Development and Validation of an Instrument for Assessing the Learning Environment of Outdoor Science Activities

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ABSTRACT: The SOLEI (Science Outdoor Learning Environment Inventory) was developed and content-validated in high schools in Israel. The instrument consists of seven scales (55 items). Five of the scales are based on the Science Laboratory Learning Environment Instrument (SLEI) developed in Australia. The other two scales are unique to the learning environment existing in outdoor activities. The instrument was found to be a sensitive measure that differentiates between different types of field trips conducted in the context of different subjects (biology, chemistry, and earth science). It is suggested that the instrument could be an important addition to the research tools available for studies conducted in informal settings in science education. © 1997 John Wiley & Sons, Inc. *Sci Ed* **81**:161–171, 1997.

INTRODUCTION

The purpose of this article is to describe the development of an instrument for assessing students' perceptions of the psychosocial environment of the outdoors; that is, field trips. It is suggested that the development of such an inventory will provide one missing link in the study of science learning environments and will encourage research-based evidence with a more comprehensive perspective. Because the outdoors is regarded as a unique instructional setting it deserves a unique inventory for assessing students' perceptions.

Science teaching is conducted predominantly in three types of learning environments: classroom; laboratory; and outdoors. The outdoor environment is the one most neglected by

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teachers, curriculum developers, and researchers (e.g., Orion & Hofstein, 1994). A series of articles (Fido & Gayford, 1982; McKenzie, Utgard, & Lisowski, 1986) reported that teachers tended to avoid outdoor activities because they were frequently unfamiliar with the philosophy, technique, and organization of field trips. McClafferty and Rennie (1992) reviewed 39 studies published between 1974 and 1992. They reported that these studies neither investigated factors that influenced students' ability to learn in an outdoor setting, or focused on the implementation of the field trip as an integral part of the science curriculum. We suggest that the neglected state of outdoor education may reflect our limited knowledge and understanding of the outdoors as an effective learning environment. It is also claimed that one of the reasons for this limited knowledge and understanding is the lack of unique and adequate assessment and evaluation techniques. The development of an outdoor learning environment inventory could help us to better understand students' views of the outdoors in general and the field trip in particular. The learning environment has been defined by Anderson (1973) as:

> The interpersonal relationship among pupils, relationship between pupils and their teachers, relationship among pupils and both subject matter studied and the method of learning and finally, pupils perception of the instructional characteristics of the class. (p. 1)

Over the last two decades, considerable interest has been shown in the conceptualization, measurement, and investigation of the psychosocial characteristics of the science classroom (e.g., Haertel, Walberg, & Haertel, 1981; Fraser & Walberg, 1991). The LEI (Learning Environment Inventory) has been used as a predictor and a criterion variable in many different studies and in different countries (Fisher & Fraser, 1983; Hofstein & Lazarowitz, 1986). Measures of classroom learning environments were found to predict both affective and cognitive variables in students.

Recently, a laboratory version of the LEI was developed in Australia for the purpose of assessing the specific learning environment of the science laboratory. The SLEI (Science Laboratory Learning Environment Inventory) was developed and validated in Australia by Fraser, McRobbie, and Giddings (1993). They claimed that since the laboratory is a unique mode of instruction and that:

> . . . . it is timely to initiate a new line of research which could help us to obtain feedback about students view of laboratory, settings and investigate the impact of laboratory classes on student outcomes. (p. 2)

Yet science education takes place in another important learning environment, namely outside the classroom. Field trips were defined by Krepel and Durall (1981) as:

> A trip arranged by school and undertaken for educational purposes in which students go to place where the material of instruction may be observed and studied directly in their functional setting. (p. 7)

Orion (1993) suggested a model for the development and implementation of field trips based on earlier studies (Falk, Martin, & Balling, 1978; Mackenzie & White, 1982; Novak, 1986; Orion & Hofstein, 1994). The model is based on the following major principles:

- A process-oriented approach, which focuses on an active interaction process between the students and the environment. In this process, students actively construct information from the environment, rather than passive absorbance of information from teachers. The advantage of active learning over passive learning is based on constructivist theory as well as outcomes of studies conducted in this domain.

- A field trip conducted as an integral part of a particular curricular unit should be placed as early as possible in the learning sequence to provide a more concrete basis for understanding the abstract concepts.
- Students should be properly prepared for the field trip. The preparation should employ concrete activities to reduce the effect of the "novelty space" of the outdoor event. Orion and Hofstein (1994) found that the novelty space of the field setting consists of at least three novelty factors: the cognitive novelty; the geographical novelty; and the psychological novelty. The cognitive novelty depends on the concepts and skills that students are asked to deal with throughout the field trip. The geographical novelty reflects the acquaintance of the students with the field trip area. The psychological novelty of the study group in this research reflected their previous experiences with field trips as socially adventurous events rather than learning activities.

Similar to the laboratory, outdoor activities (field trips) have the potential to enhance constructive social relationships among students as well as many of the variables that characterize learning environment measures. To create a healthy learning environment, there is a need for more research that will assess how time spent on field trips affects students' perceptions of the learning environment. It is desirable to further study the effect of different modes of field trips in the context of different science subjects on the learning environment.

PURPOSE OF THE STUDY

The purpose of this study is to describe the development and validation of an instrument to assess the learning environment of science studied in the outdoors. It is believed that the development of such an instrument will:

1. Provide a missing link in the study of science learning environments and will encourage research studies with a more comprehensive perspective.
2. Provide an additional measure allowing investigation and differentiation to be made between the educational characteristics of different outdoor learning environments.

SAMPLE

The sample consisted of 643 high school students in 28 classes from 18 urban high schools in Israel who participated in a science outdoors learning experience during the year of this study. They participated in three different types of field trips that were conducted as an integral part of their studies. These field trips were conducted in relation to three different disciplines: Biology, chemistry, and earth science (see Table 1).

Schools participating in this study were selected based on:

1. The school and its teachers had been conducting field trips for a long period of time.
2. Willingness of teachers from these schools to participate in the study. A preliminary survey was conducted to identify and select participants.

DATA ANALYSIS

The reliability (internal consistency) was determined by calculating Cronbach's alpha internal consistency coefficient. Frequency distributions, means, and standard deviations were calculated for each subgroup. Significance levels for differences were established using a series

TABLE 1
Description of the Sample

Study Population	N	No. of Classes	No. of Schools	Type of Outdoor Activity
Earth science	214	11	5	Geology field trip
Biology	227	9	6	Environmental project
Chemistry	202	8	7	Industrial visit
Total study population	643	28	18	

of *t*-tests. Educational significance of difference was assessed by calculating the effect sizes. This was obtained using the difference between two means divided by the pooled standard deviation. An effect size of .2 is very low, .5 is medium, .7 is high, and .8 is very high.

DEVELOPMENT OF THE SCIENCE OUTDOOR LEARNING ENVIRONMENT INVENTORY

The development of the Science Outdoor Learning Environment Inventory (SOLEI) included the following steps:

1. Conceptualization and item formulation.
2. Content validation.
3. Construct validation and reliability calculation.
4. Field testing for sensitivity of the measure.

Step 1: Conceptualization and Item Formulation

The development of the SOLEI was based on the existing SLEI (Fraser et al., 1993). Most of the original scales and many items of those inventories were found to be relevant to the needs of the SOLEI as well. However, some modifications and additions both in the scales and the items had to be made to adjust the new inventory to the specific and unique outdoor learning environment. Four scales, namely open-endedness, integration, student cohesiveness, and material environment, are similar to the scales originally used in the SLEI by Fraser et al. (1993). Two other scales, "teacher supportiveness" and "preparation and organization," were originally part of the SLEI, but were omitted in the final shortened teacher version (Fraser et al., 1993). It was found, however, that for the purpose of the SOLEI, these two scales were vital and logical. This finding was also proved by content validation described in the next validation stage. The subjects of each of the items included in these six scales were changed, of course, and referred to the outdoor learning environment rather than the laboratory.

In the SOLEI, one scale designated as "environment interactions" is entirely original. The development of this scale was based on the educational philosophy of a learning field trip, noted in the introductions, which perceives the active interaction with the concrete environment as a key factor for meaningful learning during a field trip. The initial version of the SOLEI consisted of 65 items. A description of each of the scales together with sample items is presented in Table 2.

TABLE 2
Descriptive Information of the Inventory's Scales Together with Cronbach Alpha Reliability Coefficient

Scale Name	No. of Items	Description	Sample Items	Cronbach's alpha
Environmental interaction	7	Extent to which students are actively involved in learning through interaction with their peers and their surroundings	Students spend time during the field trip being involved in investigation of field phenomena	.55
Integration	9	Extent to which the outdoor event is integrated with the indoor learning	The field trip is used for investigation and solving of problems which arise during regular classes	.76
Student cohesiveness	6	Extent to which students help and are supportive of each another	During field trips there is a collaboration between students while carrying out the task	.66
Teacher supportiveness	7	Extent to which the teacher/ instructor is helpful and shows concern for all students	The field instructor assists those students who find difficulties conducting their assignments	.71
Open-endedness	8	Extent to which the outdoor activities emphasize an open-ended, divergent, individual approach	The learning pattern during field trips encourages personal thinking	.58
Preparation and organization	7	Extent to which students were prepared for the field trip in terms of expectations and organization of the event	Before going on field trips we receive detailed information about what to expect	.73
Material environment	6	Extent to which students are provided and use adequate learning materials for the outdoor learning event	The materials and equipment that students need for the field activities are readily available	.60

Step 2: Content Validation

For the purpose of content validation, a group of 12 science educators, high school teachers, and environmental tutors were provided with a list of 65 items classified in seven categories (scales). They were asked to assess the quality of each of the items, check their classification in the scale, and suggest necessary item revisions (Edwards, 1957). Following this procedure there was agreement regarding 55 items, which were retained in the first revised version of the SOLEI.

Step 3: Construct Validation

Item Analysis. The final 55-item version of the SOLEI was administered to 643 high school students in 28 classes in 18 urban high schools in Israel, who participated in the science outdoor learning experiences. The reliability (internal consistency) was determined by calculating Cronbach's alpha reliability coefficient. Five items that reduced the value of the Cronbach alpha internal consistency were excluded, thus the final measure consists of 50 items. Table 2 describes the sample items of the scales together with the Cronbach alpha reliability coefficient of the final version. Relatively low Cronbach's alpha coefficient values were found in relation to two scales, namely "environmental interaction" and "open-endedness." Hatcher and Stepanski (1994) claimed that, for social science studies, a Cronbach alpha coefficient even low as .55 can be recognized and accepted for statistical consideration. However, it is suggested that, in the future, these two scales should be tested and improved by further studies.

Step 4: Field Testing for Sensitivity—Results and Discussion

Treatment. All classes went on a field trip conducted as an integral part of a specific science curriculum. Information regarding the different treatments in relation to the outdoor events (prior, during, and after the field trip) was obtained using a teacher's self-report. The inventory administrated among all teachers was modified and implemented by Orion and Hofstein (1994) and is based on the original instrument developed and validated by Tamir (1983).

This information enabled us to characterize the specific components involved in relation to the three discipline-oriented types of field trips.

Earth science. The earth science group undertook a 1-day geology field trip developed according to the model suggested by Orion (1993). This model emphasizes the use of the outdoor activity as a concretization tool. Throughout the field trip students were engaged in active and cooperative learning. This interactive learning was guided by a field booklet which included specific assignments for each learning station that directed the students to observe, identify, measure, collect samples, draw, ask questions, and draw conclusions. The field booklet allowed teachers to act more as facilitators and not as the main source of knowledge.

About half of the students in the study group were geology majors, and the others were geography majors. The earth science teachers followed Orion's model to the letter, namely, placing the field trip at the beginning of the course after a short preparatory unit which focused on reducing the "novelty space" of the field trip. The outdoor concrete experiences were used in a later stage as a basis for the more theoretical part of the program. In the field, during the self-learning stage, teachers were involved in directing students' work and they later summarized the self-learning activity by a class discussion.

The geography classes used the same learning and teaching materials as the earth science classes; however, most of them went on the field trip at the end of the course after completing the theoretical background of the program.

Biology. This subgroup included biology majors who participated in a 3-day ecological camp. This camp was an investigative type project conducted as an integral part of a course of a biology matriculation examination called "Biotope" (Bakshi & Lazarowitz, 1982). Usually, these projects took place in a field center and were guided by a professional field leader. The students were engaged in an active field investigation of a specific biological niche or ecosystem. The varied projects included the investigation of ecosystems such as a sand dune, a pool, a coral reef, or a desert acacia tree. Students were involved in formulating the specific research questions, gathering field data, and writing a scientific report based on their findings.

Chemistry. This subgroup consisted of chemistry majors who participated in a 1-day industrial visit. The visit was conducted at the end of the course and was guided by a local scientist or engineer who had a very limited educational training. During the industrial field trips the students were told by a local guide about chemical and technological industrial processes as well as methods used by the industry to protect the environment. Some of the explanations were given while watching a specific phenomenon from a distance, but most of the explanations were given in a lecture room. Because during most of the visit the students were engaged in passive listening to oral lectures and explanations, they might be designated as "passive learners." This was in contrast to most of the geology and biology students who were designated as "active learners," because their field experiences were based on personal investigations and interactions with the natural environment.

Administration. The SOLEI was administered during the academic year 1992–1993. It was given to the students by their science teacher (biology, chemistry, earth science) in the first lesson in the classroom, about 1 week after the outdoor learning event. Students were told orally and literally that their responses will be used for further development and planning of outdoor activities. To give them the freedom to express their sincere and objective perceptions students were only asked to note their grade and gender, and writing their name was optional. Students spent about 20 minutes answering the questionnaire's items.

Categories of Sensitivity. The sensitivity of the SOLEI was tested with different student study groups and different outdoor educational settings. As mentioned, the study groups included chemistry students who participated in field trips to an industrial site, biology students who participated in an investigative project in a natural setting, and earth science and geography students who participated in a 1-day geology field trip to a natural setting. Each study group was heterogeneous in relation to variables such as type of learning in field trips (passive vs. active), type of preparation toward the field trip, and learning strategies during the field trip (investigative vs. confirmatory). The passive vs. active and the investigative vs. confirmatory approaches to learning represent the degree of involvement of students in the learning event.

We act as science educators in an era in which the constructivist approach to learning science has become a major issue which guides us both in the development and implementation of the science curriculum. Based on this approach meaningful learning could be achieved, provided the student is highly involved and takes an active role in the learning process. The investigative approach has the potential to serve as a useful method to engage students actively in the learning process.

In relation to Orion's model (briefly described earlier in this article), these differences should cause different performances during the outdoor learning events and inevitably different outcomes for each of these different types.

Therefore, on the basis of this model, one might expect that the outcomes of the classes that participated in active outdoor learning events will be significantly more positive compared to the classes that experienced a passive outdoor learning experience. We also might expect that classes in which preparation was directed to reduce the "novelty space" of the outdoor setting will show more positive attitudes toward the learning environment compared to those classes that arrived at the field trip following minimal preparation or with more "novelty space." Finally, it is suggested that students who experienced an investigative process-oriented experience will show significantly more positive attitudes than those who experienced activities aimed at confirming the teachers' lectures that were given in the classroom prior to the field trip.

The grouping of the different classes in relation to the aforementioned categories was conducted on the basis of the information collected from the teacher's self-report.

Results. *Active vs. passive learning.* The perceptions of the students who participated in the active outdoor learning events were found to be significantly more positive, both statistically and educationally, in five of seven scales (see Table 3). In other words, students who were actively involved in the geology and biology outdoor events perceived the learning environment significantly more positively than chemistry students who were passive during most of their outdoor event.

It is suggested that the differences between the two types of field trips could be explained mainly by the nature of the learning event throughout the field trip. As already mentioned, the passive vs. active nature of learning during the field trip supports the constructivist approach to learning science in which the student is actively involved in the process of knowledge construction. In addition, the difference that was also found in relation to the "integration" scale might suggest that the extent to which the outdoor event is integrated with the indoor learning strongly influenced the perception of the learning environment during the outdoor experience.

Preparation of students for the outdoor activity. The teachers' self-reports enabled us to obtain information regarding the preparation of each of the classes for the outdoor experi-

TABLE 3
Comparison of Active Versus Passive Approaches to Field Trips

	Geology + Biology, Active ($N = 376$)		Chemistry Passive ($N = 202$)				
Scale	Mean	SD	Mean	SD	t	p	ES*
Environment interaction	3.16	.53	2.86	.48	8.68	.0001	.57
Integration	3.83	.54	3.50	.61	6.62	.0001	.57
Student cohesiveness	3.67	.55	3.47	.60	4.16	.0001	.34
Teacher supportiveness	3.90	.59	3.87	.48	0.76	N.S.	.05
Open-endedness	3.45	.53	3.09	.45	8.61	.0001	.53
Preparation and organization	3.24	.68	3.17	.67	1.19	NS	.10
Material environment	3.52	.62	3.02	.55	9.64	.0001	.78

*Effect Size.

TABLE 4
The Effect of Preparation for the Field Trip

Scale	Optimal Preparation (*N* = 107) Mean	Optimal Preparation (*N* = 107) SD	Minimal Preparation (*N* = 230) Mean	Minimal Preparation (*N* = 230) SD	*t*	*p*	ES*
Environment interaction	3.43	.56	3.04	.50	6.93	.0001	.73
Integration	4.07	.54	3.74	.51	5.31	.0001	.57
Student cohesiveness	3.74	.52	3.67	.53	1.11	NS	.12
Teacher supportiveness	4.14	.60	3.76	.54	5.74	.0001	.69
Open-endedness	3.68	.52	3.42	.45	4.78	.0001	.49
Preparation and organization	3.50	.63	3.12	.64	5.18	.0001	.56
Material environment	3.82	.58	3.38	.59	6.40	.0001	.69

*Effect Size.

ence and the extent of treatment students received to reduce the psychological, geographical, and cognitive novelties of the outdoor setting. It was found that some of the earth science classes received minimal preparation for the field trip, whereas others received optimal (comprehensive) preparation in relation to the three novelty factors. A similar pattern was also found among the biology classes. Since the chemistry classes were exposed to only minimal concrete preparation, and experienced only passive learning, it was decided to omit this group from this part of the analysis, because we could not distinguish between the preparation effect and the influence of the type of learning during this particular field trip experience.

Comparison of the two approaches in the preparation of outdoor activity revealed clear advantages of optimal preparation (Table 4). These significant differences were entirely supported by the effect size values. Field trips can be successful as an instructional strategy and can create a positive learning environment, provided that students are prepared adequately and have a clear knowledge and understanding regarding the objectives and activities of the field trip. No significant difference was revealed in relation to the "students cohesiveness" scale. Thus, it might be suggested that the type of preparation influenced the students' interaction with the environment, the instructor, and the learning materials, but did not affect the social interactions among the students during the outdoor learning event.

Investigative vs. confirmatory approaches to the field trip. The analysis of teachers' self-reports revealed that most (but not all) of the biology and earth science classes experienced an investigative learning approach, whereas all the chemistry classed underwent a confirmatory type of outdoor event. Here, again, the comparison between the two approaches included only the earth science and biology groups. The students who experienced the confirmatory approach were compared randomly to a similar number of students who experienced an investigative approach to field trips. The first approach emphasized problem-solving tasks and investigation of natural phenomena, whereas the other approach focused on explanations of concepts and phenomena already discussed in the classroom prior to the field trip. Our findings (Table 5) showed an advantage of the investigative approach over the confirmatory approach regarding students' perceptions of the outdoor learning environment. This advantage was demonstrated across each of the seven scales.

TABLE 5
Comparison of the Investigative Versus Confirmatory Approaches to the Field Trip

Scale	Investigative (*N* = 227)		Confirmation (*N* = 180)				
	Mean	SD	Mean	SD	*t*	*p*	ES*
Environment interaction	3.31	.50	3.01	.51	5.84	.0001	.57
Integration	3.98	.50	3.74	.50	4.76	.0001	.41
Student cohesiveness	3.75	.55	3.60	.55	2.59	.01	.26
Teacher supportiveness	4.01	.58	3.74	.53	4.76	.0001	.49
Open-endedness	3.58	.55	3.38	.42	4.04	.0001	.38
Preparation and organization	3.41	.66	3.04	.63	5.68	.0001	.54
Material environment	3.68	.58	3.29	.59	6.68	.0001	.61

*Effect Size.

SUMMARY

This study describes the development and validation of an instrument for use in research focusing on field trips and other outdoor activities. The seven dimensions of the SOLEI (Science Outdoor Learning Environment Inventory) appraise dimensions comprising the actual environment in which outdoor science activities take place. The findings presented in this article are in agreement with the theoretical model developed by Orion (1993) and the findings by Orion and Hofstein (1994) regarding the importance of sound field trip preparation. It was also shown that students who were involved in investigative rather than confirmatory activities perceived the outdoor learning environment to be more positive and perceived their teacher to be more supportive. In addition, the students were more involved in the learning event as compared to those who were involved in the more confirmatory approach.

It is suggested that the differences between the two types of outdoor learning environments, namely industrial and natural sites, can be explained by the passive nature of the industrial visit and by its confirmatory approach. To date, visits to industrial sites have been based mainly on passive listening of the students. Thus, it is suggested that the SOLEI is a sensitive instrument for use as a measure of the extent of students' involvement in the learning process during an outdoor event. In the current study, the absence of actual interactions with the environment during the industrial field trips appeared to have a negative influence on students' perceptions of outdoor learning environments. However, it might be suggested that, if industrial visits could provide a more interactive type of field trip, then students might perceive them to be a more positive event.

It is important to note that, in general, all the groups expressed positive attitudes toward the outdoor learning environment. On the other hand, one has to realize that the outdoor setting is one of the most complicated and costly learning environments. Hence, it is crucial to understand the optimal conditions for the implementation of such activities. The ability of the SOLEI to distinguish between different approaches of outdoor learning suggests directions for the employment of more fruitful activities, which will justify the extensive efforts involved in their implementation.

In conclusion, the SOLEI appears to have a potential for use in further investigations and studies of outdoor learning environments. There is a need, however, to use the instrument on a larger sample in other educational settings with different students' cultural and educational backgrounds. It is also important to conduct a correlation study to find out the interrelationships between the outdoor learning environment and other cognitive and affective variables related to the type of activities to which the student is exposed during the outdoor event.

It is our hope that, after modifications and specific adaptations, both researchers and teachers will make use of the SOLEI in assessing and evaluating outdoor learning. Furthermore, it is suggested that the SOLEI could serve as an effective tool for investigating and expanding our knowledge regarding outdoor learning activities in general and field trips in particular.

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