Innovations in Education and Teaching International,
Vol. 42, No. 4, November 2005, pp. 337–348

Routledge
Taylor & Francis Group

A web-based learning system for question-posing and peer assessment

Fu-Yun Yu[a]*, Yu-Hsin Liu[b] and Tak-Wai Chan[c]
[a]*National Cheng-Kung University, Taiwan;* [b]*National Chi-Nan University, Taiwan;* [c]*National Central University, Taiwan*

A web-based learning system has been developed to facilitate question-posing, peer-assessing, item-viewing and drill-and-practice learning activities. In this paper, the pedagogical basis underlying the design and development of the system is explained in the light of information-processing theory, social construction of knowledge theory and social modelling theory. A preliminary study to evaluate the instructional potential of the system has been conducted; this has also identified the factors that influence students' use of the system. Results taken from questionnaires and open-ended questions revealed that by enabling students to play various roles such as composers, critics and adapters, the system was perceived as a cognition-enhancing and motivational learning tool by the participants. Data analysis further indicated that various factors worked together to influence the performance of question-posing.

Introduction

Currently, as computer and telecommunication technologies converge, web-based learning systems are gaining popularity and presenting themselves as a promising learning environment for the twenty-first century. In addition to many of the distinct features that are frequently associated with computers—such as immense storage space, high processing speed, multimedia appeal, learner control, instant and personalized feedback, and multiple-branching capabilities, etc. (Heinich *et al.*, 2002), there are several additional advantages in having learning activities implemented via the Internet. First, and foremost, web-based learning systems are less device-dependent. Secondly, the fact that information and resources can be accessed by anyone from anywhere at anytime (as long as he or she has a computer with an Internet connection) permits global accessibility. Because they do not have time and place restrictions, web-based environments help promote worldwide connectivity and collaboration. Thirdly, updating, maintenance and management of information are easy as materials and users' databases are stored at the server site (Zhang *et al.*, 2001).

*Corresponding author. Graduate Institute of Education, National Cheng-Kung University, No. 1, Ta-Hueud Rd, Tainan, Taiwan 701. Email: fuyun@mail.ncku.edu.tw

ISSN 1470–3297 (print)/ISSN 1470–3300 (online)/05/040337–12

DOI: 10.1080/14703290500062557

In view of the Web's inviting features and its potential for social active learning, a web-based domain-independent learning system, named Question-Posing and Peer Assessment learning system (hereinafter named QPPA) was developed. In QPPA, students are invited to construct multiple-choice questions, comment upon items posed by their peers, and view items and comments that their peers have contributed. They can also practice answering questions for all levels of schooling for various subject matters in a more instantaneous, convenient, anonymous and environmentally friendlier way.

In the following sections, an overview of the theoretical foundations of QPPA is presented and the various functions embedded in QPPA are explained. A description is then given of a preliminary study that set out to evaluate the instructional potential of QPPA and identify the factors influencing its implementation for various subject matters.

Theoretical foundations underpinning QPPA

Most psychologists, learning specialists and instructors would agree that one of the most important elements for effective instructional outcomes, which, when present, almost always would facilitate learning, is practice (Gagne, 1985; Gagne *et al.*, 1992). As most learning can be enhanced greatly by providing students with drill-and-practice learning activities that are directly related to learning objectives (Dick *et al.*, 2001), numerous web-based performance elicitation and assessment systems have been developed to support the process (Bicanich *et al.*, 1997; Zhang *et al.*, 2001). However, in such systems students can only respond to questions given solely by teachers. Systems encouraging students to pose questions on concepts and principles they view important and worth testing, and the subsequent tasks of peer-assessing, item-viewing and practising answering student-constructed questions are not yet available commercially as far as we are aware. Bearing in mind previous researchers' suggestion that engaging in the process of question-posing and/or peer assessment may be conducive to students' cognitive growth (Balajthy, 1984; Brindley & Scoffield, 1998; English, 1998; Purchase, 2000; Topping & Ehly, 2001), a project gearing towards supporting such learning activities was launched. In the following sections, theoretical perspectives that can help explain why question-posing, peer-assessing and item-viewing would be beneficial and conducive to learning are briefly described followed by its implications for the design and development of the main functions supported in QPPA.

Information-processing theory

Researchers in cognitive psychology have long held that if information is to be retained and related to information already stored in memory, learners must engage in some sorts of information-processing, such as rehearsal, organisation and elaboration (Gagne, 1985; Gagne *et al.*, 1992). In addition to helping learners consolidate knowledge better and longer, cognitivists believe that such processing techniques can help cognitive structuring or re-construction (Wittrock, 1978; Reigeluth, 1983).

When engaging in the task of generating a multiple-choice question in QPPA, students need to construct a question-stem, the correct answer and three alternatives. During the process, students must first figure out which parts of the learning material are important and worth testing, and which are not. Then, they need to tactically phrase the question and come up with the correct answer if not already provided in the material. In other words, question-posers sometimes need to go through the process of question-solving. Moreover, they need to ponder three distractors that can effectively discriminate those who have learned the materials from those who have not. As for peer assessment, students need to gauge the appropriateness of the question-stem, the correctness of the answer and the appeal of the three alternatives. To accomplish these tasks, students (no matter what role they are playing, question-posers or assessors) must constantly re-examine instructional materials so as to point out critically distinctive features and differences among closely related categories. They must also clarify relationships among pieces of information, and compare newly acquired concepts to previously learned concepts. These activities involve the cognitive processes of rehearsal, organisation and elaboration, which, in the light of information-processing theory, should be beneficial to cognitive development.

Social construction of knowledge

Another perspective that may help explain why assessing others' work may be conducive to cognitive development is social construction of knowledge. The fundamental assumption of social construction of knowledge is that interaction among peers, while performing appropriate tasks, facilitates learning of critical concepts (King, 1989). From Piaget's (1926) perspective, when students interact with their peers in learning situations, disequilibration will occur, inconsistent knowledge will be exposed, opposing perceptions and ideas will be explored, and inadequate logical reasoning and strategies will be challenged, which will result in higher-quality comprehension by the learners (Slavin, 1992).

The peer-assessing learning activity supported in QPPA in essence encourages participants to gauge objectively and critically the adequacy and correctness of the posted questions, and to offer written recommendations to allow further refinement of the questions. Through online interaction and open communication with peers pertaining to the question-stem, the correct answer and three distractors, students presumably add details to their existing cognition, explore and correct their misconceptions, and/or re-organise their current knowledge structures. As a result, higher performance and more elaborated schemata on the content domain may occur (King, 1989).

Social modelling theory

Social modelling theory may account for the beneficial effects of viewing others' work on cognitive development. From the social modelling perspective, as proposed by Bandura (1986), social interaction provides opportunities for observing and imitating successful behaviours from models, which essentially results in changes in students' levels of competence in a task.

By allowing students to view items their peers have constructed and the comments and suggestions their peers have given online, exemplars are exhibited for observation and modelling, which, in the light of Bandura's (1986) social modelling, should enhance observers' existing competency and knowledge levels in the task.

In summary, each of the previously mentioned theories supports the idea of engaging students in the process of question-posing, peer-assessing, item-viewing and drill-and-practice exercises for students' cognitive enhancements in the applied content domain. Bearing this in mind, a web-based learning system gearing towards integrating all of these tasks into a composite activity was developed.

Overview of the QPPA learning environment

QPPA was designed to provide four functions. They are (1) question-posing, (2) peer-assessing, (3) item-viewing, and (4) drill-and-practice learning activities.

1. *Question-posing*

As shown in Figure 1, to contribute a question, composers need to not only provide a question-stem and an answer key, but also come up with four alternatives. In addition, composers can give hints, cues and reference/citations, etc. to be used as learning aids or feedback during drill-and-practice exercises. All questions contributed by students are kept in a temporary item bank database until after the peer assessment phase.

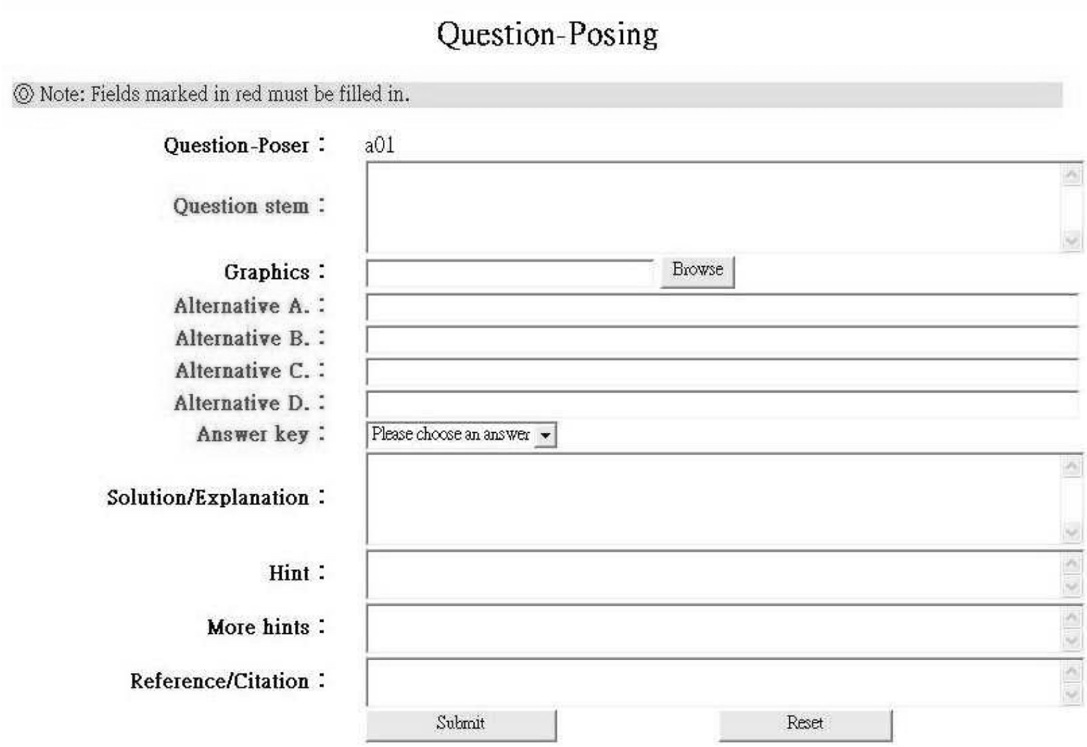


Figure 1. Question-posing

2. *Peer-assessing*

Having decided which item to assess (from the list of questions in the peer assessment window) and having reviewed the information related to the item, assessors can give their feedback using an online assessment form. Frequently made mistakes in multiple-choice test construction are provided through a pull-down menu (see Figure 2 for details). This built-in list acts not only as a set of criteria for objective peer assessment, but also as a scaffolding device for the iterative process of item revision and re-submission on the question-posers' part. In addition, students can type in detailed suggestions for further refinement of the examined item in a feedback type-in space. In short, peer assessment intends to enhance learning via critically evaluating others' works and synthesising comments given by their peers in the later question refinement stage.

3. *Item-viewing*

The development team set up an item-viewing function to promote learning by observing and imitating other people's work. That is, by observing questions composed by others and comments/suggestions given by assessors (see Figure 3), item-viewing provides an observational learning opportunity for students to learn from each other.

4. *Drill-and-practice exercises*

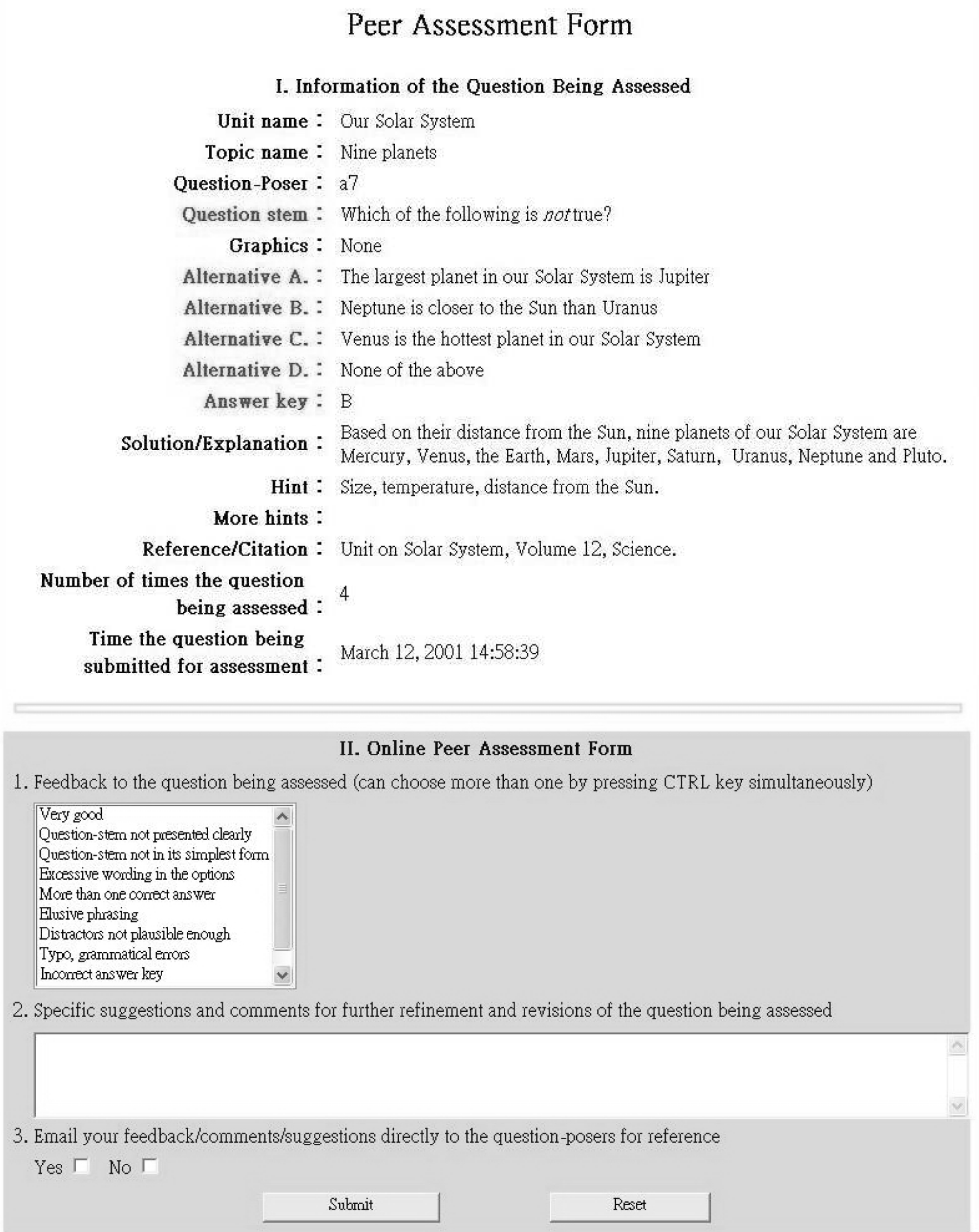
After the peer assessment phase, questions are transferred from the temporary item bank and imported into the formal item bank database to be used for drill-and-practice exercises. Students first decide on the number of questions for a given learning unit for the drill-and-practice exercises. On completion, feedback as to the percentage of correct answers and a review button for the missed ones is provided for review purposes.

Some additional features, for instance, six types of online ranking lists and statistics summaries are included in QPPA to increase its informational and motivational value to users.

Methodology

In order to shed some light on the instructional potential of QPPA, as well as identifying factors which influence the use of QPPA for various subject matters, a preliminary study was conducted. Two classes of sixth-grade students ($n = 52$) from one primary school in Taiwan participated in the study. Students participated in the study for six instructional sessions. In these sessions, students used the system as an extra-curricular activity for mathematics, natural science and social science. A training session on general question-posing techniques (i.e. where, who, when, what, which and how) as well as the features and operating procedures of QPPA was arranged first for participating students.

A post-session self-report questionnaire was disseminated to students to be completed individually to collect data on students' perceptions of QPPA's instructional potential. The questionnaire consisted of two parts. The first part measured Students' Confidence Towards QPPA's Potential in Promoting Cognitive Ability (seven items) and Intrinsic Motivation of the Learning Tasks to Students (nine items). Hung's Learning Experience Scale was adopted and



Peer Assessment Form

I. Information of the Question Being Assessed

Unit name :	Our Solar System
Topic name :	Nine planets
Question-Poser :	a7
Question stem :	Which of the following is *not* true?
Graphics :	None
Alternative A. :	The largest planet in our Solar System is Jupiter
Alternative B. :	Neptune is closer to the Sun than Uranus
Alternative C. :	Venus is the hottest planet in our Solar System
Alternative D. :	None of the above
Answer key :	B
Solution/Explanation :	Based on their distance from the Sun, nine planets of our Solar System are Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto.
Hint :	Size, temperature, distance from the Sun.
More hints :	
Reference/Citation :	Unit on Solar System, Volume 12, Science.
Number of times the question being assessed :	4
Time the question being submitted for assessment :	March 12, 2001 14:58:39

II. Online Peer Assessment Form

1. Feedback to the question being assessed (can choose more than one by pressing CTRL key simultaneously)

Very good
Question-stem not presented clearly
Question-stem not in its simplest form
Excessive wording in the options
More than one correct answer
Elusive phrasing
Distractors not plausible enough
Typo, grammatical errors
Incorrect answer key

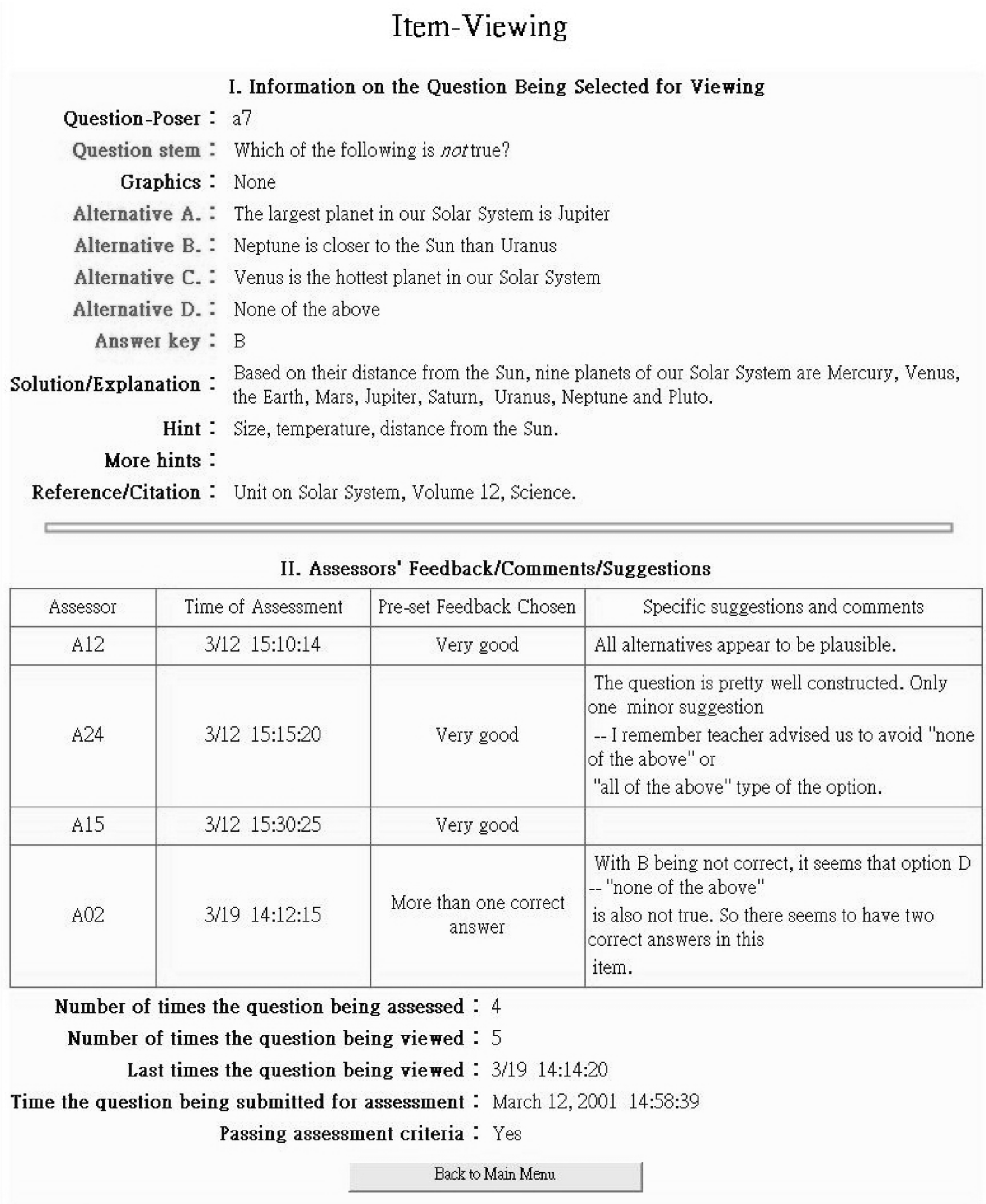
2. Specific suggestions and comments for further refinement and revisions of the question being assessed

3. Email your feedback/comments/suggestions directly to the question-posers for reference

Yes ☐ No ☐

Submit Reset

Figure 2. Peer assessment form



Item-Viewing

I. Information on the Question Being Selected for Viewing

Question-Poser : a7
Question stem : Which of the following is *not* true?
Graphics : None
Alternative A. : The largest planet in our Solar System is Jupiter
Alternative B. : Neptune is closer to the Sun than Uranus
Alternative C. : Venus is the hottest planet in our Solar System
Alternative D. : None of the above
Answer key : B
Solution/Explanation : Based on their distance from the Sun, nine planets of our Solar System are Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto.
Hint : Size, temperature, distance from the Sun.
More hints :
Reference/Citation : Unit on Solar System, Volume 12, Science.

II. Assessors' Feedback/Comments/Suggestions

Assessor	Time of Assessment	Pre-set Feedback Chosen	Specific suggestions and comments
A12	3/12 15:10:14	Very good	All alternatives appear to be plausible.
A24	3/12 15:15:20	Very good	The question is pretty well constructed. Only one minor suggestion -- I remember teacher advised us to avoid "none of the above" or "all of the above" type of the option.
A15	3/12 15:30:25	Very good	
A02	3/19 14:12:15	More than one correct answer	With B being not correct, it seems that option D -- "none of the above" is also not true. So there seems to have two correct answers in this item.

Number of times the question being assessed : 4
Number of times the question being viewed : 5
Last times the question being viewed : 3/19 14:14:20
Time the question being submitted for assessment : March 12, 2001 14:58:39
Passing assessment criteria : Yes

Back to Main Menu

Figure 3. Item-viewing

adapted to make the items better fit the learning situation and target population involved (Hung, 2001). Items were rated on a five-part discrete scale, with corresponding verbal descriptions ranging from 'strongly disagree' through 'disagree', 'no-opinion', 'agree', to 'strongly agree'. To counteract possible response-set tendencies, both positive and negative statements were included. Sample statements included:

- QPPA had a facilitating effect for content comprehension.
- If I could use QPPA to support my learning throughout the semester, I am confident that my capability in the applied content domain would improve.
- After initial contact, I frequently thought of using the system again.
- The system grabbed my attention at first, but did not sustain my attention for long.

The second part of the questionnaire was used to solicit students' opinions on the system's usability. Four questions were included:

1. In your opinion, which one of the learning tasks was most difficult (i.e. question-posing, peer-assessing, item-viewing, drill-and-practice exercises)?
2. Posing multiple-choice questions on QPPA, for which of the following subject matter is this most difficult (mathematics, natural science, social studies—mark only one), and in what way?
3. Posing multiple-choice questions on QPPA, for which of the following subject matter is this easiest (mathematics, natural science, social studies—mark only one), and in what way?
4. What is your overall reaction and suggestions to the system?

Results

The potential of QPPA for promoting cognitive ability

After tallies on the negative statements on the confidence scale were reversed, it was found that on average 73.7% of the participants felt 'agree' or 'strongly agree' to the statements on the scale. Data analysis on the scale with one-group *t*-tests, using 3 as the expected mean, showed that all were statistically significant. The data obtained provided positive evidence to support the system's potential in promoting students' cognitive capability in the applied content domain.

Intrinsic motivation of the learning tasks

After tallies on the negative statements on the scale were reversed, it was found that on average 66.62% of the participants agreed or strongly agreed with statements on the scale. Overall, students rated the system's motivational value favourably. Students' written responses (58 entries obtained) to the question 'What is your overall reaction and suggestions to the system?' gave clues to the system's motivational value as viewed by students:

- Constructing questions on QPPA gave me a sense of achievement.
- By constructing and assessing questions, I could help others master the subject matter as well as the learning task better.
- Quizzing each other via the system was fun, exciting and less threatening.

- I could challenge other's thinking and reasoning, so do others.
- Online ranking lists made learning more rewarding and satisfying.
- A larger chance of being recognised was provided via various kinds of ranking list embedded in the system.

Analysis of the above statements suggested that students' sources of motivation may have come from a hybrid of 'a sense of achievement', 'altruism', 'play and entertainment', 'sense of security', 'challenging one's own and other's existing knowledge', 'feeling of satisfaction' and 'sense of confidence'. In the light of the work of motivational theorists, such as the self-determination theory of Deci *et al.* (1991), Maslow's (1991) self-actualisation theory, Malone and Lepper's (1987) intrinsic motivation theory and Keller's (1987) ARCS model, it appeared that by embedding various sources of motivation within the system, QPPA was perceived by participants as a motivational learning environment.

The system's usability for different content areas

Data from students' opinions towards various functions in QPPA indicated that among question-posing, peer-assessing, item-viewing and drill-and-practice exercises, a predominant percentage of students (69%) felt that question-posing was the most difficult task of the four (see Table 1 for details). Data on the system's usability for different subject matters further indicated that among mathematics, natural science and social science, 55.8% of the respondents felt that posing multiple-choice questions on QPPA for mathematics was the most difficult one whereas 40.4% thought posing multiple-choice questions on QPPA for natural science was the easiest (see Table 2 for details). A one-group chi-squared test was used to test for statistical significance. This showed a statistically significant difference for the most difficult one ($\chi^2 = 268.67$, df = 2, $p < .0005$), but it did not yield a statistically significant result (at the $p = .05$ level) for the easiest ($\chi^2 = 1.529$, df = 2, $p > .05$).

A constant comparative method was used on students' 82 entries for the written responses to open-ended questions 2 and 3 to provide explanations for the observed phenomenon. Data analysis indicated that several factors influenced question-posing learning activity. These factors include keyboarding skills, availability of sample items for reference, expertise in the applied domain knowledge and the subject-matter complexity. For instance, students mentioned that:

- Constructing questions for natural science was the easiest because many sample items were contained in the textbook for reference.
- Constructing questions for mathematics was the most difficult one partly because there were a lot of numbers and symbols involved, which took not only more time to type, but also

Table 1. Students' opinion towards the difficulty of various functions in QPPA

	Question-posing *n* (%)	Peer-assessing *n* (%)	Question-viewing *n* (%)	Drill-and-practice *n* (%)
Most difficult	36 (69.2%)	6 (11.5%)	1 (2.0%)	9 (17.3%)

Table 2. Students' opinion towards usability of QPPA for different subject matter

Subject matter	The easiest *n* (%)	The most difficult *n* (%)
Mathematics	14 (26.9%)	29 (55.8%)
Natural science	21 (40.4%)	6 (11.5%)
Social science	16 (30.8%)	15 (28.8%)
Total	51 (98.1%)	50 (96.2%)

required keyboarding skills, and mainly due to the fact that you need to understand all the principles and rules covered in the instructional materials.

- Mathematics was more difficult and harder to comprehend as compared to other subject matters.
- I am good at natural science.

The system's usability for students with different achievement levels

Observations during the study showed that lower-achieving students had an especially difficult time generating questions. The product-moment correlation coefficient r was used to determine the magnitude of the relationship between students' academic achievement and the average number of questions generated. Based on the data analysis, it was found that a significant relationship existed between student academic achievement and the number of questions generated, $r = .397$, $p < .01$.

Discussion and conclusions

With the advent of networking and multimedia technologies, the emphasis on technology-based education of all kinds for the support of student learning has been a focus of contemporary education. In the present study, a project gearing towards designing and developing a networked system which enables students to contribute to multiple-choice item development (which in turn are evaluated, reviewed and practised by peers) was launched. By enabling students to construct, assess, review and practise answering questions, the system, as viewed by the participants, had a facilitating effect for promoting their confidence and cognitive ability in the applied content domains. In addition, the system appeared to cultivate a motivating learning environment by including various sources of motivation. Finally, factors including keyboarding skills, availability of sample items for reference, individual expertise in different content domains, the complexity of the subject matter itself and the academic achievement levels worked together to influence student performance in question-construction learning activity.

Based on the obtained data, guidelines pertaining to instructional implementation are offered. As mentioned previously, a significant percentage of respondents felt that question-posing was the most difficult task among the four main learning activities in QPPA. Instructors interested in implementing question-posing instructional strategy in classrooms might need to pay attention to factors influencing its learning process and outcomes, and, wherever possible, provide supporting mechanisms to help make the task more manageable. Moreover, before introducing the online question-posing activity in the classroom, tutorial sessions for entering special symbols (such as operators for addition, subtraction, multiplication, division, equation, power and fractions for mathematics) would be indispensable—particularly for younger learners whose keyboarding skills are limited. Finally, data analysis showed that higher-achieving students tended to generate more questions while lower-achieving students tended to generate fewer questions. Bearing in mind that the use of questions has long been recognised as a useful tactic to improve text retention and comprehension (Balajthy, 1984; English, 1998), finding ways to improve lower-achieving students' question-posing ability and performance (using various instructional interventions, for example, co-operative learning) will be another important issue for instructors.

Acknowledgements

This project was funded by the Ministry of Education of the Republic of China (number 89-H-FA07-1-4–92-H-FA07-1-4). Thanks are extended to Chung-Chi Hung for implementing and collecting data. Finally, the authors are grateful to the anonymous reviewers and the Editor (Philip Barker) for their constructive comments and assistance in revising and polishing the paper.

Notes on contributors

Fu-Yun Yu received her Ph.D. in Instructional Technology from the University of Texas at Austin in 1996. She is currently a professor at the Graduate Institute of Education of National Cheng-Kung University. Her current research interests are instructional design and evaluation of web-based learning environments, and individual differences in learning and instruction.

Yu-Hsin Liu received his Ph.D. in Civil Engineering from the University of Texas at Austin in 1997. He is currently an assistant professor at the Department of Civil Engineering, National Chi-Nan University. His current research interests are learning strategy applied in science and engineering education, dynamic choice behaviour and multinomial probit model estimation.

Tak-Wai Chan received his Ph.D. in Computer Science from the University of Illinois at Urbana-Champaign in 1989. He is a professor at the Graduate Institute of Network Learning Technology at National Central University. His current research interests are social learning theory and systems, and intelligent educational agents.

References

Balajthy, E. (1984) Using student-constructed questions to encourage active reading, *Journal of Reading,* 27(5), 408–411.

Bandura, A. (1986) *Social cognitive theory* (New York, Holt, Rinehart & Winston).

Bicanich, E., Hardwicke, S. B., Slivinski, T. & Kapes, J. T. (1997) Internet-based testing: a vision or reality?, *Journal of Technological Horizons in Education,* 25(2), 61–64.

Brindley, C. & Scoffield, S. (1998) Peer assessment in undergraduate programmes, *Teaching in Higher Education,* 3(1), 79–90.

Deci, E. L., Vallerand, R. J., Pelletier, L. G. & Ryan, R. M. (1991) Motivation and education: the self-determination perspective, *Educational Psychologist,* 26(3/4), 325–346.

Dick, W., Carey, L. & Carey, J. O. (2001) *The systematic design of instruction* (5th edn) (New York, HarperCollins).

English, L. D. (1998) Children's problem posing within formal and informal context, *Journal for Research in Mathematics Education*, 29(1), 83–106.

Gagne, R. M. (1985) *The conditions of learning and theory of instruction* (4th edn) (New York, Holt, Rinehart and Winston).

Gagne, R. M., Briggs, L. J. & Wager, W. W. (1992) *Principles of instructional design* (4th edn) (Fort Worth, TX, Harcourt Brace Jovanovich College Publishers).

Heinich, R., Molenda, M., Russell, J. D. & Smaldino, S. E. (2002) *Instructional media and technologies for learning* (7th edn) (Upper Saddle River, NJ, Merrill).

Hung, M. H. (2001) *The effects of subtitles and captions on foreign language learning.* Masters thesis, Graduate Institute of Education, National Cheng-Kung University.

Keller, J. M. (1987) Development and use of the ARCS model of motivational design, *Journal of Instructional Development,* 10(3), 2–10.

King, A. (1989) Verbal interaction and problem-solving within computer-assisted cooperative learning groups, *Journal of Educational Computing Research,* 5(1), 1–15.

Malone, T. W. & Lepper, M. R. (1987) Making learning fun: a taxonomy of intrinsic motivations for learning, in: R. E. Snow & M. J. Farr (Eds) *Aptitude, learning, and instruction* (vol. 3: *Cognitive and affective process*
AQ1 *analyses*) (Hillsdale, NJ, Erlbaum).

Maslow, A. H. (1991) Critique of self-actualization theory, *Journal of Humanistic Education and Development,* 29(3), 103–108.

Piaget, J. (1926) *The language and thought of the child* (New York, Harcourt Brace).

Purchase, H. C. (2000) Learning about interface design through peer assessment, *Assessment & Evaluation in Higher Education,* 25(4), 341–352.

Reigeluth, C. M. (1983) *Instructional-design theories and models* (Hillsdale, NJ, Lawrence Erlbaum Associates).

Slavin, R. (1992) When and why does cooperative learning increase achievement? Theoretical and empirical perspectives, in: R. Hertz-Lazarowitz & N. Miller (Eds) *Interaction in cooperative groups* (Cambridge, MA,
AQ2 Harvard University Press).

Topping, K. E. & Ehly, S. E. (2001) Peer-assisted learning, *Journal of Educational and Psychological Consultation,* 12(2), 113–132.

Wittrock, M. C. (1978) The cognitive movement in instruction, *Educational Psychology,* 13, 15–29.

Zhang, J., Cooley, D. H. & Ni, Y. (2001) NetTest: an integrated web-based test tool, *International Journal of Educational Telecommunications,* 7(1), 33–35.