Web-based quiz-game-like formative assessment: Development and evaluation

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Abstract

This research aims to develop a multiple-choice Web-based quiz-game-like formative assessment system, named GAM-WATA. The unique design of ‘Ask-Hint Strategy’ turns the Web-based formative assessment into an online quiz game. ‘Ask-Hint Strategy’ is composed of ‘Prune Strategy’ and ‘Call-in Strategy’. ‘Prune Strategy’ removes one incorrect option and turns the original 4-option item into a 3-option one. ‘Call-in Strategy’ provides the rate at which other test takers choose each option when answering a question. This research also compares the effectiveness of three different types of formative assessment in an e-Learning environment: paper-and-pencil test (PPT), normal Web-based test (N-WBT) and GAM-WATA. In total, 165 fifth grade elementary students (from six classes) in central Taiwan participated in this research. The six classes of students were then divided into three groups and each group was randomly assigned one type of formative assessment. Overall results indicate that different types of formative assessment have significant impacts on e-Learning effectiveness and that the e-Learning effectiveness of the students in the GAM-WATA group appears to be better. Students in the GAM-WATA group more actively participate in Web-based formative assessment to do self-assessment than students in the N-WBT group. The effectiveness of formative assessment will not be significantly improved only by replacing the paper-and-pencil test with Web-based test. The strategies included in GAM-WATA are recommended to be taken into consideration when researchers design Web-based formative assessment systems in the future.

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Keywords: e-Learning; GAM-WATA; Online quiz game; Web-based formative assessment; WATA system

1. Introduction

Due to the rapid development of networking technology, e-Learning has become an alternative learning tool facilitating students’ learning. According to Bodzin and Cates (2003) and Santally and Raverdy (2006), in comparison with the traditional teaching, e-Learning is able to provide learners with increased resources and in turn promote their learning effectiveness. Therefore, making use of e-Learning to facilitate learning effectiveness has become a major issue in the e-Learning field.

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Santally and Raverdy (2006) indicated that the biggest strength of e-Learning lies in breaking down the time and space restriction and providing learners with more opportunities to learn with greater spontaneity. Although e-Learning has many advantages which seemingly can facilitate learning, there is still no solid evidence to prove that it can always lead to better learning outcome. Some researches revealed that e-Learning had better effectiveness than traditional learning (e.g. Asan, 2003; Cole & Hilliard, 2006; deLeon & Killian, 2000), while some indicated that there was no significant difference between e-Learning and traditional learning effectiveness (e.g. Jones, 2003; Ryan, 2002; Shen, Chung, Challis, & Cheung, 2007). One of the reasons leading to this inconsistency is learners’ attitudes toward e-Learning. Santally and Raverdy (2006) suggested that learners have to be responsible for their own learning effectiveness in an e-Learning environment. Sujo de Montes and Gonzales (2000) also argued that online students tended to be risk takers in terms of technology use and technology integration and suggested that learners in the e-Learning environment needed to be their own teachers. Therefore, designing an effective e-Learning environment that encourages students to take the initiative in their own learning is crucial.

The idea of assessment-centred learning environment (Bransford, Brown, & Cocking, 2000) can be taken as the basis of designing an effective e-Learning environment. Bransford et al. pointed out that in an assessment-centred learning environment, a successful teacher would not only make use of formative assessment to give learners constant feedback but also cultivate their ability of self-assessment, with which learners could evaluate their own learning at any time, thus in turn promoting overall learning effectiveness. However, it is difficult for the advantages of formative assessment to manifest themselves in a traditional learning environment because teachers often need to deal with many learners at the same time, or face the pressure of adhering to scheduled progress of instruction (Bransford et al., 2000; Buchanan, 2000). In other words, it is difficult for teachers to administer effective formative assessment and offer feedback in a traditional learning environment.

On the basis of Web-based Assessment and Test Analysis System (WATA System; Wang, Wang, Wang, Huang, & Chen, 2004), this research develops the Game Assessment Module of the WATA system (GAM-WATA). Implemented in an e-Learning environment, GAM-WATA will be able to help teachers administer Web-based formative assessment and interact with students. The unique strategy in GAM-WATA is ‘Ask-Hint Strategy’, including two quiz-game-like designs: ‘Prune Strategy’ and ‘Call-in Strategy’. In addition to enabling students to obtain increased feedback from Web-based formative assessment, GAM-WATA also aims to endow Web-based formative assessment with the characteristics of online quiz games and in turn encourage students to perform self-assessment spontaneously. This research not only develops GAM-WATA but also investigates the effectiveness of GAM-WATA in an elementary school e-Learning environment.

This research aims to answer the following two questions:

1. In comparison with normal Web-based test, can GAM-WATA more motivate students to actively participate in Web-based formative assessment to do self-assessment in an e-Learning environment?
2. In comparison with paper-and-pencil test and normal Web-based test, can GAM-WATA lead to better student learning effectiveness in an e-Learning environment?

2. Literature review

2.1. Formative assessment and learning effectiveness

Formative assessment is a key element in a teaching activity capable of considerably improving student learning effectiveness (Bell & Cowie, 2001; Black & Wiliam, 1998; Gipps, 1994). Bell and Cowie stated that formative assessment was an assessment integrated into the interaction between teachers and students. It can offer feedback to them in the process of learning and teaching. Primarily due to the positive effects of the feedback, formative assessment can facilitate student learning (Bell & Cowie, 2001; Clarke, 1995; Perrenoud, 1998; Sadler, 1989) and learners can learn to undertake ‘formative learning’ (Orsmond, Merry, & Callaghan, 2004). Scholars thus see feedback as an essential component of the formative assessment interaction, whose intention is to facilitate student learning.
Formative assessment plays an important role in both the traditional learning environment and the e-Learning environment. Many researchers have observed that student learning effectiveness could be improved if an e-Learning environment included the design of Web-based formative assessment (Buchanan, 2000; Burrow, Evdorides, Hallam, & Freer-Hewish, 2005; Gardner, Sheridan, & White, 2002; Henly, 2003; Khan, Davies, & Gupta, 2001; Peat & Franklin, 2002; Velan, Kumar, Dziegielewski, & Wakefield, 2002). Buchanan used PsyCAL to establish a Web-based formative assessment environment and applied it to the teaching of ‘Psychology’ in a university. He found that Web-based formative assessment could improve student interest in learning and learning effectiveness. Burrow et al. used TRIADS software to devise a formative assessment in a Web-based virtual learning environment (VLE) and applied it to the MSc programme in Road Management and Engineering. They concluded that Web-based formative assessment was a tool that not only promoted but also motivated students’ further learning. Gardner et al. designed a Web-based formative assessment tool, ‘Self-Assessment’, and integrated it into an e-Learning environment, where the university students were allowed to do Web-based formative assessments designed by the teachers any time they wanted. Gardner et al. found that the design of ‘Self-Assessment’ was helpful to the effectiveness of e-Learning and that students liked to use this design to facilitate their own learning in the e-Learning environment. Henly used ‘WebCT (http://www.webct.com)’ to administer a Web-based formative assessment to the students from the School of Dentistry in an e-Learning course entitled ‘Introduction to Biological Chemistry and Molecular Biology’. Results showed that about 80% of the students involved in the research felt the assessment was beneficial. Khan et al. adopted ‘Questionmark Perception (http://www.questionmark.com)’ to administer a Web-based formative assessment to the students from the School of Medicine in an e-Learning course on ‘Obstetrics and Gynaecology’; Velan et al. also used ‘Questionmark Perception’ to administer a Web-based formative assessment to the students from the School of Medicine in an e-Learning course on ‘Pathology’. Both studies appeared to indicate that Web-based formative assessment could help students facilitate and direct their own learning. Peat and Franklin adopted ‘Adobe Macromedia Authorware’ to develop SAM (Self-Assessment Module; Peat, 2000) and integrated it into the e-Learning environment of the university ‘Biology’ course. SAM allowed students to perform Web-based formative assessment online. The study found that such assessment could help improve students learning effectiveness.

The foregoing shows that formative assessment is beneficial to student learning in both traditional and e-Learning environments. Moreover, feedback is essential to an effective formative assessment. However, relevant experimental researches have not been adequately done and its theoretical basis has not been soundly constructed. Consequently, researchers argue for the further investigation on formative assessment (Bell & Cowie, 2001; Bransford et al., 2000; Black & Wiliam, 1998). Bell and Cowie supported that deeper investigation into the process of doing formative assessment should be conducted. Bransford et al. demanded the development of more new strategies for administering formative assessment. Black and Wiliam argued that probing into the correlation between learning and formative assessment and constructing the theoretical basis of formative assessment were required.

Taking the above into account, this research designs Web-based formative assessment strategies and incorporates them into the Web-based formative assessment system to develop GAM-WATA. It also attempts to understand the effectiveness of GAM-WATA in an e-Learning environment.

2.2. Design of a Web-based quiz-game-like formative assessment

To develop a Web-based formative assessment, this research takes into consideration the advice on the design of formative assessment in related research papers. Bransford et al. (2000, p. 257) argued that teachers should make use of formative assessment to provide students with numerous opportunities to perform self-assessment, obtain feedback and revise mistakes. Based on this idea, this research takes ‘repeat the test’ and ‘timely feedback’ as the key strategies in Web-based formative assessment. Buchanan (2000), Henly (2003), Khan et al. (2001), Peat (2000), Peat and Franklin (2002) and Velan et al. (2002) also believed that ‘repeat the test’ and ‘timely feedback’ should be included in the strategies of Web-based formative assessment. Buchanan further emphasized that to make the design of ‘repeat the test’ more effective, correct answers should not be given and feedback should be delivered immediately (timely feedback). According to Buchanan, if the design of ‘repeat the test’ does not give correct answers when students are repeating the test, but provides
reference as immediate feedback when they answer wrongly, students will become more focused on learning and gradually master the teaching materials. This research therefore concludes that combining the three strategies of ‘repeat the test’, ‘correct answers are not given’, and ‘timely feedback’ will enable students to make good use of Web-based formative assessment to facilitate their learning. In addition, other commonly suggested design strategies in research papers, such as ‘query scores’ and ‘ask questions’, should also be included in Web-based formative assessment system. For ‘query scores’, Gardner et al. suggested that the grade book function could record up-to-date scores for teachers and students to query. This allowed students and teachers to track learning status anytime and anywhere. Khan et al. further argued that allowing students to query their own or peer scores could help students track their own performance and encourage them to take the formative assessment. For ‘ask questions’, Burrow et al. (2005) stated that when students face difficulties, they should be encouraged to discuss the questions with peers or teachers. The strategy of ‘ask questions’ would provide students with the opportunity of interacting with their teachers through email. Based on the foregoing recommendations, this research concludes that a successful Web-based formative assessment system should include at least four important strategies: ‘repeat the test’, ‘correct answers are not given (with timely feedback)’, ‘query scores’ and ‘ask questions’.

Besides the designs stated above, this research further devises the strategies which can motivate students to actively participate in Web-based formative assessment by taking as reference the suggestions by Vogel, Greenwood-Erickson, Cannon-Bower, and Bowers (2006). According to Vogel et al., the interaction with computers itself can improve learning motivation, and the design which makes learning process resemble playing a game can enhance learning motivation even more. Vogel et al. also point out that ‘play’ is an important element of the game and also of learning motivation. In other words, ‘play’ has the potential to engage students in the learning process. In addition to ‘play’, ‘interactivity’ is another important element because the ‘interactivity’ between users and game programs determines the level of users’ participation in activities. Vogel et al. believe that ‘appropriate challenge’ is also an important component because a game which brings learners ‘appropriate challenge’ can scaffold their learning. If the challenge is too difficult, learners will feel it is unlikely to overcome the difficulties and therefore give up the chances to participate in the challenge; if the challenge is too easy, learners will become distracted and lose the interest of participating in the challenge. Besides ‘play’, ‘interactivity’ and ‘appropriate challenge’, ‘rewards and scores’ are the final components of a game. Vogel et al. argue that ‘rewards and scores’ cannot only provide learners with feedbacks, which make them know whether their answers are correct or wrong, but also serve as the motivating entity because when a student take higher scores or rewards as his/her target of efforts, he/she will learn more quickly and efficiently. The views of Vogel et al. stated above suggest that in a computer-assisted learning environment, the design which makes learning process like playing a game can promote learning motivation, and the four main components of a game are ‘play’, ‘interactivity’, ‘appropriate challenge’ and ‘rewards and scores’. In other words, a game should be equipped not only with proper ‘challenge mechanism’, making learners encounter challenges during ‘gameplay (Kiili, 2005)’, but also with the features of providing ‘rewards and scores’. Moreover, the rules of gameplay should be set to enhance the ‘interactivity’ between learners and game programs. In this way, a game will be able to effectively promote learning motivation.

Based on the suggestions by Vogel et al., this research adds ‘all pass and then reward’, ‘monitor answering history’ and ‘Ask-Hint strategy’ in addition to the four strategies illustrated above (‘repeat the test’, ‘correct answers are not given’, ‘query scores’ and ‘ask questions’) to construct GAM-WATA. The design of GAM-WATA can construct the ‘challenge mechanism’ and ‘game mechanism’, which assist teachers to administer Web-based quiz games in an e-Learning environment. The seven strategies of GAM-WATA are implemented in the following ways.

The three strategies, ‘repeat the test’, ‘correct answers are not given’ and ‘all pass and then reward’, mean that if students answer a certain item correctly three times in succession, this item will not appear again in further tests. If the three times are not consecutive, the system will assume that the student answered correctly in previous tries merely by guessing. Since the items correctly answered for three consecutive times are removed from the test, the number of items requiring an answer will fall with each iteration of the test. Finally, there will be no questions that the student has not answered correctly three times in a row. The student will then be deemed as passing the test, and the system will play an Adobe Macromedia Flash animation as a reward. ‘Monitor answering history’ allows students to query their own answering history after all items have
been passed, which helps them know how they pass the test. The ‘ask questions’ function allows students to send their questions to teachers by e-mail. Based on the responses from their teacher, students can revise their mistakes. ‘Query scores’ allows students to query their own and peer scores, which helps them track their own learning status. To reduce student boredom, GAM-WATA also has to randomly arrange options and items.

‘Ask-Hint strategy’ is a unique strategy in GAM-WATA. In quiz games, the challenge mainly comes from the difficulty of the items. When the items are too difficult for the less-competent students, they will feel hopeless in overcoming the difficulties and in turn give up taking the challenge. The design of ‘Ask-Hint strategy’ can prevent this from happening. ‘Ask-Hint Strategy’ is composed of ‘Prune Strategy’ and ‘Call-in Strategy’, providing students with immediate online hints (rather than correct answers) about how to answer (see Section 3.2.1 below for more discussion). ‘Ask-Hint Strategy’ can reduce the difficulty of an item and provide the info about how their peers answer each question for the less-competent students. This will maintain less-competent students’ motivation in participating in the challenge. This research tries to examine the effectiveness of GAM-WATA in facilitating elementary school student learning in an e-Learning environment and understand whether GAM-WATA can promote students motivation to actively participate in Web-based formative assessment.

3. Methodology

3.1. Participants

Four elementary school science teachers who were experienced in Web-based instruction, along with 165 fifth graders from six classes they teach, were invited to participate in this research. The teachers and students came from three different schools in central Taiwan. The six classes totalling 165 (84 female and 81 male) valid participants were randomly divided into three different groups: the PPT group (paper-and-pencil test group), the N-WBT group (normal Web-based test group), and the GAM-WATA group (Table 1). All the six classes took the same e-Learning course. The 165 students all had taken computer classes before and were equipped with basic computer skills and were able to use e-Learning system.

3.2. Instruments

3.2.1. GAM-WATA and the e-Learning environment

GAM-WATA is one of the modules in the WATA system. Its design primarily aims to help teachers administer a Web-based quiz-game-like formative assessment in an e-Learning environment. It contains the six strategies suggested in research papers (see Section 2.2) and ‘Ask-Hint Strategy’. ‘Ask-Hint Strategy’ provides online hints as feedback for students who have difficulties in answering questions. However, the number of times students may use the ‘Ask-Hint Strategy’ is limited. Students are expected to use ‘Ask-Hint Strategy’ carefully to get online hints when they fail to answer a certain item correctly in a Web-based formative assessment. This strategy design mainly aims to allow students of different competency levels to take the challenges corresponding to their levels in the Web-based quiz game. The less-competent students can make use of ‘Ask-Hint Strategy’ to gain hints or reduce the difficulty of each item by reducing the number of options. Once the

| Table 1 |
| Participant distribution by TFA and Gender |
| Gender | TFA |  |  |  |
|        | PPT | N-WBT | GAM-WATA | Sum |
| Female | 26  | 30    | 28       | 84  |
| Male   | 27  | 29    | 25       | 81  |
| Sum    | 53  | 59    | 53       | 165 |

TFA, types of formative assessment; PPT, formative assessment is administered in the form of paper-and-pencil test; N-WBT, formative assessment is administered in the form of normal Web-based test; GAM-WATA, formative assessment is administered in the form of GAM-WATA.
difficulty of passing the challenge is lowered, the less-competent students will not become less motivated to actively participate in Web-based formative assessment when they encounter too many difficulties during the assessment. As to the students with better competency, they can choose not to use ‘Ask-Hint Strategy’ and the difficulty of passing the challenge will be maintained. In addition, the objective of implementing formative assessment is different from that of implementing summative assessment. Formative assessment is not meant to evaluate the final learning effectiveness of students but to motivate them to actively engage in self-assessment (Bransford et al., 2000). It cannot only help students monitor their own learning but also facilitate them to do ‘formative learning (Orsmond et al., 2004)’ and further improve their learning effectiveness. Therefore, before GAM-WATA is implemented, teachers will inform students of the way and meaning of administering formative assessment. In this way, the design of ‘Ask-Hint Strategy’ will not make students feel that the assessment is unfair.

There are two designs in ‘Ask-Hint Strategy’: ‘Prune Strategy’ and ‘Call-in Strategy’. These two strategies are introduced in the following.

- ‘Prune Strategy’ (Fig. 1)

Rodriguez (2005) points out that the difficulty of multiple-choice items can be influenced by the number of options, so reducing the number of options will reduce the difficulty of an item. Moreover, if the respondents of an item are in lower grades or of lower competency, the number of options should be reduced (Hopkins, 1998). Based on these arguments, the design of ‘Prune Strategy’ is included in ‘Ask-Hint Strategy’. This strategy can be used to make an item less difficult. With this design, students of different levels of competency can take the challenges whose difficulty corresponds to their levels. According to Rodriguez’s analysis, although reducing the number of options can reduce the difficulty of an item, reducing the number from 5 or 4 to 2 will make the item significantly easier, less discriminating, and the scores less reliable. However, if the number is reduced from 5 or 4 to 3, these negative effects will not happen. Therefore, ‘Prune Strategy’ removes one incorrect option and turns the original 4-option item into a 3-option item to reduce its difficulty. Students can press the ‘scissors icon’ located in front of the item number to use the ‘Prune Strategy’.

- ‘Call-in Strategy’ (Fig. 2)

In the viewpoints of socio-psychology, when people do not have a clear idea about the situation and do not know what correct actions to take or proper opinions to express, they tend to gather information by observing others’ behaviours and take it as an important guide for their own behaviours. This is called ‘informational social influence (Baron & Byrne, 1997)’. Based on this view, ‘Call-in Strategy’ is included in ‘Ask-Hint Strategy’. ‘Call-in Strategy’ provides the rate at which different options are chosen as the correct answer by other test takers for a specific item. When the less-competent students encounter difficulties in answering an item,
they can make use of this strategy to know how their peers answer this item and take the information as reference to decide which option to choose. In this way, their motivation of actively participating in Web-based formative assessment will not be reduced by too many difficulties they encounter during the Web-based quiz game. Students can click on the ‘telephone icon’ in front of the item number to use the ‘Call-in Strategy’.

Teachers can set the limit for the number of times students may use ‘Ask-Hint Strategy’ according to the difficulty of the GAM-WATA formative assessment. The number of cartoon characters along the bottom of the screen in Figs. 1 and 2 represents the remaining times the test-taker can use ‘Ask-Hint Strategy’. The cartoon character at the top of the screen in Figs. 1 and 2 informs users of what percentage of items they have answered correctly three times consecutively, thus indicating their progress.

In the design of the e-Learning environment, this research focuses on the topic, ‘Roots, Stems and Leaves of Plants’. This topic is quite important in the elementary school ‘Nature and Life Technology’ course in Taiwan. A number of researchers (Barman, Stein, McNair, & Barman, 2006; McNair & Stein, 2001; Tunnicliffe & Reiss, 2000) have found that students’ understanding of plants is often limited and needs to be improved. This research tries to construct an e-Learning environment by taking into account four important concepts about plants elementary school students should know about, which are ‘water and plants’, ‘roots’, ‘stems’ and ‘leaves’. The topics included in this research cover the following learning contents:

Water and plants: The importance of water to plants and sprouting; the transmission and transpiration of water in the body of plants.

Roots: The functions of roots; vegetative propagation (roots); the mutation of roots.

Stems: The functions of stems; vegetative propagation (stems); the mutation of stems.

Leaves: The shapes of leaves, vegetative propagation (leaves); the mutation of leaves.

It is expected that after students learn in this environment, their concepts about plants can be improved. This environment is powered by ATutor Learning Content Management System (http://www.atutor.ca/). As shown in Fig. 3, it is composed of the e-Learning materials with illustrations and text, references, Adobe Macromedia Flash animations and so on.

3.2.2. Summative assessment and formative assessment

The design of the items in the formative assessment is based on the e-Learning contents and these items are used to establish an item bank. The item bank provides all items for the three different types of formative assessment in this research. Students taking these three different types of formative assessment practice the same items. In addition, items in the formative assessment are never used in the summative assessment.

The design of the items in the summative assessment is based on the four important concepts about plants introduced in the e-Learning environment, which are ‘water and plants’ (five items), ‘roots’ (ten items), ‘stems’ (nine items) and ‘leaves’ (six items). For the Two-Way Chart of the summative assessment in this study, please see Table 2. The items in this research are designed by three experts in biology education and assessment and focus on the four important concepts. This design takes the idea of ‘Knowledge Level’ and ‘Comprehension
Level’ defined in Bloom’s taxonomy of cognitive domain (Bloom, Engelhart, Furst, & Krathwohl, 1956) as its basis to ensure that the summative assessment will include not only Knowledge-level items but both Knowledge-level items and Comprehension-level items (see Appendix). Knowledge-level items involve recalls or
recognition of ideas or concepts, and Comprehension-level items emphasize on student understanding of ideas or concepts (Çepni, Taş, & Köse, 2006). It is expected that the summative assessment will be able to evaluate student learning effectiveness in the e-Learning environment. This research will also probe into how students answer the Knowledge-level items and Comprehension-level items.

In this research, the pre-test scores of the summative assessment represent entry behaviour of learning, and the post-test scores represent the learning outcome. The average difficulty of the summative assessment test in this research is 0.573 and the Cronbach’s $\alpha$ is 0.842. In addition, the discrimination index of each item is over 0.300.

3.3. Research design and procedures

This research required two weeks in total (six classes). There were three different types of formative assessment, including paper-and-pencil test (PPT), normal Web-based test (N-WBT) and GAM-WATA (see Table 3). This experimental design aims to explore how student learning effectiveness will differ when teachers use paper-and-pencil test (PPT group), normal Web-based test (N-WBT group) and GAM-WATA Web-based formative assessment (GAM-WATA group) to facilitate their learning in an e-Learning environment. It also tries to explore whether GAM-WATA can make students more willing to actively participate Web-based formative assessment. Regarding the research process, before the 2-week e-Learning course, students took the pre-test of the summative assessment. Afterward each class as a unit participated in one of the three different types of formative assessment, and familiarized itself with the e-Learning environment. Students in the GAM-WATA group could learn on the Web and take part in GAM-WATA at any time spontaneously. Students in the N-WBT group could also study on the Web and take formative assessments at any time spontaneously, but formative assessments were administered in the form of normal Web-based test. The strategy design in the N-WBT group resembles that in general Web-based test. It only turns the paper-and-pencil formative assessment tests administered in classrooms into Web-based test. The major difference between the GAM-WATA group and the N-WBT group is that students in the N-WBT group cannot use ‘Ask-Hint Strategy’. In addition, students in the N-WBT group may repeat the tests several times and have to answer all of the items every time. When students of the N-WBT group answer an item incorrectly, the system will directly provide the correct answer along with the reference. Unlike GAM-WATA, the system does not create an answering history which shows whether the students have passed the tests or not. Students in the PPT group could also study on the Web at any time, but formative assessments (paper-and-pencil test) were administered after each class. After the assessments, correct answers were given but not actively explained by teachers. Instead, students were supposed to actively ask teachers questions and were asked to find answers on the Web pages. Furthermore, test papers were returned to the PPT group students for review. The e-Learning environment and the items in the three different types of formative assessment were identical. After receiving the 2-week instruction, all the students had to take the post-test of the summative assessment.

3.4. Data collection and analysis

In this research, three sets of quantitative data were collected, including ‘times of taking Web-based formative assessment (TIMES)’, ‘pre-test scores of summative assessment (PRE)’ and ‘post-test scores of summative assessment (POST)’. All the data were analysed with SPSS™ Ver.12 (SPSS Inc., Chicago). To understand whether GAM-WATA makes students more actively participate in Web-based formative assessment, this research used independent t-test to know how students in GAM-WATA group and in N-WBT group differ in their TIMES. In addition, to explore whether GAM-WATA can promote student learning effectiveness, the PRE was taken to represent the entry behaviour of learning, while the difference between the PRE and the POST was taken as the indication of student learning effectiveness. This research used Analysis of Covariance (ANCOVA), taking the PRE as the covariate, the POST as the dependent variable and the ‘types of formative assessment (TFA)’ as the fixed factor, to test the relationship between the POST and the TFA. The LSD method was also used to compare the effectiveness of three different types of formative assessment. Besides doing analysis on the PRE and the POST, this study also took the Two-Way Chart of the summative
assessments as reference to analyze how students answered Knowledge-level items (PRE_know, POST_know) and Comprehension-level items (PRE_comp, POST_comp) in the pre-test and the post-test of the summative assessment. In this way, it can be better clarified how the three different types of formative assessment influence student learning effectiveness.

<table>
<thead>
<tr>
<th>Types of formative assessment</th>
<th>GAM-WATA</th>
<th>N-WBT</th>
<th>PPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designs</td>
<td>Administered by GAM-WATA. Learners can use GAM-WATA to challenge themselves. Concrete strategies are as follows:</td>
<td>Normal Web-based test (N-WBT) is a kind of Web-based formative assessment without all of the GAM-WATA strategies. It only turns the traditional paper-and-pencil test into Web-based test.</td>
<td>Instead of Web-based assessment, all the formative assessments are administered by paper-and-pencil test.</td>
</tr>
<tr>
<td>1. Ask-Hint Strategy</td>
<td>1. Repeat the test</td>
<td>1. Repeat the test</td>
<td>1. Repeat the test</td>
</tr>
<tr>
<td>There are two designs in the ‘Ask-Hint Strategy’, the ‘Prune Strategy’ and the ‘Call-in Strategy’. Students who have difficulties in answering questions are allowed to use this strategy to obtain online hints.</td>
<td>Students may repeat the test for more practice. The system randomly chooses at most five items for students to answer each time. If the students answer a given item correctly three times consecutively, the system will judge that the students ‘truly answer correctly’ and the item will not appear again on the test.</td>
<td>The formative assessment is done during the teaching process, playing a role quite similar to quizzes. Corrected test papers are handed back to students so that they can repeat the tests and practice answering the questions after class by themselves.</td>
<td></td>
</tr>
<tr>
<td>2. Repeat the test</td>
<td>2. Correct answers are not given</td>
<td>2. Correct answers are given</td>
<td>2. Correct answers are given</td>
</tr>
<tr>
<td>Students may repeat the test for more practice. The system randomly chooses at most five items for students to answer each time. If the students answer a given item correctly three times consecutively, the system will judge that the students ‘truly answer correctly’ and the item will not appear again on the test.</td>
<td>After students submit the answers, correct answers are not given directly, but a reference is provided.</td>
<td>The system will provide correct answers directly, along with a reference.</td>
<td></td>
</tr>
<tr>
<td>3. Correct answers are not given</td>
<td>3. Ask questions</td>
<td>3. Ask questions</td>
<td>3. Ask questions</td>
</tr>
<tr>
<td>After students submit the answers, correct answers are not given directly, but a reference is provided.</td>
<td>Students are allowed to ask questions of teachers asynchronously through the system.</td>
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</tr>
<tr>
<td>Students are allowed to ask questions of teachers asynchronously through the system.</td>
<td>Students may check their own scores and those of peers.</td>
<td>Students may check their own scores and check peer scores privately.</td>
<td></td>
</tr>
<tr>
<td>5. Query scores</td>
<td>5. Monitor answering history</td>
<td>5. All pass and then reward</td>
<td>5. All pass and then reward</td>
</tr>
<tr>
<td>Students may check their own scores and those of peers.</td>
<td>Students can query personal and peer answering history of each item.</td>
<td>When students reach the level of ‘pass the test (truly answer all items correctly)’, the system will show an animation as a reward.</td>
<td></td>
</tr>
<tr>
<td>Students can query personal and peer answering history of each item.</td>
<td>7. All pass and then reward</td>
<td>7. All pass and then reward</td>
<td>7. All pass and then reward</td>
</tr>
<tr>
<td>7. All pass and then reward</td>
<td>When students reach the level of ‘pass the test (truly answer all items correctly)’, the system will show an animation as a reward.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. Results

First, to understand whether the strategy design of GAM-WATA can make students more willing to actively participate in Web-based formative assessment, this research used independent \( t \)-test to know how students in GAM-WATA group and in N-WBT group differ in their TIMES. For the analysis results, please see Table 4.

Table 4 shows that there is a significant difference between the TIMES of students in the GAM-WATA group and that of the students in the N-WBT group (\( t = 8.920, p < 0.01 \)). Students in the GAM-WATA group appear to take Web-based formative assessment more actively than students in the N-WBT group.

In order to understand the effectiveness of the three different types of formative assessment, the ANCOVA was used. In addition to doing analysis on how students score in the pre-test (PRE) and the post-test (POST) of the summative assessment, this research also analyzes how students answer Knowledge-level items and Comprehension-level items in the pre-test and the post-test of the summative assessment. Before ANCOVA, the homogeneity of variance assumption was tested. The Levene’s test for equality of variances was not significant (Knowledge: \( F_{2,162} = 0.255, p > 0.05 \); Comprehension: \( F_{2,162} = 0.871, p > 0.05 \); Total: \( F_{2,162} = 0.057, p > 0.05 \)). In addition, the assumption of homogeneity of regression coefficients was also tested (Knowledge: \( F_{2,159} = 3.043, p > 0.05 \); Comprehension: \( F_{2,159} = 0.053, p > 0.05 \); Total: \( F_{2,159} = 0.457, p > 0.05 \)). These results indicated that both homogeneity assumptions were not violated.

Concerning the analysis of how students answer the Knowledge-level items in the pre-test (PRE know) and the post-test (POST know) of the summative assessment, Table 5 shows that the PRE know has a significant impact on the POST know (\( F_{1,161} = 27.728, p < 0.01 \)), and the TFA is also found to have a significant impact on the POST know (\( F_{2,161} = 5.756, p < 0.01 \)). On the other hand, concerning the analysis of how students answer the Comprehension-level items in the pre-test (PRE comp) and the post-test (POST comp) of the summative assessment, Table 5 indicates that both PRE comp (\( F_{1,161} = 68.212, p < 0.01 \)) and TFA (\( F_{2,161} = 5.918, p < 0.01 \)) are found to have a significant impact on the POST comp. As to the analysis of how students score in the pre-test and post-test of the summative assessment, Table 5 also shows that both PRE (\( F_{1,161} = 98.616, p < 0.01 \)) and TFA (\( F_{2,161} = 6.825, p < 0.01 \)) have a significant impact on the POST.

Furthermore, the LSD method was used to compare the effectiveness of the three different types of formative assessment (Table 5). Table 5 shows that there is no significant difference between the PPT group and the N-WBT group. However, concerning students’ performance in the summative assessment as a whole or in answering Comprehension-level items, students in the GAM-WATA group appear to perform significantly better than those in the PPT group and the N-WBT group. As to the performance in answering Knowledge-level items, students in the GAM-WATA group appear to perform significantly better than those in the PPT group.

Afterward ANCOVA was also used to separately assess student learning effectiveness of the four concepts about plants in the three groups. Before ANCOVA, the homogeneity of variance assumption was tested. The Levene’s test for equality of variances was not significant (‘water and plants’: \( F_{2,162} = 0.195, p > 0.05 \); ‘roots’: \( F_{2,162} = 0.729, p > 0.05 \); ‘stems’: \( F_{2,162} = 0.349, p > 0.05 \); ‘leaves’: \( F_{2,162} = 0.710, p > 0.05 \)). In addition, the assumption of homogeneity of regression coefficients was also tested (‘water and plants’: \( F_{2,159} = 0.058, p > 0.05 \); ‘roots’: \( F_{2,159} = 0.854, p > 0.05 \); ‘stems’: \( F_{2,159} = 0.586, p > 0.05 \); ‘leaves’: \( F_{2,159} = 0.008, p > 0.05 \)). These results indicated that both homogeneity assumptions were not violated.

In terms of how effectively the four concepts are learned by the three groups of students who take three different types of formative assessment, Table 6 shows that the PREs on the four concepts (‘water and plants’:...
**Table 5**  
ANCOVA summary table \((n = 165)\)

<table>
<thead>
<tr>
<th>Item type</th>
<th>Variable</th>
<th>Level</th>
<th>Mean(^{a}) (Std. error)</th>
<th>(F) value</th>
<th>Post Hoc(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge-level</td>
<td>(\text{PRE}_{\text{know}})</td>
<td>TFA</td>
<td>PPT</td>
<td>15.915 (0.934)</td>
<td>27.728**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N-WBT</td>
<td>17.999 (0.869)</td>
<td>5.756** GAM-WATA &gt; PPT**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GAM-WATA</td>
<td>20.400 (0.918)</td>
<td></td>
</tr>
<tr>
<td>Comprehension-level</td>
<td>(\text{PRE}_{\text{comp}})</td>
<td>TFA</td>
<td>PPT</td>
<td>30.472 (1.108)</td>
<td>68.212** GAM-WATA &gt; N-WBT**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N-WBT</td>
<td>30.838 (1.020)</td>
<td>5.918** GAM-WATA &gt; PPT**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GAM-WATA</td>
<td>35.262 (1.093)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>PRE</td>
<td>TFA</td>
<td>PPT</td>
<td>47.451 (1.596)</td>
<td>98.616** GAM-WATA &gt; N-WBT**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N-WBT</td>
<td>48.460 (1.460)</td>
<td>6.825** GAM-WATA &gt; PPT**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GAM-WATA</td>
<td>55.018 (1.560)</td>
<td></td>
</tr>
</tbody>
</table>

---

\(^{a}\) Covariates appearing in the model are evaluated at the following values:
- \(\text{PRE}_{\text{know}} = 14.707\).
- \(\text{PRE}_{\text{comp}} = 24.707\).
- \(\text{PRE} = 39.414\).

\(^{b}\) Adjustment for multiple comparisons: Least significant difference (equivalent to no adjustments).

Knowledge-level: Only those items in the summative assessment which can be categorized as ‘Knowledge Level’ in Bloom’s taxonomy of cognitive domain.

Comprehension-level: Only those items in the summative assessment which can be categorized as ‘Comprehension Level’ in Bloom’s taxonomy of cognitive domain.

Total: All items in the summative assessment.

TFA, types of formative assessment.
\(\text{PRE}_{\text{know}}\), pre-test scores of summative assessment (knowledge-level items only).
\(\text{PRE}_{\text{comp}}\), pre-test scores of summative assessment (comprehension-level items only).
\(\text{PRE}\), pre-test scores of summative assessment.

** \(p < 0.01\).**

\(F_{1,161} = 26.367, p < 0.01\); ‘roots’: \(F_{1,161} = 12.139, p < 0.01\); ‘stems’: \(F_{1,161} = 36.986, p < 0.01\); ‘leaves’: \(F_{1,161} = 16.203, p < 0.01\) and the TFA (‘water and plants’: \(F_{2,161} = 4.317, p < 0.05\); ‘root’: \(F_{2,161} = 5.090, p < 0.01\); ‘stems’: \(F_{2,161} = 4.463, p < 0.05\); ‘leaves’: \(F_{2,161} = 5.809, p < 0.01\)) all have significant impacts on the POSTs. Furthermore, the LSD method was used to identify how the TFA influenced student learning effectiveness. As shown in Table 6, there is no significant difference between the PPT group and the N-WBT group in the effectiveness of student learning of the four concepts. However, the students in the GAM-WATA group appear to perform significantly better than those in the PPT group. It is also found that except in the learning of the concept about roots, the learning effectiveness of the GAM-WATA group is significantly better than that of the N-WBT group.

These results reveal that the strategies in GAM-WATA encourage students to take Web-based formative assessment more actively than strategies in N-WBT. Moreover, different types of formative assessment may lead to different learning effectiveness in an e-Learning environment. Students appear to have better effectiveness in an e-Learning environment equipped with GAM-WATA. However, it is also found that students in the GAM-WATA group perform significantly better in answering the Knowledge-level items than students in the PPT group and also perform significantly better in answering the Comprehension-level items than students in the N-WBT group and the PPT group. These results may be explained by the fact that the strategies in GAM-WATA can motivate students to actively participate in Web-based formative assessment for self-assessment. With the active self-assessment, students can monitor their own learning and their learning effectiveness can also be improved (Bransford et al., 2000). Moreover, since students can know the rate at which each option of an item is chosen by their peers by using ‘Call-in Strategy’ in GAM-WATA, they cannot only take the information as reference but be motivated to do more thinking and actively try to find other reference resources when they find that more peers choose the option they themselves do not take to be correct. As to ‘Prune Strategy’, besides making an item easier by reducing the number of options, it can also motivate students
to do more thinking and actively try to find other reference resources when they find that the option they take to be correct is pruned. These can all be the possible reasons why students in the GAM-WATA group perform better in answering Knowledge-items and Comprehension-items, but these inferences still require the support of more empirical evidences.

In addition to the above, the results also reveal that if the administering of formative assessment in an e-Learning environment only involves changing paper-and-pencil test into Web-based test and no assessment strategies are offered to help students during the tests (this is the case of N-WBT), then the effectiveness of formative assessment in promoting student learning will not necessarily be improved. All in all, if Web-based formative assessment is administered in the form of a Web-based quiz game, it will successfully evoke students’ motivation to actively participate in Web-based formative assessment. Moreover, if more strategies are used in a Web-based formative assessment to provide feedback, it would have a positive effect on the effectiveness of the assessment. Therefore, the strategies included in GAM-WATA are recommended to be taken into consideration when researchers design Web-based formative assessment systems.

5. Concluding remarks

The effectiveness of GAM-WATA in an e-Learning environment is promised. GAM-WATA has the potential to engage students in taking Web-based formative assessment more actively. There are seven strategies in GAM-WATA, including ‘repeat the test’, ‘correct answers are not given’, ‘query scores’, ‘ask questions’, ‘monitor answering history’, ‘all pass and then reward’ and ‘Ask-Hint Strategy’. These strategies make a Web-based formative assessment become an online quiz game. This research compares students’ active participation in

Table 6

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Variable</th>
<th>Level</th>
<th>Meana (Std. error)</th>
<th>F value</th>
<th>Post Hoc(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water and plants</td>
<td>PRE</td>
<td>PPT</td>
<td>9.051 (0.548)</td>
<td>26.367**</td>
<td>GAM-WATA &gt; PPT**</td>
</tr>
<tr>
<td></td>
<td>TFA</td>
<td>PPT</td>
<td>9.660 (0.514)</td>
<td>4.317*</td>
<td>GAM-WATA &gt; N-WBT*</td>
</tr>
<tr>
<td></td>
<td>N-WBT</td>
<td></td>
<td>11.265 (0.548)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GAM-WATA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roots</td>
<td>PRE</td>
<td>PPT</td>
<td>11.496 (0.816)</td>
<td>12.139**</td>
<td>GAM-WATA &gt; PPT**</td>
</tr>
<tr>
<td></td>
<td>TFA</td>
<td>PPT</td>
<td>13.378 (0.765)</td>
<td>5.090**</td>
<td>GAM-WATA &gt; N-WBT*</td>
</tr>
<tr>
<td></td>
<td>N-WBT</td>
<td></td>
<td>15.183 (0.807)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GAM-WATA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stems</td>
<td>PRE</td>
<td>PPT</td>
<td>14.474 (0.706)</td>
<td>36.986**</td>
<td>GAM-WATA &gt; PPT**</td>
</tr>
<tr>
<td></td>
<td>TFA</td>
<td>PPT</td>
<td>15.208 (0.654)</td>
<td>4.463*</td>
<td>GAM-WATA &gt; N-WBT*</td>
</tr>
<tr>
<td></td>
<td>N-WBT</td>
<td></td>
<td>17.339 (0.696)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GAM-WATA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves</td>
<td>PRE</td>
<td>PPT</td>
<td>10.207 (0.519)</td>
<td>16.203**</td>
<td>GAM-WATA &gt; PPT**</td>
</tr>
<tr>
<td></td>
<td>TFA</td>
<td>PPT</td>
<td>10.946 (0.486)</td>
<td>5.809**</td>
<td>GAM-WATA &gt; N-WBT*</td>
</tr>
<tr>
<td></td>
<td>N-WBT</td>
<td></td>
<td>12.639 (0.514)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GAM-WATA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{a}\) Covariates appearing in the model are evaluated at the following values:
Water and plants: PRE = 7.737.
Roots: PRE = 10.081.
Stems: PRE = 12.748.
Leaves: PRE = 8.849.

\(^{b}\) Adjustment for multiple comparisons: Least significant difference (equivalent to no adjustments).

PRE, pre-test scores of summative assessment.
TFA, formative assessment is administered in the form of paper-and-pencil test.
N-WBT, formative assessment is administered in the form of normal Web-based test.
GAM-WATA, formative assessment is administered in the form of GAM-WATA.

\(^*\) p < 0.05.
\(^{**}\) p < 0.01.
Web-based formative assessment when it is conducted in the form of GAM-WATA and normal Web-based test (N-WBT). The results show that students in the GAM-WATA group more actively participate in Web-based formative assessment than students in the N-WBT group. In other words, in this research, the ‘challenge mechanism’ and ‘game mechanism’ of GAM-WATA turning Web-based formative assessment into a Web-based quiz game appear to promote students’ motivation to actively participate in Web-based formative assessment. This research also investigates the effectiveness of administering formative assessment in the form of paper-and-pencil test (PPT), normal Web-based test and GAM-WATA in an e-Learning environment. The results show that there are significant differences in the effectiveness of the three different types of formative assessment. It is also found that in answering Knowledge-level items in the summative assessment, the performance of the GAM-WATA group is significantly better than the PPT group. Concerning the answering of the Comprehension-level items, its performance is significantly better than both the N-WBT group and the PPT group. As to the performance in the summative assessment as a whole, the GAM-WATA group performs significantly better than the N-WBT group and the PPT group. Furthermore, the N-WBT group performs better than the PPT group, though not significantly so. The possible reason is that the strategies in GAM-WATA can motivate students to actively participate in Web-based formative assessment for self-assessment and in turn improve their learning effectiveness. On the other hand, when students in the GAM-WATA group use ‘Prune Strategy’ and ‘Call-in Strategy’ and find that the options they take to be correct are pruned (in ‘Prune Strategy’) or not chosen by most of the peers (in ‘Call-in Strategy’), they may feel it strange and curious. This feeling may motive them to do more thinking and actively try to find other reference resources. In this way, the learning effectiveness of the students in the GAM-WATA group can be improved. Nevertheless, the mechanism and theoretical basis of learning motivation stated above still require the support of more empirical evidences.

It is also found that if the administering of formative assessment only involves changing paper-and-pencil test into Web-based test and no assessment strategies are offered (this is the case of N-WBT), this change will not necessarily improve the effectiveness of formative assessment. Additionally, if more strategies are used in a Web-based formative assessment system to provide feedback and enhance the human–computer interaction, it would have a positive influence on the effectiveness of the system. This research suggests that more effective strategies should be incorporated in Web-based formative assessment to construct a successful e-Learning environment. When Web-based formative assessment is administered in the form of a Web-based quiz game, students will more actively participate in Web-based formative assessment and the assessment can better facilitate their learning effectiveness. In addition, the strategies of GAM-WATA in this research appear to be successful in attracting students to actively participate in Web-based formative assessment and improving students’ e-Learning.

According to the research results illustrated above, if GAM-WATA can be included into the e-Learning environment with all the strategies it contains adopted, it will hopefully be able to help students achieve better e-Learning effectiveness. However, since this study only analyses the use of GAM-WATA by the students in the fifth grade of elementary school and mainly focuses on the concepts about plants in Biology, the results cannot be inferred to cover the students in other grades and their learning of other concepts in other subjects. More qualitative and quantitative researches should be conducted to extensively examine the effectiveness of GAM-WATA and understand the mechanism and theoretical basis of how learning effectiveness is promoted. GAM-WATA also waits to be put into practice by more teachers in the e-Learning environment. In this way, the effectiveness of GAM-WATA can be clarified and more suggestions for improvement about the strategy design will be gained. With these suggestions, GAM-WATA can be further perfected. Another important problem deserving attention is the fact the feedback provided by ‘Ask-Hint Strategy’ of current GAM-WATA is not as direct and resourceful as the reference information provided by teachers to facilitate student learning in a traditional learning environment. According to Narciss (1999), the effectiveness of the formative assessment depended on the effectiveness of the feedback, which in turn depended on its informativeness. Narciss defined three feedback conditions, ‘knowledge about result (low informativeness)’, ‘knowledge about mistakes (medium informativeness)’, and ‘knowledge about how to process (high informativeness)’. Narciss further pointed out that the informativeness of feedback affected both information processing and learner motivation. In this research, GAM-WATA tends to provide the feedback belonging to the category of ‘medium informativeness’ defined by Narciss. In the future construction of the Web-based formative assessment system, it is suggested that techniques and technologies of intelligent tutoring should be integrated into the system to provide feedback with ‘high informativeness’. The data collected from Web-based formative assessment system,
such as answering history and all the discourse (student asks questions online and teachers answer the questions) between teachers and students about each item, should undergo analysis. These data can be used to clarify and address students’ misconceptions. A feedback database can in turn be established, which enables Web-based formative assessment system to intelligently generate feedbacks and help students correct their own mistakes and recover from the impasse of misconceptions effectively.

The influence of Web-based formative assessment on e-Learning effectiveness (Buchanan, 2000; Burrow et al., 2005; Gardner et al., 2002; Henly, 2003; Khan et al., 2001; Peat & Franklin, 2002; Velan et al., 2002; Wang, 2007) and the significant role of feedback in formative assessment (Brown & Knight, 1994; Buchanan, 2000; Wiliam & Black, 1996) have been pointed out in many researches. Furthermore, Brown and Knight (1994), Buchanan (2000) and Wiliam and Black (1996) all argued that the major purpose of formative assessment was to provide students with feedback, not merely to evaluate student learning outcome. Concerning the statements above, this research also suggests that further research on the design of Web-based formative assessment feedback strategies should be performed. More researches on how the Web-based formative assessment strategies attract students to actively participate in Web-based formative assessment and how these strategies affect e-Learning effectiveness are also necessary.

Notes

1. It is herein stated that all the trademarks and product names referred to in this paper are the property of their respective owners.
2. ATutor is an Open Source Web-based Learning Content Management System (LCMS). For more information about ATutor, you can visit http://www.atutor.ca.
3. Fig. 3 is a screenshot of the e-Learning environment in this research. This e-Learning environment was constructed in the ATutor system.

Acknowledgements

The author deeply appreciates the National Science Council in Taiwan for the financial support and encouragement under Grant No. 95-2511-S-134-002-MY3. The author is grateful for the insightful comments from the referees. The author also thanks Dr Shih-Chieh Huang, Dr Kuo-Hua Wang, and Dr Wei-Lung Wang, professors of National Changhua University of Education in Taiwan, for their assistance in this research. Lastly, the author would like to thank ‘Giant Riches’, (http://www.ttv.com.tw/drama/2003/GiantRiches), a TV program produced by Taiwan Television Enterprise (TTV), and ‘Who Wants to be a Millionaire’ (http://millionaire.itv.com/millionaire/home.php), a U.K. TV program produced by Independent Television (ITV). These two programs give rise to the original concept of designing ‘Ask-Hint Strategy’.

Appendix

Sample items of summative assessment

Knowledge-level item
Which kind of plants has bulbs?

A. Cabbages
B. Sweet potatoes
C. Strawberries
D. Garlic

Comprehension-level item
In which way can the withered plants be made full of life again in the shortest time?

A. To put them in the sun.
B. To apply fertilizer.
C. To put them in the room.
D. To dip their roots into the water.

References


