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Project-Based Learning and Gender Inclusion in Secondary STEM Education

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Abstract

The purpose of this study was to examine the different effects of project-based and lecture-driven teaching methods on female high school engineering students. Participants were male and female high school students who were enrolled in a three-year-long engineering class. Participants were asked to fill out a questionnaire that included a Likert scale section where students answered on a 1-5 scale, 1 meaning a strong disagreement and 5 meaning a strong agreement. The Likert scale questions consisted of lecture-favorable and project-favorable statements. The responses from each question were categorized into female and male averages. From the data, the overall trend was that the averages for females were higher for project-based questions than for lecture-based questions. Additionally, for all the questions, the male and female averages were very similar, with only about a 0.1 to 0.3 difference. Therefore, meaning that all students preferred project-based teaching methods in an engineering classroom.

Keywords: project-based learning, lecture-based learning, high school female students, engineering, teaching

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INTRODUCTION

Women remain underrepresented in engineering education and careers, making their early engagement with engineering an important concern for STEM education. According to Bix (2004), in the United States during the 19th century, it was very rare for females to undergo the proper education and get a formal engineering degree. Similarly, Rosser (2003) stated that in 1996, out of the 55.5% of females who got a master's degree, only 39.3% of them got a degree in engineering or science. Women continue to face significant problems within the field of engineering, especially in their education, which makes them feel underrepresented despite the constant reinforcers of gender equality within STEM. Many women who enter these programs encounter an environment where they feel unconfident, unwelcome, out of place, and deal with overly competitive peers. While academic ability within students is not the main issue, it is the way that engineering is taught that can make them feel confident, successful, and participate more in learning or activities. Education within engineering should emphasize teaching methods that encourage engagement and motivate students to continue in the field. This makes secondary engineering education a particularly important context, as students' early experiences of confidence, participation, inclusion, and meaningful engagement may shape how they perceive engineering as a field in which they can participate and potentially continue. To continue, Bystydzienski and Brown (2012) affirmed the fact that little to no attention has been given to females' engagement with engineering during their beginning stages of decisions as their interest increases, consisting of their education, what engineering truly is, and if they want to pursue it as a career.

One aspect that has a major role in shaping whether students want to continue in a subject is their learning environment. For instance, Sonnert et al. (2007) measured the impact of having more women in the

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classroom and then concluded that it causes other females to become more confident in the classroom. However, instructional design may also shape how students experience and engage with engineering learning. For instance, lecture-based learning tends to focus on memorization and individual performance, while project learning focuses on teamwork and hands-on examples. These contrasting instructional approaches may create different learning experiences, particularly in students' perceived confidence, participation, motivation, inclusion, and engagement with engineering. While some research has been done on early education in engineering college classrooms, minimal studies have been done focusing on the early education of students in high school engineering classrooms. A peer-reviewed article written by Vieira et al. (2025) stated that when female students are younger, they have more confidence in STEM, but this confidence decreases over time. By examining how different learning techniques and environments influence the number of women entering engineering based on their experiences, this could allow for future educators and researchers to create spaces to help support females in the male-dominated field for long-term success. Understanding these early instructional experiences therefore has relevance beyond a single classroom, contributing to the broader challenge of designing more inclusive secondary engineering learning environments that can support female engagement in STEM pathways.

Research Objectives:

Against this background, this study examines female students' perceptions of project-based and lecture-based learning in high school engineering education. The study focuses on how these instructional approaches relate to students' perceived learning, confidence, participation, motivation, inclusion, and overall instructional preference. It also considers whether the patterns reported by female students differ from those of male students. Accordingly, the study addresses the following research questions:

1. How do female high school engineering students perceive project-based and lecture-based learning in supporting their learning and understanding of engineering concepts?
2. How do female students perceive project-based and lecture-based learning in relation to their confidence, participation, motivation, and inclusion in engineering learning?
3. What are female students' overall preferences for project-based, lecture-based, or combined instructional approaches in high school engineering education?
4. How do female students' perceptions and instructional preferences compare with those reported by male students?

LITERATURE REVIEW

Gender, Inclusion, and Engagement in Engineering Classroom

The learning environment is an important dimension of students' engagement in engineering education, particularly in relation to confidence, participation, motivation, and sense of inclusion. For female students, these dimensions are especially relevant because engineering learning environments have historically been shaped by gender imbalances that may influence how students participate in and identify with the field. For many women, these settings contribute to the feeling of lower confidence and isolation, specifically when the environment is male dominated. According to Dasgupta et al. (2015), STEM fields have a very low population of women, more so in engineering than in others, which causes their motivation, career aspirations, and participation to be lower compared to men's. This is most likely brought on by isolation, stereotypes, and sexism. In line with that conclusion, Allan et al. (2006) stated that in a hostile environment, some of the most common things that happen are gender bias and gender discrimination, as they describe the disadvantages that girls and

women have within the male-dominated environment. Within engineering classrooms, men are treated differently from women, which contributes to their poor learning experience. In their study, Murray et al. (1999) found that men were more likely to get called on to answer and ask questions in classrooms, resulting in women not getting any time to respectfully speak. If this behavior within classrooms continues, the population of women will most likely continue to drop. Fox et al. (2009) illustrated the problems that if women do not get the help they need in classrooms, then programs are going to be implemented to help them succeed in their studies, such as extra study groups.

However, Orton et al. (2022) have shown that an effective solution would be to find a simple and effective teaching method that can easily be implemented into classrooms that will help engineering students' self-efficacy, expectations, motivation, and behaviors from their peers. Additionally, Balakrishnan and Low (2016) executed a study that affirmed the fact that in order for women to succeed in engineering, educators need to make their classroom environment more conducive to provide a proper, positive learning environment that improves their academic performance. Collectively, these studies suggest that female engagement in engineering cannot be understood solely through academic performance. Confidence, participation, motivation, peer interaction, and inclusion are also shaped by the instructional environment. However, much of this evidence comes from undergraduate or broader STEM settings, leaving less understood how these dimensions are experienced by female students during secondary engineering education.

Lecture-Based Learning in Engineering Education

Lecture-based instruction remains a widely used approach in secondary and higher education, typically emphasizing structured content delivery, conceptual explanation, and individual knowledge acquisition. Based on Varao-Sousa and Kingstone's (2015) research, lectures have an effect on students' overall memory performance within their chosen subject, as they enhance their memories and give them a greater motivation to continue learning. Additional information about students' learning is presented by Young and Bedker (1997), who clarified the point that the material used in lectures is very organized, fact-based, highly structured, and relies on logical analysis, which allows students to get the most valuable information out of their time listening.

However, while lectures are beneficial for memorization skills, it presents a problem when it comes to accessibility and flexibility. As Bosshardt and Chiang (2016) explain, when a student misses a class that is based on lectures, it is hard for them to catch up on the work, and they have limited ways to make it up, mainly relying on classmates' notes, textbook pages, and online assignments. Similarly, another downside is looked at by Park and Choi (2014), who stated that the physical way a classroom is set up, whether as a lecture hall or a collaborative space, normally matches how the teacher believes students learn the best, showing little to no concern for the actual results presented. While that may not affect students' learning as much, it might show that lecture classrooms are good for some students and not for others. Thus, lecture-based instruction may provide structure and support theoretical knowledge, but its predominantly teacher-directed format may offer fewer opportunities for collaboration, active participation, and interpersonal engagement. These characteristics are particularly relevant to the present study because confidence and participation constitute important dimensions of female students' experiences in engineering learning environments.

Project-Based Learning and Student Engagement

Project-based learning is an active instructional approach in which students develop knowledge and skills through sustained engagement with authentic problems, design tasks, or hands-on projects. Within engineering education, such learning environments can provide opportunities for collaboration, application of conceptual knowledge, and engagement with engineering practices. Knowledge collected from prior

conclusions, Rezvanifar and Amini (2020) stated that classrooms that use active learning techniques show a higher potential to increase a student's educational experience.

Their findings are similar to those from Apkarian et al. (2021), who found that research within the field of science, mathematics, and engineering has led to conclusions that the usage of active learning within classrooms leads to content understanding and positive attitudes, which allows for the gap between uneducated students and students who have foundation knowledge to close slightly. While some students do benefit from memorizing lectures, there is a beneficial outcome from using material objects. As stated by Mitropoulos et al. (2024), objects allow students to learn concepts in a visual way, which encourages them to use their mental solutions and apply them in a concrete way. However, according to Fox et al. (2011), implementing programs that have projects within classrooms does not have any guarantee that the female students will begin to have a positive experience in engineering. Taken together, the literature indicates that active and project-oriented learning can support understanding, engagement, and application of knowledge, but these benefits should not be assumed to occur equally for all students. In particular, evidence remains limited regarding how female students at the secondary level perceive project-based learning in relation to confidence, participation, motivation, inclusion, and their broader engagement with engineering.

Research Gap

Although research has extensively examined women's participation in engineering and the potential benefits of active and project-based learning, two limitations remain evident. First, much of the existing evidence concerns undergraduate engineering education or broader STEM populations, whereas comparatively less is known about students' experiences during secondary engineering education. Second, studies of instructional approaches have frequently emphasized achievement, retention, or general learning outcomes, providing less attention to how female students perceive confidence, participation, motivation, inclusion, and learning across different instructional environments.

Addressing this gap is important because secondary engineering education represents an early stage at which students develop perceptions of engineering learning and their place within the field. Examining female students' experiences of project-based and lecture-based learning, while comparing these patterns with those reported by male students, can therefore provide evidence about how instructional design may support more inclusive engagement in engineering education. Such evidence may also contribute to the broader international discussion on creating equitable pathways into engineering and STEM education across diverse educational contexts.

RESEARCH METHOD

Research Approach and Research Method

This study employed a quantitative descriptive survey design to examine patterns in students' perceptions of project-based and lecture-based learning in high school engineering education. The purpose of this study was to compare how project-based lessons and lecture-based teaching methods in classrooms were perceived by students in engineering, specifically females. A structured questionnaire allowed students to answer different questions that measured varying feelings and personal opinions about teaching strategies. Using a Likert scale and closed-ended questions made it possible for the translation of students' responses into numerical data, such as percentages. Their responses on how they felt in the classroom based on their confidence, engagement, and learning effectiveness were translated into overall average values and compared to other results from differing studies. This approach allowed responses to be collected from the participating students within an engineering classroom in a limited time frame, increasing the reliability of the trends that

were concluded from the data. In addition, answers from students about self-reported academic performance and career intentions were also collected to provide more contextual data that could be looked at alongside other classroom preferences to better understand how the learning environment in engineering classrooms has a better understand female students' perceptions and experiences across different engineering learning environments.

The usage of a survey method and quantitative approach was supported by the researchers Apkarian et al. (2021) as they used a national survey to gather both quantitative and qualitative data to reflect the different types of teaching methods used in STEM classrooms. Their survey consisted of observational questions and opinions that were related to both students and teachers. The questionnaire focused on some of the reasons why a teacher may be for or against using projects or lectures to teach within their classrooms. From their data, they effectively showed that behaviors, attitudes, and common trends can be efficiently measured using a survey. Apkarian et al.'s research led to the conclusion that survey-based data is a very credible and reliable method to use when looking at educational experiences and environments in STEM fields. Similarly, Sonnert et al. (2007) also used a survey to effectively conduct their research study on how the learning environment and institution have had an effect on undergraduate women in engineering. The survey collected data over time from institutions and students about how classroom and institutional factors influenced women's motivation to continue in science or engineering. This showed that surveys can also help to assess gender related experiences and also establish environmental factors within engineering education. Overall, surveys are a recognized and logical way to study women's experiences, persistence, motivation, and their preferred teaching method.

Subject Selection and Sampling Procedure

The study primarily focused on high school students enrolled in a three-year-long engineering program at a Delaware public high school, because the study focused on female students' experiences of different instructional approaches during secondary engineering education. The study was not limited to just female participants, as responses from both genders allowed for compassion to be shown within the data collected. The group of participants was chosen for the study because they were directly affected by different instructional styles and were at a vital stage of learning where confidence and academic experiences can have an influence on future decisions. The participants provided a relevant population for examining perceptions of project-based and lecture-based learning within an authentic high school engineering setting. Due to limited resources and time constraints, the participants of the survey were selected through a convenience sampling procedure. Convenience sampling was used by selecting students enrolled in the existing engineering class from the public school, which allowed for access to participants who directly experienced the different teaching methods. This approach is appropriate for comparing teaching methods within the same classroom environment.

Instrument Validity

The questionnaire was designed to align with the primary constructs examined in the study, including perceived learning, confidence, participation, motivation, inclusion, and instructional preference. All participants received the same questions, response options, and administration procedures to support consistency in data collection. Content alignment was established by mapping questionnaire items to the constructs addressed in the research questions. However, because the instrument was developed for this study and was not subjected to extensive psychometric validation, the findings should be interpreted as descriptive evidence of students' self-reported perceptions.

Procedures

In this research study, data were collected using one method: a survey. The survey (see Appendix) was distributed to high school students enrolled in an engineering pathway class that takes place over the course of three years. The survey started with four closed-ended personal questions, which asked about the participants' gender, grade in the class, what year of the program they are in, and if they want to continue in engineering for college. The following were two more closed-ended questions about how often they feel their educator used lectures and projects within their lessons. The next section was made up of seventeen Likert scale questions about statements that revolved around their experiences in the engineering class. The survey then concluded with two closed-ended questions about which teaching method students prefer overall. After collecting all the information from the survey, the data was analyzed.

Data Analysis

The data was analyzed using charts and tables on Google Sheets, which allowed for patterns to be identified amongst the students' responses. Likert scale responses were converted into numerical values on a scale from 1 to 5, where 1 was a strong disagreement and 5 was a strong agreement. In order to account for the differences across the groups, responses were then organized into the following three groups: male, female, and other. An average score was then calculated for each survey question for each group. The averages were then organized into a table that allowed for direct comparison between the groups, focusing on the observation of trends in confidence, participation, and opinions on lecture-based and project-based learning environments. The analysis was not focused on determining statistical significance, but rather on identifying patterns in the data. The analysis was organized to examine patterns in perceived learning (RQ1), confidence, participation, motivation, and inclusion (RQ2), overall instructional preferences (RQ3), and similarities or differences between female and male students (RQ4). Instead, descriptive statistics, such as averages, were used to compare the responses from students about the instructional styles. Responses from the Likert scale portion were averaged and represented in the following way: averages below 2.5 indicated general disagreement, averages near 3 were considered neutral, and averages above 3.5 indicated general agreement.

RESULTS

This section presents the findings according to the four research questions. Descriptive results are reported for students' perceived learning and understanding, confidence, participation, motivation and inclusion, overall instructional preferences, and gender-based patterns across project-based and lecture-based learning. The teaching methods that were studied were lecture-driven and project-based. Data was collected from students using closed-ended and Likert scale questions. Using the Likert scale questions, students were able to express their perceptions of the instructional methods on a 1-5 scale. All participants were selected by convenience sampling, and all responses are represented within the data.

Participant Profile

A total of 44 students participated in the study. Of these, 63.6% were male, 34.1% were female, and 2.3% identified as other (Fig. 1). Regarding academic performance, 75.0% reported an A, 11.4% a B, 2.3% a D, and 11.4% preferred not to report their grade. No clear descriptive pattern was observed between students' reported grades and their instructional preferences.

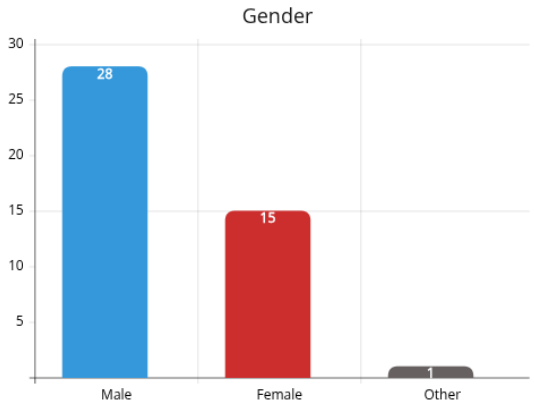


Figure 1. Number of students who participated in the survey and gender distribution

The data for each question was calculated using the average formula (total sum of all numbers/number of values) based on all the answers from each student. The data was split into two sections: male and female. Each section had its own average per question, ranging from 1-5: 1 = strongly disagree, 5 = strongly agree.

Perceived Learning and Understanding

For RQ1, female students reported more positive perceptions of project-based learning than lecture-based learning in relation to learning and understanding engineering concepts. Female students reported a mean of 4.0 for learning topics and concepts better through project-based classes, compared with 2.4 for lecture-based classes. They also reported a means of 4.3 for retaining information longer through projects and hands-on work. Project-based learning was perceived positively as preparation for real engineering work (M = 4.1), whereas lecture-based instruction received a neutral female rating for building a theoretical foundation (M = 3.0). These findings indicate that female students perceived project-based learning more positively for understanding, retention, and application of engineering learning.

Confidence, Participation, Motivation, and Inclusion

For RQ2, project-based learning received consistently positive ratings from female students across confidence, participation, motivation, and inclusion. Female students reported greater confidence in project-based lessons (M = 4.3) than in lecture-based lessons (M = 2.7), and greater active participation in project-based lessons (M = 4.1) than in lecture-based lessons (M = 2.3). Project-based learning was also rated positively for engagement and motivation (M = 4.2), connection with classmates (M = 4.2), seeking teacher feedback (M = 4.0), and motivation to attend or participate (M = 4.4). These patterns indicate that female students associated project-based learning with a more engaging and participatory engineering learning environment.

Overall Instructional Preferences

For RQ3, female students demonstrated a clear overall preference for project-based learning. When asked about their preferred teaching style, 60% of female participants selected project-based learning and 40% selected a balanced combination of project- and lecture-based instruction; none selected lecture-based learning alone. When required to choose only one instructional approach for all engineering courses, 93.33% of female participants selected project-based learning. These results reinforce the positive perceptions of project-based learning observed across the Likert-scale items.

Gender-Based Patterns

For RQ4, female and male students demonstrated broadly similar patterns of perception. Both groups consistently rated project-based learning more positively than lecture-based learning, with differences between female and male means generally small across the survey items. Female ratings for project-based items ranged from 4.0 to 4.4, while male ratings showed a comparable pattern. Although female students reported slightly higher ratings on several measures of confidence, participation, and engagement, the descriptive data do not indicate a substantial gender-specific difference in overall instructional preference. Rather, project-based learning was positively perceived by students across gender groups.

In the closed-ended questions about the students' personal information, the following was answered about their course grade in the class: 75% have an A, 11.4% with a B, 2.3% with a D, and the remaining 11.4% preferred not to answer. With these differential answers in grades, they can be used to show how the preferred teaching method of the student could affect their learning. However, this analysis of the students' grades indicated no clear relationship between their academic performance/success in their engineering class and the students' reported teaching style preferences. Students across different grade levels all reported similar preferences within the data, suggesting that the academic performance did not have a strong correlation with preferred instructional style.

Table 1: Likert Scale Student Response Average

No.	Question	FA	MA	OA
1.	I learn topics and concepts better in lecture-based classes	2.4	2.9	2
2.	I learn topics and concepts better in project-based classes	4	3.9	5
3.	Lecture-based lessons make me feel more confident in my engineering skills	2.7	2.9	3
4.	Project-based lessons make me feel more confident in my engineering skills	4.3	4	4
5.	I participate actively in lecture-based lessons	2.3	2.8	1
6.	I participate actively in project-based lessons	4.1	4	5
7.	I retain information longer when learning through projects / hands-on work	4.3	4	4
8.	Lecture-based instruction helps me build a stronger theoretical foundation	3	3.2	4
9.	Project-based learning better prepares me for real engineering work in the field	4.1	4.3	3
10.	I find lecture-based learning easier to follow because they are more organized	2.7	2.8	2
11.	I find project learning more engaging and motivating	4.2	4.1	5
12.	The type of learning environment affects how confident I feel in class	3.7	3.9	5
13.	The type of learning environment affects how I feel in class	3	4	5
14.	I feel more included and connected to my classmates in project-based learning than with lecture learning	4.2	4	4
15.	I am more likely to seek help or feedback from my teacher in project-based lessons	4	3.7	5
16.	The learning environment (lecture or projects) influences how much I enjoy engineering overall	3.9	4.1	5
17.	I am more motivated to attend and or participate in project-based learning	4.4	4	5

Note–FA = Female Average; MA = Male Average; OA = Other (non-male/female) Average

FINDING AND DISCUSSION

The findings of this study show that female students consistently reported more positive perceptions of project-based learning than lecture-based instruction. Female ratings for project-based items ranged from 4.0 to 4.4, whereas ratings for lecture-based items ranged from 2.3 to 3.0. The strongest positive responses were associated with confidence, participation, information retention, motivation, and connection with classmates. At the same time, male students showed a broadly similar pattern, indicating that the preference for project-based learning was not limited to female students. These findings should therefore be interpreted as evidence of

students' perceived learning experiences rather than as evidence of a causal effect of one instructional method over another.

Project-Based Learning, Confidence, and Participation

Female students reported greater confidence in their engineering skills during project-based learning (M = 4.3) than during lecture-based learning (M = 2.7). They also reported greater active participation in project-based lessons (M = 4.1) than in lecture-based lessons (M = 2.3). These findings are consistent with previous research indicating that learning environments can play an important role in women's participation and confidence in engineering. Dasgupta et al. (2015), for example, found that social learning environments involving female peers were associated with greater motivation, verbal participation, and engineering career aspirations among women. Similarly, Balakrishnan and Low (2016) emphasized the importance of learning experiences and socio-cultural conditions in shaping female engineering students' perspectives toward engineering courses and careers.

The present findings extend this discussion to the secondary school level by showing that female high school students also reported more positive perceptions when engineering learning involved projects and hands-on activities. This is relevant because much of the literature cited in this study has focused on undergraduate engineering populations, whereas the present study examines students at an earlier stage of their engineering education.

Project-Based Learning and Perceived Learning

Female students also perceived project-based learning positively in relation to understanding and retaining engineering content. They reported that they learned topics and concepts better through project-based classes (M = 4.0) and retained information longer through projects and hands-on work (M = 4.3). They also viewed project-based learning positively as preparation for real engineering work (M = 4.1).

These findings correspond with research on active and project-oriented learning in STEM. Rezvanifar and Amini (2020) reported positive educational experiences associated with project-based active learning in engineering, while Apkarian et al. (2021) identified active learning as an important instructional practice across science, mathematics, and engineering education. Mitropoulos et al. (2024) further demonstrated that working with physical objects can help engineering students understand abstract and difficult concepts by connecting conceptual thinking with concrete applications.

The present results are therefore consistent with the broader literature suggesting that active engagement with engineering tasks can support students' perceived understanding and application of concepts. However, because this study measured students' perceptions rather than objective learning gains, the findings should not be interpreted as demonstrating that project-based learning produces higher academic achievement.

Motivation, Inclusion, and Engagement

Project-based learning also received strong ratings from female students for engagement and motivation (M = 4.2), connection with classmates (M = 4.2), willingness to seek teacher feedback (M = 4.0), and motivation to attend or participate (M = 4.4). These findings are particularly relevant to the literature on female participation in engineering, because previous studies have identified social interaction, participation, and supportive learning environments as important dimensions of women's engineering experiences.

Dasgupta et al. (2015) demonstrated that participation in small-group environments can strengthen women's motivation and verbal participation in engineering. Balakrishnan and Low (2016) likewise showed that female engineering students' experiences are influenced not only by academic content but also by the socio-cultural characteristics of their learning environment. The current findings are consistent with these studies

because female students reported stronger perceptions of inclusion, participation, and motivation in project-based environments.

The importance of these experiences may extend beyond immediate classroom preference. Lewis et al. (2025) found that women's technical participation during engineering education was associated with longer-term retention. Although the present study did not measure persistence or subsequent engineering enrollment, its findings suggest that participation and engagement during secondary engineering education warrant attention in future longitudinal studies.

Similarities Between Female and Male Students

An important result of this study is that female and male responses were generally similar. Differences between the two groups were typically small, and both groups rated project-based learning more positively than lecture-based learning. Female students therefore did not demonstrate a fundamentally different instructional preference from male students.

This finding is important because previous research does not indicate that project-based or active learning automatically produces gender-specific benefits. Fox et al. (2011), for example, cautioned that educational programs intended to support women do not necessarily guarantee more positive experiences. Likewise, Rezvanifar and Amini (2020) explicitly considered project-based active learning in relation to gender and self-efficacy, showing that instructional method and gender should not be treated as simple or isolated explanations of students' experiences.

The present findings therefore suggest that project-based learning may be positively perceived by female students without necessarily being uniquely preferred by them. This distinction strengthens rather than weakens the contribution of the study: instructional practices that support female confidence, participation, and engagement may also be valued by other students within the same engineering classroom.

Instructional Preference and Engineering Education

The overall preference data further reinforces the Likert-scale findings. Sixty percent of female participants selected project-based learning as their preferred instructional approach, while the remaining 40% selected a combination of project-based and lecture-based learning. When required to select only one method for engineering courses, 93.33% of female participants selected project-based learning.

These findings align with the active-learning literature reviewed in this study (Rezvanifar & Amini, 2020; Apkarian et al., 2021; Mitropoulos et al., 2024), which emphasizes learning through participation, application, and engagement with authentic or tangible tasks. At the same time, the results do not imply that lecture-based teaching should be eliminated. Female students gave a neutral rating ($M = 3.0$) to the statement that lecture-based instruction provides a stronger theoretical foundation. This suggests that students may recognize different instructional functions for lecture and project-based approaches. The findings therefore support consideration of instructional designs that provide substantial opportunities for project-based and hands-on learning while retaining structured instruction where it supports conceptual foundations. This interpretation is also consistent with the fact that 40% of female participants initially preferred a balanced combination of the two approaches rather than project-based learning alone.

Implications for Female Engagement in Engineering Education

The contribution of this study lies in examining instructional experiences at the high school level, before students enter university engineering programs. Previous studies cited in this manuscript have largely examined women already participating in undergraduate engineering or STEM education (Dasgupta et al., 2015; Balakrishnan & Low, 2016; Rezvanifar & Amini, 2020; Lewis et al., 2025). The current findings indicate that

confidence, participation, motivation, inclusion, and instructional preference are already relevant dimensions of female students' experiences during secondary engineering education.

This has broader implications for efforts to increase female participation in engineering. Rather than focusing only on recruitment into engineering programs, attention should also be given to the instructional environments students experience during earlier stages of education. Project-based learning may represent one approach through which female students experience engineering as more participatory, collaborative, and engaging. However, because male students reported similar perceptions, these findings should be understood within the broader goal of designing engineering learning environments that support engagement while ensuring that female students are fully able to participate.

CONCLUSION

This study examined female high school engineering students' perceptions of project-based and lecture-based learning, with particular attention to perceived learning, confidence, participation, motivation, inclusion, and instructional preference. The findings consistently showed that female students perceived project-based learning more positively across these dimensions and strongly preferred project-based experiences when asked to select an instructional approach. However, male students demonstrated a broadly similar pattern, indicating that the positive perceptions of project- based learning were not exclusively gender-specific.

The findings contribute to engineering education by highlighting the importance of instructional experiences in supporting female engagement during the secondary school years, an educational stage that has received less attention than undergraduate engineering education. Rather than suggesting that female students require a fundamentally different pedagogy, the results indicate that project-based learning may provide participatory, collaborative, and applied learning experiences that female students value while also being positively perceived by students more broadly.

These findings should be interpreted cautiously because the study was based on a small, single-school sample, self-reported perceptions, and descriptive analysis. The results therefore do not establish that project-based learning causes improvements in academic achievement or subsequent persistence in engineering. Future research across larger and more diverse educational contexts is needed to determine whether these patterns are sustained and whether positive early experiences of confidence, participation, motivation, and inclusion contribute to longer-term engagement in engineering pathways.

More broadly, efforts to increase female participation in engineering should consider not only access to engineering education but also the quality of the learning experiences students encounter once they enter these environments. Designing secondary engineering education around meaningful opportunities to participate, collaborate, apply knowledge, and engage with authentic engineering tasks may represent an important step toward more inclusive engineering pathways.

LIMITATION & FURTHER RESEARCH

Several limitations should be considered. The study involved only 44 participants from one high school engineering program and used convenience sampling, which limits the general inability of the findings. All students were also exposed to the instructional practices of the same program, and their experiences with project-based and lecture-based teaching were not experimentally controlled. In addition, the study relied on self-reported perceptions and descriptive statistics. Consequently, the results cannot establish causal relationships between project-based learning and confidence, academic achievement, persistence, or future engineering enrollment. The lack of a clear relationship between students' reported grades and instructional preferences further indicates that positive perceptions of project-based learning should not be interpreted as evidence of improved academic performance. Future research should therefore include larger samples across

different schools and engineering programs and should examine whether the patterns observed here are reproduced across different educational contexts. In line with Lewis et al. (2025), longitudinal research would also be valuable for examining whether early participation, confidence, and engagement in project-based engineering environments are associated with later persistence in engineering education. Mixed-method studies could further explore why female students perceive particular aspects of project-based learning positively and how these experiences influence their developing relationship with engineering.

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APPENDIX

Survey Questionnaire

1. What is your gender?
   A. Female
   B. Male
   C. Nonbinary
   D. Prefer not to say

2. What is your current grade in engineering?
   A. A
   B. B
   C. C
   D. D
   E. Prefer not to say

3. What year of engineering are you in?
   A. Year 1
   B. Year 2
   C. Year 3
   D. I have graduated from the program.

4. Do you plan to pursue engineering as a career? *This question is not limited to a certain field of engineering, such as mechanical engineering, etc., as engineering is the creative application of science, math, and technology within designing things to help solve real-world problems and improve life.*
   A. Yes
   B. No
   C. Unsure

5. How often does your engineering teacher use lecture-based instruction (teacher explains concepts while you take notes)?
   A. Almost all classes
   B. Most classes
   C. About half
   D. Few classes
   E. None

6. How often does your engineering teacher use project-based or hands-on learning (team projects, design challenges, or labs)?
   A. Almost all classes
   B. Most classes
   C. About half
   D. Few classes
   E. None

Likert scale questions

(Using a 1-5 Likert scale 1 = Strongly Disagree, 5 = Strongly Agree) Answer the following statements:

1. I learn topics and concepts better in lecture-based lessons.

   Strongly Disagree 1 2 3 4 5 Strongly Agree

2. I learn topics and concepts better in project-based classes.

   Strongly Disagree 1 2 3 4 5 Strongly Agree

3. Lecture-based lessons make me feel more confident in my engineering skills.

   Strongly Disagree 1 2 3 4 5 Strongly Agree

4. Project-based lessons make me feel more confident in my engineering skills.

   Strongly Disagree 1 2 3 4 5 Strongly Agree

5. I participate actively in lecture-based lessons.

   Strongly Disagree 1 2 3 4 5 Strongly Agree

6. I participate actively in project-based lessons.

   Strongly Disagree 1 2 3 4 5 Strongly Agree

7. I retain information longer when learning through projects / hands-on work.

   Strongly Disagree 1 2 3 4 5 Strongly Agree

8. Lecture-based instruction helps me build a stronger theoretical foundation.

   Strongly Disagree 1 2 3 4 5 Strongly Agree

9. Project-based learning better prepares me for real engineering work in the field.

   Strongly Disagree 1 2 3 4 5 Strongly Agree

10. I find lecture-based learning easier to follow because they are more organized.

    Strongly Disagree 1 2 3 4 5 Strongly Agree

11. I find project learning more engaging and motivating.

    Strongly Disagree 1 2 3 4 5 Strongly Agree

12. The type of learning environment affects how confident I feel in class.

    Strongly Disagree 1 2 3 4 5 Strongly Agree

13. The type of learning environment affects how included I feel in class.

Strongly Disagree	1	2	3	4	5	Strongly Agree

14. I feel more included and connected to my classmates in project-based learning than with lecture learning.

Strongly Disagree	1	2	3	4	5	Strongly Agree

15. I am more likely to seek help or feedback from my teacher in project-based lessons.

Strongly Disagree	1	2	3	4	5	Strongly Agree

16. The learning environment (lecture or projects) influences how much I enjoy engineering overall.

Strongly Disagree	1	2	3	4	5	Strongly Agree

17. I am more motivated to attend and or participate in project-based learning.

Strongly Disagree	1	2	3	4	5	Strongly Agree

Overall preference:

1. Which teaching style do you prefer overall?
   A. Lecture-based learning
   B. Project-based learning
   C. A balanced mix of both
   D. Neither

2. If you had to choose one of the teaching methods to be used in all of your engineering courses, which would it be?
   A. Lecture-based learning
   B. Project-based learning