~Additionally,~~ some studies highlight uneven learning outcomes, with high-achieving students benefiting disproportionately compared to peers who require more structured guidance (Kirschner et al., 2006; Schwarz et al., 2023). Together, these critiques emphasize the need for balanced implementation strategies that address both pedagogical promises and structural constraints.

2.1.4 Towards Equitable Science Education

When supported by comprehensive professional development and adequate resources, PBL offers significant opportunities to reduce inequities in science education. Its emphasis on relevance, inquiry, and collaboration can increase motivation and provide students from disadvantaged communities with meaningful entry points into scientific learning (Bass, 2011); Rivera et al., 2015). To maximize impact, however, education systems must invest in scalable models of teacher support, including adaptive curricula, collaborative teacher networks, and sustained professional learning opportunities (Chu et al., 2023; Deehan et al., 2024). Such systemic investments ensure that PBL does not remain an isolated innovation but becomes an equitable, sustainable approach for diverse educational settings.

2.1.5 Science Teaching in a Societal Context

Persistent gaps in scientific achievement underscore the tension between innovative pedagogy and systemic structures. Data from TIMSS over the past 25 years show limited progress in narrowing disparities in elementary science education worldwide (Deehan et al., 2024). Promising innovations are often tested in pilot projects but struggle to achieve large-scale adoption due to misalignment with curricula, testing demands, or teacher preparation systems (Kneen et al., 2023).

Contemporary science curricula increasingly emphasize integration of disciplinary content with higher-order skills such as critical thinking, problem-solving, and creativity (Grapin et al., 2023). Yet socioeconomic and cultural inequities continue to shape uneven outcomes, particularly in under-resourced contexts. Against this backdrop, PBL emerges not as a universal solution but as one promising pathway for aligning curriculum, pedagogy, and equity goals.

2.1.6 Motivation in Education

Motivation remains a central factor in effective science education, influencing persistence, emotional engagement, and learning outcomes (Albitar, 2004; Sakiz et al., 2008). It comprises both intrinsic drivers, such as curiosity and personal growth, and extrinsic incentives, such as recognition or grades (Acquah et al., 2021). Teachers play a pivotal role in shaping these motivational dynamics through their instructional choices and classroom climate (Buckley & Doyle, 2016).

Integrating SDT, SCT, and PBL provides a robust framework for advancing both teacher and student motivation. By promoting autonomy, competence, relatedness, and self-efficacy, PBL-based approaches can support not only student learning but also teacher professional growth, creating a foundation for scalable and sustainable reform in science education.

3. Methodology

This study employed mixed-methods intervention research. A mixed-methods intervention design was employed to examine both the measurable changes in student motivation and teachers' experiences with the PBL model. Quantitative

surveys captured pre- and post-intervention shifts across behavioral, cognitive, emotional, and social dimensions, while qualitative interviews and observations provided contextual insights into instructional practices and student engagement. Combining these approaches strengthens validity and offers a comprehensive understanding of how intervention enhances motivation and professional development.

This method was designed to assess the implementation of a multi-tiered Project-Based Learning (PBL) professional development (PD) model. Grounded in the U.S. National Research Council (NRC) Framework for K-12 Science Education, the study explored how PBL influences teacher motivation, instructional effectiveness, and student engagement. By integrating self-determination theory (SDT) and social cognitive theory (SCT), this research examined the role of autonomy, competence, and social learning in fostering sustained pedagogical change. The primary objective was to evaluate the impact of PBL on Year 8 science students' motivation, with a focus on enhancing thinking competencies, collaboration, and intrinsic motivation.

This study adopted a multi-tiered PD structure, wherein academic staff mentored M.Ed. students (science teachers), who subsequently designed and implemented PBL learning units for in-service teachers. This cascading model (as presented in Figure 1) facilitated knowledge dissemination and skill development at multiple levels, creating a structured framework for sustainable PBL integration. The research compared traditional teaching methods with PBL to provide empirical evidence for informed educational practices and curricular design, particularly in socioeconomically disadvantaged schools.

3.1 Control group

To compare the effects of PBL with traditional instruction, a quasi-experimental design was implemented. The PBL intervention was conducted in selected classrooms while a control group of students in comparable classrooms received traditional teacher-centered instruction during the same period. Both groups covered the same science curriculum topics, with identical learning objectives and assessment schedules, ensuring equivalence in content exposure. Teachers in the control group continued their usual instructional practices, including lectures, textbook exercises, and guided problem-solving, without engaging in PBL activities. Student motivation and learning outcomes were measured in both groups at the same time points (pre- and post-intervention) to allow for valid comparisons.

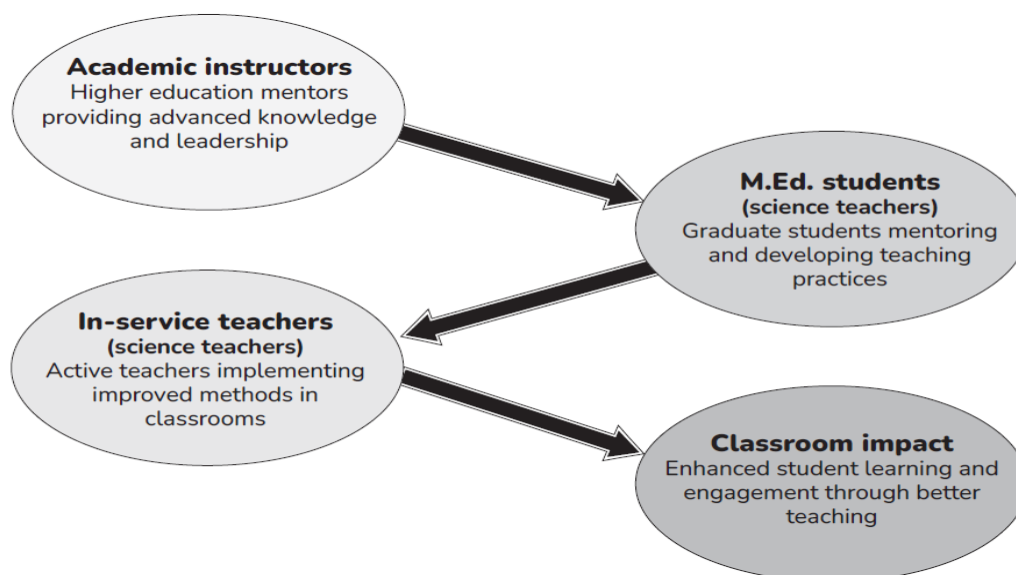


Figure 1: The Cascading Mentorship Model

3.2 Research Population

This study involved a convenience sampling of 90 science and technology teachers from 10 middle schools in northern Israel. These schools are located in socioeconomically disadvantaged areas, where the socioeconomic index is 4 out of 10 and only 60% of high-school graduates obtain a matriculation certificate. The participants were selected based on their agreement to participate in an intervention program, which included the delivery of a PBL-based study unit in scientific knowledge and an analysis of students' motivation levels under different instructional styles (traditional learning vs. PBL).

Although no formal power analysis was conducted to determine the required sample size, the study included 90 teachers across 10 schools, which aligns with sample sizes commonly reported in similar educational intervention studies (e.g., Bas, 2011; Krajcik & Shin, 2014). The sample was sufficient to detect meaningful differences in student motivation and teacher outcomes between the PBL and traditional instruction groups, as evidenced by the statistically significant t-test results obtained. Future studies could incorporate power analysis to guide sample size selection more rigorously.

The participating teachers engaged in a structured PD program that emphasized inquiry-based learning, collaboration, and reflective teaching practices. By leveraging this structured training framework, the study aimed to foster a sustained culture of innovation and motivation in STEM education, providing practical insights for scaling PBL in under-resourced education settings. Their characteristics are shown in Table 1.

Table 1: Study participant demographics (N=90).

Demographic characteristics		%
Gender	Male	32%
	Female	68%
Age	25-30	28%
	31-40	28%
	41+	44%
Years of teaching experience	1-5	8%
	6-10	40%
	11-15	24%
	+ 15	28%
Education	B.Ed.	48%
	M.Ed	52%

3.3 Research Tools

An online, independently developed anonymous questionnaire consisting of 20 items was used to assess various aspects of student motivation as perceived by teachers. Each item was rated on a 5-point Likert scale (1 = 'Does not describe my students at all' to 5 = 'Describes my students to a very high degree'), with summary indices calculated for behavioral, cognitive, emotional, and social dimensions of motivation. The instrument drew on established frameworks (Harter, 1981; Pintrich et al., 1987) and underwent content validation by three PhD experts, who reviewed clarity, relevance, and construct alignment. Two additional independent judges confirmed the reliability of the scales ($\alpha=0.81$).

While the questionnaire reflects teachers' perspectives, data triangulation was achieved through classroom observations and semi-structured interviews, including insights from students. Nevertheless, the reliance on teacher-reported data represents a limitation, and incorporating direct student-reported measures would enhance instrument robustness in future studies.

3.4 Research Procedure

First, 100 science teachers received questionnaires to gather insights into their teaching practices and perspectives on middle school science education, with 90 responses collected. Following this, comprehensive teaching units structured around the Six Engineering Design Process Steps were developed in collaboration with three veteran science teachers pursuing master's degrees in science education as part of their final project. Collaboration was integral to developing the Six Engineering Design Process Steps to ensure that the framework reflected both pedagogical best practices and practical classroom applicability.

By involving academic staff, M.Ed students, and in-service teachers in co-designing the steps, the process incorporated diverse perspectives, fostered shared ownership, and aligned with constructivist principles that emphasize active participation, reflection, and contextualized learning. This collaborative approach also models the inquiry-based, problem-solving skills that the framework aims to cultivate in students, ensuring coherence between teacher professional development and classroom implementation.

3.5 Questionnaire Administration

Participants completed an online, independently developed, and fully anonymous questionnaire consisting of 20 items. This ensured that teachers could provide honest and unbiased responses regarding their perceptions of student motivation and their own experiences with the PBL intervention.

These instructional units emphasize connections between scientific concepts, real-world events, and hands-on activities to foster motivation and deepen understanding. Once developed, the teaching units underwent a review process, where participating teachers provided feedback to refine and enhance the content before implementation. This iterative process ensured the units aligned with classroom needs and promoted an inquiry-based learning approach. Figure 2 presents these steps.

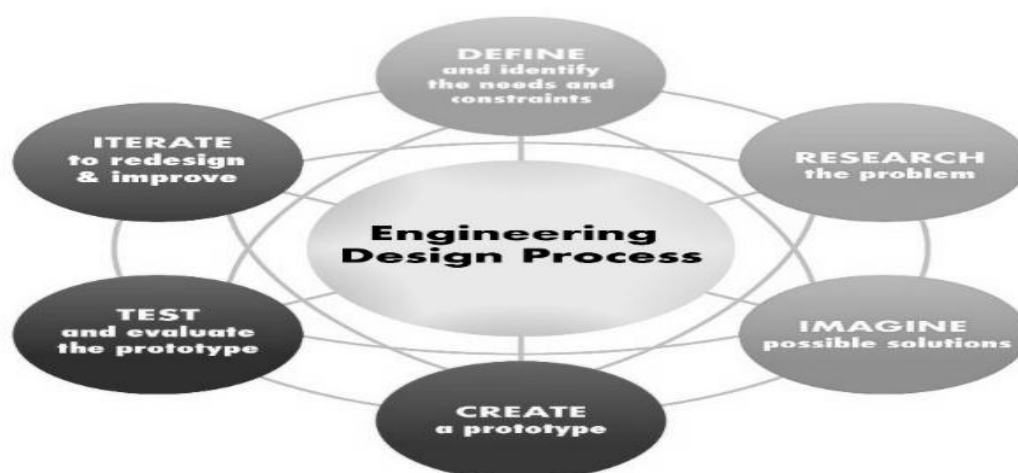


Figure 2: The Six Engineering Design Process Steps: Define, Research, Imagine, Create, Test and Iterate

Teachers then implemented the study units in their classes and provided post-activity feedback on their experiences and the effectiveness of the units. Each instructional unit included the following: (a) Framing the topic and posing a guiding question; (b) Engaging students in active inquiry and investigation; (c) Offering ongoing individual and group feedback (d) Developing and showcasing the final outcome in product presentations; (e) Engaging in reflection - facilitating discussions on the learning process.

The unit was shared with participating teachers via a WhatsApp group for relevant educators in the northern region of the country, along with detailed guidelines for pre- and post-intervention activities and for research questionnaires. Prior to the intervention, teachers received training on the PBL framework and specific teaching units, aimed at equipping them with the necessary tools and strategies for effective PBL implementation. The training included guidance on facilitating student collaboration, providing formative feedback, and assessing progress throughout the project.

Both before and after the intervention program, participants completed the anonymous online questionnaire relating to their students' perceived motivation. Detailed indicators for motivation assessment were outlined to ensure clarity in responses, (see Table 2).

Table 2: Indicators For Assessing Motivation Across Various Dimensions

Dimension of motivation	Measures for the expression of motivation in the learner
Behavioral	Investing in effort without reward or external pressure Investing time without reward or external pressure Independent learning Demonstrating involvement in learning Expression of interest
Cognitive	Concentration and attention in carrying out the task Higher-order thinking Use of technological tools Reflective thinking
Emotional	Less anxiety and stress Pride and satisfaction Positive feelings Calm Desire to improve Pleasure
Social	Collaboration Attentiveness

After completing the pre-intervention questionnaire, teachers selected a project-based teaching unit they wished to implement and were provided with detailed lesson plans accordingly.

3.6 Data Analysis

Prior to conducting t-tests, the assumption of normality was evaluated for each dependent variable using the Shapiro-Wilk test. All variables met the normality assumption, supporting the use of paired-sample and independent-sample t-tests to examine differences between pre- and post-intervention scores, as well as between traditional and PBL instructional groups.

The data analysis involved both quantitative and qualitative techniques. Statistical analysis was conducted using t-tests to examine pre- and post-intervention differences in student motivation, assessed across behavioral, cognitive, emotional, and social dimensions. The independent variable was the pedagogical approach (traditional learning vs. PBL) and the dependent variable was the level of student motivation. Although normality was not formally tested, the sample size ($N = 90$) supported the use of t-tests based on the Central Limit Theorem. The significance level was set at $\alpha = 0.05$. Open-ended questionnaire responses were analyzed thematically to provide deeper insight into teachers' experiences with PBL and their observations on student engagement, collaboration, and learning outcomes.

3.7 Ethics

The teachers gave their informed consent to participate in completing the questionnaires anonymously. No identifying information about the participants was collected. The questionnaires were transferred in the same way. The participants in the study reported on the learners' level of motivation as expressed in the lessons before and after the implementation of the PBL study unit. The research received the approval of the College Ethics Committee (approval No. 11621). Figure 3 summarizes the research process.

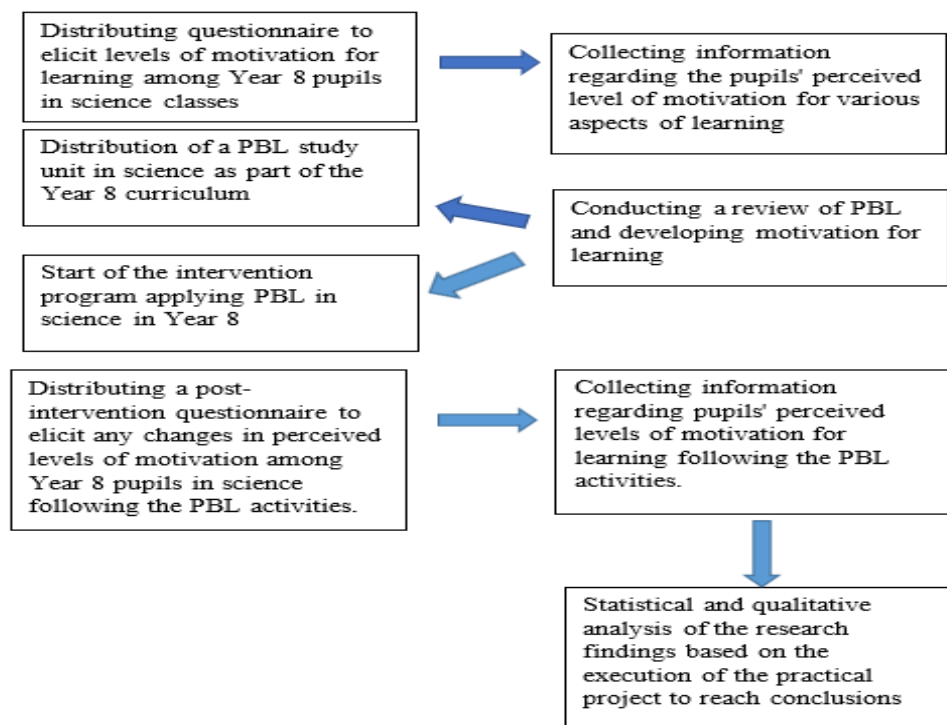


Figure 3: Research project and process: Pre-questionnaire, Project implementation, Post-questionnaire and Data analysis

4. Findings

The study findings are presented below in two parts. First the quantitative findings are presented and elaborated. This is then followed by the qualitative findings.

4.1 Quantitative Findings

The aggregated results from the pre- and post-PBL questionnaires are presented in Tables 3 and 4.

Table 3: Comparison of pupils' motivation before and after exposure to PBL as perceived by their teachers

Statements	POST-PBL		PRE- PBL	
	SD	M	SD	M
Behavioral motivation				
Students invest effort in acquiring knowledge without receiving a reward (grade).	0.82	3.91	0.92	1.98
Students invest effort in carrying out a task without extrinsic motivation from the teacher.	0.90	3.84	0.942	2.23
Students acquire new knowledge independently.	0.93	3.92	0.92	2.07
Students take an active part in the learning process.	0.82	3.92	0.90	2.07
Students express interest in the learning.	0.93	3.96	0.86	1.74
Students can concentrate and pay attention when performing tasks.	96.0.	3.92	1.14	2.25
Students acquire the skill of asking questions.	0.77	4.14	1.14	2.38
Students acquire the skill of drawing conclusions	0.61	4.39	1.11	2.57
Students use technological tools for learning.	0.78	4.20	0.94	2.03
Students perform an experiment to test the knowledge acquired.	0.76	4.29	0.90	1.83
Students can analyze the learning process that occurred.	0.72	4.09	0.99	2.11
Cognitive motivation				
Students show apprehension when faced with new or challenging study material.	0.61	4.37	0.93	1.97
Students feel proud and satisfied when they manage to understand new study material.	0.69	4.24	0.99	2.03
Students express positive emotions while learning.	0.67	4.27	0.96	2.12
Students are relaxed and calm while learning.	0.71	4.29	0.92	2.01
Students express a desire to improve their learning abilities.	0.73	4.29	1.15	2.27
Students take pleasure in the learning process.	0.74	4.16	0.98	1.86
Social motivation				
Students collaborate in group work.	0.69	4.27	1.14	2.28
Students divide the work among the group members according to their strengths.	0.71	4.08	0.80	1.64
Students are attentive and tolerant towards group members.	1.08	3.68	1.15	2.40

The findings presented in table 3 reveal a significant increase in students' motivation following the implementation of Project-Based Learning (PBL), as perceived by their teachers. Across all dimensions, behavioral, cognitive, and social, mean scores rose substantially from the pre- to post-intervention measurements. Teachers reported that students showed greater effort, independence, and engagement in the learning process, even in the absence of extrinsic rewards.

Cognitive motivation also improved, with students expressing more positive emotions, pride in their understanding, and a desire to enhance their learning abilities. Moreover, social motivation indicators, such as collaboration, tolerance, and effective group work, showed notable gains. These results suggest that PBL encourages fosters holistic motivation, making it a promising approach for supporting students' academic and social development, especially in low

socioeconomic contexts. Table 4 summarizes the main aspects of the teachers' reports.

Table 4: Averages and standard deviations of the teachers' reports

Aspect of learner motivation	Sample statements	PRE-PBL		POST-PBL	
		M	SD	M	SD
Behavioral	Students express interest in learning.	1.74	0.86	3.96	0.83
Cognitive	Students can concentrate and pay attention in performing tasks.	2.26	1.14	3.92	0.89
Emotional	Students express positive emotions during learning.	2.12	0.96	4.27	0.67
Social	Students cooperate in group work.	2.28	1.14	4.24	0.69
Average		2.10	1.02	4.09	0.77

The average motivation scores post-PBL (M=4.09, SD=0.77) was notably higher than the pre-PBL score (M=2.10, SD=1.02), further supporting the positive impact of PBL on student motivation. Table 5 shows the level of the aspects of motivation following PBL, as reported by teachers.

Table 5: The level of the aspects of motivation following PBL, as reported by teachers: General summary

Level of learner motivation after PBL	M	SD
Learner motivation: behavioral aspect	3.912	0.840
Learner motivation: cognitive aspect	4.147	0.758
Learner motivation: emotional aspect	4.272	0.691
Learner motivation: social aspect	4.000	0.828
General learner motivation	4.083	0.799

The level of general learner motivation after the PBL intervention unit was rated by the teachers as "high" (M=4.083, SD=0.799). Accordingly, each aspect of motivation was also rated as very high, where the emotional aspect had the highest score. These findings suggest that there may be differences in teachers' perceptions of learner motivation between traditional learning and PBL. In terms of behavior, with PBL, learners seem to express more interest in the learning process compared to traditional learning.

However, in terms of cognition, learners appear to show better ability to concentrate and pay attention during tasks in traditional learning environments. Regarding emotion, learners in both traditional and PBL environments expressed positive feelings during learning, with slightly higher scores in traditional learning. Finally, in the social aspect, learners in PBL environments appear to cooperate more effectively in group work compared to traditional learning environments. These findings indicate that PBL may promote ~~foster~~ higher levels of interest and social cooperation, while traditional learning may support better concentration and slightly higher levels of positive emotions during learning.

The marked improvement in students' social motivation, such as their ability to collaborate, divide tasks, and show tolerance toward peers, must be considered in

light of the instructional shift. Since traditional teaching did not emphasize group work or peer interaction, the introduction of PBL's structured, collaborative tasks represented a significant pedagogical change. As such, the gains in social motivation likely reflect not only increased engagement but also exposure to learning formats that actively promote social and interpersonal skills.

In order to check whether there is a difference between teachers' reports regarding the level of learner motivation after learning in traditional learning vs. PBL, before and after the intervention unit, a comparison was drawn for the four aspects of the learner's motivation level. For each aspect, one representative statement was chosen, and four t-tests were conducted for dependent (paired) samples. Each test compared a different aspect of the learner's motivation after traditional learning and after the PBL intervention unit.

A comparison was drawn regarding the indices obtained in the behavioral field for: "The student's express interest in the learning processes". A significant difference was found between traditional learning and PBL ($t_{88}=-15.688$, $p<0.01$) where the level of student motivation in traditional learning ($M=1.74$, $S.D.=0.86$) was lower than in PBL ($M=3.97$, $S.D.=0.83$).

A comparison was drawn regarding the indices obtained for cognition: "The students show the ability to concentrate and pay attention when performing tasks". A significant difference was found between traditional learning and PBL ($t_{88}=-10.409$, $p<0.01$) where the level of student motivation in traditional learning ($M=2.26$, $S.D.=1.14$) was lower than in PBL ($M=3.92$, $S.D.=0.89$).

A comparison was drawn regarding the indices obtained in the emotional domain for: "The students express positive emotions during learning". A significant difference was found between traditional learning and PBL ($t_{88}=-15.554$, $p<0.01$) where raising student motivation in traditional learning in the emotional aspect ($M=2.12$, $S.D.=0.96$) was lower than in PBL ($M=4.27$, $S.D.=0.67$).

A comparison was drawn regarding the indices obtained in the social field for: "The students cooperate in group work". A significant difference was found between traditional learning and PBL ($t_{88}=-13.861$, $p<0.01$) where raising students' social motivation in traditional learning ($M=2.28$, $S.D.=1.14$) was lower than in PBL ($M=4.24$, $S.D.=0.69$).

4.1.1 Statistical Analysis of Differences

To assess the significance of the differences between pre- and post-PBL motivation levels, paired-sample t-tests were conducted for each motivation dimension. The results indicated significant improvements in all aspects of motivation ($p<0.01$) following the PBL intervention.

For behavioral motivation: $t(88) = -15.688$, $p<0.01$, a significant increase was observed in student interest, from a pre-PBL mean of 1.74 ($SD=0.86$) to a post-PBL mean of 3.96 ($SD=0.83$). For cognitive motivation: $t(88) = -10.409$, $p<0.01$, motivation also increased significantly, with a pre-PBL mean of 2.26 ($SD=1.14$)

compared to a post-PBL mean of 3.92 (SD=0.89). For emotional motivation: $t(88) = -15.554$, $p < 0.01$, there was a significant rise, from 2.12 (SD=0.96) pre-PBL to 4.27 (SD=0.67) post-PBL. Finally, for social motivation $t(88) = -13.861$, $p < 0.01$, there was also a significant increase, from 2.28 (SD=1.14) pre-PBL to 4.24 (SD=0.69) post-PBL.

4.2 Qualitative Findings

The qualitative analysis revealed substantial changes in student motivation following the PBL intervention. Data from open-ended teacher responses, semi-structured interviews, and classroom observations were analyzed thematically, focusing on behavioral, cognitive, emotional, and social dimensions of motivation.

4.3 Lack of Interest (Pre-PBL)

Before the intervention, teachers consistently reported low student engagement and interest in learning. Classroom observations confirmed minimal participation, limited questioning, and reluctance to engage in collaborative activities. Representative themes included:

- Limited intrinsic motivation: Students participated only when prompted by grades.
- Difficulty connecting content to real-life contexts.
- General disengagement and boredom.

4.4 Poor Attention and Concentration (Pre-PBL)

Teachers noted that students had difficulty focusing on tasks, frequently becoming distracted during lessons. Observational data corroborated these perceptions, showing that off-task behaviors were common.

4.5 Negative Emotions (Pre-PBL)

Students frequently expressed frustration, boredom, and lack of enthusiasm, particularly when lessons felt irrelevant. These emotional responses were reflected in both teacher interviews and classroom observations.

4.6 Increased Interest (Post-PBL)

After the PBL intervention, the majority of teachers observed a marked improvement in student motivation. Students showed greater initiative in learning activities, were more engaged, and connected content to practical, real-world problems. Observations indicated sustained participation and enthusiasm during PBL tasks.

4.7 Enhanced Collaboration (Post-PBL)

Teachers reported significant improvements in students' collaboration skills. Classroom observations confirmed active peer-to-peer support, cooperative problem-solving, and group accountability.

4.8 Positive Emotions (Post-PBL)

Students exhibited excitement, curiosity, and enjoyment in the learning process. Teachers noted that emotional engagement facilitated deeper cognitive

involvement, consistent with the quantitative improvements in motivation indices.

Summary: Across all dimensions, qualitative evidence confirmed the quantitative findings, showing that the PBL intervention enhanced behavioral, cognitive, emotional, and social aspects of student motivation. Integrating teacher perspectives with classroom observations strengthened the validity of these results.

5. Summary and Discussion

This study explored the impact of a multi-tiered, teacher-driven PBL model on Year 8 science education, focusing on enhancing both teacher and student motivation. Grounded in the U.S. National Research Council (NRC) Framework for K-12 Science Education and aligned with Israel's emphasis on inquiry-based and experiential learning, the findings reveal that PBL nurtures fosters significant improvements in student motivation across behavioral, cognitive, emotional, and social dimensions. Emotional motivation, an essential component of deep student engagement, was particularly enhanced, suggesting that PBL effectively creates meaningful connections between students and the learning process.

5.1 Core Findings and Critical Comparison

The study demonstrated that PBL positively influenced all four motivational dimensions compared to traditional instructional methods. These results align with prior research show that inquiry-based, student-centered approaches promote interdisciplinary skills, systemic thinking, and robust emotional engagement (Bell et al., 2003; Blumenfeld et al., 1991; Ryan & Deci, 2000). However, while previous studies generally report moderate gains in student motivation, our findings suggest that a cascading, multi-tiered professional development (PD) model, where academic staff mentor M.Ed students who in turn mentor in-service teachers, may amplify these effects, particularly in socioeconomically disadvantaged schools (Chen & Yang, 2022; Xie et al., 2022).

Notably, emotional motivation exhibited the highest gains, which aligns with recent evidence highlighting the importance of affective engagement for sustaining learning in post-pandemic and digital learning contexts (Liu & Pásztor, 2022). This suggests that structured, teacher-driven PBL not only enhances cognitive outcomes but also encourages fosters meaningful student-teacher interactions that contribute to emotional engagement, a distinction nuance not fully captured in previous large-scale PBL studies.

5.2 Implications for Teacher Training

The positive shifts in teacher perspectives highlight the critical role of integrated, multi-tiered professional development in scaling PBL. Embedding PBL methodologies into teacher training equips educators with both technical and pedagogical skills needed for effective implementation. This approach promotes autonomy, competence, and collaborative practice, consistent with SDT and SCT. Compared to traditional PD models, which often rely on top-down, lecture-based instruction, our findings support a shift toward active, context-specific, and

project-focused professional development, demonstrating higher teacher satisfaction and greater alignment between PD content and classroom practice (Deehan et al., 2024; Kneen et al., 2023). Moreover, the cascading mentorship structure addresses common barriers to implementing PBL on a scale, including teacher preparedness, resource constraints, and equity challenges (Xie et al., 2022).

5.3 A Novel Approach to Professional Development

Designing PBL units as a form of PD empowers teachers to take ownership of their learning, encourages collaboration, and directly connects to classroom practice. This approach enhances intrinsic motivation and models the PBL methodology they are encouraged to implement with students. Traditional PD often fails to achieve this level of engagement or immediate applicability. Table 6 contrasts traditional PD approaches with the PBL-based model, highlighting these differences.

Table 6: Summary of the traditional PD approaches with the PBL-based model

Aspect	Traditional PD	PBL-Based PD
Structure	Lecture-based, passive	Interactive, project-focused
Teacher role	Passive recipient	Active participant and collaborator
Content relevance	Generalized, theoretical	Context-specific, practical
Motivation factors	Extrinsic (mandatory)	Intrinsic (autonomy, mastery)
Collaboration opportunities	Limited	Integral, peer-to-peer
Alignment with classroom practice	Indirect	Direct, immediate applicability

This model provides a scalable and adaptable framework for PD in under-resourced schools, potentially leading to sustained improvements in both teacher practice and student outcomes.

6. Conclusion and Future Directions

This study demonstrates that a structured, multi-tiered, teacher-driven PBL model can significantly enhance student motivation across behavioral, cognitive, emotional, and social domains, while simultaneously building ~~fostering~~ teacher autonomy, competence, and collaborative practice. These findings support integrating PBL into teacher PD programs and curriculum design, particularly in socioeconomically disadvantaged contexts.

Limitations include reliance on teacher-reported data, convenience sampling, and the absence of formal power analysis, which may limit generalizability. Additionally, long-term impacts on academic achievement and knowledge retention were not assessed.

Future research should:

- Include direct student-reported measures of motivation to complement teacher perceptions.

- Conduct formal power analysis and consider randomized or stratified sampling to enhance representativeness.
- Investigate long-term outcomes, including academic achievement, problem-solving skills, and professional growth.
- Explore the scalability of multi-tiered PBL models in diverse educational contexts and subjects, incorporating recent strategies such as digital platforms, gamification, and adaptive learning technologies (Chen & Yang, 2022; Liu & Pásztor, 2022).

By critically situating the results within prior research and incorporating recent evidence, this study contributes to ongoing discussions about effective, equitable, and scalable teacher-driven PBL interventions in STEM education.

7. Contribution

In summation, this study advances the understanding of PBL's impact on student motivation, teacher practices, and the emotional aspect of learning, particularly in secondary science education, contributing to underexplored areas in the field.

This research offers valuable implications for educational policy and practice, emphasizing the role of innovative teaching methods in shaping and enhancing student motivation. The findings contribute to a broader understanding of how pedagogical approaches can be optimized to support active engagement and critical thinking in science education.

8. Study Limitations

Despite its contributions, this study has several limitations. Firstly, the research was conducted in a limited geographical area. Furthermore, the short duration of the intervention did not allow for the exploration of long-term effects of PBL on student motivation and academic performance. Future studies should address these limitations.

9. Recommendations and Implications

For Educators and Teacher Trainers

- Integrate multi-tiered, teacher-driven PBL models into professional development programs to enhance both teacher efficacy and student motivation.
- Encourage reflective practice and collaborative lesson design to support teacher agency and sustainable instructional change.

For School Leaders:

- Facilitate the adoption of PBL by providing time, resources, and institutional support for collaborative planning and implementation.
- Promote a school culture that values inquiry-based, student-centered learning and teacher innovation.

For Policymakers:

- Consider scalable, multi-tiered PBL frameworks as part of national STEM education strategies, particularly in under-resourced or socioeconomically disadvantaged schools.
- Align curriculum reforms and teacher training programs with research-backed practices that foster intrinsic motivation and 21st-century skills.

10. Theoretical Contributions

This study provides empirical support for SDT and SCT in the context of multi-tiered professional development, demonstrating how autonomy, competence, and relatedness can enhance teacher and student motivation.

The research extends constructivism and PBL frameworks by showing how teacher-driven approaches can be implemented effectively across multiple educational levels.

11. Practical Contributions

The study offers a replicable model for designing and implementing PBL units that improve student engagement, collaboration, and emotional involvement in learning. Furthermore, it provides actionable guidance for integrating PBL into teacher professional development programs, bridging the gap between theory and classroom practice.

12. References

- Acquah, A., Nsiah, T. K., Antie, E. N. A., & Otoo, B. (2021). Literature review on theories of motivation. *EPRA International Journal of Economic and Business Review*, 9(5), 25-29.
- Albitar, L. (2004). *Academic and practical skills*. Dar Al-Shorouk.
- Bandura, A., & Wessels, S. (1997). *Self-efficacy* (pp. 4-6). Cambridge University Press.
- Barron, B., & Darling-Hammond, L. (2008). *Teaching for meaningful learning: A review of research on inquiry-based and cooperative learning*. The George Lucas Educational Foundation.
- Bas, G. (2011). Investigating the effects of Project-Based Learning on students' academic achievement and attitudes towards English lessons. *Educational Research and Reviews*, 6(1), 36-49.
- Bell, P., Bricker, L. A., Tzou, C., & Baines, A. D. (2003). Learning in and for interagency work: Modes, purposes, and outcomes of informal boundary crossing in a collaborative science project. *Journal of Research in Science Teaching*, 40(10), 1069-1096.
- Bell, P., Davis, E. A., & Linn, M. C. (2003). Design-based research and the challenge of developing tools for educational reform. *Yearbook of the National Society for the Study of Education*, 102(2), 40-55.
- Bell, S. (2010). Project-Based Learning for the 21st century: Skills for the future. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 83(2), 39-43.
- Blumenfeld, P., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, 26(3-4), 369-398.
- Buckley, P., & Doyle, E. (2016). Gamification and student motivation. *Interactive Learning Environments*, 24(6), 1162-11.
- Chen, C. H., & Yang, Y. C. (2022). Revisiting project-based learning: Examining its effectiveness in science education through meta-analysis. *Journal of Science Education and Technology*, 31(5), 655-670. <https://doi.org/10.1007/s10956-022-09972-9>
- Chen, H., & Yang, J. (2022). Revisiting the effects of project-based learning on students' motivation: A meta-analysis. *Learning and Instruction*, 76, 101521.
- Chiang, C. L., & Lee, H. (2016). The effect of project-based learning on learning motivation and problem-solving ability of vocational high school students. *International Journal of Information and Education Technology*, 6(9), 709-712.

- Chu, S. K. W., Reynolds, R. B., Tavares, N. J., Notari, M., & Lee, C. W. Y. (2023). *21st century skills development through inquiry-based and project-based learning: A global perspective*. Springer. <https://doi.org/10.1007/978-981-99-1247-7>
- Darling-Hammond, L., Hyler, M. E., Wojcikiewicz, S., & Rushing, J. (2025). *Design Principles for Teacher Preparation: Enacting the Science of Learning and Development*. Learning Policy Institute.
- Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227-268.
- Deehan, J., & Pásztor, A. (2024). Australian primary students score best ever result in global maths and science test, despite pandemic disruption. *The Guardian*. Retrieved 04/12/2024 date from <https://www.theguardian.com/australia-news/2024/dec/04/australian-primary-students-score-best-ever-result-in-global-maths-and-science-test-timss>
- Deehan, J., et al. (2024). Insights from TIMSS: Understanding global trends in science education over 25 years. *Journal of Science Education Policy*, 34(1), 12–30.
- Deehan, J., Furtak, E. M., & Timms, M. (2024). Twenty-five years of TIMSS: Trends and persistent gaps in global science achievement. *International Journal of Science Education*, 46(3), 287–309. <https://doi.org/10.1080/09500693.2024.2291123>
- Deehan, J., MacDonald, A. & Morris, C. (2024). A scoping review of interventions in primary science education, *Studies in Science Education*, 60(1), 1-43, <https://doi.org/10.1080/03057267.2022.2154997>
- Emin-Martínez, V., Hansen, C., Rodríguez-Triana, M. J., Wasson, B., Mor, Y., Dascalu, M., ... Hernández-Leo, D. (2020). Towards teacher-led design inquiry of learning analytics. *British Journal of Educational Technology*, 51(4), 1081–1099. <https://doi.org/10.1111/bjet.12932>
- Glasner, A. (2014). Motivation and creativity in the classroom: The intersection of psychological needs and educational methods. *Journal of Educational Psychology*, 32(4), 321–335.
- Goldreich, A., & Karashtranova, E. (2024). Overview of the stem education in Israel. *Pedagogy/Pedagogika* (0861-3982), 96(5).
- Grapin, S. E., Pierson, A., González-Howard, M., Ryu, M., Fine, C., & Vogel, S. (2023). Science education with multilingual learners: Equity as access and equity as transformation. *Science Education*, 107(4), 999-1032.
- Harter, S. (1981). A new self-report scale of intrinsic versus extrinsic orientation in the classroom: Motivational and informational components. *Developmental Psychology*, 17(3), 300.
- Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, 16(3), 235-266
- Imran, N., and Masood J. (2020). Artificial intelligence in medical education: Are we ready for it? *Pakistan Journal of Medical Sciences* 36(5), 857.
- Kneen, J., Breeze, T., Thayer, E., John, V., & Davies-Barnes, S. (2023). Pioneer teachers: How far can individual teachers achieve agency within curriculum development? *Journal of Educational Change*, 24(2), 243-264.
- Kirschner, P., Sweller, J., & Clark, R. E. (2006). Why unguided learning does not work: An analysis of the failure of discovery learning, problem-based learning, experiential learning and inquiry-based learning. *Educational psychologist*, 41(2), 75-86.
- Kneen, J., Howe, C., & Hennessy, S. (2023). Scaling up pedagogical innovation in science classrooms: Challenges and opportunities. *Studies in Science Education*, 59(1), 1–24. <https://doi.org/10.1080/03057267.2022.2129414>
- Kneen, M., & Pásztor, A. (2023). Teacher professional development and practice of project-based learning in Taiwan: The moderating effect of self-efficacy. *Teaching and Teacher Education*, 115, 103668.

- Krajcik, J. (2021). Project-based learning: Aligning instructional practices with the needs of today's learners. *The Science Teacher*, 88(5), 28–33. https://doi.org/10.2505/4/tst21_088_05_28
- Krajcik, J., & Shin, N. (2014). Project-based learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 275–297). Cambridge University Press.
- Liu, Y., & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis. *Thinking Skills and Creativity*, 45, 101069.
- Mostafa, T., A. Echazarra, & H. Guillou. (2018). "The science of teaching science: An exploration of teaching science practices in PISA 2015." *OECD Education Working Papers*, No. 188. OECD Publishing. <http://dx.doi.org/10.1787/f5bd9e57-en>
- NGSS Lead States. (2013). *Next generation science standards: for states, by states*. The National Academies Press.
- OECD. (2018). *Equity in education: Breaking down barriers to social mobility*. OECD Publishing.
- Pintrich, P. R., McKeachie, W. J., & Lin, Y. G. (1987). Teaching a course in learning to learn. *Teaching of Psychology*, 14(2), 81-86.
- Rivera, H. H., et al. (2015). Enhancing science learning outcomes for marginalized students through project-based learning. *Science Education International*, 26(1), 39–58.
- Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55(1), 68–78.
- Sakiz, G. (2008). An interview with Dale Schunk. *Educational Psychology Review*, 20, 485–491.
- Schneider, B., Krajcik, J., Lavonen, J., Salmela-Aro, K., Klager, C., Bradford, L., Chen, I.-C., Baker, Q., Touitou, I., Peek-Brown, D., Dezenorf, R. M., Maestrales, S., & Bartz, K. (2022). Improving science achievement – Is it possible? Evaluating the efficacy of a high school chemistry and physics project-based learning intervention. *Educational Researcher*, 51(2), 109-121. <https://doi.org/10.3102/0013189X211067742>
- Schwarz, C. V., Passmore, C., & Reiser, B. J. (2023). Helping students make sense of science by leveraging the epistemic practices of modeling. *Science Education*, 107(2), 361–389. <https://doi.org/10.1002/sce.21769>
- Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research*, 75(3), 417–453. <https://doi.org/10.3102/00346543075003417>
- Thomas, J. W. (2000). *A review of research on project-based learning*. The Autodesk Foundation
- Xie, C., Anderson, R., & Clarke, A. (2022). Equity challenges in implementing project-based learning on a scale: Lessons from STEM classrooms. *Journal of Research in Science Teaching*, 59(7), 1203–1227. <https://doi.org/10.1002/tea.21796>