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Preferences toward Internet-based Learning Environments: High School Students' Perspectives for Science Learning

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ABSTRACT

Constructivist Internet-based learning environments are advocated by contemporary educators, but few studies investigated students' preferences toward the environments for learning a specific school subject such as science. Therefore, the purpose of this study was to develop a questionnaire to explore students' preferences toward constructivist Internet-based science learning environments. The questionnaire included eight scales: ease of use, relevance, multiple sources, student negotiation, cognitive apprenticeship, reflective thinking, critical judgment and epistemological awareness. The questionnaire responses were gathered from 853 Taiwan high school students. Through factor analysis, these scales revealed highly satisfactory validity and reliability in assessing students' perceptions for Internet-based science learning environments. The students' responses also showed that they strongly preferred the Internet-based learning environments that could connect scientific knowledge with real life situations. Moreover, female students tended to place more emphasis on the instructional guidance offered by the Internet-based environments for science learning, as well as the presentation of scientific knowledge in authentic contexts than did male students. Future research and the implications for Internet-based instruction derived from this study were also discussed.

Keywords

Learning environment, Internet, science, constructivism, Taiwan

Introduction

In recent years, numerous science educators have used computer-related tools or simulations in enhancing students' knowledge construction and science learning (Ardac & Akaygun, 2004; Huppert, Lomask & Lazarowitz, 2002; Lux & Davidson, 2003; Vreman-de Olde & de Jong, 2004). Some Internet-based science learning activities and assessment systems have also been implemented (Hoffman, *et al*., 2003; Tsai, Lin & Yuan, 2001, Tsai & Chou, 2002; Wallace, 2004). In addition, many researchers have perceived Internet-based instruction as an important way of applying the ideas of constructivism (e.g., Downing, 2001; Tam, 2000; Taylor, Casto & Walls, 2004; Yakimovics & Murphy, 1995). Or, the pedagogy of Internet-based instruction is quite consistent with the philosophy of constructivism (Chou & Tsai, 2002). In particular, the integration of the constructivist thoughts and Internet-based instruction has been often applied to science education (Jonassen *et al.*, 1999, 2003; Tsai, 2001a, 2001b). To implement constructivist Internet-based science learning environments, the researchers have proposed many instructional principles. For example, Tsai (2001a) has suggested "observations in authentic activities," "contextualizing prior knowledge," "cognitive apprenticeship," "collaboration" and "multiple interpretations and manifestations" as some major principles for the constructivist Internet-based science learning environments. In other words, constructivist Internet-based science instruction should relate the scientific knowledge to real-life situations or prior knowledge, provide sufficient apprenticeship to guide students' learning, encourage student negotiation and cooperation, as well as present the scientific knowledge in a variety of aspects. Jonassen *et al.* (1999) have also highlighted the presentation of the knowledge in real problem situation or project-based learning by providing rich information resources and effective knowledge-negotiation tools. Tsai (2001b, 2004a) has further emphasized the metacognitive and epistemological activities involved in the constructivist Internet-based science learning environments; for example, adequate reflective thinking, critical judgment and epistemological awareness are fairly important when navigating in the environments where a variety of (perhaps conflicting) information concurrently exists.

Although there are some attempts on the development of the constructivist-oriented Internet-based learning environments for science students (Tsai, 2001a) and some successful or exemplary cases have been presented (Jonassen *et al.*, 1999, 2003; Linn, 2003; Linn *et al.*, 2003), few studies have explored science students' preferences toward these environments. If science educators can have more information about students' perspectives or expectations about Internet-based learning environments, they can create more favorable environments or systems for science students.

In order to explore students' preferences toward the constructivist Internet-based learning environments, Chuang and Tsai (2005) and Wen *et al.* (2004) have developed a questionnaire to survey high school students' preferences toward the constructivist Internet-based learning environments, called Constructivist Internet-based Learning Environment Survey (CILES). CILES included the scales such as "ease of use," "relevance," "student negotiation," and "reflective thinking," to assess students' preferences toward some features of the Internet-based learning environments. For example, the scale of "relevance" investigates the extent to which students prefer the Internet learning environments are authentic and represent real life situations, and the scale of "student negotiation" measures the extent to which students prefer to have opportunities to share and discuss their ideas with other students in the Internet-based learning environments. Tsai (2004b) further modified CILES by integrating more scales for a more complete description of the features involved in the constructivist Internet-based learning environments. For example, the "multiple sources," "cognitive apprenticeship," "critical judgment" and "epistemological awareness" as provided and promoted by the Internet-based learning environments were addressed in modified CILES. However, CILES assessed students' expectations for Internet-based learning environments in general, without focusing on any learning domain. To acquire more detailed information about students' perspectives, it is a need to develop a similar questionnaire like CILES, but with a clear learning domain for exploration. Therefore, this study, based upon the scales as revealed by a series of studies related to CILES (e.g., Chuang & Tsai, 2005; Tsai, 2004b; Wen *et al*., 2004), attempted to construct a questionnaire to investigate students' preferences toward the constructivist Internet-based learning environments for science, called CILES-S.

The scales used in CILES-S concurred with the principles of the constructivist Internet-based science learning environments reviewed previously. For example, the scales of "relevance" and "student negotiation" were consistent with Tsai's (2001a) principles of "observations in authentic activities," "contextualizing prior knowledge" and "collaboration" as well as Jonassen *et al.*'s (1999) ideas about problem-based learning and knowledge negotiation. The "multiple sources" scale was coherent with Tsai's (2001a) principle of "multiple interpretations and manifestations." The scales of "reflective thinking," "critical judgment" and "epistemological awareness" addressed the importance of metacognitive and epistemological activities engaged in the constructivist Internet-based science learning environments highlighted by Tsai (2001b, 2004a). Therefore, the measurement of CILES-S was based upon relevant literatures on constructivist Internet-based instruction and it also corresponded to the features of the constructivist science teaching.

In current stage, the Internet has been increasingly used in K-12 schools for assisting learning and instruction about science (Bruce *et al*., 1997; Linn, 2003; Tsai, 2001a). Particularly, high school students may gradually become one of major groups of learners participating in the Internet-based science learning environments (Clark & Slotta, 2000; Lumpe & Butler, 2002). Therefore, this study explored a group of high school students' perspectives for constructivist Internet-based science learning environments.

Method

Sample

The sample included 853 high school students (438 males and 415 females) from ten high schools in Taiwan. The sample population was stratified into three demographic areas, Northern, Central and Southern Taiwan. Four high schools from Northern Taiwan, three schools from Central Taiwan and three schools from Southern Taiwan were selected. The school number ratio selected roughly corresponds to the actual high school number ratio across these three areas. These students were tenth to twelfth graders. For each school, two or three classes were selected. These students were in 27 classes and they were in various social-economic backgrounds and science achievement. Among these classes, ten were in urban district; nine were in suburban district, while the remaining eight classes were in rural region. The selected students' age ranged from 15 to 19, with an average of 17.3-year-olds. Although this sample could not be viewed as a national sample, the surveyed students came from a variety of high schools in Taiwan, across different demographic areas and backgrounds, and they may, to a certain extent, be said to represent many high school students in Taiwan. In their seventh grade to ninth grade, all of them had enrolled the courses of biology, earth sciences, physics and chemistry as required by Taiwan's national curricula. All of them had experiences of using the Internet, and used on-line resources and activities for learning. For instance, most of them had searched some on-line information to complete school science tasks or projects.

In addition, similar to the process used by Chuang and Tsai (2005), before responding to the CILES-S, all of the participating students were advised to visit some local Internet-based instructional sites and systems, which had been nominated as the best science instructional web sites by the Ministry of Education, Taiwan, or had been perceived as creating constructivist Internet-based science learning environments for high school students. For example, all of them had visited the virtual physics laboratory developed by National Taiwan Normal University (http://www.phy.ntnu.edu.tw/demolab), and the web system has provided numerous simulations, discussion groups and animations, which build on activation of students' prior knowledge and content knowledge. Therefore, all of the students had acquired some understandings what a constructivist Internet-based science learning environment was.

The development of CILES-S

The CILES-S was modified from CILES (Chuang & Tsai, 2005; Wen *et al*., 2004) as well as the revised version of CILES developed by Tsai (2004b). However, each item in CILES-S investigated students' preferences toward Internet-based environments particularly for science learning. That is, each item in CILES was modified to the statement for assessing students' perceptions toward the constructivist Internet-based learning environments especially for science. Similar to the development of CILES (Chuang & Tsai, 2005), before actual administration of CILES-S, two experts in the field of Internet-based science instruction had commented on the items of CILES-S for face validity, and six high school students and one high school science teacher had been chosen to clarify the wording of each statement. Except minor wording modification, no considerable change was made derived from this evaluation process. A detailed description for each CILES-S scale, with a sample questionnaire item, is presented below.

Ease of use scale: measuring perceptions of the extent to which students prefer that the Internet-based science learning environments are easy-to-use, e.g., When navigating in the Internet-based science learning environments, I prefer that they are easy to navigate.

Relevance scale: assessing perceptions of the extent to which students prefer that the Internet-based science learning environments are authentic and represent real life situations, e.g., When navigating in the Internet-based science learning environments, I prefer that they show how complex real-life environments are.

Multiple sources: exploring perceptions of the extent to which students prefer that the Internet-based science learning environments contain various information sources and interpretations, e.g., When navigating in the Internet-based science learning environments, I prefer that they can connect to rich relevant web resources.

Student negotiation scale: assessing perceptions of the extent to which students prefer to have opportunities to explain and modify their ideas to other students in the Internet-based science learning environments, e.g., In the Internet-based science learning environments, I prefer that I can discuss with other students how to conduct investigations.

Cognitive apprenticeship scale: exploring perceptions of the extent to which students prefer to have opportunities to acquire helpful and timely guidance provided by the Internet-based science learning environments, e.g., When navigating in the Internet-based science learning environments, I prefer that they can provide experts' guidance to facilitate advanced learning..

Reflective thinking scale: measuring perceptions of the extent to which students prefer to have the opportunities to promote critical self-reflective thinking in the Internet-based science learning environments, e.g., In the Internet-based science learning environments, I prefer that I can think deeply about how I learn.

Critical judgment scale: assessing perceptions of the extent to which students prefer to have opportunities to critically evaluate information in the Internet-based science learning environments, e.g., In the Internet-based science learning environments, I prefer that I can evaluate the features of various information sources.

Epistemological awareness scale: assessing perceptions of the extent to which students prefer to have opportunities to explore the value, source, merit or nature of knowledge in the Internet-based science learning environments, e.g., When navigating in the Internet-based learning environments, I prefer that they can explore deeply about the nature of knowledge.

In this study, each scale included five items, presented in a five-point Likert mode, ranging from "strongly agree" to "strongly disagree." Consequently, a total of 40 items were included for developing CILES-S. Two experts in the field of Internet-based instruction commented on the items for content validity, and six high school students were selected to clarify the wording of each item.

Students' responses were scored as follows. For the "strongly agree" response was assigned a score of 5, while for the "strongly disagree" response was assigned a score of 1. Consequently, students gaining higher scores in a certain scale showed stronger preferences toward the specific feature of the constructivist Internet-based science learning environments.

Data Collection

Paper-and-pencil copies of CILES-S were mailed to the science teachers of the twenty-seven selected classes. The sample students responded to the questionnaire in their science classes. The science teachers collected the completed questionnaires and then returned to the researcher for further analysis. The total number of the students in the classes was 973; however, only 853 students responded to the items of CILES-S. The response rate was approximately 88%, and the valid sample in this study included 853 high school students.

Results

Factor analysis

This study utilized exploratory factor analysis, principle component analysis with varimax rotation, to clarify the structure of the preferences toward the Internet-based science learning environments. An item was retained only when it loaded greater than 0.50 on the relevant factor and less than 0.50 on the non-relevant factor. The high school students' preferences were grouped into eight factors, including: ease of use, relevance, multiple sources, student negotiation, cognitive apprenticeship, reflective thinking, critical judgment and epistemological awareness, presented in Table 1. These factors were exactly the same as the scales originally proposed in this study. Nevertheless, one item in the "critical judgment" scale did not be remained as a result of the factor analysis. The eight factors with 39 questionnaire items retained in the CILES-S explained 67% of the variance. The eigenvalues of the eight factors from principle component analysis were all larger than one. The reliability (alpha) coefficients respectively for these scales were 0.89, 0.78, 0.89, 0.87, 0.82, 0.90, 0.82 and 0.85, and the overall alpha coefficient for all 39 items was 0.94. These coefficients suggested that these scales of the CILES-R had highly sufficient reliability in assessing high school students' preferences toward the Internet-based science learning environments.

Table 1. The scales and item factor loadings for CILES-S

Item	Factor 1: Ease of use	Factor 2: Relevance	Factor 3: Multiple sources	Factor 4: Student negotiation	Factor 5: Cognitive apprenticeship	Factor 6: Reflective thinking	Factor 7: Critical judgment	Factor 8: Epistemological Awareness
Factor 1: Ease of use α=0.89								
1	0.638							
2	0.729							
3	0.771							
4	0.832							
5	0.839							
Factor 2: Relevance α=0.78								
6		0.575						
7		0.732						
8		0.740						
9		0.792						
10		0.659						
Factor 3: Multiple sources α=0.89								
11			0.672					
12			0.695					
13			0.727					
14			0.766					
15			0.656					

Item	Factor 1: Ease of use	Factor 2: Relevance	Factor 3: Multiple sources	Factor 4: Student negotiation	Factor 5: Cognitive apprenticeship	Factor 6: Reflective thinking	Factor 7: Critical judgment	Factor 8: Epistemological Awareness
Factor 4: Student negotiation α=0.87								
16				0.563				
17				0.654				
18				0.774				
19				0.762				
20				0.723				
Factor 5: Cognitive apprenticeship α=0.82								
21					0.722			
22					0.705			
23					0.715			
24					0.791			
25					0.717			
Factor 6: Reflective thinking α=0.90								
26						0.655		
27						0.733		
28						0.646		
29						0.788		
30						0.647		
Factor 7: Critical judgment α=0.82								
31							0.808	
32							0.804	
33							0.525	
34							0.537	
Factor 8: Epistemological awareness α=0.89								
35								0.622
36								0.766
37								0.759
38								0.799
39								0.627

Total variance explained: 67.43%, alpha for entire items, 0.94.

Students' scores on the scales

Table 2 shows the students' average item scores and standard deviations on the eight scales of the CILES-S. Their average item scores on each CILES-S scale were all above the value of three, the mean of 1-5 Likert scale. These students, on average, showed high preferences for each feature of the constructivist Internet-based science learning environments as assessed by CILES-S. The students scored highest on the relevance scale (an average of 4.35 per item), suggesting that they preferred that the Internet-based learning environments could help them make more meaningful associations between real life situations and the scientific knowledge. The students also attained relatively higher scores on the "ease of use," "multiple sources" and "cognitive apprenticeship" scales of CILES-S (mean = 4.13, 4.15 and 4.16 respectively). These results indicated that the students also expected the Internet-based science learning environments to be user-friendly, to contain a variety of information sources, and to provide useful guidance for advanced learning. However, they had the lowest item scores on the "critical judgment" scale (mean = 3.88), implying that some students might not intend to critically evaluate the information obtained from the Internet.

Table 2. The descriptive data on the scales for CILES-S

Scale	# of Items	Mean per item	S.D.	Range
Ease of Use	5	4.13	0.73	1-5
Relevance	5	4.35	0.46	2.4-5
Multiple sources	5	4.15	0.64	1-5
Student negotiation	5	3.95	0.67	1-5
Cognitive apprenticeship	5	4.16	0.51	2.2-5
Reflective thinking	5	4.10	0.70	1-5
Critical judgment	4	3.88	0.68	1-5
Epistemological awareness	5	4.00	0.68	1-5

Gender differences on the scales of CILES-S

This study further investigated students' gender differences on the scales, shown in Table 3. The results indicated that female students gained significantly higher scores on the "relevance" and "cognitive apprenticeship" than male students ($t = -4.23$, $p<.001$; $t = -2.03$, $p<.05$, respectively). The female students tended to prefer the Internet-based science learning environments where they could relate scientific knowledge to real-life problems, and they can acquire helpful guidance from the systems, on-line experts or experienced peers. Educators need to pay more attentions to these features when creating Internet-based science learning environments for female students.

Table 3. Gender differences on the scales of CILES-S

Scale	Male (mean, S.D) (n = 438)	Female (mean, S.D) (n = 415)	t
Ease of use	4.12 (0.70)	4.14 (0.75)	-0.43
Relevance	4.28 (0.46)	4.42 (0.45)	-4.23***
Multiple sources	4.13 (0.65)	4.18 (0.64)	-1.34
Student negotiation	3.96 (0.67)	3.95 (0.67)	0.25
Cognitive apprenticeship	4.13 (0.49)	4.20 (0.53)	-2.03*
Reflective thinking	4.06 (0.69)	4.14 (0.70)	-1.81
Critical judgment	3.87 (0.68)	3.90 (0.68)	-0.75
Epistemological awareness	4.00 (0.66)	4.01 (0.71)	-0.14

Discussion and Conclusion

By gathering 853 Taiwan high school students' responses, this study developed a questionnaire, CILES-S, to investigate their preferences toward the Internet-based science learning environments. CILES-S included eight scales, which were ease of use, relevance, multiple sources, student negotiation, cognitive apprenticeship, reflective thinking, critical judgment and epistemological awareness. These scales, by employing factor analysis, showed adequate validity and reliability in assessing students' perceptions for Internet-based science learning environments.

The students attained the highest score on the "relevance" scale, suggesting that they placed high emphases on the connection between real life situations and scientific knowledge as offered by the Internet-based science learning environments. Educators and web content developers should carefully present scientific knowledge in authentic tasks and relate the scientific facts to realistic situations when designing Internet-based instruction for science students.

This study also revealed some gender differences on the CILES-S responses. Female students, when comparing to male students, tended to prefer the Internet-based science learning environments where they could have more opportunities to explore science in realistic contexts and obtain helpful guidance for further learning. Science education research has revealed that female students are often disadvantaged in learning science (e.g., Kahle & Meece, 1994; Kenway & Gough, 1998). If Internet-based instruction is perceived as a possible way of lessening the gender gap in learning science, educators should pay particular attentions to creating the environments that highlight these features for female students.

CILES-S was quite different from similar instruments or questionnaires developed in the past, as CILES-S included a particular learning topic, that is, science, for exploration. Science educators can further develop more scales to elaborate students' perceptions of the Internet-based learning environments for other aspects of learning science. For example, the visualization, inquiry, or problem-based learning for science proposed by Jonassen *et al.* (1999, 2003), and the stimulation of cognitive conflict for science instruction recommended by Tsai (2000a, 2001c) can be expanded to new scales of CILES-S. Furthermore, educators in other learning domains, such as mathematics or language, can develop a series of similar instruments like CILES-S for their domains, and to survey students' relevant preferences for individual learning domains. It is clear that each domain has some unique features, and their learning in the Internet-based environments may be quite different; thus, students may respond differently to these surveys. Based on these results, it is expected that educators as well as web content developers can construct more appropriate Internet-based learning environments for each knowledge domain, and then facilitate their learning and knowledge growth.

In addition, many educators have also asserted students' learning environment preferences, to a certain extent, represent their epistemological beliefs (Hofer & Pintrich, 1997; Tsai, 2000b). Tsai and Chuang (2005) showed an interplay between students' epistemological beliefs and learning preferences for Internet-based environments. Research findings have supported that students' epistemological beliefs may guide their strategies of knowledge construction and then influence their learning outcomes (e.g., Hofer, 2001; Tsai, 1998a, 1998b, 2000c). Therefore, a better understanding about students' preferences toward certain learning environments may be viewed as a fundamental step for exploring their learning processes and outcomes in the environments. CILES-S provided a useful tool for this purpose.

Finally, as proposed by Chuang and Tsai (2005) and Tsai (2004b), a parallel version of CILES-S should be developed to probe students' perceptions toward certain existing Internet-based science learning environments. That is, the current form of CILES-S explored students' perspectives toward *ideal* Internet-based science learning environments, whereas the parallel version should investigate their perception toward some *actual* Internet-based science learning environments. Many studies have revealed that learners' preferences or expectations toward the classroom environments are often different from those in realty (Fraser, 1998, Tsai, 2003). By using both CILES-S forms described above, educators and web content developers can well understand the possible gap between students' expectations and perceptions toward some existing Internet-based learning environments. Additional improvements of these environments can be more effective to be undertaken.

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Appendix: The questionnaire items in CILES-S

Ease of use scale:
When navigating the Internet-based *science* learning environments, I prefer that they…
1. have an interesting screen design.
2. are easy to navigate.
3. are fun to use.
4. are easy to use.
5. take only a short time to learn how to use

Relevance scale:
When navigating the Internet-based *science* learning environments, I prefer that they…
1. show how complex real-life environments are.
2. present data in meaningful ways.
3. present information that is relevant to me.
4. present realistic tasks.
5. have a wide range of information

Multiple sources scale:
When navigating the Internet-based *science* learning environments, I prefer that they can…
1. provide a variety of relevant web links.
2. discuss a learning topic though various perspectives.
3. present a learning topic by different methods.
4. offer various information sources to explore a learning topic.
5. connect to rich relevant web resources.

Student Negotiation scale:
In the Internet-based *science* learning environment, I prefer that…
1. I can get the chance to talk to other students.
2. I can discuss with other students how to conduct investigations.
3. I can ask other students to explain their ideas.
4. other students can ask me to explain my ideas.
5. other students can discuss their ideas with me.

Cognitive apprenticeship scale:
When navigating the Internet-based *science* learning environments, I prefer that they can…
1. offer timely guidance.
2. provide useful feedback to guide learning.
3. inspire valuable questions to provoke thinking.
4. provide experts' guidance to facilitate advanced learning.
5. design interactive content to assist learning.

Reflective thinking scale:
In the Internet-based *science* learning environment, I prefer that…
1. I can think deeply about how I learn.
2. I can think deeply about my own ideas.
3. I can think deeply about new ideas.
4. I can think deeply how to become a better learner.
5. I can think deeply about my own understanding.

Critical judgment scale:
In the Internet-based *science* learning environment, I prefer that…
1. I can critically evaluate web content.
2. I can critically judge the value of different perspectives.
3. I can examine a variety of information and then make judgment.
4. I can evaluate the features of various information sources

Epistemological Awareness scale:
When navigating the Internet-based *science* learning environments, I prefer that they can…
1. display the source of knowledge.

2. explore deeply about the nature of knowledge.
3. evaluate the merits of knowledge.
4. present the process of knowledge development.
5. display the hidden value of knowledge.