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ORIGINAL PAPER

Identifying students' perceptions of the important classroom features affecting learning aspects of a design-based learning environment

Yaron Doppelt · Christian D. Schunn

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Abstract Across several decades, educational researchers have investigated the contribution of the learning environment to the attainment of educational goals, such as improving academic achievement and motivation to learn. The term learning environment not only includes physical activities in the classroom (e.g. experiments kits, computers), but also includes teaching methods, the type of learning in which pupils are engaged, and assessment methods. In this research, we refined an approach to measuring the impact of a variety of classroom features on many different learning outcomes through the lens of students' perception. A new instrument, the Design-Based Learning Environment Questionnaire (DBLEQ), was field-tested in an eighth-grade USA science classroom setting. This study examined pre-post changes for two different curricula, one emphasising design-based learning ($n = 464$) and another emphasising scripted inquiry ($n = 248$). The value of the instrument and ways of analysing its data are illustrated through the range of differences that were found between conditions over time.

Keywords Classroom features · Design-based learning · Learning environment · Learning outcomes · Science and technology

Introduction

What is the science classroom like in a particular setting? This is a common question in learning environment research. Previous research has investigated pupils' perceptions of their learning environment using questionnaires that assess classroom characteristics such

Y. Doppelt (✉) · C. D. Schunn
Learning Research and Development Center (LRDC), University of Pittsburgh, Pittsburgh, PA, USA
e-mail: yaron@pitt.edu

C. D. Schunn
e-mail: schunn@pitt.edu

Present Address:
Y. Doppelt
194 Hadror Street, Segev 20170, Israel

as Friction, Cohesiveness, Satisfaction, Difficulty, Competitiveness, Diversity, Goal Direction, Formality, Material Environment, Disorganisation and Democracy (Fraser 1998; Fraser et al. 1995; Henderson et al. 2000). Wong and Fraser (1996) recommended investigating the impact of learning environment characteristics on learning outcomes by using a combination of quantitative and qualitative tools in the same research.

We present a new approach for evaluating the classroom learning environment that focuses on the question: How important are particular classroom features for different learning aspects? This investigation of the interactions is in contrast to a separate investigation of classroom features or learning aspects in isolation. We suggest that, by focusing the question on the direct influence of classroom features on different learning aspects, teachers and researchers can gain more knowledge about how to improve or adjust the learning environment.

Pupils evaluated the importance of these interactions via Likert ratings. Because pupils' Likert ratings might not always faithfully represent their perceptions, we also asked pupils to justify one high score and one low score. The content of such justifications can help to establish the validity of the ratings. Moreover, the justifications helped to provide a deeper understanding of why certain environmental characteristics tend to be associated with certain learning aspects.

In order to field-test this instrument, we applied it to the context of middle-school students in a mid-sized urban school district using a scripted inquiry science curriculum and a new design-based learning module (Doppelt et al. 2004). In an attempt to gain an impression of the broader impacts of the design-based learning environment on pupils, we also asked the pupils to rate their interest in continuing to study science in high school.

Learning environment research

The term learning environment relates to the psychology, sociology and pedagogy of the contexts in which learning takes place and their influence on pupils' achievement in the cognitive and affective domains.

Researchers have previously created numerous different questionnaires based upon the classic definition of behaviour of the learner being a function of the environment and the learner's personality (Lewin 1936). Three of these questionnaires are overviewed in Table 1. These questionnaires have been used in many studies across the world. They include various items divided into the scales that are presented in Table 1.

These questionnaires have enabled researchers to study and build a broad perspective on different factors that are involved in the learning process. However, there is no differentiation in these questionnaires between learning activities and the outcomes of the learning process. These questionnaires do not refer directly to the influence of a particular learning environment characteristic on a particular learning outcome.

Various characteristics of the learning environment have been found to influence learning outcomes (Fraser 1998; Fraser et al. 1995; Henderson et al. 2000), including class arrangements, computers, laboratory experiment kits, teaching methods, learning styles and assessment methods (Doppelt and Barak 2002).

Learning environment research has examined academic achievement and other learning outcomes in the cognitive and affective domains (Doppelt 2004; Doppelt and Barak 2002) to build a broad understanding of the variables involved. According to Fraser (1998, p. 528): "Defining the classroom or school environment in terms of the shared perception of the pupils and teachers has the dual advantage of characterising the setting through the eyes

Table 1 Scales in prior learning environment questionnaires

Instrument	Scales		
	Relationship	Personal development	System maintenance and change
LEI—Learning Environment Inventory (Fraser et al. 1982)	Friction	Rate (speed)	Diversity
	Cliqueness	Difficulty	Goal direction
	Cohesiveness	Competitiveness	Formality
	Favouritism		Material environment
	Satisfaction		Disorganisation
	Apathy		Democracy
SLEI—Science Laboratory Environment Inventory (Fraser et al. 1995)	Student cohesiveness	Open-endedness	Rule clarity
		Integration	Material environment
CLES—Constructivist Learning Environment Survey (Taylor et al. 1997)	Personal relevance	Uncertainty	Shared control
	Student negotiation	Critical voice	

Moos (1974) proposed the three types of dimensions (Relationship, Personal development, System maintenance and change)

of the participants themselves and of capturing data, which an external observer could miss or consider unimportant."

Finally, several researchers have recommended combining quantitative and qualitative tools for learning environment research in order to achieve wide and deep perspectives on the research field (Fraser and Tobin 1991; Wong and Fraser 1996).

Design-based learning

Authentic science learning environments, such as larger projects or simply designing experiments, can enable pupils with different learning styles to express their skills and talents (Nicaise et al. 2000). A design process is similar to problem solving with a general structure of six stages: defining the problem and identifying the need; collecting information; introducing alternative solutions; choosing the optimal solution; designing and constructing a prototype; and evaluation and correction of the process.

Science and technology projects allow pupils to study subjects that are taken from their own surrounding world. When pupils are given the opportunity to create something that fits their needs, they can decide about their priorities. They also can design, build and assess their activities and products, thus realising that much depends on themselves, not on others. Through such experiences, pupils gain self-esteem and personal responsibility (Waks 1995). Including the teaching of thinking skills in a specific disciplinary course can provide a rich learning environment that will contribute not only to the development of thinking skills, but also to a better understanding for the pupils of the discipline under study (Doppelt 2003; Ennis 1989; Glaser 1993; Zohar and Tamir 1993).

Various approaches for teaching science and technology are suggested in the literature. De Vries (1996) claims that we should help pupils to integrate knowledge (scientific and other bodies of knowledge) into their design processes. Project-based learning (PBL) could be used as a tool to develop pupils' competencies by working on integrated projects (Barlex 2002). Authentic projects are ones that deal with real-life situations and have an integrated nature. A number of researchers have noted the advantages of design-based learning (DBL) as a means for increasing motivation, developing higher-order cognitive skills, and fostering personal and interpersonal traits (Barak and Raz 1998; Doppelt 2003). This approach has been experienced throughout the world, with research showing interesting findings regarding the opportunities of DBL (Barak and Doppelt 1999, 2000; Barak et al. 1995; Barlex 1994; Doppelt and Barak 2002; Resnick and Ocko 1991).

Design-based learning not only was shown to be effective in teaching science concepts (Mehalik et al. 2008), but also was found to enhance the achievement of all learners (Doppelt in press). This article explores relationships between particular classroom features and learning aspects for a DBL curriculum implemented in science.

Method

This research identified the most important classroom features and learning aspects in DBL through an analysis of the combined responses of pupils using the DBLEQ, which was specifically developed for this purpose.

Participants and process

In this research, an experimental group of 587 Grade eight pupils (14–15 years old) from nine different schools studied electronics using DBL. A contrast group of 466 pupils from six different schools in the same school district learned electronics using scripted inquiry. The participants completed the DBLEQ before and after they began studying electronics. Four hundred and sixty-four participants from the experimental group and 248 from the contrast group completed both pretest and posttest questionnaires.

Data collection and analyses

The current study was conducted at middle schools in a mid-size, urban public school district in the USA. In collaboration with district leaders and teachers, university researchers developed the Electrical Alarm System module in the winter of 2003–2004 (Doppelt et al. 2005). The reform curriculum was designed to supplement and partially replace the first 4–6 weeks of instruction in the established curriculum with an open-ended design project. In 2004–2005, the district officially adopted the reform curriculum and encouraged all teachers to implement it in their classrooms.

The structure and content of the DBLEQ was based on similar questionnaires used in studies of design-based learning (Doppelt 2004, 2006; Doppelt and Barak 2002). The first study (Doppelt and Barak 2002) dealt with the learning environment of design-based learning in technology education in high schools in Israel. The second and the third studies dealt with the learning environment of a science curriculum in middle schools in Israel.

In the current study, a combined questionnaire was developed to explore classroom features and learning aspects of a learning environment that integrated design and science.

From our observations and other data analysed elsewhere (Doppelt et al. 2006), we found that both inquiry and design-based settings have similar kinds of classroom features and learning outcomes. As these environment features can have different effects on student learning in the two settings, it is possible to explore pupils' perspectives on the most influential classroom features and learning aspects using a common instrument.

How important is each

Classroom Feature	for each Learning Aspect
Team projects	Good relationships with the teacher
Designing activities	Desire to learn
Performing experiments	Self-confidence
Acceptance of mistakes	Being challenged
Tolerance of different opinions	Thinking skills
Freedom to choose the learned topics	Success in the science class
Instructional worksheets	Desire to come to class
Independent learning activities	Motivation to work at home
Class discussions	Making me feel responsible for my learning
Thinking activities	Making me feel independent
Constructing activities	Making me curious
Using the computer	Interest in science topics
Different learning experiences	Understanding the ideas in class
Homework	Teamwork skills

Fig. 1 A mapping sentence for the DBLEQ

In this study, the term 'classroom features' refers to the learning environment characteristics and the term 'learning aspects' refers to the learning outcomes. The DBLEQ is based on the question that is described in Fig. 1, which serves as a mapping sentence that provides a flexible structure for researchers and teachers to construct and use in classes (Waks 1995). In this structure of 14 learning environment characteristics and 14 learning aspects, the questionnaire could have 196 items. In order to reduce the number of items that a given student is required to complete, we created four versions. Each version includes 49 items (7 learning environment characteristics with 7 learning aspects). Each student was randomly assigned to receive one of the four versions. Each questionnaire asks students to score 49 items on a scale ranging from 5 (Very High Importance) to 1 (Very Low Importance).

All pupils in this study had responded to the DBLEQ as a pretest before teachers started to teach Electronics. Pupils responded to the DBLEQ as a posttest in the first week of June at the end of the school year. Teachers were asked to devote one period (45 min) to the completion of the questionnaire by their students.

Two types of questionnaire reliability were examined: stability and Cronbach's α. Pupils were asked to justify one high score and one low score to serve as a criterion in examining the validity of the questionnaire.

Figure 2 presents the final questionnaire.

Findings

First, we present an analysis of the most influential characteristics and major outcomes. Second, we apply factor analysis to reduce the characteristics and outcomes to be considered and then compare pretest and posttest results on the questionnaire.

Pupils' perceptions on the most influential characteristics and major outcomes

Every characteristic can influence several learning outcomes in the affective and cognitive domains. Here we compare perceptions of pupils in the two research groups in terms of the most influential characteristics and major outcomes of the learning environment.

We begin with the basic question of whether ratings were higher overall in one group than the other, either indicating halo effects on ratings or that ratings generally were more positive for one group more than another. Because the overall ratings of the experimental

Classroom Features	Learning Aspects													
	Good relationship with the teacher	Desire to learn	Self-confidence	Being challenged	Thinking skills	Success in the science class	Desire to come to class	Motivation to work at home	Make me feel responsible for my learning	Make me feel independent	Make me curious	Interest in science topics	Understand-ing the ideas in class	Teamwork skills
Independent Learning Activities														
Class Discussions														
Thinking Activities														
Constructing Activities														
Using the Computer														
Different Learning Experiences														
Homework														
Team Projects														
Designing Activities														
Performing Experiments														
Acceptance of Mistakes														
Tolerance of Different Opinions														
Freedom to Choose the Learned Topics														
Instructional Worksheets														

Fig. 2 The final questionnaire—rating the importance of each classroom feature on each learning aspect

group were not significantly different from those of the contrast group, using a *t*-test, we need not worry about overall differences in using the ratings across groups as we examine more specific differences.

Figures 3 and 4 present the mean scores from the two groups for the full matrix of influence of each characteristic on each outcome. The highest means in each group are bolded. Although there are general similarities, there are also some differences.

We next examine trends in differences between groups for each particular learning environment characteristic (across outcomes) and for each particular learning outcome (across learning environment characteristics).

Focusing on the learning environment characteristics, the highest mean scores for the experimental group (M_e) and the control group (M_c) were Homework ($M_e = 2.79$, $M_c = 3.43$), Instructional Worksheets ($M_e = 2.64$, $M_c = 3.38$). Additionally, the experimental group gave high ratings for Using the Computer ($M_e = 2.62$).

Turning to outcomes, the highest mean scores for outcomes were Motivation to Work at Home ($M_e = 2.68$, $M_c = 3.49$), Interest in Science Topics ($M_e = 2.57$, $M_c = 3.45$), Making me Curious ($M_e = 2.57$, $M_c = 3.39$). Additionally, the experimental group highlighted Good Relationships with the Teacher ($M_e = 2.50$) more than the contrast group did, and the contrast group highlighted Independent Learning Activities ($M_c = 3.37$) more than the experimental group did.

Figures 5 and 6 show that the experimental group rated many of the characteristics lower, despite its curriculum being more engaging and demanding overall (from analyses of concept learning and classroom observations of engagement). This trend in the DBLEQ is perhaps explained by the fact that the developed module engaged the experimental group in activities that encourage critical thinking, which also could have influenced their critical evaluations. From our classroom observations, we suspect that the high scores for Homework and Instructional Worksheets could be explained by the fact that, for both teaching methods, the class and homework assignments were short and focused. In practice, the computer was rarely used in the newly-developed DBL curriculum or in the traditional scripted enquiry used by the contrast group, and therefore we cannot explain these data.

Comparison between pretest and posttest responses

The large number of potential variables was reduced using factor analysis to enable pre-post comparison without obtaining too many differences just by chance, as well as to focus attention on common trends. The 14 original characteristics can be reduced to eight and the 14 original learning outcomes can be reduced to six. Table 2 provides a comparison of scale scores obtained by the experimental group on the pretest and the posttest.

The results show that Homework ($M = 2.87$) and Instructional Worksheets ($M = 2.71$) were the most influential characteristics. From the outcomes viewpoint, Interest in Science Topics ($M = 2.66$), Teamwork Skills ($M = 2.61$), and Independent Learning Activities ($M = 2.60$) were found to be the most impacted outcomes.

Interest in majoring in science

Students were requested to score their interest in taking science classes in high school. The scale ranged from 5 (Very Interested) to 1 (Very Uninterested). Figure 7 presents a comparison of the experimental group with the contrast group.

Learning Environment Characteristic	Mean score														
	Good relationship with the teacher	Desire to learn	Self-confidence	Being challenged	Thinking skills	Success in the science class	Desire to come to class	Motivation to work at home	Make me feel responsible for my learning	Make me feel independent	Make me curious	Interest in science topics	Understand-ing the ideas in class	Teamwork skills	Mean
Independent Learning Activities	2.36	2.09	1.88	2.17	1.86	2.15	2.17	**2.64**	1.99	1.88	2.43	**2.70**	2.40	**3.29**	2.29
Class Discussions	2.16	2.27	2.10	**2.58**	2.26	2.24	2.37	**2.89**	**2.67**	**2.95**	**2.70**	**2.59**	2.02	2.03	2.42
Thinking Activities	**2.61**	2.31	2.20	2.08	1.85	2.19	2.26	**2.73**	2.29	2.42	2.25	**2.55**	2.44	**2.59**	2.34
Constructing Activities	2.34	2.07	2.32	2.05	2.24	2.17	2.13	2.37	2.36	**2.71**	2.46	**2.68**	2.43	2.22	2.33
Using the Computer	**2.97**	2.38	**2.57**	**2.59**	**2.57**	**2.59**	2.35	2.46	**2.74**	2.35	**2.78**	**2.84**	**2.60**	**2.83**	**2.62**
Different Learning Experiences	2.34	2.25	2.07	2.17	1.89	2.03	2.22	**2.60**	2.37	**2.60**	2.29	**2.64**	2.20	2.44	2.29
Homework	**3.30**	**2.90**	**2.52**	2.50	2.33	**2.63**	**3.23**	**2.64**	2.35	2.33	**2.94**	**3.20**	**2.73**	**3.49**	**2.79**
Team Projects	**2.58**	2.13	**2.70**	2.35	2.02	2.06	1.83	**2.98**	2.43	**3.14**	2.46	2.18	2.18	1.64	2.33
Designing Activities	2.36	2.14	2.21	1.96	2.25	2.01	2.27	2.46	2.07	2.35	2.34	2.25	2.05	2.09	2.20
Performing Experiments	2.11	2.04	2.05	2.14	2.00	2.19	2.08	**2.51**	2.25	2.36	2.22	2.07	1.99	2.03	2.14
Acceptance of Mistakes	2.42	2.21	2.26	2.38	**2.52**	2.25	2.38	**2.84**	2.17	2.44	**2.86**	**2.70**	**2.70**	2.45	2.47
Tolerance of Different Opinions	2.31	2.35	2.50	2.33	2.45	2.15	**2.52**	**3.04**	**2.52**	**2.75**	**2.66**	**2.61**	**2.66**	2.12	2.50
Freedom to Choose the Learned Topics	2.44	2.30	2.46	**2.55**	2.31	2.18	2.25	2.49	2.22	2.10	**2.64**	2.24	2.46	2.43	2.36
Instructional Worksheets	**2.75**	**2.61**	**2.80**	**2.74**	2.37	2.32	**2.93**	**2.81**	2.42	**2.59**	**2.99**	**2.70**	2.34	**2.63**	**2.64**
Mean	**2.50**	2.29	2.33	2.33	2.21	2.23	2.36	**2.68**	2.35	2.50	**2.57**	**2.57**	2.37	2.45	

Fig. 3 Mean scores for the experimental group. *Note*: The highest means in each group are bolded

Learning Environment Characteristic	Mean score													
	Good relationship with the teacher	Desire to learn	Self-confidence	Being challenged	Thinking skills	Success in the science class	Desire to come to class	Motivation to work at home	Make me feel responsible for my learning	Make me feel independent	Make me curious	Interest in science topics	Understand-ing the ideas in class	Teamwork skills	Mean
Independent Learning Activities	3.24	2.48	2.56	2.72	2.65	3.01	2.95	**3.50**	2.55	2.67	**3.32**	**3.50**	2.99	**3.70**	2.99
Class Discussions	2.64	2.59	3.12	3.23	2.72	2.95	3.08	**4.03**	**3.49**	**3.79**	3.21	**3.35**	2.97	2.93	3.15
Thinking Activities	**3.30**	2.55	3.04	2.85	2.56	2.86	3.10	**3.44**	3.29	3.27	3.18	**3.57**	2.94	3.11	3.08
Constructing Activities	2.91	2.91	3.00	3.04	2.92	2.62	3.13	3.26	3.10	**3.49**	3.27	**3.32**	3.04	2.78	3.06
Using the Computer	**3.68**	2.99	3.29	3.19	3.09	3.04	3.12	2.81	2.96	2.99	**3.35**	**3.36**	2.98	3.06	3.14
Different Learning Experiences	2.88	2.60	2.93	2.91	2.86	2.49	2.82	**3.42**	3.11	**3.36**	**3.32**	**3.38**	2.89	2.97	3.00
Homework	**3.72**	3.14	3.24	**3.32**	3.19	**3.41**	**3.73**	3.27	3.22	3.28	**3.55**	**3.97**	**3.43**	**3.59**	**3.43**
Team Projects	3.14	2.62	3.18	2.84	**3.31**	2.77	3.10	**3.73**	**3.37**	**4.30**	**3.49**	**3.46**	3.09	2.90	3.23
Designing Activities	3.14	3.30	3.11	3.07	3.13	3.07	3.26	**3.44**	3.08	3.06	3.26	3.09	3.10	3.19	3.16
Performing Experiments	3.08	3.19	2.96	3.21	3.02	3.12	3.24	**3.53**	3.06	3.03	**3.37**	3.01	3.18	3.29	3.16
Acceptance of Mistakes	3.19	3.18	**3.36**	3.28	3.22	3.24	3.16	**3.63**	3.23	**3.32**	**3.30**	**3.58**	3.27	**3.62**	**3.33**
Tolerance of Different Opinions	3.19	3.06	3.13	3.08	3.18	3.05	3.15	**3.60**	**3.74**	**3.93**	**3.54**	**3.49**	**3.33**	**3.36**	**3.34**
Freedom to Choose the Learned Topics	3.09	3.05	3.19	**3.35**	3.15	3.13	3.04	**3.57**	2.89	3.09	**3.52**	**3.47**	2.94	**3.37**	3.21
Instructional Worksheets	3.09	3.07	3.23	3.25	3.27	3.26	3.18	**3.64**	3.24	**3.65**	**3.83**	**3.77**	**3.37**	**3.42**	**3.38**
Mean	3.16	2.91	3.10	3.10	3.02	3.00	3.15	**3.49**	3.17	**3.37**	**3.39**	**3.45**	3.11	3.24	

Fig. 4 Mean scores for the contrast group. *Note*: The highest means in each group are bolded

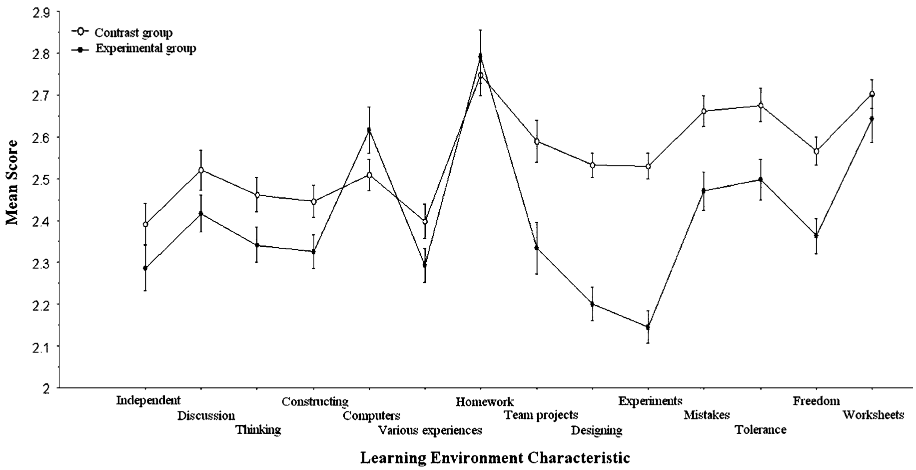

Fig. 5 Mean ratings (with *SE* bars) for each learning environment characteristic for experimental and contrast groups

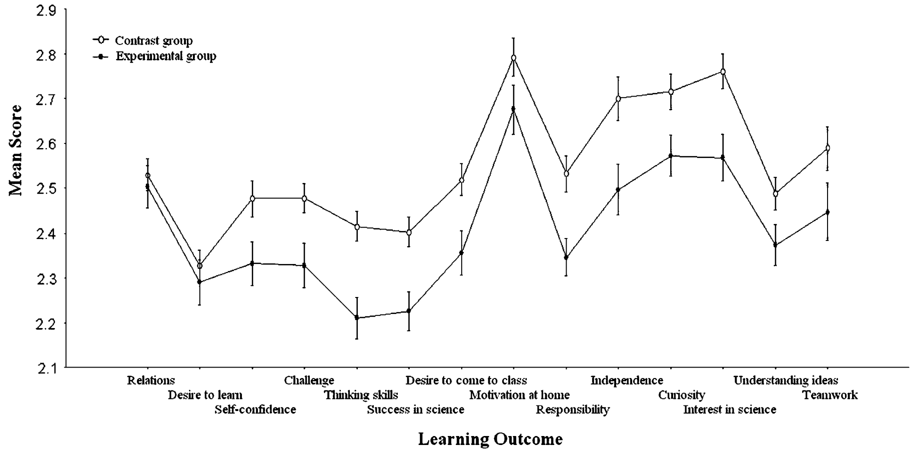

Fig. 6 Mean ratings (with *SE* bars) for each learning outcome for experimental and contrast groups

When a *t*-test was conducted for differences between the two groups in interest, no significant difference was found. There was a significant improvement in interest between pretest and posttest for the experimental group (Fig. 7). However, there was no significant difference between pretest and posttest interest for the contrast group. In addition, there was a significant difference between the experimental and contrast groups in terms of posttest interest scores (Fig. 7). Of the students in the experimental group, 19% showed an increase in interest, compared with only 9% in the contrast group.

Questionnaire reliability and validity

Two types of the reliability were examined for the questionnaire: stability reliability and Cronbach's α coefficient. The stability reliability was determined by analysing the

Table 2 Comparison of pretest and posttest means for learning environment characteristics for the experimental group

Learning environment characteristic	Cognitive		Affective		Desire to come to class		Independence		Science interest		Teamwork		*M*	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Science-design activities	2.02	2.20	2.27	2.34	2.09	2.25	2.50	**2.63**	2.33	2.43	1.89	2.25	2.18	2.35
Tolerance	2.43	2.46	2.41	2.43	2.50	2.47	**2.73**	**2.79**	**2.70**	**2.73**	2.46	2.60	2.54	2.58
Freedom to choose	2.29	2.35	2.35	2.44	2.38	2.33	2.26	2.42	2.48	2.49	2.49	**2.66**	2.37	2.45
Instructional worksheets	2.45	2.53	**2.64**	**2.61**	**2.83**	**2.66**	**2.64**	**2.74**	**2.84**	**2.95**	**2.71**	**2.74**	**2.69**	**2.71**
Cognitive activities	2.13	2.17	2.41	2.34	2.28	2.37	2.57	**2.64**	2.53	2.53	2.58	2.57	2.42	2.43
Construction activities	2.14	2.23	2.43	2.54	2.19	2.35	2.39	2.59	2.42	2.53	2.29	2.22	2.31	2.41
Using the computer	2.55	**2.63**	2.59	**2.85**	2.32	2.57	2.53	2.42	2.49	**2.66**	**2.91**	**2.77**	2.56	**2.65**
Homework	2.50	**2.62**	**2.82**	**2.82**	**2.96**	**3.15**	2.56	2.58	**2.81**	**2.94**	**3.03**	**3.10**	**2.78**	**2.87**
Mean	2.31	2.40	2.49	2.55	2.44	2.52	2.52	**2.60**	2.57	**2.66**	2.55	**2.61**		

Values significantly above the mean are in bold type

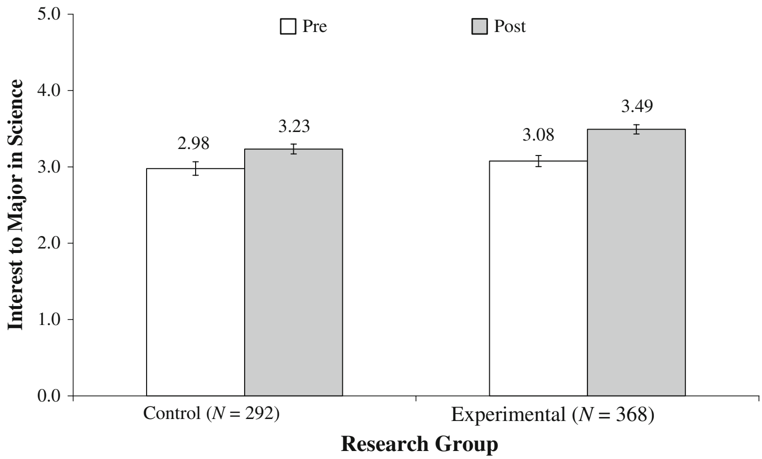

Fig. 7 Mean interest in science (with standard error bars) for pretest and posttest for both groups

correlation between pretest and posttest ratings. This Pearson correlation was $r = 0.4$ ($p < 0.01$). Cronbach's α coefficient for the questionnaire was found to be 0.78. These levels of stability and internal consistency are quite high for a questionnaire administered in an urban middle-school setting.

The questionnaire was simple to answer, as students considered only one repeated question: "How important is each classroom feature for each learning aspect?" Yet sometimes students did not reflect carefully while doing Likert ratings. Therefore, students

Table 3 Examples for common pupils' justifications

Learning environment characteristic	Outcome			
	Good relationship with the teacher	Desire to learn	Self-confidence	Motivation to work at home
Class discussions	When dealing with class discussions, you have to have a good relationship with the teacher. This way, you can agree or disagree in a good way.	The desire to learn is very important for classroom discussions. If you don't want to learn, then nobody participates and the discussion cannot happen.	You have to have the self-confidence to ask the question to know the answer.	I don't like science very much. I don't like to come to school.
Constructing activities	Constructing activities in the class always goes more smoothly with good relationships with your teacher. Mostly they can help you and guide you with things you need help with.	This is the most important because, when you construct something, you have to think.	Constructing activities is a very good way to boost self-confidence. I believe this because you can look at what you have done and be proud.	It is important because constructing activities helps children understand more things about science.
Team projects	When we have to do projects, the teachers are there to help.	You need to have a desire to learn in order to do a team project. If you don't, you won't be motivated to do well.	Working in groups without so many guides is very challenging.	Taking responsibility to finish work at home prepares me for high school.
Acceptance of mistakes	The relationship with my teacher and acceptance of mistakes are very important to me.	Acceptance of mistakes is good for a desire to learn because it makes you think and mistakes can be fixed.	Acceptance of mistakes is good for yourself and a healthy life.	If I make a mistake, I can change it instead of being laughed at.
Freedom to choose the learned topics	If we got to learn what we want, we would like class way more. We would be learning what we want to learn and not this boring stuff.	The difference between desire to learn and freedom to choose could make a successful class.	It is important because you need self-confidence because you need to know that confidence is in learning. Freedom to choose the learned topics because we have to learn.	The class should be able to pick the classroom topic.

were asked to pick one high score and one low score and to give a reason why they rated highly the importance of a specific classroom feature to a specific learning aspect. Using students' qualitative justifications, we can discover if they understood the content of the questionnaire. Table 3 presents some of the common reasons that students used to justify their scoring.

The reasons that pupils used to justify their scores varied in appropriateness. Three assessors rated the quality of the pupils' responses to a specific classroom feature and a specific learning aspect. We used a scale of 5–1. If the response fitted both classroom feature and learning aspect, the assessor rated 5 or 4; if the response fitted one of them, the assessor rated 3 or 2; and if it did not fit at all, the assessor rated 1.

We used Cohen's Kappa to measure the agreement between the evaluations of each of the peers of three individual evaluations. Each assessor rated the same objects. A value of 1 indicated perfect agreement. A value of 0 indicated that agreement is no better than chance. The agreement (Cohen's Kappa) was 0.90 between assessor 1 and assessor 2, 0.81 between assessor 1 and assessor 3, and 0.79 between assessor 2 and assessor 3. These Kappa values are quite high, showing that our ratings were highly reliable.

The average rating was 3.54 ($SD = 1.33$), suggesting that pupils did generally appear to understand the ratings task.

Discussion and conclusions

This study had two main goals. The first goal was to identify the characteristics of design-based learning environments. The second goal was to investigate whether pupils' perceptions of learning environment characteristics impact on learning outcomes.

Design-Based Learning Environment Questionnaire (DBLEQ)

The DBLEQ developed in this study could be used by educators and researchers to explore different groups and different learning environments. We used the DBLEQ to investigate the impact of learning environment characteristics on learning outcomes from the pupils' perspectives. The questionnaire results showed that pupils had differentiated views of the impact of learning environment characteristics upon different learning outcomes.

According to pupils' perceptions, the most influential characteristics of design-based learning environments were Homework and Instructional Worksheets. We cannot explain why Homework was perceived to be an important feature, because the DBL curriculum did not specifically instruct teachers to give pupils homework assignments. However, the DBL curriculum did have instructional sheets especially for documenting the design. This might explain why pupils rated this feature to be very influential. The learning outcomes were Motivation to Work at Home, Interest in Science Topics and Making me Curious. These outcomes might signal that both curricula motivated pupils' learning. Although both groups scored the influence of the characteristics on outcomes similarly, the experimental group reported a significantly higher interest in choosing science as a major in high school after they finished the design-based learning module.

The high quality of pupils' justifications for their ratings suggest that the questionnaire can serve as a valid instrument for investigating pupils' perceptions regarding the importance of the classroom features to the learning aspects. The DBLEQ might be used to assist educators and researchers in exploring different groups and different learning environments.

Contrast with prior studies

Our findings are in contrast to those of previous studies in different settings. In a previous study that explored pupils' perceptions of their learning environment in an Israeli comprehensive high school (Doppelt and Barak 2002), the overall learning environment involved designing authentic team projects in LEGO-Logo. That study revealed that pupils rated Team Projects and Constructing Activities as the most influential characteristics upon the learning outcomes. The most impacted outcomes were: Understanding the Ideas in Class, Interest in Science Topics and Good Relationships with the Teacher. The findings might be explained not only by cultural differences, but also by content differences (such as the length of the intervention) and the students selecting science-technology rather than being required to take a science class in middle school.

In another research study, middle-school science pupils involved in a design-based learning experience of longer duration than the current study rated Team Projects, Class Discussions and Performing Experiments as the most influential characteristics upon their learning environment. The most impacted learning outcomes according to pupils' rating were Understanding the Ideas in Class, Interest in the Science Topics, Independent Learning Activities, and Desire to Learn (Doppelt 2004). Again the differences might have resulted from a different length of intervention, in that longer design-based learning experiences are required for producing very different styles of learning and perceptions of the learning. These two examples suggest that further research needs to be undertaken to explore pupils' perceptions of their learning environment.

This article focused on differences between pupils' perceptions of the impact of learning environment characteristics on learning outcomes across different learning environments and across time. Teachers and researchers can gain insights into how to further improve learning environments by exploring pupils' perceptions of the learning environment. Further research is needed into factors underlying pupil perceptions regarding the impact of learning environment characteristics on learning outcomes.

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