Assessment of the constructivist physics learning environments

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Abstract

Nearly last two decades, constructivist theory has had a great importance in shaping science learning environments. Learning theories have been implemented in different instructional models in learning environments. Measuring learning environments has been found to be sensitive and related to instructional methods, and they can be used in order to improve teaching in certain scientific subjects taught in schools. The purpose of this study is to develop and use a survey according to a constructivist 5E model to assess related factors effecting the physics learning environments. Interviews and classroom observations are used to confirm the constructed survey.

Keywords: Physics education, constructivism, learning environments

Introduction

Professionals are exposed to demanding requirements in society today. Increasing internationalization, the growing proportion of knowledge-intensive work, the rising usage of information technology, and a new organization of work based on networks and teams have extended the range of abilities needed in a professional workforce. What new world expects of individuals is not only a good command of relevant knowledge, but diversified social, communication and cooperation skills, ability to work in different contexts with experts from other fields, and ability to critically select, acquire, reproduce, and use knowledge. Since today's society and working life are rapidly changing, individuals must continuously construct and reconstruct their expertise in a process of lifelong learning. Therefore, these requirements pose considerable challenges to educational systems that are expected to produce experts for the world of the future (Tynjala, 1999).

Until the last few decades, research involving science students' outcomes focused primarily on educational objectives in behavioral theory, but in more recent times, attention has been given to process of the cognitive and affective domain. In this context, constructivism and similar cognitive theories also represent a paradigm shift from behavioral to cognitive theory. Constructivism is to premise new cognitive meanings to describe learning. For example, constructivist conceptions of learning assume that knowledge is individually constructed and socially co-constructed by learners based on their interactions in an environment. The meaning that learners construct depends on their needs, beliefs and prior knowledge. Piaget (1973), one of the eminent leaders in the fields of learning theory and cognition, asserted that, "*The basic principle of active methods will have to draw its inspiration from the history of science and may be expressed as follows: to understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simply repetition.*" (p.20) In that respect, constructivism is an epistemology that views knowledge as being "constructed" (or generated) within learners' minds as they draw on their existing knowledge to make sense of perplexing new experiences (Akdeniz & Keser, 2002). From the constructivist perspective, learners attempt to make good sense of their new learning experiences by constructing their ideas or understandings from, and in relation to, their existing network of concepts. This process of conceptual assimilation involves incremental knowledge growth and only a small degree of perplexity for the alert and motivated learner with appropriate background knowledge. Therefore, one of the challenges facing a good teacher is to provide learning experiences that enable students to critically appraise the quality of their background knowledge (Churach & Fisher, 2001). Without this foundation, the connection with and between new ideas and understandings is likely to remain tenuous or shallow. In this process, learning environments have the most important role for the learner facing their experiences (Akdeniz & Keser, 2002).

An environment in which students are given an opportunity to explore and generous access to information resources – books, CD's, print and video materials, etc., and tools – word-processing programs, e-mail, search tools, etc. – are likely to learn something if they are also given proper support or guidance. Under this conception, learning is fostered and supported, but not controlled or dictated in any strict fashion. For this reason, it is desirable to hear less about instructional environments and more about learning environments. Thus, a learning environment can be defined is a place where learning is fostered and supported. Wilson emphasized (1996) learning environments, as opposed to instructional environments, in order to promote "a more flexible idea of learning," and he also stressed "meaningful, authentic, intentional, complex, cooperative and reflective learning activities that help the learner to construct and develop skills relevant to problem solving." These characteristics have been seen among the goals of constructivist learning environments. According the Wilson (1996), one definition of constructivist learning environments is "*a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities*." (p5)

Perkins (1991) distinguishes between constructivist and traditional learning environments. Constructivist learning environments contain more construction kits, phenomena and place more control of environment in hands of learners themselves. In such places, students are typically engaged in multiple activities in pursuit of multiple learning goals, with the teacher serving the role of coach and facilitator; whereas traditional classrooms would be a lean learning environment with relatively few tools for manipulating and observing content, making exploration and problem solving. Perkins also emphasizes differences in the amount of guidance or direct instruction found in learning environments, and he notes that poorly designed learning environments are vulnerable to failure due to the lack of support, leaving students with unreasonable performance expectations.

Learning environments in science have been studied extensively in last 30 years in order to determine their relationship to instructional strategies and social interaction between participants. These studies have shown that learning environments are closely related and sensitive to instructional methods. From this point of view, how we learn has been viewed as more important than what we actually do learn. Therefore, measures of learning environments can be used in order to improve instructional models and pedagogy in certain scientific subjects taught in schools (Hofstein, Nahum & Shore, 2001). All of these measures are a call for varying the instructional techniques that are used in the science classroom that will improve the learning environment. The most important mission for researchers, teachers and any decision-makers should be monitoring and assessing running processes in selected instructional models and designed learning environments according to related theories. This process should not only involve achievement tests, attitude scales, interviews and observations, but also include multiple research approaches, which should be composed of qualitative and quantitative data collection techniques and analyzing interrelated findings for any confirmation and comparison (Aldridge, Fraser & Huang, 1999; Akdeniz & Keser, 2002, Chang & Fisher, 2003). Hence, multiple research instruments have been designed for reliability and validity, which are very vital to secure an in-depth understanding of the learning environment and to provide richness to whole. In the last years, most learning environment research has involved students in several countries. Fraser (2002) gives the examples of these instruments as The *Cultural Learning Environment Questionnaire*–CLEQ (Waldrip & Fisher, 2000), the *Constructivist Learning Environment Survey*–CLES (Aldridge, Fraser & Taylor, 2000) and *What Is Happening In This Class*–WIHIC (Aldridge et al., 1999) . Although these instruments have been used and validated, many of the questionnaires overlap in what they measure; some contain items that might not be pertinent in current classroom settings. Furthermore, none of the instruments referred were specifically designed to assess any instructional model.

Constructivist theory has been implemented with several instructional models in education recently. The most commonly used model, with a convenient format to view constructivism, has been defined by 5E model (Smerdan & Burkam, 1999). In this model, the process is explained by employing five "E"s. They are: enter/engage, explore, explain, elaborate and evaluate.

The 5E Model is explained as follows. **Engagement/enter** is where teacher engages students in a new concept using short activities or problematic questions, thus, students' pre-existing knowledge is activated. **Exploration** is where student generate new ideas not only carried out during activities such as lab activities, group discussion, hands-on activities, but also conducted as a preliminary investigation by means of the problems created in their minds during the engagement stage or their own pre-existing knowledge. **Explanation** is the most important phase in 5E model. Sahin et al. (2009) stated that the explanation phase is the most teacher-centered phase in 5E model. And teachers directly introduce a concept, a process or a skill so that (s)he confirms/disconfirms students' experienced knowledge claims (Sahin et al. 2009). This definition may only be appropriate to traditional teaching approaches and is not acceptable for application to the constructivist theory. In contrast, student in this phase explain their solutions with evidence about their research problems that are determined in the engagement phase (Keser, 2003). Explanation gives students the opportunity to explain their findings to others. Students must first give their explanations while the teacher subsequently introduces relevant scientific explanations. These explanations need to be clearly linked to the engagement and exploration activities as well as student explanations (Keser, 2003; Boddy et al. 2003; Turk & Calik, 2008). In **elaboration** phase**,** students try to expand their newly acquired knowledge to a deeper and broader understanding and to extend their conceptual understanding and skills. Thus, children apply their new understandings to different contexts in a problem solving environment**.** **Evaluation** is where the teacher can track student's progression in terms of students' scientific process skills and goal oriented studies during the previous four phases (Keser, 2003)

The 5E model provides a tangible reference for teachers to scaffold their developing expertise in structuring a learning environment that will facilitate students' interaction with a learning context in a critical, reflective and analytical way (Boddy et al. 2003). The five E's is an aid or organizer for the teacher to structure and sequence potential learning experiences in a systematic and synergistic way consistent with a constructivist view of teaching and learning. In itself, the five E's are not an essential part of student learning. The five e'sis a model, scaffold or framework for the teacher. For these reason, students must be provided with a learning environment that encourages them to explain their ideas and understandings and gives opportunity them to extend their knowledge of concepts to other contexts (Boddy et al. 2003).

The main goal of this study is to develop, implement and assess the survey of a constructivist learning environment designed according to 5E model. This was implemented in the context of high school physics classes in Turkey. Thus, the constructivist 5E model is central in our attempt to construct a learning environment. More specifically, the objectives of this study are:

i. to create a constructivist learning environment according to the 5E model;
ii. to develop a method for the professional development of physics teachers who plan to implement similar learning models and theories;
iii. to present some recommendation to assess students' perceptions regarding their constructivist learning environments; and
iv. to design methods determining (qualitatively and quantitatively) whether the incorporation of 5E model into the physics course reduced the differences between the actual and preferred students' perceptions of the constructivist learning environment.

Methodology

The research task was to develop the *Constructivist Learning Environment Survey According to 5E Model* (CLESAF). For this reason, a learning environment was designed according to constructivist 5E model. The primary 60-item version of the survey containing some items derived from CLES (Aldridge et al., 2000), CLEQ (Waldrip et al., 2000), and WIHIC (Aldridge et al., 1999) was administrated to a sample composed of 204 8th to 10th grade students from in two high schools in Turkey.

The survey consisted of five primary components: entrance *to* activities, exploration of the subject, explanation of concepts, elaboration of subject with tasks, and evaluation of the entire process. Each student in the sample responded to the CLESAF. Data collected from the survey was analyzed to provide information about its reliability and validity. The revised CLESAF contained 50 items, as shown in Table 1, and the content was validated by teachers, students and fellow researchers. Each of the five scales contained ten items, which were responded to on a five-point scale (0, 1, 2, 3, 4) with the extreme alternatives of Disagree-Agree. Students were asked to indicate to what extent they agreed that each item described their physics classroom.

Table 1. Distribution of CLESAF items in view of selected from reference scales and developed by researcher

	Item Numbers in			By Researcher	Total Items
	CLES	CLEQ	WIHIC		
Enter/Engage	2	9,22,29	19,20	4 Items	10
Exploration	16,19,23,25	-	27,32,41,42,45	1 Item	10
Exploration	27,28,29	25	15,16,26,28	2 Items	10
Exploration	6	30	12,23,24,34,37,40	2 Items	10
Exploration	-	-	-	10 Items	10
Total Items	9	5	17	19	50

To measure students' perceptions of their classroom environment and to assess the 5E model in this environment, qualitative and quantitative methods were combined as recommended by earlier studies (Fraser & Tobin, 1991; Tobin & Fraser, 1998). The data collected from the survey was used as a springboard for further data collection involving different research methods including interviews with teachers and students and classroom observations.

Triangulation was used to secure an in-depth understanding of the learning environment. At least 2 students from each of eight classes were initially interviewed on the basis of student responses to selected survey items. Observations were the source of many student and teacher interview questions about various actions that took place in the classroom environment.

Results and Conclusions

The refinement and validation of the CLESAF involved a series of principle component analysis, in order to examine the internal structure of the 50 item set. A principle component analysis with varimax rotation was used to generate the factors. Results of the factor analysis indicated that five factors explained all ten items. This result was very satisfactory to the expected factors and intended objectives for the model used.

Table 2 shows the factor loadings and final version of the CLESAF. The only factor loadings included in this table are those greater than or equal to the conventionally accepted value of 0.4. Reliability and validity of the CLESAF was established by examining the internal consistency or reliability (Cronbach alpha reliability coefficient) and discriminant validity (mean correlation with other scales) of the CLESAF. These are shown in Table 3, which indicates the alpha coefficient ranged from 0.62 to 0.77, exceeding the threshold of 0.60 given by Henderson, Fisher and Fraser (1998) as the acceptable reliability for research purposes.

Table 2. Constructivist Learning Environment Survey According to 5E Model - CLESAF and Factor Loadings for Items.

Factor Loadings			Items	Variance %
Enter	1	0.46	My new learning started with problems about real world	12.6
	2	0.72	I felt that I could challenge and question the subject	
	3	0.59	It was important for me to be involved in class discussions	
	4	0.68	I used my previous knowledge and experiences in discussions	
	5	0.64	My ideas and suggestions were used during classroom discussions	
	6	0.47	I enjoyed having teachers tell me how to work in this class	
	7	0.60	I listened to other students during the classroom discussions	
	8	0.56	Questions gave me a chance to review my previous experiences	
	9	0.61	The teacher asked me questions before starting the activities	
	10	0.73	My previous knowledge encouraged me when learning a new subject	
Exploration	11	0.65	I planned what I was going to learn after pre-discussions	22.2
	12	0.74	I got the chance to talk to other students	
	13	0.71	I helped the teacher decide which activities were best for me	
	14	0.62	I complained about anything that preventing me from learning	
	15	0.68	I shared resources with other students when doing activities	
	16	0.72	When I worked in groups in this class, there was teamwork	
	17	0.81	I cooperated with other students when doing research	

	18	0.76	I learned from other students in this class	
	19	0.71	I carried out investigations to answer the questions that puzzled me	
	20	0.64	I found answers to my questions by investigating	
Explanation	21	0.47	I explained my comprehension to teacher or other students	11.7
	22	0.55	I asked other students to explain their thoughts	
	23	0.62	Other students or teachers asked me to explain my ideas	
	24	0.64	The teacher's questions helped me understand	
	25	0.49	I was asked to think about evidence for statements	
	26	0.71	The teacher moved around the classroom to talk with me	
	27	0.66	I enjoyed showing the teacher what I did	
	28	0.73	The teacher gave me explanations using several resources	
	29	0.68	The teacher helped me share my experiences with others	
	30	0.54	I explained the meaning of statements, diagrams and graphs	
Elaboration	31	0.64	I learned how science could be part of my life ouside of school	10.4
	32	0.82	I knew what I was trying to accomplish in new situations	
	33	0.74	I knew how much I work in new situations with group (confusing)	
	34	0.72	I relied on my ability to know what I had to do	
	35	0.69	I enjoyed seeing how other students attempted to solve problems	
	36	0.76	I was asked to explain how I solved the problems	
	37	0.68	Students discussed how to go about solving problems with me	
	38	0.62	I explained my ideas to other students	
	39	0.81	The teacher helped me when I had trouble with the work	
	40	0.82	I did as much as I set out to do	
Evaluation	41	0.65	I would have wanted to understand the subject before starting the task activities	9.2
	42	0.71	I needed to do theoretical research again during task activities	
	43	0.68	I used knowledge from my studies that took place previous stages in task activities	
	44	0.48	I needed the teacher during all activities	
	45	0.71	It's OK for me to assign to participate in various homework and projects	
	46	0.77	It is important that my contributions to the activities were used for evaluations	
	47	0.62	I believe that my interactions with others are considered by the teacher	
	48	0.74	Talking with teacher is very important in the assessment of my knowledge	
	49	0.78	My performance on activities should be considered for success	
	50	0.65	I enjoyed having an active role in my learning activities	

Table 3. Internal Consistency and Discriminant Validity for the CLESAF

Scale	Alpha reliability	Discriminant validity
Enter/Engage	0.67	0.36
Exploration	0.77	0.44
Explanation	0.73	0.40
Elaboration	0.62	0.33
Evaluation	0.74	0.35

Combining qualitative and quantitative data revealed that the CLESAF has proven to be useful instrument for providing important insights into the key characteristics of the constructivist learning environment using the 5E model. CLESAF explains 66.1% of the total variance. The most interesting data is about the distribution of the variance to the five factors. 22% of the total variance was explained by the exploration factor. In other words, a third of the total explained variance belongs to the discovery phase. This situation is very important when considering implementing the constructivist 5E model. The exploration phase is the heart of the 5E model. The enter phase, explains 12.6% of the total variance, and the explanation phase, explains 11.7% of the total variance, and are critically important for 5E model and its applicability. These results are compatible with Akdeniz et al. (2002) and Keser (2003). The 5E model can be used to implement a constructivist view of teaching and learning in the classroom. Although this model was successful, it may not be suited to all teachers and to all strands of a curriculum. Teachers have a variety of structured, convenient and effective ways to teach based on a constructivist theory of teaching and learning available to them (Boddy et al., 2003).

Because CLESAF contains most characteristics of the constructivist perspective, it should be considered as an instrument to be use when designing constructivist environments, especially well-equipped constructivist physics classes (Keser, 2003).

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