

Project-Based Learning in Education for Sustainable Development: A Case Study of Graduate Planning Students

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ABSTRACT Urban planning can serve a vital role in meeting the goals of education for sustainable development (ESD); it could potentially provide future planners with the environmental considerations necessary to meet the needs of the present without compromising the ability of future generations to meet their own needs. This article presents findings from a quantitative study of planning students' experiences with Project- and Problem-Based Learning (PPBL). Graduate planning students in an environmental planning class were divided into two groups according to their course assignment, PPBL or non-PPBL, and given pre- and post-questionnaires, with questions to grade statements on environmental attitudes and behaviors. PPBL students reported a statistically significant change in environmental behavior involving others, while neither behavior nor attitudes changed significantly for students in the control group. Then, semi-open interviews were conducted with 11 of the students 3 years later. The interviews indicate that PPBL students remembered more content related to their assignments and felt they received more types of planning experiences and tools than those in the control group.

INTRODUCTION

Urban planning practitioners are key players in developing sustainable communities and cities. Since today's planning students will design tomorrow's urban and rural areas, integrating environmental sustainability issues across planning curricula is essential for meeting sustainable development goals. Thus, planning curricula need to provide future planners with the environmental knowledge, considerations, and the tools necessary to meet these goals [1–5].

The importance of education for sustainable development (ESD) was already articulated in Agenda 21, the blueprint of the 1992 UN Rio Conference on Environment and Development, which called for changed attitudes, values, and dispositions that are supported by skills and behaviors [6]. Particularly, relevant to this study is the notion that a basic outcome of ESD should be the establishment of a pro-environmental stance or competency that involves intellectual and motivational aptitudes that advance one's propensity to act in an ecologically responsible manner [7]. Sustainabil-

ity is already among the key themes in planning education programs in Europe and North America today [3, 8], and it has received attention overall in planning curriculum professional discourse (e.g., [4, 9]). Nevertheless, monitoring and research of pedagogical considerations of ESD in urban planning curricula is rare, resulting in a lack of information about the effects of various practices on ESD learning outcomes [10]. This research suggests that incorporating project and problem-based learning (PPBL) in ESD can improve environmental education (EE) outcomes for planning students.

ESD Curriculum Considerations: Contents, Objectives, and Pedagogy

ACTIVE, TRANSFORMATIVE, AND EXPERIENTIAL LEARNING IN ESD. Active learning, which involves significant participation on the part of the learner, is considered as having great potential to enhance students' engagement and to foster deep learning, especially in comparison to teaching methods that engender passivity [11]. Active learning can take place in various ways, such as computer simulations,

collaborative teamwork, real-life case studies, policy-laboratories, and reflective journal writing [12, 50].

Active learning is related to two other types of learning that have been given special attention in higher education (HE) literature in recent years: transformative learning and experiential learning. Transformative learning is the process of effecting change in the structure of the assumptions through which people understand their experiences. It is enhanced through critical self-reflection on the assumptions upon which our interpretations, beliefs, and habits of mind are based [13]. According to experiential learning theory, learning is a holistic process of adaptation to the world, which involves the integrated functioning of the total person—thinking, feeling, perceiving, and behaving. This process involves a creative tension between concrete experience and abstract conceptualization of experience through reflective observation [14].

It is widely agreed that providing students with opportunities to learn actively and collaboratively is conducive to ESD [12, 15, 16], and that the interactions that are part of collaborative learning enhance higher order thinking skills (e.g., critical thinking) [17]. Group (or class) field trips to industries, natural environments, communities, and social institutions are also recommended as educational experiences that promote better understanding of sustainability [18, 19].

Among the approaches that incorporate both active learning, collaborative learning, and the direct involvement with real-life problems associated with transformative and experiential learning are project- and problem-based learning, which is the focus of this article. This is due to its unique mixture of learning activities and ability to enhance various learning outcomes, as explained in more detail in the following subsections.

PPBL in HE ESD

Problem-based learning and project-based learning are student-centered experiential learning approaches in which students are engaged in real-world problems and seek their solutions, usually in small groups [20]. The main differences between project-based learning and problem-based learning are: 1) the structure of the learning setting and 2) the focus of inquiry. Project-based learning develops case-specific understanding of the problem with the goal of creating feasible solution options. Problem-based learning focuses on characterization of the problem and less on constructing solutions. In addition,

while for problem-based learning the setting is open, project-based learning involves highly structured project framing and a more systemic teaching approach [20, 21]. Nevertheless, because of their common features, the two approaches are often addressed together in the literature and referred to collectively as PPBL (e.g., [20, 21]).

Several other teaching approaches that encourage participatory learning, such as student-centered learning and flip classroom, use projects and problems as part of their teaching methodology [22–24]. Student-centered learning, in which the instructor facilitates individual learning or learning in groups by posing problems and asking questions, is even seen by some as synonymous with PPBL [23, 24]. The flipped classroom, a novel teaching method that employs video lectures and practice problems as homework, also includes active, group-based problem-solving activities [22].

While PPBL has been used as an important learning framework for many disciplines, it is particularly recommended as an approach that can prepare students to solve interdisciplinary real-world problems associated with sustainability [25, 26]. Steinemann [25] specifically highlights a wide range of contributions of PPBL activities, from working with decision makers and the public, and dealing with uncertain and incomplete information to enhancing the motivation and skills that are essential for dealing with sustainability problems.

Wiek et al. [21] argue that the hands-on practice, teamwork, and community engagement opportunities made available in courses that employ PPBL provide students with competencies essential for dealing with complex sustainability problems. Further, directing students to work through real sustainable development scenarios builds their capacity to address the complex interactions between human decisions and the biophysical environment [26]. For planning students, this includes learning to cope with future challenges that they will face when trying to promote sustainable development, such as navigating tensions between government mechanisms, social and cultural norms, and environmental considerations [10].

Attitudes and Behavioral Change in ESD

While it is a commonplace belief that environmental attitudes simply lead to environmental behavior, the link between the two involves several other variables that might moderate or mediate them, and therefore some choose to address them separately [27, 28].

Environmental attitudes are defined as concern for the environment or caring about environmental issues. Education is seen as one of the main ways to enhance environmental attitudes [29] and reach “affective learning” outcomes [30–32]. However, changing attitudes is considered quite challenging in comparison to the achievement of cognitive outcomes, such as knowledge and higher order thinking skills [33]. Active and experiential learning, engagement in real-world sustainability issues, personal responsibility, and student involvement in the learning process have been suggested as ways of enhancing affective outcomes in general and environmental attitudes in particular [15, 29]. Past assumptions contend that providing students with knowledge on environmental issues will promote environmental attitudes and changes in behavior, but a significant body of research has led to the conclusion that a change in attitude requires more than the provision of knowledge [27]. In fact, many EE programs have been unsuccessful in changing students’ environmental attitudes, and many programs succeed in increasing knowledge but not environmental (attitude-based) concern [29].

Behaviors related to enhancement of sustainability are commonly termed “pro-environmental behavior” and refer to actions that have a positive impact on the environment. Taxonomies of such sustainability enhancing pro-environmental behaviors (see [7, 34]) differentiate between private and public sphere environmental behaviors. Private sphere environmental behaviors include those taking place at home and in one’s personal life, such as water and electricity consumption, purchasing food, recycling, and driving to work [35]. In the case of the public sphere, Stern [35] distinguishes between two environmental citizenship behaviors: 1) non-activist behaviors (e.g., signing petitions) and 2) activist behaviors (e.g., active involvement in environmental organizations). Alisat and Riemer [36] suggested that these two types of public sphere behaviors are situated on a continuum, on one side are behaviors that represent low levels of environmental activism and on the other side are behaviors linked to a high level of environmental activism.

Behavioral change is both the ultimate goal of ESD and EE¹ [15, 51] and its biggest challenge. Thus, effective

outcomes require new perspectives and innovative teaching methods [33]. Sipos et al. [15] suggest that behavior modification is the outcome of a holistic change, which involves cognitive, conative, and emotional aspects. For transformative learning, the educational activity should involve multiple aspects of learning: active participation (“hands-on”), emotional engagement (“heart-on”), and cognitive aspects (“head-on”) [15]. We suggest that PPBL, which includes direct involvement with real-world sustainability problems and an active search for solutions and participatory work with others, can be used to meet these requirements.

ESD in HE for Planners

Until recently, few researchers examined the efficacy of actions taken in ESD in HE with regard to promoting pro-environmental behavior. Furthermore, research that focuses on assessing the effect of learning on behavioral change has usually focused on private sphere behaviors, such as the ecological footprint and personal consumption, and not on behaviors related to civic engagement [38]. Civic engagement activities, such as grass-root organizing and citizen activism are seen as one of the most efficient ways to achieve change in environmental outcomes [36]. Therefore, it is important that studies of ESD in HE focus on behaviors and attitudes that relate to the public sphere—by nature part of urban planning—and environmental citizenship, which is best reported at the personal level. This study attempts to address both spheres and is one of the first attempts to study the effect of ESD learning in HE on students’ behavior.

Only a few studies were conducted that examine the use of PPBL in planning HE or related subjects. In a study examining a sustainable urban development course that included a project-based learning assignment, Steinemann [25] found that tackling complex and interdisciplinary problems makes for meaningful learning. Students who participated in the course regarded it as an effective way to learn about sustainability and about inter-relations between issues. In a study of a sustainable development graduate-level course for architecture and planning students at Texas A&M University, which employed a problem-based learning approach, Brody and Ryu [26] found that participating in problem-based learning led to a significant decrease in students’ reported ecological footprint. In qualitative interviews described by Portman and Tefl-Seker [10] with urban and regional planning students

1. In the present paper we use the term ESD rather than EE, as it is commonly used in literature on sustainability in HE, and the learning process described in this paper fits the definition of ESD as an educational approach [37].

who participated in PPBL assignments, some students reported to have changed their environmental behavior, and some stated that the assignments made them aware of environmental considerations and increased their willingness as well as gave them confidence in their ability to employ them in their future professional planning endeavors.² The current study tested the following hypotheses:

1. Participating in a PPBL assignment will lead to change in the levels of pro-environmental attitudes;
2. Participating in PPBL assignment will lead to change in the levels of pro-environmental behaviors.

To that end, in the current study, one group of students who enrolled in an environmental planning course engaged in PPBL, while the second (control) group received a different assignment. Questionnaires administered at the beginning and the end of the course, and between the two student groups, allowed investigation of the use of PPBL practices for ESD among graduate students. Additionally, semi-open interviews were performed to further assess these and other aspect experiences of ESD learning. The study includes an analysis intended to gauge the effects of the PPBL assignments on student environmental attitudes and behaviors.

CASE STUDY DESCRIPTION

Course Description

The study took place in the graduate course, Introduction to EP (EP course), offered at the Technion – Israel Institute of Technology during the fall semester of 2015–2016. Students in the urban planning track take this required course in their first year of graduate studies (Master's level). The course was obligatory, although students who already had an academic background in environmental studies were exempt from the course. Thus, students who had previous experience or advanced academic knowledge pertaining to EP would be unlikely to take the course.

The goals of the course are to provide students with knowledge about the environmental issues, most relevant to urban planning, as well as to convey the importance

of integrating environmental considerations in the field of planning. During the course, topics relating to these considerations are taught, including: environmentalism and environmental ethics; land uses and sustainability; population, demography and their environmental implications; water sensitive urban development; environmental aspects of waste planning; sustainable transportation planning; environmental justice; and environmental impact statement (EIS).

The course included a description of universal environmental threats, challenges, and solutions, and then linked the issues raised to local examples. Student PPBL assignments were therefore intended to encourage students to use various types of information taught in the course (e.g., information about global and local environmental concerns) and to implement knowledge gained in their planning schemes or analyses. The course also included other key goals of ESD; it was designed to give planning students information and raise their awareness of important environmental matters (e.g., climate change), as well as socially related environmental goals (e.g., environmental justice). It is attempted to develop environmental ethics and values, as well as a sense of environmental stewardship and how to implement it [39].

In addition to lectures and class discussions, semi-weekly guided reading tasks and a mid-course quiz, students take on a semester assignment. Mid-way through the semester, students were divided into groups with each group choosing one of two final assignments: one project and problem based (PPBL assignment) and another consisting of document analysis (non-PPBL assignment). The PPBL assignment involved creating a plan³ that would bring about significant environmental improvement in the town of Jisr A Zarka; for the non-PPBL assignments, students analyzed an environmental impact statement of their choosing from among those prepared for past development projects in the country.

Assignment Location: Jisr A Zarka

Jisr A Zarka is Israel's only exclusive Arab coastal village. At the end of 2016, the town's population consisted of 14,200 residents, 100% of whom were Muslims. It is one of Israel's poorest communities, falling in the second

2. The study also included a quantitative portion, however that portion yielded no significant findings.

3. The term "plan" used here refers to the documents and ideas presented by the students in their final presentations and papers, containing text of visions, program elements, guidelines, maps, and other graphic elements (e.g. visual simulations of the proposed project).

lowest socio-economic cluster [40]. The town faces many planning challenges: it is allotted very limited space by the state in relation to its population size and is environmentally neglected (with large amounts of solid waste in public areas and a substantial coastal litter problem); resident tax collection rates are low and unemployment rates are high [40, 41].

However, the town also offers many opportunities that provided students with useful starting points for their assignments: it is close to Israel's center, in the busy heart of the country between two major cities (Tel-Aviv and Haifa), close to well-off Jewish villages and adjacent to a major tourist attraction consisting of the ancient Roman-era Port of Caesarea. It has a beautiful and dramatic view of the Mediterranean Sea, relatively undeveloped beaches with great potential for ecotourism and a small and pastoral fishing enclave ("fishing village"), where artisanal fishing takes place. Local entrepreneurs have recently erected a small hostel and café in the center of the town, and some other initiatives are underway to develop tourism within the village [42, 43]. At the same time, the lack of infrastructure development by the local authorities, cultural norms that lead to poor waste management and coastal littering, create challenges for further development of tourism; both environmental management and economic development are needed.

The EP course instructors chose the village as the venue for the PPBL exercise due to the opportunities and challenges the town offers for EP initiatives. In particular, planning in Jisr A Zarka provides the opportunity for students to learn about specific aspects of sustainable development, including the study and assessment of socio-environmental issues pertaining to local environmental policies and norms, coastal planning, waste management, eco-tourism, and environmental stewardship, offering solutions that could simultaneously bring about social, economic, and environmental change.

The PPBL Exercise

The PPBL assignment was designed to meet certain requirements, but as part of an academic course also had some constraints. On the one hand, the assignments sought to give students "real world" experience in terms of the implementation of the EP knowledge they gained during the course. Assignments were meant to encourage creative designs, foster the use of environmental consideration and a community-centered approach for planning.

On the other hand, assignments also had to result in an end-product that the instructors could grade by the end of the semester, and the amount of work required had to be similar to that demanded in other one-semester two-credit courses as well as involve a similar amount of work as assigned to the (non-PPBL) control group.

As directed, the 31 students in the class self-divided into groups of two to four students. All the students who choose to work on the PPBL assignment (approximately half of the class) visited the village at least once and were encouraged to make more visits before completing the assignment.⁴ When preparing the course, the instructors met with Jisr A Zarka's city engineer who identified the following environment-related issues that needed work in the town: poor waste management; lack of public open spaces; and noise pollution from the main road and air pollution. He also informed the instructors that the village is trying to develop eco-tourism and tourism in general to promote work opportunities for village residents. With these topics as background, each PPBL group of students chose one previously identified issue to address and was asked to develop a project that would offer an EP solution to that problem.

As part of their assignment, students walked the town's streets and spoke to the residents in an attempt to better understand the population's needs, perspectives, and attitudes. Each group of students received guidance and support from the teaching assistant (TA) to address any questions or doubts that arose during their work. All students scheduled mandatory group advisements (whether having chosen the PPBL exercise or the non-PPBL assignment) with the TA to assess each team's work plan at early stages. In these sessions, students received feedback on their ideas and advice regarding the manner in which to proceed with their ideas. At the end of the semester, each group of students handed in a report that described their chosen assignment; they also presented their work before the class. Students working on the PPBL exercise were informed that their reports will be submitted to the Jisr A Zarka municipality. A final document was edited and published online⁵ and sent to officials in the municipality

4. Due to the nature of the course (one semester) and the location of the village, which is outside of Haifa and difficult to reach with public transportation, the instructors felt that requiring more than one visit would have deterred students from participating in the PPBL projects.

5. See reports in Hebrew and Arabic available online: <http://portman.net.technion.ac.il/courses/>.

and to some members of the community who had been involved in helping students.

The final PPBL assignments consisted of the following:

1. **Aqueduct Project:** After consulting with the owner of the only hostel in Jisr A Zarka, one group of students prepared a plan⁶ to clean the underground Roman aqueduct that runs between the village center and its beach, with the aim of promoting its development as a tourist attraction. The aqueduct is currently inaccessible and blocked by solid waste.
2. **Seaside Park:** The second group noticed the town's lack of public parks, as well as the attractiveness of the undeveloped Jisr A Zarka beach, which is a meeting place for families on the weekend. They decided to prepare a plan to develop a stretch of uninhabited land close to the beachfront as a park, designing it as a meeting place for the village youth, a place for community and educational activities, and a rest stop for guided tours and hikers walking the nearby Cross Israel Trail. The project proposes that the village youth will be involved in the construction of the park, using recycled or reused materials to construct park amenities.
3. **Educational Recycling Park:** The students of the third project attempted to simultaneously address two environmental issues: public littering and lack of public parks. They proposed two environmental educational parks in central locations in the village, constructed from recyclable or reusable materials, and which contain a variety of colorful recycling bins, inspirational messages, and signs that explain how and why to recycle. The park targets young children (up to age 12) and their families, as well as school groups, to inculcate environmental behaviors and to provide a physical solution for the town's waste problem.
4. **Village Ring-Path:** In an attempt to promote eco-tourism and tourism in general, as well as offer residents, some form of structured green

public space and improve their well-being, the fourth group offered a plan that aims to create a ring-shaped path around the village for residents and tourists. It connects several small undeveloped open spaces (currently neglected and not designated for public recreation) and includes an acoustic wall to prevent noise pollution from the nearby highway. The plan suggests improving the visual appearance of the areas near or on the path by incorporating local (children's) art.

5. **Peace Garden:** After meeting with one of the prominent members of the community, the fifth group of students became interested in his plan for a "Peace Garden" located on the border between the village and an existing national park (Nahal Taninim) which is visited by both Arabs and Jews. The EP course group provided detailed suggestions on how to make the garden an ecological park that includes much needed spaces for children to play, for families and youths to meet, and for events (such as weddings) to take place. The suggested plan includes the use of reused materials, as well as a detailed landscape plan that has several separate areas designated for the enjoyment of children of different ages and families (Figures 1 and 2).

METHODS

The mixed-methods approach [44] consisting of two parts was used: a quantitative survey administered to all 31 course students and 11 semi-open interviews with course participants, 3 years after the course had ended.

Survey

The study used a quasi-experimental design with a control group and a pre- and post-test to measure the change in environmental attitudes and behavior of the 31 EP course students. Students in the control group were those who had chosen to conduct and submit the non-PPBL assignment. To prepare the final assignment, the students working on the PPBL assignment (P) and those in the "control" groups (NP) were asked to work in the same size groups; they generally attended the same course lectures throughout the semester, had the same tasks, and received the same

6. See footnote 2 above.



FIGURE 1. Te Jisr a Zarka Peace Park Proposal – Graphic illustration – High angle.*
* Submitted by students Osher Davidov, Dalit Dover, Sabri Huri, and Tehila Dafni-Klein.



FIGURE 2. Te Jisr a Zarka Peace Park Proposal – Graphic illustration – side view.

amount of guidance and feedback, with the only difference being the PPBL or non-PPBL nature of the final assignment.

Out of 31 students enrolled in the EP course, 13 (7 males and 6 females) chose the PPBL assignment and 18 (13 males and 5 females) chose the non-PPBL assignment (an analysis of an environmental impact statement). Participants in both groups varied in age (between 22 and 60), gender, ethnicity (Jewish and Arab Israelis), as well as in other characteristics such as work experience or academic background, with some students already working as planners or in related areas in parallel to their studies.

Students answered the same anonymous questionnaires before and after working on and submitting their final class assignments; these were distributed at the beginning of the first lesson of the course and at the end of the last lesson of the course. The questionnaires consisted of a total of 30 questions: 15 about environmental attitudes and 15 about environmental behavior (see Appendix 1). An anonymous coding system was used to match pre- and post-questionnaires according to the identity of the respondent to enable a before and after comparison between the results for each participant. For the first round, students did neither know what assignment type they would choose nor the content of the final course assignment. In the second round, students indicated which of the two assignment types they had worked on.

Twenty-six of the total 30 questions that were taken from a general environmental attitudes and behavior questionnaire meant to measure learning efficiency, which was already statistically validated [45], and which in turn was based on previously developed tools for EE assessment, such as Children Environmental Attitude and Knowledge Scale used by Leeming et al. [46] and General Environmental Behavior Scale developed by Frick et al. [47]. The questionnaires included four additional original questions specifically about environmental planning, two addressing environmental attitudes and two addressing environmental behavior⁷.

For each of the two questionnaires A and B, factor analysis was applied, which revealed two factors in each one. Following these preliminary findings, we divided each questionnaire into two question themes, reaching a total of four question themes or groups: AA, AB, BA, and

7. These were not validated beforehand, as they pertain directly to environmental planning, see Appendix 1.

BB (see Table 1 below). A mixed model was fitted for each of the four question themes. The model included a random subject effect to allow for the correlation within each subject. Explanatory (independent) variables were: the group type (PPBL vs. non-PPBL) and the time period (pre vs. post within subjects). Since birth years made up part of the coding to pair pre- and post-responses, we were also able to consider age as an additional explanatory variable and investigate whether it had any significant relation to the results and their interaction. The differences of least squares means was calculated for each question group.

SEMI-OPEN FOLLOW-UP INTERVIEWS. Eleven semi-open interviews were conducted with the students who participated in the EP course of 2015–2016. The interviews were conducted during February 2019, 3 years after the students completed the course. We interviewed six students who performed the PPBL assignment (four males and two females) and five (three males and two females) who belonged to the control group. In the interview, students were asked what they remembered from the course in general; what they remembered about the PPBL or non-PPBL assignment; why they chose this assignment (and not the other); what they felt the assignment provided them; and what tools and abilities they used to perform it. Questions were intentionally phrased as such to minimally influence students' recollection of their experiences. The interviews were recorded and their content analyzed using thematic analysis, in which all parts of the text are summarized into short phrases, or "codes", which are in turn aggregated into themes, particularly addressing emerging themes that relate to the research questions or hypotheses [48].

FINDINGS

Quantitative Findings - Surveys

ASSIGNMENT TYPE. Results for the attitudes questions (groups AA, AB) were not found to be statistically significant either between pre- and post- in each assignment group or between the assignment groups (PPBL – P; non-PPBL – NP). That is, there were no significant differences between changes among the two assignment-type groups in relation to their reported environmental attitudes. Marginal difference between pre- and post- (indicating marginal positive effect of the assignment) was found for the PPBL group (P) for question-group BA (behavior not involving others), but not for the non-PPBL group (NP) (Table 2). Marginal difference

TABLE 1. Division of Questionnaire into four categories by question assignment type and question themes

Category	Type	Attributes	Questions
AA	Attitudes A	Involving theoretical or general attitudes	1, 3, 4, 5, 6, 7, 8, 14, 15
AB	Attitudes B	Involving attitudes that refer directly and personally to the participant	2, 9, 10, 11, 12, 13
BA	Behavior A	Behavior that only involves the respondent	2, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14
BB	Behavior B	Behavior that involves others	1, 3, 9, 13, 15

TABLE 2. Differences of Least Squares Means – Question BA

Effect	Test	Project	Test	Project	Estimate	Standard error	DF	<i>t</i>	<i>p</i>
Group assignment	Pre	NP*	Post	NP	0.03947	0.1311	26.9	0.30	0.7656
Group assignment	Pre	P**	Post	P	-0.3210	0.1586	26.6	-2.02	0.0532

*NP – Non-PPBL

**P – PPBL

TABLE 3. Estimates for Questions BA

Label	Estimate	Standard error	DF	<i>t</i>	<i>p</i>
Dif_E vs Dif_J	-0.3605	0.2058	26.7	-1.75	0.0913

was found between Groups NP and P for these score changes over time ($P=0.09$) (Table 3).

Statistically significant ($p \leq 0.05$) results were obtained for the mean of the answers to questions BB – environmental behavior that involves others as addressed in the following questions (numbers: 1, 3, 9, 13, 15, respectively; see Appendix 1):

1. I try to influence the opinions of my family and friends regarding environmental issues;
2. If I see someone throwing waste on the floor, I say something to him/her;
3. When I encounter an environmental hazard, I report it to the authorities;
4. I participate in projects that clean and care for public places;
5. I am looking into potential opportunities for work in areas that relate to the environment.

The responses for these questions among group NP showed no difference between pre- and post-responses, yet for group P a higher score was observed among post-

responses when compared to that of pre-assignment responses. In other words, part of the reported behavior for the PPBL group—that which related to behavior that involves others—showed statistically significant improvement at the end of the course ($t=-2.55$; $p<0.05$). There was no significant difference between the pre- and post-questionnaire for group NP (Table 4). Differences between groups in terms of assignment impact (differences between pre- and post-answers) were also found to be statistically significant ($t=-2.14$; $p<0.05$), as shown in Table 5.

AGE. Respondents' age was found to be associated with answers to the questions related to environmental behavior, as increase in age correlated with overall higher scoring. The differences in age were not significant in regard to the attitudes part of the questionnaire (AA and AB). They were found to be marginally significant with regard to the BA questions of the behavior part of the questionnaire ($\beta = 0.017$, $t=1.79$, $p=0.085$) and were statistically significant in relation to part of the questionnaire that had to do with behavior involving others (BB) ($\beta=0.048$, $t=4.02$, $p=0.0005$). However, age was not found to be significant for assignment impact (i.e., it had no statistical significance associated with assignment type) either with

TABLE 4. Differences of Least Squares Means – Questions BB

Effect	Test	Project	Test	Project	Estimate	Standard error	DF	<i>t</i>	<i>p</i>
Group assignment	pre	NP	Post	NP	0.03612	0.1362	25.4	0.27	0.7930
Group assignment	pre	P	Post	P	-0.4203	0.1646	25.2	-2.55	0.0171

TABLE 5. Estimates – Questions BB

Label	Estimate	Standard error	DF	<i>t</i>	<i>p</i>
Dif_E vs Dif_J	-0.4564	0.2136	25.3	-2.14	0.0425

regard to the pre- and post-answers or with regard to the impact between groups.

Overall, the findings indicate that taking part in the PPBL was associated with change in self-reported environmental behavior pertaining to others, in other words change in behavior that requires interaction with other people. However, only marginally significant change was found in behavior that pertains to the respondents alone (and does not involve others), and no significant change was found in their environmental attitudes. The control group (respondents who did not take part in the PPBL assignment) showed no significant change in either environmental behavior or environmental attitudes between pre- and post-assignment periods.

Qualitative Findings—Follow-up Interviews

We interviewed 11 former students who completed the class 3 years earlier. Today, they all either worked for municipalities or private companies as planners or as part of a planning team, or continued their studies or became researchers in a related field. In the follow-up interviews, they were first asked what they remembered from the course, and being interviewed several years after the course had ended, the majority did not remember much about the content of the lectures given in class. However, most could recall much more about the final course assignment, and students who did the PPBL assignment tended to recollect considerably more details that pertained to their assignment. One student, who went on to continue his studies in the US, performed the non-PPBL assignment said that what he remembered from the course was his own (EIS) project and the Jisr A Zarka (PPBL) projects of others. An interviewee who performed the PPBL assignment said “honestly, I don’t remember that much from the classes, except for water sensitive planning” and when

asked about the PPBL assignment she replied: “oh, I really remember that project, I mean, that was a really nice idea, creative, it really connect us to what we learned, let us be creative, and connected us to the rest of our degree in planning.”

CHOICE OF ASSIGNMENT. The students were also asked why they chose the PPBL or non-PPBL (EIS) assignment. Reasons given for choosing the latter were as follows: that it was a type of document that is very important for planners; that other courses did not teach it; that it was clearer to the student what needed to be done; and that the non-PPBL assignment enabled the student to be more flexible and work from home in their spare time, while the Jisr A Zarka project was perceived as more demanding in time and energy, particularly because it required to physically visit the village. Those who chose the PPBL project explained that they liked the fact that it was working “in the field”; that it was active/creative and involved something that they themselves produced; and that they felt it helped the community. They were also relatively knowledgeable about the specific environmental issue relevant to their particular project: recycling and reusing materials, green spaces, water management, EE, etc.

PERCEIVED LEARNING OUTCOMES. In the interviews, students were asked what they thought they had learned from the assignment, and which tools and knowledge they used to complete their assignment. Statements of students who performed the PPBL assignments included: creating something themselves (some for the first time), particularly small-scale community-centered projects⁸; studying statutory plans (some for the first

8. Other planning courses ask students to look at the municipal level, and this project was intended to focus on a small-scale project (e.g. a single park).

time); connecting theory and practice; drawing information and knowledge from local community members and understanding their needs; accessing and analyzing government and local government documents; combining information from different sources; and finally, understanding the importance and the need to address the residents' actual needs, while implementing environmental considerations or designing projects that emphasize environmental sustainability. As one PPBL student, currently a Ph.D. candidate in urban planning who also works as a freelance civil engineer, explained:

“It was nicer [than the non-PPBL assignment] because we met people, and walked around the place itself, and understood the meaning of what we learned in comparison to what already existed, and we brought an idea [...] and we worked as a team [...]. We also looked at work done in Jisr and at different approaches to these issues and interviewed one of the educators in the village, so it was really comprehensive. [...] It was multi-dimensional, because there was a plan to make, there was a literature review, and there was visiting the place itself, so it was really diverse”.

In response to the same question, students who chose the non-PPBL assignment included references mostly to the fact that they got to know this important type of document and now understand what it includes, as all of them stated that they had never read an Environmental Impact Statement (EIS) before the course. Some said that the analysis of the EIS allowed them to perform a critical reading of such a document, which they felt enhanced their ability to better understand EP considerations.

DISCUSSION AND CONCLUSION

Findings partially support the research hypothesis that assignment type (i.e., conducting PPBL/non-PPBL assignments) influences students' self-reported environmental behavior and attitudes, suggesting that PPBL can successfully be used to promote ESD in HE.⁹ Only those behaviors that pertain to others were reported as having changed significantly for students who participated in the PPBL assignment, suggesting a specific association

9. It should be noted that due to the small sample size, the data analysis only demonstrates an association between student participation in PPBL projects and the changes in attitudes and behaviors, but cannot substantiate significant causality.

between environmental attitudes and behavior, and student's participation in PPBL as conducted for the course assignment. Environmental attitudes and behavior types overall seemed to be unchanged.

This difference in answers to the two “question themes” of the items featured in the environmental behavior questionnaires (BA and BB), aided in locating the specific types of reported environmental behavior found to be related to the PPBL exercise. These findings correspond with Stern's [35] differentiation between various environmental citizenship behaviors: non-activist behaviors in the public place and activist behaviors. Activist behaviors of the students who took part in the PPBL assignment were found to have undergone a significant change compared to those who did not do the PPBL assignment.

It could be argued that because students chose their own assignment type, the answers of students to the questionnaires would also be different and perhaps would logically reflect the pre-project biases that led to their choice of project type (either PPBL or non-PPBL). Therefore, we posit that an improved research design would divide course students into two assignment groups arbitrarily. In the current case study, instructors, and researchers, feared that mandating assignment types would bias students against the PPBL and reduce cooperation. Also, administrative concerns might have arisen.¹⁰ However, if there were a direct association between assignment type and student environmental predisposition, we would expect to see statistically significant differences in answers to the first questionnaire between group P and NP. Such differences were in fact not observed.

As previously noted, students participating in this course were unlikely to have taken any environmental studies courses in the past. This might suggest that an academic background in environmental studies was not an influencing factor in this case. Moreover, it also suggests that PPBL in university-level planning curricula could (also) potentially develop environmental behavior in students that did not previously display an academic interest in this area of study.

10. Assignment to the PPBL project could have been perceived as more demanding than the non-PPBL assignment: it meant visiting the village, requiring more time and money to reach the village and tour it, in certain cases several times. Additionally, the village is considered by some as unsafe, and the university decided to not sponsor the student excursion to Jisr A Zarka requested by the course instructors, thereby compelling students who participated in PPBL assignments to reach it independently.

Nevertheless, the fact that environmental attitudes were not found to have changed significantly for either group contradicts the research hypothesis, which assumes a positive influence of PPBL on all forms of ESD in HE, including both attitudes and behavior. These findings, therefore, correspond with the claim that while it is assumed that environmental attitudes shape environmental behavior, the link between the two also involves other influencing factors. This finding supports the claim that the relation between pro-environmental attitudes and pro-environmental behavior is complex and could include several mediators and moderators [27, 28]. It should also be noted that this was a one-semester project, limited in scope as well as time and effort dedicated to it by the students. A long-term project with a larger scope and perhaps more structured, direct involvement with the community and municipality, would have perhaps yielded different results.

Age was found to be associated with participants' answers regarding environmental behavior involving others and had a marginally significant effect on their answers regarding behavior not involving others. Older participants gave higher scores, on average, but with no correlation to assignment type (PPBL or non-PPBL). However, this finding matches other study findings on age impact on pro-environmental behavior (e.g., [49]), in which older students had a general tendency to give higher scores when reporting their environmental behavior. Nevertheless, their scores were not associated with the assignment in any statistically significant manner.

Interviews with students who chose the PPBL assignment indicate that these projects contributed to their planning knowledge and skills, although not necessarily related to environmental issues *per se*. Community needs, for instance, were a more dominant theme of interest in the interviews than concern for the environment or the incorporation of environmental considerations. It seems that the latter were seen as given or default approach, while the challenges and added value were often elsewhere—in understanding the planning process, and in particular accessing, analyzing, and integrating different types of information. However, one might suggest that according to the literature, this is what PPBL is all about: it touches on several disciplines, information sources and skills, and is not confined to one field of inquiry, one skill, or one type of considerations. As a holistic teaching tool, the project left a much stronger

mark on the students, was more productive, and especially more effective than the non-PPBL (EIS) assignment. This is an important and relevant finding for the application of PPBL in ESD and HE in general, as teachers need to understand the particular advantages that PPBL can bring, while also consider that they do not always have a direct impact on specific or measurable environmental knowledge, attitudes, and behavior, and that these can vary and be more implicit or indirect, depending on a variety of factors that may often be difficult to fully control or foresee.

Nevertheless, quantitative results suggest that PPBL is likely to be effective in changing student planned environmental behavior that pertains to others. This can perhaps be explained by the concept, shared by several student interviewees from the PPBL group, that the project enabled them to appreciate and to better understand the importance of addressing and integrating community needs in (environmental) planning. This may not be confined to environmental aspects, but also relates to other community-related planning considerations. Why have attitudes not changed? That is more difficult to answer and requires further research. It does, however, support the notion that learning is not always a linear process, and that changed environmental behavior is not necessarily preceded by a change in environmental approach.

We therefore also look at what could be done in future research efforts looking into ESD in HE, especially for planning students. The current study relied on a specific group of participants—graduate students of a particular one-semester environmental planning course—and therefore limited with regard to both its sample size and longitudinal scope, as well as potentially affecting participant backgrounds and knowledge. Future research would benefit from a larger sample size that would improve the ability to develop further findings. A larger sample would enable researchers to ascertain a statistically significant association between PPBL participation and the changes in environmental attitudes and behavior and the role of other variables in this process. It could also potentially allow researchers to investigate the effectiveness of specific methods or tools of the PPBL learning process, such as pre-field preparation, journaling, debriefing, and group discussions. However, this would be complicated by the need to use, at least within a single planning school case study, a larger class of students so that all other variables

(e.g., assignment type and general class materials) could be held constant.

Other demographic data not collected in this study would be interesting as well, including more specific socio-economic, academic, religious, and ethnic background, in addition to other potentially confounding or moderating variables. None of the students who chose the participative assignments lived in the village or had family there, and most of them (apart from three) were Jewish, while the village is predominantly Muslim and Arab-speaking (though many residents also speak Hebrew and/or English). We propose that it would be interesting to examine in the future whether aspects such as similarity or dissimilarity between participants and the community in terms of ethnic background, language, or religion have any influence over the effectiveness of PPBL for ESD in HE. Further research could also investigate whether ESD is effectively achieved when PPBL takes place in the students' own communities in comparison to PPBL taking place in neighboring or more distant communities. While the spirit of the assignment, as well as the interviews, suggests that students were often interested in the potential suitability of their projects for the local population, it is also important to further investigate how the communities might be influenced by such PPBL HE initiatives, and whether students addressed the community merely as their "lab," or whether they see them as their clients and truly attempt to make a positive impact on their lives. This act of scientific and pedagogic reflection is particularly important in cases where most learners come from a different ethnic or socio-economic background than that of the community for which they are proposing solutions as part of the PPBL process, be they environmental or not.

AUTHOR CONTRIBUTIONS

As the main author of the article, Dr. Yael Teff-Seker designed and executed the study, distributed the surveys, and performed the interviews. She performed the analysis of the quantitative and qualitative findings and wrote most of the manuscript.

Associate Prof. Michelle E. Portman developed the course curriculum and contributed to the development of the research plan. She advised the survey and interview structure as well as supervised the statistical analysis portion of the research, edited, and advised the writing of the manuscript.

Dr. Keren Kaplan-Mintz contributed to the manuscript by the development of the theoretical framework, and made a significant contribution to the introduction, in particular on the subject of education for sustainable development (ESD). She also advised on the writing of the methods and discussion sections.

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COMPETING INTERESTS

The authors have declared that no competing interests exist.

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APPENDIX 1

Environmental Attitudes Questionnaire: Environmental Planning 2015–2016

The questionnaire is anonymous. For statistical reasons please write your birth date (using six digits: xx/xx/xx): _____

This part of the questionnaire has to do with **attitudes** regarding environmental protection and planning. Please state, next to each question, the appropriate number according to the following key:

- 1 = Strongly disagree
- 2 = Somewhat disagree
- 3 = Agree to a medium extent
- 4 = Agree
- 5 = Strongly agree

-
1. It is very important for me to protect the environment _____
 2. I am willing to contribute 20 NIS from my money to protect wildlife _____
 3. The topic of the environment should receive a higher priority in Israel _____
 4. I can contribute to the environment through my personal behavior _____
 5. Factories must be obligated to reduce harmful emissions even if it causes prices to rise _____
 6. I have the ability to influence the environment _____
 7. It is important to preserve plants and animals even if they are not useful to people _____
 8. Private people should be punished for damaging the environment _____
 9. I would be willing to buy less products to reduce environmental damage _____
 10. Given the chance, I would be willing to sign a petition for reducing environmental pollution _____
 11. If I recycle it will improve the state of the environment _____
 12. I would be willing to go door to door to convince people to recycle _____
 13. I would be willing to use public transportation in order to reduce pollution _____
 14. Including environmental considerations in planning is very important _____
 15. It should be mandatory for planners to take environmental considerations into account in every project _____
-

Environmental Behavior Questionnaire

This part of the questionnaire has to do with **behavior** regarding environmental protection and planning.

-
1. I try to influence the opinions of friends and family members regarding the environment _____
 2. I turn off the lights and air conditioning when I leave the house _____
 3. If I see someone throwing waste on the sidewalk I say something to them about it _____
 4. I try to use cloth or paper bags instead of plastic bags when shopping _____
 5. I reuse printed pages as draft paper _____
 6. I read articles about environmental protection and nature preservation _____
 7. I recycle various containers and materials _____
 8. I try to buy environmentally friendly products _____
 9. When I encounter an environmental damage problem I notify the authorities _____
 10. I pack my food in a box rather than in a plastic bag _____
 11. I try to avoid purchasing bottled water _____
 12. I shower faster to conserve water _____
 13. I participate in projects to clean and beautify public spaces _____
 14. I combine environmental considerations in my work and in my studies _____
 15. I look for employment opportunities that have to do with the environment _____
-