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Full Length Research Paper

An analysis of the interactive behaviors of self-learning management in a web-based Moodle e-learning platform

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This study adopted quasi-experiments and semi-structure interviews to investigate students' interactive behaviors in a situated internet-assisted learning environment. Forty senior university students participated in the study after taking a three-hour introductory energy course each week for 18 weeks with web-based cooperative learning at a Moodle learning platform. It was found that 62% of the students who have participated in the interactive discussions demonstrate significantly better learning outcomes than those who do not. Students believed that asynchronous web-based cooperative learning offered good learning approaches and experience. Through Moodle's e-learning platforms, students could express their own opinions freely and refer to other people's viewpoints towards the teaching themes. From the interview data, it was found that when students provided possible answers or gave their own explanations, they were not only connected to their previous knowledge, but also had self-reflections on their own opinions and re-examine their opinions when they were evoked by the stimulus of different opinions. From the feedback data, it showed that 52.4% of students were satisfied with the web-based cooperative learning. By means of interviews, it was verified that students held positive thoughts that on-line discussions offered them the chance to express different opinions and stimulated their thinking to promote their robust optimal self-learning management.

Key words: Situated learning theory, web-based cooperative learning, introduction to energy, moodle e-learning platform, self-learning management.

INTRODUCTION

Internet has become a technological tool for interactive communication among people. Messages are communicated through this interpersonal interaction mode and community interactions are made. The concept of web-based learning community implies that every professional share his experiences through Internet technology (Owston, 1997). The learning communities are thus constructed by means of knowledge interaction and communication. Therefore, internet has played an important role in university teaching activities. Learners make synchronous and asynchronous discussions and exchange information through the use of Skype, MSN and blogs. It has become common in universities' related teaching activities to adopt web-interactive based cooperative learning for knowledge exploration and construction.

In a learning environment, students can be cooperators and competitors with their peers. The cooperation and competition environment makes learners imitate, support and assist with each other in the cognition learning process and they can interpret other people's learning with their own languages. This will enable learners to use new approaches to explore, integrate and evaluate learning, and promote learners' meta-cognition strategies.

In the process of web-based learning, it is suggested that scholars should proceed with cooperative learning. Due to the characteristics of the web, learners will not feel isolated from support while learning, and with the assistance of web technology, they can cooperate with their peers and even interact with other participants

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HHY, HMY2, **HLY, MMY2, LLN2,** represented five students' code names who participated into on-line discussion to offer their opinions in this study

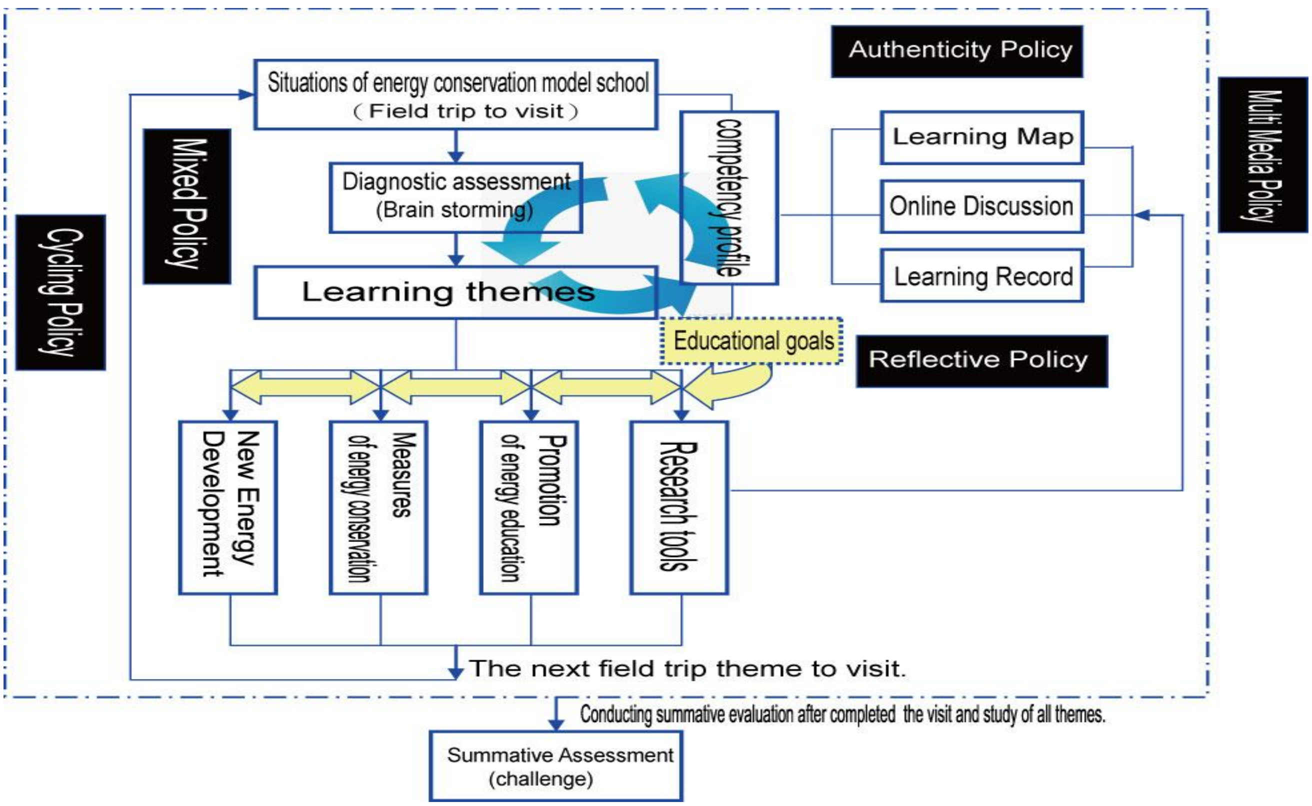

Figure 1. Introduction to the energy teaching system of the Web situational learning environment interaction diagram.

through synchronous and asynchronous discussions and information-exchanging. Learners can also interact with other participants and scholars from other areas to solve the current problems and accomplish their learning tasks.

Previous researches (Alexander, 1992; Steeples, 1993; Watabe, 1995) have pointed out some advantages of using web-learning for cooperative learning: (a) students can get different viewpoints from other classmates and better understanding of the teaching materials; (b) the exchange of personal experience and thoughts are encouraged, and group capability and experience are shared in cooperative learning; (c) learners have to display and demonstrate what they have learnt and with the process of articulation, old and new knowledge is combined and integrated for further applications of new knowledge; (d) group participation, identification and belonging are promoted. Therefore, with the assistance of web-based technology, cooperative learning not only improves learning effects, but also enhance the development of social communities (Edelson, 2001; Hoadley and Linn, 2000; Krajcik, 2000). The concept of the course materials is to get to know the culture and development trend of the university learning environment, influenced by the effect of information technology. Combined with the situated learning theory and the function of the Internet technology, the Introductory Course to Energy is presented in a web-form to assist university students to self-check their own learning and be autonomous.

The content of the energy materials is on a “field trip situation” theme. Situated learning places emphasis on the learners’ interactive process of a real-situation when paying their field visits. Through real activities, learners are exposed to real situations and they learn about energy-related materials, and can further make rational and meaningful interpretations of energy knowledge.

Collins (1994) pointed out that the teaching strategies of situated learning include authenticity, mixed, cycling, reflective and multimedia policies. It stresses that learners learn things in an automatic manner and explore sequences and clues of energy by exploration. Teachers can moderately guide students to find problems in situations and help them develop expert problem-solving strategies and abilities. Finally, students can be able to apply the energy knowledge they have learnt to real-life situations. Based on this concept, the learning framework of the web situational learning environment is described in Figure 1.

METHODOLOGY

Research samples

This study adopts quasi-experimental for pretest and posttest control group design, and the research samples comprise forty students from an elective introductory course to energy at a university. In consideration of the class sections for easy computer classroom access, samples were negotiated in order to motivate their willingness to cooperate with any research-related arrangements and requirements. Student teams-achievement divisions (STAD) were adopted to divide the students of the experimental group into heterogeneous grouping. Students' pre-test scores were prioritized and then divided into eight groups with S distribution.

Quasi-experimental method

a) Quasi-experimental research design.
b) Both groups took pretests before the experiment.
c) Five to six people were divided as a group based on the ranking of the pretest with S distribution. Students' pre-test scores were prioritized and were divided into four experimental groups and four control groups with S distribution.
d) The experimental groups took experimental treatment, while the control groups took no experimental treatment. However, both groups took post-tests after the experiment.

Definition of the experimental variable

Control variable

a) Teaching materials were taken from the web-based introductory energy course materials of the National Science Council Project (NSC 98-2511-S-018-010-MY2) by Liao, Chin-Wen and integrated with the experimental course context, including animation, learning area and learning tools.
b) Teaching time: Both the experimental and control groups attended the courses at the same period for three hours per week for eighteen weeks.
c) The research participants for both groups were university seniors.
e) Instructor: The same instructor, with one teaching assistant, taught both the experimental group and the control group with the experiment teaching.

Independent variable

(a) The experimental group adopted the heterogeneous grouping and was provided with Moodle learning platform for extended learning.
(b) The control group adopted the random grouping and was instructed with traditional instruction.

Covariance

Obtain the basic energy concept of the pre-test scores through the testing section at the Moodle learning platform.

Dependent variable

a) Obtain the "basic energy concept" of the post-test scores through the "Testing section" at Moodle learning platform.
b) Submit homework through "Homework section" at Moodle learning platform.
c) Submit group project reports through "Homework section" at Moodle learning platform.
d) Experimental group students filled out their opinions on the "web-based cooperative learning questionnaire".

Research tools

Web-based cooperative learning

On-line discussion area: It includes leaving messages on the web through on-line discussion. Students made synchronous and asynchronous discussions and exchanged information through the Internet. The web-based discussion area was divided into two-layer structures: the first layer showed all of the first-post discussion topics, and the responding posts, followed by the first-post discussion, were listed on the same web page of the second layer. Users can click on the discussion list of the first layer, and then browse all of the related articles corresponding to that article or join the article's discussion (Brown et al., 1989). However, learners' learning situations were guided and modified in time through web-based cooperative learning, peer evaluation form, web-based cooperative learning peer review form and cooperative leaning behavior checklist.

Electronic notebook: It was made with cgi programming and its function was similar to windows' notebook. Students can make records of their own learning focuses or learning afterthoughts, and be able to gain access to them if they want.

Interview outline of the "homework section"

It was implemented to get a closer understanding of students' cognitive process, interaction situations of the online discussion section, and opinions and suggestions on web-based materials. Sixteen students were interviewed (ten males and six females), but before the formal interview, six participants were selected for a pre-interview and moderate changes were made with the interview questions and interview skills. During the formal interview, all the participants agreed to be interviewed. Each person was interviewed for about twenty to thirty minutes and the interview data were analyzed for further research reference.

Web-based material test

The test was conducted to understand students' learning outcomes in the interactive situated-learning environment. The test content covered related concepts in "new energy development, energy conservation, and promotion of energy education." It comprised 23 multiple-choice questions. The content validity was modified by four university experts in energy education field and was distributed with a trial at an elective Introductory Energy Course at a university. The test was analyzed with index of difficulty, discrimination index and reliability. Test samples were selected with discrimination of 0.25 and above and the index of difficulty was selected between 0.4 and 0.85. Then, the original test numbers were modified from 25 to 23 questions. The test was distributed in a pilot study and maintained at a consistent Cronbach α.

Web-based interactive learning behavior questionnaires

The questionnaire was divided into four parts: "Internet content and surface design", "Theme situation design", "Web-based cooperative learning" and "Overall learning thoughts", and there were thirty-four questions in total. Expert validity was constructed and the questionnaire was administered after a pilot study. All of the valid data were examined with cross-validation before data analysis and its internal consistency reliability was analyzed to get a reliable α.

Table 1. Comparison of mean and standard deviation between pre-test and post-test.

Scores of pre-test and post-test		Experimental group	Control group
Pretest	Mean	67.00	71.50
	Standard deviation	0.96	0.93
Posttest	Mean	63.00	66.50
	Standard deviation	0.91	0.86

Table 2. T test table of differences in pre-test scores.

Group	Mean	Standard deviation	Degrees of freedom	t value	significance level
Experimental group	61.00	19.69	18	-1.27	.22
Control group	71.50	17.33			

Table 3. Marginal means of adjusted post-test scores.

Group	Adjusted marginal means	Standard deviation	95% Confidence interval	
			lower limit	upper limit
Experimental group	65.33	0.93	54.88	75.78
Control Group	64.17	0.95	53.72	74.62

RESULTS AND DISCUSSION

The cognition score of the 'Basic energy concept' was analyzed to indicate the influence of the basic energy concept on learning scores between web-based cooperative learning and the traditional instruction environment. The "opinion on Web-based cooperative learning questionnaire" was administered to the experiment group to investigate students' opinions on integrating web-based cooperative learning into teaching.

Test scores of research samples

This study aimed to investigate the effect of learning score between providing students with web-based cooperative learning and traditional instruction environment by the instrument of "One-way analysis of covariance." Groups were taken as the independent variable, post-test scores as the dependent variable, and pre-test scores as covariate for statistical analysis.

Descriptive statistics of pre-test and post-test scores on basic energy concept

Table 1 shows that in terms of the "basic energy concept" unit, the average pre-test score of the experiment group (67.00) was lower than the control group (71.5), and the average post-test score (63.00) was lower than the control group (66.50).

Test of difference in pre-test scores

The analysis result of t test on pre-test scores is shown in Table 2. It was found that t test has no significant difference on students' pre-test scores of "basic energy concept" between the experiment and control groups, showing that there was no significant cognition difference at the starting point between the two groups.

Adjusted marginal means

To eliminate the differences of the two group of students and investigate the effect of the experiment on the dependent variable (post-test scores), statistical control methods were carried out to eliminate the differences before the experiment.

The aim of the ANCOVA analysis was to get rid of the interference to pre-test scores in order to investigate if the experimental treatment of the two teaching activities worked. A further analysis was required to compare the calculated "Adjusted means" based on covariate (pre-test scores) and statistical parameter with the average sum of the adjusted post-test scores of the two groups as shown in Table 3.

One-way analysis of covariance (ANCOVA)

To investigate whether or not the experimental group and control group had any significant differences in the experiment with post-test results, after excluding the pre-test score influence, one-way analysis of covariance was analyzed. Students of different groups were analyzed in terms of cognition of their scores between web-based cooperative learning and traditional teaching. During the analysis, the groups were considered as the independent variable, the cognition of the post-test scores as the.

Table 4. Group test of homogeneity of regression coefficients of pre-test and post-test.

F-test	Numerator degrees of freedom	Denominator degrees of freedom	Significance level
1.818	1	18	0.194

Table 5. ANCOVA analysis (no interaction of covariate and dependent variable).

Source	Sum of squares of type I	Degrees of freedom	The average sum of squares	F test	Significance level
Corrected model	1280.266	2	640.133	2.725	0.094
Intercept	83851.250	1	83851.250	356.949	0.000
Pre-test	1274.102	1	1274.102	5.240	0.032
Post-test	6.164	1	6.164	0.026	0.873
Error	3993.484	17	243.911		
Sum	89125.000	20			
The total number of corrected	5273.750	19			

*P<0.05

Table 6. ANCOVA analysis (Interaction of covariate and dependent variable).

Source	Sum of squares of type I	Degrees of freedom	The average sum of squares	F test	Significance level
Corrected model	3228.197	7	461.171	1.897	0.171
Intercept	335405	4	83851.250	344.868	0.000
Pre-test	5096.408	4	1274.102	5.240	0.036
Post-test	24.656	4	6.164	0.025	0.875
Pre-test*post-test	412.984	4	103.246	0.425	0.524
Error	3890.238	16	243.140		
Sum	89125.000	40			
The total number of corrected	5273.750	39			

*P<0.05

dependent variable, and the pre-test scores as the covariance for one-way analysis of covariance

Before analysis of covariance, the assumption of the group test of homogeneity of regression coefficients was examined. The assumption of homogeneity was to examine if there was equal slopes between the regression analysis of covariate and the dependent variable among each group. The assumption was that if covariate was taken as an independent variable, then it was used to test if there was significant interaction between the independent variable and covariate. If the interaction is significant, then it means that there is interaction between the independent variable and covariate. Then, this result would violate the assumption of the group test of homogeneity of regression coefficients. On the contrary, if there is no significant interaction between the independent variable and covariate, it indicates that it does not violate group test of homogeneity of regression coefficients, and in this way, analysis of covariance can be administered.

Test for homogeneity: Table 4 shows the group test of homogeneity of regression coefficients. The test result shows that it does not reach a significance level (F= 1.818p> 0.05). This indicated that there was a consistent linearity among two regression lines and the two slopes could be regarded as the same, meaning that the relation of covariate (pre-test scores) and dependent variables would make no difference because of the experiment on independent variables. The regression coefficients obtained from covariate (pre-test scores) for prediction of the dependent variables (post-test scores) of each experiment showed no difference. This result indicated that it corresponded with the assumption of analysis of covariance on group test of homogeneity of regression coefficients and that the analysis of covariance could be conducted.

Analysis of covariance: The data of Tables 5 and 6 are analyzed with the analysis of covariance and the results are described as follows:

i. From the analysis of covariance, it was found that F (1, 16) = 5.240, and p = 0.036, which meant that it achieved a significance level, that is, the covariance has a significant effect on the dependent variable in statistics. The purpose of ANCOVA was to control the influence of covariance to lower the error variance; therefore, the adjustment of the average sum of covariance was meaningful. The original post-test scores of the experiment group and control group were 63.00 and 66.50, and the adjusted average sum was 65.33 and 64.17, respectively.
ii. The effect of the test group did not reach a significant level with F = 0.026 and p = 0.87. The statistics showed that there was no significant post-test difference between the experiment group and the control group. Besides, it also indicated that there was no significant difference in the cognition score of "Basic energy concepts" between web-based cooperative learning experiment group and traditional instruction control group.

From the analysis of covariance, it was found that extensive learning at web-based learning platform did not show significant improvements from the scores of "Basic energy concepts." An open questionnaire of "opinion on web-based cooperative learning questionnaire" was conducted to further investigate any key factors seen when students took the introductory energy course.

Web-based cooperative learning

Analysis of web-based cooperative learning behavior

Content analysis of the new energy development: In the new energy development, there are four valid discussion clusters, and all of them have brainstorming questions. The question was to examine students' understanding of the new energy types, such as solar power and wind power. Students were expected to explain the relationship between energy transformation and availability to be a guideline of the new energy development (Rey et al., 2007). In combining the interactive behavior checklist to discuss students' interaction behavior, it was found that four posts asked about energy development. Although the total number of responded posts was sixteen, six posts answered questions (thirty-seven points, 5%) and they had the highest percentage, two posts asked for help, and only one post asked for clarification of questions. The data showed that the answers of the participating students were not exactly the same. They provided their questions, but did not get into further discussions about the hidden factors. It seemed that most participants gave answers based on guessing.

Content analysis of measures of energy conservation: Solar water heater systems, roof thermal nets, power control systems, power monitoring system, campus greenery and soil-water retention, use of parallel circuit in air conditioning and refrigeration, and promotion of energy conservation are energy conservation measurements commonly seen in our daily lives. In the brainstorming section, students were asked to list some examples of energy conservation in their daily lives and use the concept of energy conservation and the efficient use of energy to illustrate energy-saving measurements in their daily lives. The number of students' posts showed that the students were active in this topic, and of the nineteen topic posts, seventeen were responded to by other students. The valid discussion clusters of this topic were more than ten, and the total discussion numbers were eighty-eight. Students' interactions were not merely based on raising questions, but on answering them (forty-eight posts, 54.5%), asking for help (seven posts), commenting on other people's viewpoints (five posts) and providing related information (two posts). It is found that on the seventh discussion cluster of energy conservation and efficient use of energy, nearly ninety percent of the students could list examples of energy conservation from their daily life experience.

When investigating incentives of energy conservation, the data of students' energy conservation in their daily lives indicated that two students maintained that energy conservation can reduce the influence of global warming and lower the dependence on energy, and the other two students further mentioned that the so-called efficient use of energy meant that energy should be used when it is necessary and saved when it is possible, while the habit to conserve energy should be developed in their daily lives. The four students mentioned earlier provided answers to the questions, while the other four students demonstrated consent or questioned people's answers.

Three discussion clusters, accounting for twenty articles, showed misconception about energy conservation. Six posts of the seventeen responded articles indicated that energy conservation was merely a formal cooperation behavior.

The discussion data on the benefits of energy conservation indicated that twenty-three students thought that energy conservation can reduce expenses. While two students maintained a questioning attitude, the rest of the students regarded that the act of energy conservation was out of spontaneity and influence of the external factor.

Content analysis of promotion of energy education: In the animation of the energy conservation model school, the characters mentioned many questions about energy education. Therefore, in the online discussion section, the majority of the discussion topics are about the energy display hall, with twenty-two topics in total, accounting for 26.2% of the overall discussion.

With the animation situation, this issue was gradually used to guide students to find the important factors of energy education as follows: (1) to know the importance of energy; (2) to compare the current energy situation domestically and abroad, and the types and properties of electricity generation through reusable energy; (3) to put energy conservation into practice, make use of reusable energy, and promote reusable energy; and (4) to list the most suitable reusable energy for its promotion in Taiwan to enable students build up a complete concept of energy. According to interactive behavior checklist, students mostly provided their questions (twenty-one posts, 28%), followed by commenting on other people's opinions (fifteen posts, 20%), and providing personal explanation to express their own viewpoints (twelve posts, 16%).

In the discussion clusters, students posted questions about energy in the classroom to know: (1) energy transformation; (2) input power and output power; and (3) instruments, including oscilloscope, power supply unit, signal producer, digital multimeter, electric engineering experiment kit, electric machinery dissector, computer control, power signal retrieval system and instrument kit.

The responding dialogues showed that students would give personal explanation to these topics. Some students maintained that energy education can be promoted with green energy teaching net to provide students with correct knowledge of energy, while other students thought that La Niña would pose a threat to human survival and would arouse people's awareness of energy conservation. Students pointed out that energy was the major factor that accounted for abnormal climate changes and La Niña. Besides, some of the students gave personal explanation to describe that overuse of energy would lead to global warming, abnormal climate changes and La Niña. The data obtained from students' interview indicated that students had some misconceptions about energy education. It was generally thought by some students that the formation of energy concept was based on new energy development, energy conservation and promotion of energy education with an emphasis of active learning. Students explore sequences and clues of energy hidden in situations and then teachers moderately guide students to find problems in situations and help them develop expert problem-solving strategies and abilities. In the end, students are able to apply the energy knowledge they have learnt on real situations.

Opinions of the on-line discussion section

In the interview questions, one question was about students' opinions in terms of on-line discussion. The question was: what do you think about the discussion contents made by your classmates on the discussion section? Does it help you in learning, that is, does it clarify concepts or hinder learning? The purpose of the interview question was to understand the effect of learning on establishing the on-line discussion section in the web-based teaching environment.

It was found that of the twenty students interviewed, only two students never used the on-line discussion section to post or browse articles, whereas six students only browsed the content without leaving messages. Among these six students, four students made more focuses on the use of electronic notebook; so, they refer to people's opinions by browsing the content, while the other two students mainly referred to people's answers only. The rest of the twelve students had raised questions or answered questions on the on-line discussion section. Most students (sixteen) held positive attitudes towards the establishment of the on-line discussion section; among them, nine students maintained that the exchange of different opinions on the discussion section helped stimulate them to learn. In particular, when they saw people leaving messages with different opinions, they tended to question their attitudes and then made self-reflections to decide whether to deny or accept the opinions. Some of the students' responses to the on-line discussion are as follows:

i. HHY: I posted questions and answered questions. In my opinion, the discussion section helped me to learn. Some of my classmates' answers seemed to be correct so I referred to them and I suddenly figured out my wrong answers. (So, did you have your own thoughts before viewing the discussions and then made modification about the incorrect answers?) Yes, and then I related it to my previous knowledge, which helped me to be sure of my answers. (Can it help you to examine your answers?) Yes, if I saw that some people's answers were different from mine, I would think about them first. My answers were based on my previous learning impression on energy, so if my classmates' answers were not the same with mine, I would feel uneasy and start to wonder whose answers were wrong. Since I was not sure about the correct answer, I would ponder on the question over and over again, and I would take a look at the answers provided online by other people.

ii. HMY2: It was good to have a discussion section because sometimes my answers about introduction to energy might be wrong; so, if I could discuss with others, I could refer to more opinions for reference, and if I was not sure of my answers, I checked on my classmates' answers. On the contrary, if I was sure about my answers, I would ponder on my classmates' wrong answers and the discussions thoroughly, after which I will then check to see if I missed anything.

iii. HLY: I raised questions and answered questions as well. I believed that the contents of energy introduction helped me a lot. Through discussing with others, my thoughts were clarified. If I had different viewpoints, I would discuss them with my classmates, and if their answers did not seem reasonable, I stuck to my answers; but if at the end of the discussion, their answers seemed to be better, I would use their answers. I usually tend to discuss questions with closer classmates, but with the web, we could see everyone's answers and get more opinions from there and with various opinions, more people could be involved in the discussion and then integrate answers by themselves. It was helpful for learning.

iv. MMY2: People discussed with one another, which was different from the traditional class when one only cared about himself/herself. Everyone exchanged information about energy introduction and could refer to other people's opinions. I thought we had to look at things from everyone's perspective, instead of a person's perspective only. Since everyone had a different answer, we could combine all of them and get the answer we wanted. This would also help to clarify concepts. When we were met with different answers, we did not have to fight with others; instead, we expressed our answers and judged from what was right or wrong. In common classes, people tended to speak quickly, while on the web, it required texts. When we typed words, we got to think and communicate with others, which was good for improving our friendship. Unlike traditional classes where we only discuss with closer friends, on-line discussions are open and they have wider discussion dimensions. However, there were two students who provided reasons which accounted for bad efficiency with online discussion. For example, discussions were stopped because some topics were old or rarely responded to (perhaps it was because questions were too difficult to answer or people could not concentrate on one topic because there were too many topics) and it made students lose their confidence. Although, two students thought that online discussion sections helped, discussions made merely through texts tended to lead to chatting.

v. LLN2: (Why did you not join the discussion section?) It was of no use to make statements on the discussion section because everyone was expressing their own viewpoints and I could not tell which one was correct. I would rather think of an answer rather than find an answer closer to mine. (Will it not help you find your answers if you make discussions with others?) People would not discuss with me based on a specific topic because there were too many questions out there; as such, discussions were easily stopped midway. Perhaps, one had to discuss with people who had better grades; otherwise, it was possible to get a wrong answer and got oneself confused with nothing. So, I tended to take a look at the discussion and left no messages there.

Analysis and discussion of the "opinion on web-based cooperative learning questionnaire": Through the "opinion on web-based cooperative learning questionnaire", we got to know students' thoughts and opinions of the process of web-based learning activity. Most students maintained that web-based cooperative learning could enhance their learning, motivate them about introduction of energy, get further understanding of the content materials, and enable them to learn more efficiently. Students thought that with web-based cooperative learning, they had more chances to interact with other learners, had relaxing class atmosphere and found it more interesting to learn. They also hoped to continue with the introduction of the energy course through web-based cooperative learning in the future. Students considered it easy to make reports based on the surveyed data in the Internet and took delight in questions or expressing their own opinions through the web-based cooperative learning environment.

Most students were of the view that the Moodle-based cooperative learning platform was of easy access, provided a good communication tool, discussion section, small group section, "homework section", and made their learning more interesting. The analysis of the web-based cooperative learning questionnaire indicated that students could accept web-based cooperation learning activities; although they held positive attitudes towards energy introduction. The reasons are further summarized as follows:

(a) The change of instruction methods aroused students' learning motivation. Students felt that this kind of instruction is innovative and interesting. Many studies have pointed out that the application of computer multimedia enhances students' learning interests. With the assistance of animation, pictures and sound effects, it is easier to catch students' attention than the text descriptions in the books.

(b) The real situation of energy introduction was established through field trips, whereas sequences and clues of energy hidden in situations were explored with the use of Moodle digital learning platform. Teachers could moderately guide students to find problems in situations and help them develop expert problem-solving strategies and abilities.

(c) Students had theme-based learning and discussions in classes. They undertook further web-based learning with small groups without the time constraint. They could post materials they found on the discussion section for their group member discussion with one another and integrate their information into reports.

The results of the present study suggested that although students did not demonstrate significant grades in the energy basic concept test with Moodle digital learning platform, students' grade performance improved. The analysis of "opinion on web-based cooperative learning questionnaire" indicated that students held positive and affirmative learning attitudes.

Conclusions

It was found that 52.4% of the students were satisfied with the learning tools (online discussion and electronic notebook). Most students regarded web-based asynchronous cooperative learning as good learning approaches and experience. Students could express their own opinions at will and refer to different viewpoints from different perspectives. The interview data suggested that when students provided answers or gave their own explanations to a topic, they were not only connected to their previous knowledge, but also they had self-reflections on their own opinions and they re-examined their opinions when evoked by the stimulus of different opinions. Therefore, in the web-supported cooperative learning environment, students were making self-reflections and rechecking their own opinions. However, the constant response and reflection was absolutely beneficial for students' self-concept integration and learning.

In this web-based interactive learning environment, students could choose discussion topics freely; therefore, all the discussions were spontaneous, meaning that the establishment of the on-line discussion section had successfully created a cooperative learning environment which motivated students for automatic learning and knowledge exploration. The essence of two-way interactive Internet communication was to make users become constructive participants, rather than passive recipients. With the inter-subjective communication mode of Internet, users could form true communities. Students who participated in the on-line discussion interaction of this study maintained that the way of discussing on-line in turn promoted a better interaction, which not only helped to build up friendship among classmates, but also aroused their interests in learning energy education. However, there is a significant correlation between students' posts on the on-line discussion section and students' participation and identification during the cooperation process. On-line discussions provided students with the sense of participation, and made them feel that they were not just onlookers; instead, it was the reason why their learning efficiency was increased. During the experimental teaching, the more the interactions provided, the more the students' interests increased. As pointed out by Marchionini (1988), in a dynamic learning environment, learners had to constantly make self-judgments and evaluations on learning effects, forcing themselves to apply high-level problem-solving skills to learning and help to cultivate creation and thinking abilities (Webb, 1995; Hoadley and Linn, 2000; Wang, Tzeng and Chen, 2000; Su, Chen, Chen and Tsai, 2000). The present study veryfied that web-based interactive learning method was significantly helpful to students' learning on energy concept and problem-solving abilities. It was also found that students who participated in the online discussions had better learning effects than those who did not.

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