
From Content to Commitment: Effects of Problem-Based Learning on Student Relevance and Engagement in Sustainability Education — A Quasi-Experimental Study

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Abstract

Students' engagement with sustainability content varies widely, and this variation may depend less on the content itself than on how it is taught. This quasi-experimental study tested that possibility, comparing a problem-based, expectancy-value- and self-determination-informed sustainability teaching practice against standard instructional practice, and directly addressing the absence of comparison-group evidence in a literature that has so far been largely correlational or single-group in design. Using a nonequivalent control-group, pretest-posttest design, 102 undergraduate Education students (51 Experimental Group, 51 Control Group) enrolled in a mandatory Education for Sustainable Development course at a College in Lahore, Pakistan, completed an adapted six-item Task Value subscale of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991) to assess perceived relevance and the 23-item Student Course Engagement Questionnaire (SCEQ; Handelsman et al., 2005) to assess engagement across four dimensions, administered before and after the instructional unit. Analysis of covariance, controlling for pretest scores, showed that the Experimental Group reported significantly higher adjusted posttest perceived relevance, $F(1, 99) = 12.49, p < .001$, partial $\eta^2 = .11$, and significantly higher engagement across all four dimensions and the overall composite (partial $\eta^2 = .08-.26$), with baseline equivalence and satisfactory reliability rang from ($\alpha = .76-.90$). These findings suggest that embedding relevance-building, applied, and autonomy-supportive pedagogy within mandatory sustainability curricula can help move students from passive content coverage toward genuine commitment.

Keywords: Sustainability Education; Problem-Based Learning; Perceived Relevance; Student Engagement; Quasi-Experimental Design; Expectancy-Value Theory; Self-Determination Theory; Pakistan

Introduction

No longer can sustainability be an afterthought at universities. Today, education is part of the mainstream of debates from the center of the global policy, with the UN 2030 Agenda for Sustainable Development and the 17 Sustainable Development Goals, which explicitly include a commitment to education and higher education in particular as the key means for the transfer of knowledge, values, and competencies needed for a sustainable future across generations. In response, universities across the globe have introduced sustainability themes into subjects that traditionally do not have much to do with environmental or developmental issues (Habib et al., 2021). However, in an era when a growing number of courses are offered that focus on sustainability, there has been less work to date to empirically examine a more basic question: Could the way sustainability content is delivered be intentionally designed to make it feel more

relevant and engaging for students – or less – or is it something that is just there or not there? In other words, teaching practice as a lever to engage to deliver better outcomes for students, or a background variable to describe? This is one of the more significant and less causally analyzed questions currently examined in higher education research.

This question is more than just curriculum design. As the Literature Review progresses in detail, there is a preponderance of correlational and cross-sectional evidence that investigates the association of instructional practice with sustainability-related relevance and engagement, that is, how they appear to go together if they do go together, but where one does not necessarily cause the other. Expectancy-value theory proposes that the perceived utility value of content shape the relevance of instruction (Eccles & Wigfield, 2020), while self-determination theory suggests that students' needs for autonomy, competence and relatedness are met by instruction determine engagement (Deci & Ryan, 1985; Ryan & Deci, 2023). As the Literature Review demonstrates, the specific integration of these accounts for SE proposed by MacIntosh & Asghar (2025) has never been empirically tested against a true comparison condition and the best available evidence of intervention comparison stops short of excluding alternative explanations such as maturation or concurrent coursework.

In Pakistan, specifically the situation is rhetorical as sustainability integration in higher education is still not consistent and is mostly symbolic in nature and strongest evidence within Pakistan in relation to instructional style and sustainability outcomes is correlational as the instructional styles are not intentionally varied by the researchers but are rather perceived by the students as a natural phenomenon. Till now, no identified study in Pakistan or elsewhere has employed a quasi-experimental, nonequivalent control group design to evaluate the effectiveness of a purposeful, innovative instructional approach focused on sustainability to achieve significantly more student perceived relevance and multidimensional engagement than a comparison group with traditional instruction. This is a substantive theoretical and practical gap. For the time being, the lack of evidence from comparison group studies has made it impossible to differentiate between whether the observed relationships between instructional style and engagement are due to genuine causal effects (as proposed by expectancy-value and self-determination theory) or selection effects (whereby already motivated students are more likely to respond positively to some teachers). Realistically, pressure is growing on Pakistani institutions to present tangible evidence of sustainability integration in their teaching, but the evidence so far available is correlational, rather than causal, and therefore fails to answer the question of whether the extra design effort involved in an innovative teaching method is reparable by the additional learning outcomes it achieves, compared to a traditional method.

The present study fills this gap with the help of quasi-experimental, nonequivalent control group, pretest posttest design using two intact groups of undergraduate students of Education of a University in Lahore, Pakistan. The former group was taught sustainability content using an innovative, expectancy-value, and self-determination-based instructional approach, and the latter group was taught using a traditional approach to the content, and in both groups, perceived relevance and multidimensional engagement were measured before and after the unit. This study represents one of the earliest direct empirical tests of the causal mechanisms suggested by the expectancy-value and self-determination theories and extends the body of Pakistani research beyond correlational description of naturally occurring teaching styles to a comparison group framework that can be used to make causal inferences.

The above-mentioned gaps in knowledge led to the rationale for this study. Expectancy-value and self-determination theory (SDT) would suggest that actively redesigning instruction should increase perceived relevance and engagement, but this prediction had not been tested against a true comparison condition, in Pakistan or elsewhere in the world, so it could just be a selection effect. In practice, there is an increasing demand for meaningful integration of sustainability in Pakistani HEIs, while teachers and program leaders have not had comparable evidence of the added design effort required to support an innovative pedagogy using a problem-based approach compared to a traditional approach to teaching. The purpose of this study

was to offer causal, not just correlational, evidence that can inform theory building and teaching decisions in required sustainability classrooms.

Research Objectives

1. To compare the post-test perceived relevance of sustainability content between a treatment group who learned using an innovative, problem-based sustainability-focused instructional approach and a comparison group who learned using standard instructional approach, controlling pre-test scores.
2. To compare overall and behavioral, emotional, participation/interaction and performance levels of undergraduate students in the posttest with the problem-based treatment group and the standard-practice comparison group while controlling pretest scores.

Research Questions

RQ1. Have students in the treatment group (problem based) significantly greater perceived relevance of sustainability content than students in the comparison group on the posttest, controlling for the pretest scores?

RQ2. After controlling pretest scores, are posttest scores significantly higher for the problem-based treatment group than the comparison group on each of the following subscales of engagement with sustainability content: behavioral, emotional, participation/interaction, and performance?

Research Hypotheses

H1. The results of the problem-based treatment group indicate a significant higher posttest perceived relevance of sustainability content compared to the control group on average, after controlling pretest perceived relevance.

H2. After controlling pretest engagement, students in the problem-based treatment group report significantly higher engagement, overall and on each of the four dimensions of the posttest than do students in the comparison group.

Conceptual Framework

The conceptual framework places the independent variable of instructional practice (based on expectancy-value and self-determination theory) into a treatment condition and a comparison condition of standard instructional practice in an interrelated manner that is related to two dependent variables: motivation and learning. In the treatment condition, problem-based learning is used as a structure and pedagogical approach to operationalize these theoretical principles, with applied, professionally relevant problems of sustainability providing utility value as described by expectancy-value theory, and student-driven problem analysis, solution design and peer teaching providing student autonomy, competence opportunities and relatedness as described by self-determination theory. Expectancy-value theory predicts that instruction will influence students' perceived relevance of the sustainability content, based on changes in its perceived utility value. This increased relevance is theorized through self-determination theory, to increase behavioral, emotional, participation/interaction and performance engagement by meeting learners' needs of autonomy, competence and relatedness. Perceived relevance is then a more proximal, mechanism-based product of instructional practice that is directly connected to a more distal outcome, namely engagement, as is hypothesized in Hypotheses 1 and 2.

Figure 1
Conceptual Framework of the Present Study



Note. Problem-based learning served as the pedagogical vehicle through which expectancy-value and self-determination principles were operationalised in the treatment condition. Perceived relevance is modelled as the mechanism linking instructional practice to engagement (H1, H2). Both constructs were measured at pretest and posttest; instructional condition (treatment vs. comparison) constitutes the between-subjects factor.

Literature Review

Sustainability education has grown fast: research output on the topic has multiplied several times over in the past five years. Yet most of that growth is descriptive. We know a great deal about what students think about sustainability content, and comparatively little about whether teaching itself can be purposefully redesigned to change how they respond to it. Knowing that students say a topic matter is not the same as knowing how to make it matter to them. This review draws together the literature on perceived relevance and engagement to answer four questions. What mechanisms in the literature would justify the claim that an innovative instructional approach can raise perceived relevance and engagement? How far do the empirical findings bear this out? What is known, specifically, about this relationship within the Pakistani context? And, finally, what methodological gap remains that only a quasi-experimental test can close?

Theoretical Foundations

This study rests on two extant motivational theories that complement each other in providing answers to why instructional practice should be of interest at all. Expectancy-value theory and its situated counterpart predict that motivation is a product of a person's expectation of success and the subjective value of a task; utility value is the perceived usefulness of a task for future objectives and is similar to what sustainability-education researchers have called perceived relevance (Eccles & Wigfield, 2020; Wigfield et al., 2021). This theory suggests that explicit links between sustainability content and students' disciplinary and/or civic outcomes should increase perceived relevance directly, thus suggesting that teaching practice is an independent variable rather than a correlate. This account is supported by self-determination theory which outlines pedagogical conditions for relevance to lead to sustained engagement, suggesting that motivation thrives when instruction meets the needs of the learners for autonomy, competence, and relatedness (Deci & Ryan, 1985; Ryan & Deci, 2023). In the field of sustainability education, a recently proposed approach is that of linking problem-based learning with the psychological theory of self-determination theory, making the strong case for the combination of authentic problems and learner autonomy as the best way to meet all three psychological needs (MacIntosh & Asghar, 2025). This conceptual framework has not yet been tested in science classrooms in secondary schools with a comparison condition and is relevant to the present study. The main outcome of interest is engagement, which is most influentially conceptualized as being multidimensional, with behavioral, emotional, and cognitive components of engagement (Fredricks et al., 2004), with subsequent validation work identifying additional social and academic dimensions of

engagement, only moderately correlated (Laranjeira & Teixeira, 2025). The fragmentation is relevant for intervention research specifically: when a teaching practice increases emotional involvement, learners are likely to find content more relevant to themselves, but it is not necessarily accompanied by an increase in behavioral or performance involvement, and this could lead to misinterpretation of the actual effect of an intervention, if only one dimension is measured.

Empirical Evidence on Teaching Practice and Engagement

Current empirical research linking teaching practice and related student outcomes on sustainability is theoretically compatible but less methodologically robust in its ability to make causal inferences. There is qualitative evidence from a Higher Education Institution in Malta that in some institutions, the teacher's role is so constrained by institutional rigidity that even by choice, it is difficult for motivated educators to relate the content to real life problems, and/or to use active teaching methods, such as flipped classroom, and that not only is this difficult, it is also perceived as such by the lecturers themselves, after the fact, which is not necessarily true (Micallef, 2025); however, this evidence is based on a self-report of the lecturers' perception rather than a pre-registered comparison of outcomes. The most similar precedent for the use of engagement as an interventional manipulable curricular outcome is a semester-long intervention, delivered across four undergraduate courses, that tested a conceptual framework based on the principles of self-determination theory and found that students' motivation was the best predictor of their subsequent development of sustainability-competency (Núñez et al., 2024). The strengths of this study are the emphasis on engagement as a product of intentional design, and the fact that there is no comparison group for this study because it employed a single group design without a comparison group taught in a traditional method, which is acknowledged by the authors as a limitation that must be taken into consideration when interpreting the gains observed. But problem-based learning (PBL) has also received direct support within the field of sustainability education, in addition to the indirect support provided by active or applied pedagogy. A qualitative case study of problem-based learning modules (PBLs) showed that structuring the coursework around real sustainability problems has led to higher engagement and better linkages to real-world sustainability challenges to the disciplinary content across various courses (Carrió Llach & Llerena Bastida, 2023), while a curriculum-mapping study of seven problem-based learning programmes showed that PBLs have proven to be an effective approach to embedding Sustainable Development Goals (SDGs) content at scale across a variety of courses (Nguyen et al., 2024). These studies lend support to the rationale for using problem-based learning, in particular, as the vehicle for teaching in the present study, rather than active or applied pedagogy in general. As in the other studies found throughout this literature, however, neither of these studies compares performance to an actual control presentation of the material, so the question of whether there is a measurable difference in the relevance and engagement gained from problem-based learning as compared to conventional instruction remains unanswered until the present study. The survey results for Turkey and Germany also showed that perceived institutional commitment was a stronger predictor of engagement than curricular content alone (Sevim & Pala, 2026), and a large-scale survey in Finland indicated that previous learning in sustainability courses was a stronger predictor of further interest in sustainability learning than institutional commitment, depending on the discipline (Hyytinen et al., 2023); both studies were cross-sectional and thus described association rather than isolating the causal contribution of any single instructional approach. This literature, taken together, suggests that instruction impacts relevance and engagement, but clearly does not match the comparison group designs that would establish the expectation causally.

Not all studies of active and problem-based learning in higher education report consistent and positive findings on engagement and motivation; autonomous and problem-based learning approaches have been shown to have less or mixed effects when implementation fidelity is low, when students have not previously experienced self-directed learning approaches, and when classes are large and teachers are stressed. The

literature is reviewed thematically here because it comes together most directly to address the causal question that was the impetus for the present study, but the boundary conditions under which instructional redesign is successful versus unsuccessful are an open empirical question that can't easily be answered by the present study alone.

The Pakistani Context and the Awareness-Behaviour Gap

This trend is more evident in Pakistan in particular. The survey with almost one thousand students from seven public sector institutions found that the teaching style 'autonomy supportive – delegator' had a significant impact on all three aspects of sustainability consciousness, knowledge, and attitude and behavior while the more common expert and formal authority had a positive influence on knowledge and attitude only (Nousheen & Tabassum, 2024). This finding provides strong indirect support for the self-determination-theoretic logic underlying the present study because it shows that engagement does not necessarily translate into behavior, as evidenced by the fact that the instructional style was the students' perception of it occurring in their naturally occurring classrooms but did not necessarily require a deliberate manipulation by researchers, and so the finding remains correlational and factors that were not measured by the researchers could not be ruled out as an alternative explanation. This can also be observed in a larger sample of pre-service teachers from Pakistan and international samples, as Pakistani pre-service teachers were found to be less knowledgeable about sustainability compared to Swedish undergraduates and the behavioral dimension was found to be the least (Kalsoom et al., 2017); furthermore, positive attitudes toward campus sustainability in Italian university students did not always translate into willingness to participate (Genovese, 2022); the same pattern was observed among students across three Bangladeshi institutions, with positive attitudes toward sustainability on campus not consistently resulting in participation (Haque et al., 2023). The literature in Pakistan also suggests that integration of sustainable development into institutions is not consistent or unified, with a national survey reporting major differences in institutional commitment (Habib et al., 2021), another survey reporting low overall levels of education for sustainable development and low teacher confidence in education for sustainable development content (Saqib et al., 2020), and a systematic review reporting on the persistent issue of teacher-student-administrator communication gaps and lack of institutional governance (Hinduja et al., 2023). This study was conducted using structural equation modelling (SEM) on undergraduates from Lahore and Islamabad, and the results indicated that environmental awareness and sustainability focused education influenced attitudes and perceived behavior control that subsequently influenced sustainable entrepreneurial intentions (Yasir et al., 2025), similar to the findings of the wider literature, but with the difference that this study measured naturally occurring exposure as opposed to comparing the effects of instructional approaches. This body of research, however, is limited by the methods it has relied on, pointing to a clear methodological gap.

All of these literatures together, several methodological patterns limit what it currently can support. Most Pakistani and international studies use cross-sectional designs or single group designs that describe association, rather than test causation (Genovese, 2022; Nousheen & Tabassum, 2024; Yasir et al., 2025), and even the few studies on curricular intervention do not have a comparison group, making the counterfactual unobserved (Núñez et al., 2024). A framework that combines SCT and PBL has been proposed theoretically for use in sustainability engagement but has yet to be compared to any comparison condition (MacIntosh & Asghar, 2025). The measurement of engagement varies from one study to another making it difficult to compare the results, and can help explain why, for example, results from studies in Finland were more positive (Hyytinen et al., 2023) than those in studies in Turkey-Germany (Sevim and Pala, 2026) (Laranjeira and Teixeira, 2025). Research within Pakistan has focused on pre- and in-service teachers (Kalsoom et al., 2017; Nousheen & Tabassum, 2024), and there has been little research on students even though they are a major stakeholder in the research. Also, common method variance has been a

concern since self-report instruments are given by the intervening teacher.

In brief, the literature is consistent in suggesting a plausible linkage between instructional practice and relevance and engagement and that an attitude-behaviour gap exists among Pakistani students which seems to be bridged by instructional style (Nousheen & Tabassum, 2024). This link it cannot say, however, whether or not it is causal, as there has been no identified study in Pakistan or abroad that directly tests this question with a quasi-experimental, nonequivalent control group design. This gap is theoretical in that selection effects cannot be excluded, and practical because there is no causal evidence to justify redesigning instruction within institutions. The present study tackles this gap by employing quasi-experimental, nonequivalent control group pretest-posttest comparison design with the BS Education students of undergraduate level in Lahore, Pakistan, with validated multidimensional engagement measure administered by an independent instructor.

Methodology

Research Design and Participants

This study tested the effectiveness of an innovative approach to teaching sustainability that leads to improved outcomes in terms of the perceived relevance of sustainability content and student engagement, as compared to the traditional approach to teaching sustainability, using a quasi-experimental, nonequivalent control-group, pretest-posttest design. The study participants were undergraduate BS Education students, analytic sample ($N = 102$) from two intact sections of a college affiliated to the University of Education, Lahore, Pakistan ($N = 51$ per section). One section (Experimental Group) was given the problem-based sustainability-integrated teaching unit with expectancy-value and self-determination principles detailed in the Instructional Conditions section below, and the other was given the same or very similar content in the regular way (Control Group). The researcher did not deliver instruction but only design the instructional protocol and the study; and both parts were taught by the same instructor, thus differences in the identity of the instructors, rapport or teaching skill between the two parts could not explain any between-group differences observed. The design is quasi-experimental, since the two sections were not randomly drawn but were pre-existing (Shadish et al., 2002).

The sampling procedure was of non-probability type and it was an intact group, approximating sampling of total population within each section (Etikan et al., 2016); this was due to the fact that random assignment of individual students to condition is administratively impracticable in an operating degree programme. There are generally recommended guidelines for sample size in behavioral research, as outlined by Roscoe (1975); for most studies the guidelines suggest that the sample be greater than 30 but less than 500 people, while for between-groups comparisons, the suggested minimum sample size is 30 people per category. This is adequate as the final analytic sample was consistently 51 students per group. The inclusion of pretest covariate in the ANCOVA allows for greater precision in the estimates gained from the design than the simple posttest-only comparison (Dimitrov & Rumrill, 2003).

Instructional Conditions

The Experimental Group was given a four-session sustainability integrated teaching unit (195 minutes in total) entitled "Education for Sustainable Development (ESD) and the Sustainable Development Goals (SDGs): Designing Sustainability-Integrated Teaching. The design of the unit was based on the following principles which were used to operationalise the theoretical framework outlined above. First, reflecting the expectancy-value theory (Eccles & Wigfield, 2020), the first step of each session was to explicitly link sustainability content with students' future professional lives as teachers, in an attempt to increase the perceived utility of the content. Second, self-determination theory principles of meaningful autonomy over problem choice, grade level and content, scaffolding to develop competence, and structured collaborative work with peers to foster relatedness were followed as students engaged with problems (Ryan & Deci,

2023). Third, the unit was organized in a problem-based learning approach where problems from sustainability were used to guide each session and not concrete content itself, following the framework for sustainability education proposed by MacIntosh and Asghar (2025) based on self-determination theory and problem-based learning.

The session started with a relevance hook to have students reflect on themselves on a teacher who had impacted them prior to the teacher explicitly connecting sustainability content to their future teaching practice; it included an interactive overview of ESD and SDGs, a small group activity using problem-based learning to have students identify a sustainability related problem for children and/or young people in Pakistan, and a closing reflection card. In Session 2, small groups explored a sustainability problem that is significant to them in their local area, for example, water scarcity, air quality, waste management, or access to energy, and discussed its impact on schools and students in their area by following a problem analysis framework and receiving feedback from peers and instructor. In Session 3, the same groups used the same sustainability problem to design a short teaching activity for a self-chosen grade level and subject area and the instructor facilitated autonomy-supportive coaching by asking questions and not giving direct corrections. During session 4, groups of students presented a brief version of their designed activity and individual students wrote a reflection on how they connected what they learned during the unit with their personal values and professional goals, followed by a whole class discussion.

Treatment fidelity was established for each session through a six item checklist that calls for documentation of the session beginning with an explicit relevance connection, a minimum of one opportunity for students to choose, and that the session includes a sufficient amount of instructor questioning and coaching without direct correction and that the session includes sufficient amount of structured peer interaction and that the session is organised around an authentic problem rather than a didactic lecture, and that the direct instruction is not more than approximately 25 minutes of continuous, uninterrupted instruction. The Experimental Group was compared to the Control Group, who were delivered the same or close to the same amount of the same sustainability content, but not the expectancy-value, autonomy-supportive, or problem-based design elements that the Experimental Group received, the six-item fidelity checklist was not applied to the Control Group as it was designed to characterise the design elements of the treatment condition, but session count and topical content coverage were confirmed to be matched across the sections prior to data collection.

Measures

Task value was assessed on an adapted six-item subscale of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991), adapted to measure the perceived relevance of the sustainability content in the course, which was rated on a 7-point scale (1 = not at all true of me, 7 = very true of me); the original reliability was .90 (Pintrich et al., 1993). The 23 items of the Student Course Engagement Questionnaire (SCEQ; Handelsman et al., 2005) were used to measure engagement, consisting of four subscales: Skills (9 items; referred to hereafter as Behavioural Engagement, consistent with the behavioural, emotional, participation/interaction, and performance dimensions framing the study's objectives and hypotheses), Emotional (5 items), Participation/Interaction (6 items) and Performance (3 items), which were rated on a 1 to 5 scale (1 = not at all characteristic of me to 5 = very characteristic of me), with reliabilities for the subscales ranging from $\alpha = .76$ to $.82$, and all items worded in relation to sustainability content. The two instruments were given at the same time at pre test (just before the unit started) and post test (just after the unit ended) and expert review was used to establish content validity, and baseline equivalence between groups was statistically confirmed before the main analysis.

Procedure

After receiving approval from the principal of the college affiliated with the institute and getting permission

from the department and from the instructor of the Control Group section, the required permission was taken. Because data collection is independent of the instructional delivery and the researcher's participation in study design, the administration of the questionnaires and the consent process were handled by a researcher Assistant in both sections rather than by the instructor and any identifiable responses were not made known to the researcher until after final course grades were submitted, consistent with recommended procedural remedies for common-method bias (Harman, 1976; Podsakoff et al., 2003). The instructor who gave both sections was trained in the Experimental Group's problem-based protocol, but was blind to the specific research hypotheses being tested, and was given a structured training on the fidelity checklist described below. The students were asked to participate in this process freely and all students provided informed written consent, and were expressly informed orally and in writing that there would be no implications if they participated or did not, and that they could withdraw at any time. All the participants' responses were anonymised and subject to specific codes created by the participants themselves that were only used to link pre- and post-test responses; all the data were kept on devices with passwords and kept securely, in accordance with the Declaration of Helsinki and the ethical guidelines of the institutions.

Data Analysis Plan

The data were checked for accuracy, missing values, and univariately and multivariately for outliers (Tabachnick & Fidell, 2019). Pre test scores were used to examine the equivalence of the Experimental Group and Control Group first, using independent-samples t-tests. Analysis of covariance (ANCOVA) was the primary analysis used with the nonequivalent-groups pretest-posttest research design as it is preferred over simple gain-score or repeated-measures analysis because it statistically controls for pre-existing group differences (Dimitrov & Rumrill, 2003). effect sizes (partial eta-squared and Cohen's d) were calculated in conjunction with the statistical significance for all analyses; 95% confidence intervals were also provided. IBM SPSS Statistics was used for analyses.

Results

Results are interpreted based on data below

Table 1

Demographic Characteristics by Group

Characteristic	Experimental Group	Control Group
N	51	51
Age, M (SD)	20.90 (1.33)	21.00 (1.39)
Gender	100% Female	100% Female
Prior Sustainability Exposure – Yes	22 (43%)	15 (29%)
Prior Sustainability Exposure – No	29 (57%)	36 (71%)

Table 1 summarises the demographic composition of the Experimental Group and Control Group. The two groups were broadly comparable in age, semester of study, and degree programme. Because the study was conducted at a single-sex (female) institution, all participants (100%) were female; this characteristic is therefore constant across the sample and is reported here for completeness rather than as a between-group comparison.

Reliability Analysis

Table 2

Cronbach's Alpha Reliability by Subscale and Time Point

Subscale	k items	α (combined)
Perceived Relevance	6	0.851
Behavioural Engagement	9	0.908
Emotional Engagement	5	0.860
Participation/Interaction Engagement	6	0.863
Performance Engagement	3	0.738
Overall Engagement	23	0.903

Reliabilities ranged from acceptable to excellent ($\alpha = .76-.90$) of estimates were broadly consistent with the values reported in the original validation studies (Handelsman et al., 2005; Pintrich et al., 1993), supporting the internal consistency of the adapted instruments.

Table 3

Descriptive Statistics (M, SD) by Group and Time Point

Measure	Experimental Pretest	Experimental Posttest	Control Pretest	Control Posttest
Perceived Relevance	3.86 (0.63)	4.59 (0.67)	3.82 (0.54)	4.23 (0.72)
Behavioural Engagement	3.00 (0.50)	3.32 (0.57)	2.86 (0.57)	3.00 (0.61)
Emotional Engagement	2.88 (0.56)	3.30 (0.61)	2.72 (0.56)	2.91 (0.68)
Participation/Interaction Engagement	2.69 (0.59)	3.04 (0.63)	2.60 (0.45)	2.68 (0.57)
Performance Engagement	3.02 (0.56)	3.65 (0.57)	2.87 (0.58)	3.15 (0.68)
Overall Engagement	2.90 (0.36)	3.33 (0.39)	2.76 (0.37)	2.94 (0.41)

Descriptive statistics for all six outcome measures, by group and time point, are presented in Table 3. At the observed-means level, both groups showed higher scores at posttest than pretest, with the Experimental Group showing numerically larger gains than the Control Group on every measure.

Table 4

Baseline Equivalence: Independent-Samples t-Tests at Pretest

Measure	Experimental M (SD)	Control M (SD)	t(100)	p	D
Perceived Relevance	3.86 (0.63)	3.82 (0.54)	0.32	.750	0.06
Behavioural Engagement	3.00 (0.50)	2.86 (0.57)	1.33	.188	0.26
Emotional Engagement	2.88 (0.56)	2.72 (0.56)	1.47	.145	0.29

Participation/Interaction Engagement	2.69 (0.59)	2.60 (0.45)	0.91	.363	0.18
Performance Engagement	3.02 (0.56)	2.87 (0.58)	1.31	.194	0.26
Overall Engagement	2.90 (0.36)	2.76 (0.37)	1.89	.062	0.37

* $p < .05$. ** $p < .01$. *** $p < .001$.

Independent-samples t -tests compared the Experimental Group and Control Group on all six measures at pretest, prior to the intervention (Table 4). No statistically significant baseline differences were found on any of the six outcome measures (all $ps > .06$), indicating that the two intact sections were reasonably comparable prior to the intervention despite the absence of random assignment. Age likewise did not differ significantly between groups, $t(100) = -0.36$, $p = .716$. Because the study was conducted within a single-sex (female) institution, gender showed no variability in this sample (100% female in both groups) and could not be formally tested. This baseline equivalence strengthens confidence in the subsequent ANCOVA-adjusted comparisons, although the covariate adjustment remains appropriate given the nonrandom, intact-group assignment inherent to the design.

Table 5

Within-Group Paired-Samples t -Tests: Pretest to Posttest Change by Group

Group	Measure	Pretest M (SD)	Posttest M (SD)	$t(50)$	p	D
Experimental	Perceived Relevance	3.86 (0.63)	4.59 (0.67)	11.83	< .001***	1.12
Control	Perceived Relevance	3.82 (0.54)	4.23 (0.72)	5.83	< .001***	0.64
Experimental	Behavioural Engagement	3.00 (0.50)	3.32 (0.57)	6.48	< .001***	0.59
Control	Behavioural Engagement	2.86 (0.57)	3.00 (0.61)	3.36	.001**	0.24
Experimental	Emotional Engagement	2.88 (0.56)	3.30 (0.61)	7.28	< .001***	0.70
Control	Emotional Engagement	2.72 (0.56)	2.91 (0.68)	2.82	.007**	0.30
Experimental	Participation/Interaction Engagement	2.69 (0.59)	3.04 (0.63)	7.60	< .001***	0.57
Control	Participation/Interaction Engagement	2.60 (0.45)	2.68 (0.57)	1.36	.180	0.16
Experimental	Performance Engagement	3.02 (0.56)	3.65 (0.57)	9.78	< .001***	1.13
Control	Performance Engagement	2.87 (0.58)	3.15 (0.68)	3.79	< .001***	0.45
Experimental	Overall Engagement	2.90 (0.36)	3.33 (0.39)	14.32	< .001***	1.15
Control	Overall Engagement	2.76 (0.37)	2.94 (0.41)	5.05	< .001***	0.45

* $p < .05$. ** $p < .01$. *** $p < .001$. $n = 51$ per group. d is the paired (within-subject) Cohen's d .

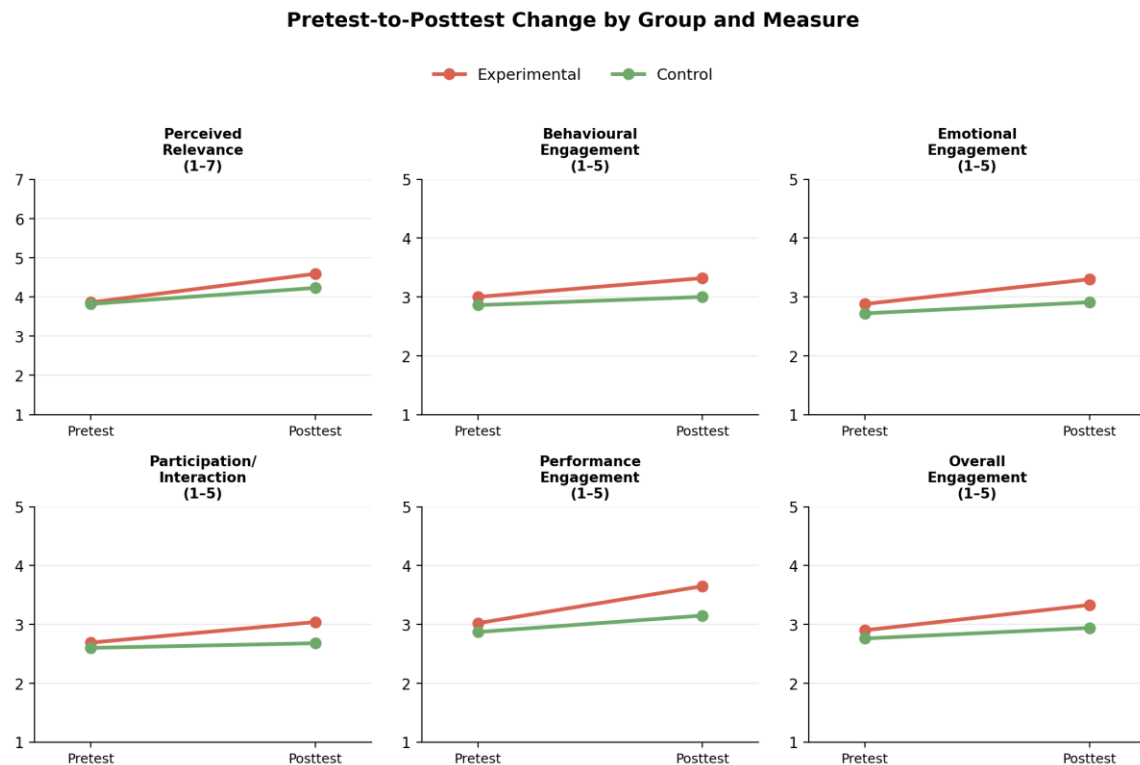
Within-Group Change: Pretest to Posttest

To complement the between-groups baseline comparison above, paired-samples t -tests examined whether each group changed significantly from pretest to posttest on each measure, independent of the between-group ANCOVA comparison reported later (Table 6). The Experimental Group improved significantly from pretest to posttest on all six measures (all $ps < .001$), with effect sizes ranging from medium to very large ($d = 0.57$ – 1.15). The Control Group also improved significantly on five of the six measures ($ps < .01$), with smaller effect sizes ($d = 0.24$ – 0.64), consistent with some degree of natural growth over the course of the unit independent of the experimental instructional practice; the exception was Participation/Interaction Engagement, on which the Control Group's improvement did not reach statistical significance, $t(50) = 1.36$, $p = .180$, $d = 0.16$. This pattern indicates that while both groups tended to

improve over time, the Experimental Group's gains were consistently larger and, for Participation/Interaction Engagement specifically, present where the Control Group's gain was not, reinforcing the between-groups ANCOVA findings reported below rather than substituting for them.

Figure 2

Pretest-to-Posttest Change by Group and Measure



Note. Values are raw (unadjusted) group means at pretest and posttest, plotted on each measure's original response scale (1–7 for Perceived Relevance; 1–5 for all Engagement measures). Corresponds to the data reported in Table 3.

Figure 2 displays these same pretest-to-posttest changes graphically for both groups across all six measures. Plotted on their original response scales, the figure shows that both groups moved modestly upward from pretest to posttest, with the Experimental Group's line consistently rising more steeply than the Control Group's; no measure shows a ceiling effect or an implausible jump, which is consistent with the effect sizes reported above being genuine rather than artefactual.

Table 6

ANCOVA Results: Effect of Group on Posttest Scores, Controlling for Pretest

Measure	Adj. Experimental	M Adj. Control	M F(1, 99)	p	partial η^2
Perceived Relevance	4.57	4.24	12.49	<.001***	0.112
Behavioural Engagement	3.25	3.07	8.17	.005**	0.076
Emotional Engagement	3.23	2.98	8.46	.004**	0.079

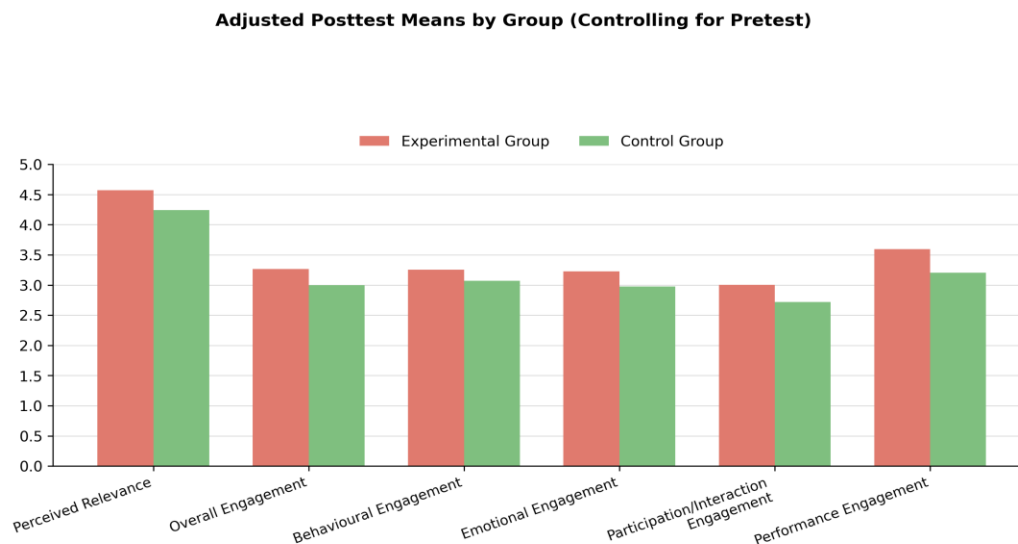
Participation/Interaction Engagement	3.00	2.72	13.42	< .001***	0.119
Performance Engagement	3.60	3.21	16.96	< .001***	0.146
Overall Engagement	3.27	3.00	34.00	< .001***	0.256

* $p < .05$. ** $p < .01$. *** $p < .001$. Adjusted means are estimated at the sample mean of the pretest covariate.

Hypotheses 1 and 2 were tested using analysis of covariance (ANCOVA), with posttest scores as the dependent variable, Group (Experimental vs. Control) as the independent variable, and the corresponding pretest score entered as a covariate. Results are presented in Table 6 and illustrated in Figure 3. Consistent with Hypothesis 1, the Experimental Group reported significantly higher adjusted posttest Perceived Relevance than the Control Group, $F(1, 99) = 12.49$, $p < .001$, partial $\eta^2 = .11$. Consistent with Hypothesis 2, the Experimental Group also reported significantly higher adjusted posttest scores on every engagement dimension — Behavioural, $F(1, 99) = 8.17$, $p = .005$; Emotional, $F(1, 99) = 8.46$, $p = .004$; Participation/Interaction, $F(1, 99) = 13.42$, $p < .001$; Performance, $F(1, 99) = 16.96$, $p < .001$ — as well as on Overall Engagement, $F(1, 99) = 34.00$, $p < .001$, partial $\eta^2 = .26$. Effect sizes across the six outcomes ranged from medium to large (partial $\eta^2 = .08$ –.15 for individual dimensions, rising to .26 for the aggregated Overall Engagement composite). Performance Engagement showed the largest single-dimension effect (partial $\eta^2 = .15$), while Behavioural Engagement showed the smallest (partial $\eta^2 = .08$). The pretest covariate was a strong, statistically significant predictor of posttest scores in every model (all F s > 72 , all p s $< .001$), confirming that pretest standing was meaningfully related to posttest standing and that the ANCOVA adjustment was substantively, not merely nominally, appropriate.

Figure 3

Adjusted Posttest Means by Group, Controlling for Pretest



Note. Bars represent estimated marginal means from the ANCOVA models reported in Table 6, adjusted for pretest scores. Behavioural Engagement corresponds to the Skills Engagement subscale of the SCEQ (Handelsman et al., 2005).

Discussion

This study compared the effectiveness of an innovative expectancy value- and self-determination theory-based sustainability pedagogy problem-based learning and "professional as usual" sustainability pedagogy in an obligatory Education for Sustainable Development (ESD) class in terms of the degree of increased students' views of the relevance of sustainability material and their multi-dimensional interaction with it. As predicted in Hypothesis 1, the Experimental Group reported a significantly higher level of adjusted posttest Perceived Relevance than did the Control Group. Again, as expected in Hypothesis 2, the Experimental Group also had significantly higher adjusted posttest Engagement scores across all four dimensions and across the composite, with the differences varying from moderate on the individual engagement dimensions to much larger on the composite. These results provide some of the first quasi-experimental, comparison-group evidence that instructional practice – not just the exposure to curricular content alone – can impact the relevance students feel about curricular content on sustainability, and their engagement with it.

These findings complement the literature reviewed above in several ways. The present pattern of results is broadly consistent with MacIntosh and Asghar (2025)'s conceptual model of autonomy-supportive, applied instruction that would enhance engagement relative to didactic instruction, which has not yet been tested with an applied comparison condition. They further replicate Nousheen and Tabassum's (2024) Pakistani results, indicating that the pattern of autonomy-supportive, delegator teaching styles that predicts sustainability consciousness is replicated when the teaching style condition is directly manipulated and a validated multidimensional engagement measure used instead of the students' perceptions of naturally occurring teaching style. The results indicate that the effect of the instructional redesign, as implemented here, does not equally raise every aspect of engagement, as argued in the literature and as is reflected in the differences between the dimensions of engagement found here (Laranjeira & Teixeira, 2025).

The pretest scores were also strong, statistically significant predictors of posttest standing across all models. This relationship between students' baseline standing and their posttest scores confirms the appropriateness of the ANCOVA-adjusted comparison as the primary analysis.

The findings should be interpreted within the curricular context in which they were obtained. The observed pattern of gains is not due to a process of self-selection of students who were already motivated to take the ESD course, as every student in each section was enrolled by curricular requirements and over half of students in each section said they had never taken a course on sustainability prior to joining the ESD course. This strengthens the practical relevance of the findings for curricular decision-making and is already informing decisions for the programme as a whole, but it also means the results apply to a captive population enrolled in a compulsory course and may not generalize to elective sustainability courses where the motivation of the participants entering the course may systematically differ. The sample of students was also female and drawn from a single institution, single discipline (Education) and outcomes were measured in the immediate aftermath of the completion of the unit so that the results were applicable to short-term gains in relevance and engagement rather than longer term retention and learning over a whole semester or academic year. Both measures of outcome were also completely self-reported, a practice that is standard for these constructs, and limits the conclusions the study could draw about any changes in observed classroom behaviours that might have occurred, given reports of increased relevance and engagement. A major strength of the comparison, however, is that it is delivered by the same instructor rather than by the researcher, so that the between-group differences noted here cannot be attributed to differences in instructor identity, rapport, or teaching skill. Also, the instructor was unaware of the specific study hypotheses, further reducing the chance that his or her own expectancy effects influenced the results.

Recommendations

The above results, coupled with the fact that the ESD course is a required course for all students, not elective, results in the following recommendations:

- 1-Instructional redesign. Incorporate real-world, discipline-relevant sustainability examples into the standard ESD sections to raise perceived relevance.
- 2-Structured applied activities. Implement short, applied tasks or projects connected to sustainability topics within existing class time, to narrow the gap between conditions on Behavioral and Participation/Interaction engagement.
- 3-Affect-oriented content. Complement Emotional Engagement with storytelling, real cases, or input from sustainability practitioners to produce a clearer, larger gain on this dimension, which was still statistically significant here.
- 4-Explicit performance targets and feedback. Provide explicit criteria and formative feedback throughout the unit for Performance Engagement, which showed the largest single-dimension gain observed.
- 5-Faculty development. In faculty training for this course, emphasize an autonomy-supportive teaching style, given Pakistani evidence that teaching style matters more for behavioral outcomes than content alone.
- 6-Independent administration. Continue to have a research assistant uninvolved in instructional delivery administer the data-collection instruments, to minimize common-method bias, as was done in the present analysis.

Conclusion

The study sought to differentiate a causal effect of teaching that deliberately incorporated sustainability content and engaged undergraduate students in the learning process from the correlations reported in previous studies by examining the impact of a deliberately designed problem based learning as innovative teaching practice on students' perceived relevance of the sustainability content and their engagement with it, using a quasi-experimental comparison-group design to address the gap identified across the reviewed literature: the lack of quasi-experimental, comparison-group evidence that can distinguish a genuine causal effect of teaching practice from the correlational associations reported in previous studies. Both hypotheses were supported under the condition of equivalence of the scores of the Experimental and the Control Groups at baseline, acceptable reliability, and procedural safeguards against common-method bias, as the scores of the Experimental Group on all four dimensions of the Perceived Relevance and Engagement had significantly higher scores than the scores of the Control Group at the end of first semester after the intervention. Theoretically, the results provide preliminary support for viewing the problem-based learning as instructional process as a manipulable factor in relevance and engagement – in line with expectancy-value and self-determination accounts – and are among the first empirical tests of a new, untested self-determination and problem-based learning framework for sustainability education. On a practical level, the findings are pertinent to programme level decision-making for teaching ESD content within a whole child and whole-course, not just an elective - and the six recommendations proposed above are meant to be implemented within this existing, required course structure. The limitations of this study include reliance on self-reported outcome measures, assessment of outcome immediately after completion of the unit, single-sex and single-institution sample, and a nonrandom (intact group) design, which would benefit from being replicated with a larger, more representative sample population and with a longer follow-up period.

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