Research Article

Collaborative Learning in Physics: Study Preferences, Self Efficacy, and Peer Influence

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Abstract: Collaborative learning is widely promoted in physics education, yet its influence on students' independent study practices remains insufficiently understood, particularly regarding whether collaborative practices transfer from structured teaching to students' independent study in Nordic higher education contexts. This pilot study examines first-year physics students' preferences for collaborative versus individual study and explores how these preferences relate to self-efficacy and peer influence on self-efficacy (PISE). Survey data were collected from 100 students enrolled in an introductory physics course at the Norwegian University of Science and Technology (NTNU). Students who preferred group study reported slightly higher PISE than those preferring solo study, although the difference was small with a small to moderate effect size ($d = 0.38$) that should be interpret cautiously due to sample size limitations. Male students reported higher self-efficacy than female students, particularly within one programme ($d = 0.62$), consistent with prior research on gender disparities in STEM confidence. Despite regular structured collaborative activities during teaching, a majority of students (61%) reported a preference for studying alone outside class.

These findings suggest a limited transfer of collaborative practices from formal teaching to independent study and highlight the need for more intentional design of collaborative learning environments that address both social and motivational factors. The study contributes to ongoing discussions in Nordic STEM education by emphasising

the importance of supporting not only in-class collaboration but also students' adoption of collaborative strategies in self-directed learning.

Keywords:
Collaborative learning, Self-efficacy, Peer influence, Physics education, Study preferences

1 Introduction

Peer collaboration is widely recognised as an effective approach to supporting physics learning. Discussing concepts, explaining reasoning, and solving problems together can deepen conceptual understanding and strengthen confidence (Mazur, 1997; McDermott, 1984, 2001; McDermott et al., 1997; Singh, 2005). Collaborative activities encourage students to articulate their thinking and engage with alternative perspectives - processes central to meaningful learning. This forms the common theme for different active learning methods, such as: Peer Instruction (Mazur, 1997), Investigative Science Learning Environment (ISLE) (Etkina and van Heuvelen, 2007) and Student-centered Active Learning Environment with Upside-down Pedagogics (SCALE-UP) (Beichner et al, 2007).

Several theoretical perspectives help explain the benefits of collaboration. From a distributed cognition perspective, cognitive load can be shared across group members, enabling more effective problem-solving in complex tasks (Hutchins, 2014; Xu & Clarke, 2012). The Zone of Proximal Facilitation (ZPF) similarly predicts that collaboration is most productive when group members possess complementary but incomplete knowledge (Nokes-Malach et al., 2015), extending Vygotsky's Zone of Proximal Development (ZPD) (Vygotskiĭ & Cole, 1978). These theoretical perspectives suggest that collaboration should enhance both learning outcomes and students' confidence, making it relevant to examine how such processes relate to self-efficacy and study preferences in this study.

However, research also shows that effective collaboration does not occur automatically. It requires carefully structured learning environments that promote positive interdependence and individual accountability (Johnson & Johnson, 1999; Laal, 2013; Laal et al., 2013; Yamarik, 2007).

In parallel, socio-psychological factors such as self-efficacy play an important role in shaping students' engagement with collaborative learning. Self-efficacy, defined as a student's belief in their ability to succeed in specific tasks (Bandura, 1977), has been shown to influence persistence, participation, and learning outcomes in STEM education. Recent work has further highlighted the importance of peer influence on self-efficacy (PISE), emphasising how interactions with peers can strengthen, or in some cases undermine, students' confidence (Malespina & Singh, 2024). These dynamics may be particularly relevant in physics education, where gender differences in self-efficacy remain a persistent concern. Although learning outcomes are the educational goal motivation and affective constructs, such as self-efficacy are important because they influence engagement, persistence and academic achievement (Bandura, 1977). In the same way, peer influence on self-efficacy provides insight into how students perceive the role of social interactions in physics learning (Malespina & Singh, 2024). Examination of these therefore offers an important perspective on whether collaborative learning influences not only what students learn but also how they approach learning and study practices. While collaborative approaches are increasingly integrated into physics teaching, less is known about whether and how such practices extend beyond structured classroom settings into students' independent study habits. This question is especially relevant in Nordic higher education contexts, where students are expected to take a high degree of responsibility for their own learning. If students do not adopt collaborative

strategies outside formal teaching situations, the potential benefits of collaboration may remain limited.

This pilot study investigates how first-year physics students at the Norwegian University of Science and Technology (NTNU) perceive collaborative learning and how their study preferences relate to self-efficacy and peer influence on self-efficacy. Guided by Bandura's theory of self-efficacy and collaborative perspectives based on Vygotsky's work and subsequent research on collaborative learning (Nokes-Malach et al., 2015; Vygotskiĭ & Cole, 1978), the study addresses the following research questions:

1. What proportion of students prefer solo versus group study?
2. Do students who prefer group study differ from those who prefer solo study in PISE or self-efficacy?
3. Are there gender differences in PISE and self-efficacy?

By examining the relationship between preferred study modes, physics self-efficacy, and peer influence on self-efficacy, this study contributes to Nordic STEM education research by highlighting the challenges of transferring collaborative learning from structured teaching environments to students' self-directed study.

2 Method

2.1 Participants and Context

This study was conducted in an introductory university-level physics course at the Norwegian University of Science and Technology (NTNU) covering mechanics and electromagnetism. The course is compulsory for two selective programmes: the Master's in Applied Physics and Mathematics (MTFYMA) and the Bachelor's in Physics (BFY). Although upper-secondary Physics 1 is required for admission, Physics 2 is recommended.

Of 186 enrolled students, 100 completed an anonymous and voluntary survey in the final weeks of the semester (54% response rate). Among respondents, 61% were male (n = 61), 37% were female (n = 37), and two respondents did not report gender and were excluded from gender-stratified comparisons. This matches the gender distribution of the enrolled students. In addition, 87% had taken upper-secondary Physics 2. MTFYMA students comprised 71% of responses (n = 71), BFY students 24% (n = 24). This cohort provides a relevant context for examining collaborative learning, as the course systematically integrates both individual and group-based activities.

2.2 Measures

The survey gathered demographic data (gender, programme, upper-secondary physics background) and assessed out-of-class study preferences (individual vs. group work). Study preference was measured with the item "I prefer to study physics problems alone rather than in a group". Responses were categorised into group-study and solo-study preference categories for analysis.

Self-efficacy and peer influence on self-efficacy (PISE) items were adapted from Malespina and Singh (2024) and rated on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). Self-efficacy items (4) included statements such as "I am confident I can solve most physics problems on my own". PISE items (4) included "Working with

peers has increased my confidence in physics". Scale scores were computed as the mean across items (higher scores indicate higher self-efficacy/PISE). The items were adapted from established instruments (Malespina & Singh, 2024). The self-efficacy and PISE scales demonstrated excellent internal consistencies (Cronbach's α_{SE} = .92 and α_{PISE} = .95), supporting content validity.

2.3 Teaching Context and Procedure

Teaching activities included lectures, lecture-integrated exercise segments, small-group conceptual exercises (maximum 16 students), and laboratory work. During lecture-integrated exercise segments, students worked individually or in pairs for approximately 5–10 minutes on problems posed by the lecturer. In selected sessions, a classroom response system was used for anonymous submission of answers, followed by whole-class discussion and a brief summary or worked solution presented by the lecturer. In small-group sessions, students collaborated on written responses to conceptual questions, with teaching assistants facilitating discussion by prompting students to justify reasoning, compare alternative approaches, and support broad participation. The anonymous survey was administered online during a scheduled course session in the final two weeks of the semester.

2.4 Analysis

Independent-samples t-tests were selected to compare mean differences between clearly defined groups (e.g., group vs. solo preference), aligning with the study's focus on identifying group-level differences.

Cohen's d effect sizes and p-values are reported for all comparisons. Subgroups smaller than n = 10 were excluded from statistical comparisons due to limited statistical power (Table 1). Analyses were exploratory, and no correction for multiple comparisons was applied. As the analysis is based on cross-sectional self-reported data, conclusions are limited to associations rather than causal relationships.

2.5 Ethics

Participation in the survey was voluntary and anonymous. Students received both oral and written information on the purpose of the study and consent was implied through completion of the survey. No personally identifying information was collected. According to NTNU's guidelines no formal ethical approval was required.

3 Results

3.1 Study Preferences

A majority of students in the sample reported a preference for studying independently rather than collaboratively. In total, 61% of the respondents indicated that they preferred studying alone, while 39% preferred group study. This pattern was observed in both study programmes, with slight variations between cohorts (Table 1).

The findings suggest that, despite systematic incorporation of collaborative learning activities within courses, most students continue to favour independent study outside the classroom.

This preference for independent study is noteworthy given the evidence supporting collaborative approaches for learning in STEM disciplines, possibly reflecting educational and cultural norms that value self-directed learning.

In relation to the overall aim of the study, the result provides empirical support for the notion that collaborative practices introduced in structured teaching settings do not automatically transfer to independent study behaviour.

Table 1. Overview of student subgroups. Bolded group sizes indicate n < 10 and were excluded from inferential comparisons.

Study program	Total	Male (61)	Female (37)	Group (39)	Solo (61)
MTFYMA	71	42	29	28	43
BFY	24	16	**6**	**8**	16
Other	**5**	**3**	**2**	**3**	**2**
Secondary school physics					
Physics 1	**8**	**4**	**4**	**3**	**5**
Physics 2	87	54	31	34	53
Other	**5**	**3**	**2**	**2**	**3**

3.2 Study preferences, Physics Self-Efficacy and Peer Influence on Self-Efficacy

Students preferring collaborative study reported slightly higher levels of PISE than those who preferred solo study. Mean PISE scores were M = 3.72 (SD = 0.88) for student preferring group study and M = 3.38 (SD = 0.90) for students preferring solo study. This difference was not statistically significant (p = .07) with a Cohen's d of 0.38, suggesting a small to moderate effect (Table 2).

For physics self-efficacy, students preferring collaborative study reported a mean score of M = 3.86 (SD = 0.54), compared with M = 3.94 (SD = 0.51) among students preferring solo study. The difference was not statistically significant, p = .64, with a Cohen's d of 0.15, suggesting a very small effect.

Taken together, these findings suggest that students' study preferences were more strongly associated with peer-related confidence beliefs than with general physics self-efficacy. However, because the study is cross-sectional, no conclusions can be drawn regarding the direction of these relationships.

Table 2. Mean PISE and self-efficacy (SE) scores by preferred study mode. Values are means (SD). Cohen's d and p values summarise the group vs. solo comparison.

	PISE (SD)	Cohen's d	p-value	SE (SD)	Cohen's d	p-value
Group	3.72 (0.88)			3.86 (0.54)		
Solo	3.38 (0.90)	0.38	.07	3.94 (0.51)	0.15	.61

3.3 Gender Differences in Peer Influence on Self-Efficacy and Physics Self-Efficacy (SE)

Male students reported higher self-efficacy than female students (Table 3). Within the MTFYMA programme, male students had a mean score of M = 4.05 (SD = 0.46) compared with M = 3.77 (SD = 0.44) among female students. The difference corresponding to a Cohen's d of d = 0.62, indicating a moderate effect, that is statistically significant (p = .02). This is consistent with prior research documenting gender differences in physics self-efficacy (Marshman et al., 2018).

In the case of PISE, the gender differences are smaller. For MTFYMA, male and female students reported mean scores of M=3.76 (SD = 0.69) and M = 3.40 (SD = 0.86), respectively, yielding a Cohen's d of 0.47 (p = .08). This finding suggest that gender differences were more pronounced for physics self-efficacy than for PISE.

This finding relates to Research Question 2 and indicates that disparities in perceived competence remain present even within collaborative learning environments.

Table 3. Mean PISE and self-efficacy (SE) scores by study programme and gender. Values are means (SD). For programme-level comparisons, Cohen's d and p-values compare MTFYMA (all) and BFY (all). For gender comparisons, Cohen's d and p-values compare male and female students within the same programme.

	PISE (SD)	Cohen's d	p-value	SE (SD)	Cohen's d	p-value
MTFYMA (all)	3.61 (0.79)			3.94 (0.47)		
BFY (all)	3.26 (1.07)	0.41	.18	3.86 (0.67)	0.15	.63
MTFYMA male	3.76 (0.69)			4.05 (0.46)		
MTFYMA female	3.40 (0.86)	0.47	.08	3.77 (0.44)	0.62	.02
BFY male	3.57 (0.96)	0.25	.83	4.11 (0.46)	0.13	.66

4 Discussion

This study examined first-year physics students' preferences for collaborative learning versus individual study in a Norwegian university context and explored how these preferences relate to self-efficacy and peer influence on self-efficacy (PISE). Three main findings emerge: (1) a majority of students preferred to study alone despite regular exposure to collaborative activities in teaching, (2) male students reported higher self-efficacy than female students, and (3) students who preferred group study reported slightly higher PISE, although the effect was small.

First, the finding that most students preferred solo study—even in a course that systematically incorporates collaborative activities—suggests a limited transfer of collaborative practices from structured teaching environments to students' independent study routines. This aligns with prior research indicating that students do not automatically adopt collaborative strategies outside formal settings unless their value is made explicit and repeatedly reinforced (Nokes-Malach et al., 2015; Singh, 2005). In the present context, collaborative work may be experienced as a situational requirement rather than as a generally useful learning strategy. In Nordic higher education systems, where independent study is a central expectation, this gap between in-class practice and out-of-class behaviour is particularly consequential. If collaborative skills are not

integrated into students' self-directed learning practices, the long-term educational benefits of collaboration may remain underutilised.

An additional explanation may be that students do not perceive collaborative or active learning approaches as being more effective, even when such approaches improve learning outcomes. Deslauriers et al. (2019) found that students in active-learning environments reported feeling that they learned less than students in traditional settings, despite showing significantly greater actual learning. The difference between perceived and actual learning may provide an explanation as to why students in the present study preferred independent study despite extensive experience with collaborative learning activities. If the benefits of collaboration are not immediately visible, students may be less likely to adopt collaborative approaches outside formal teaching situations.

Second, the observed gender difference in self-efficacy, particularly within the MTFYMA programme, is consistent with a substantial body of research documenting disparities in STEM confidence (Marshman et al., 2018; Deiglmayr et al., 2019). While the present study does not examine underlying mechanisms, it is plausible that differences in perceived belonging, prior experiences, or classroom dynamics contribute to this pattern (Doucette et al., 2020; Cwik and Singh, 2021). Importantly, these findings reinforce that collaborative environments are not inherently equitable. Without deliberate structuring, group work may reproduce or even amplify existing differences in confidence, for example, by allowing more confident students to dominate discussions or solution processes. From an instructional perspective, this underscores the importance of designing collaborative activities that actively support balanced participation, such as through clearly defined roles, guided discussion prompts, and facilitation strategies that ensure all students contribute. This reinforces that collaborative environments must be intentionally structured to avoid reproducing inequities.

Third, students who preferred group study reported slightly higher PISE scores, suggesting a modest association between favourable attitudes towards collaboration and perceived confidence gains from peer interaction. However, the small effect size and lack of statistical significance indicate that these constructs should not be treated as equivalent. Some students may recognise the value of peer interaction without preferring it as their primary mode of study, while others may prefer group work for social or motivational reasons without necessarily experiencing substantial gains in self-efficacy. This distinction points to the importance of designing collaborative tasks that make the cognitive benefits of interaction visible, for example, by requiring explanation, comparison of reasoning, or collective evaluation of alternative solutions.

Taken together, the findings highlight the importance of viewing collaboration not simply as an instructional format, but as a learning practice that must be explicitly developed and sustained across contexts. For Nordic STEM higher education, this implies that courses should not only incorporate collaborative activities during scheduled teaching but also support students in recognising when and how collaboration can enhance independent study. Practical measures may include integrating short reflective activities that prompt students to evaluate the effectiveness of collaboration, providing guidance on forming and managing study groups, and aligning assessment practices with collaborative problem-solving skills.

Several limitations should be noted. The study is based on a single course at one institution, with a moderate sample size and reliance on self-reported data, which may

limit generalisability. The cross-sectional design also precludes conclusions about causal relationships between collaboration, self-efficacy, and study preferences. Future research could address these limitations by following students longitudinally, incorporating qualitative data to better understand students' reasoning and experiences, and experimentally evaluating interventions aimed at strengthening the transfer of collaborative practices beyond the classroom.

5 Conclusion

Despite sustained exposure to collaborative learning in teaching, most first-year physics students at NTNU (61%) prefer to study independently, highlighting a persistent disconnect between instructional design and students' self-directed learning practices.

Within MTFYMA, male students reported higher self-efficacy than female students ($d = 0.62$, $p = .02$), while students who preferred group study reported slightly higher PISE ($d = 0.38$, $p = .07$).

These findings suggest two key priorities for teaching practice: (1) explicit scaffolding may be needed to support transfer of collaborative skills beyond scheduled teaching, and (2) structured facilitation may help address self-efficacy gaps and promote more equitable participation. Future research should evaluate targeted interventions designed to strengthen links among structured collaboration, self-beliefs, and out-of-class study practices. A deeper analysis of the gender differences should also be performed as well as a longitudinal study on SE and PISE throughout the study programme. This underscores the need for instructional strategies that explicitly support the transfer of collaborative practices beyond the classroom.

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