

On-line question-posing and peer-assessment as means for web-based knowledge sharing in learning

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Abstract

This study is an examination of a novel way for merging assessment and knowledge sharing in the context of a hybrid on-line learning system used in a postgraduate MBA course. MBA students carried out an on-line Question-Posing Assignment (QPA) that consisted of two components: *Knowledge Development* and *Knowledge Contribution*. The students also performed self- and peer-assessment and took an on-line examination, all administered by QSIA—an on-line system for assessment and knowledge sharing. Our objective was to explore student's learning and knowledge sharing while engaged in the above. Findings indicated that even controlling for the students' prior knowledge or abilities, those who were highly engaged in on-line question-posing and peer-assessment activity received higher scores on their final examination compared to their counter peers. The results provide evidence that web-based activities can serve as both learning and assessment enhancers in higher education by promoting active learning, constructive criticism and knowledge sharing. We propose the on-line QPA as a methodology, and QSIA system as the technology for merging assessment and knowledge sharing in higher education.

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1. Introduction

Networked computers can be used for sharing information and knowledge. They can also be used in on-line evaluation of learning outcomes. Can the process of on-line knowledge sharing be made relevant to learning and assessment? This study is an examination of a novel way of merging assessment and knowledge sharing in the context of a hybrid on-line learning system, used in a postgraduate MBA course.

The internet has always been a prominent space for learning (Dori et al., 2003; Potelle and Rouet, 2003) and testing (Rafaeli and Tractinsky, 1989, 1991). This paper describes a unique way of implementing a web-based testing mechanism that goes beyond just the administration of on-line tests. The system, named QSIA, was designed to enhance knowledge sharing among both instructors and students. QSIA, employed in a Graduate School of Business, was used as a platform for carrying out an on-line Question-Posing Assignment (QPA). In this assignment, students were required to contribute questions (knowledge items) for public use. The students were also asked to rank their peers' contributions. The on-line QPA was graded for quality and persistence. This sort of knowledge sharing assignment is only feasible in a web-based on-line supported environment, if only for the sheer volume of data flows. These new procedures, grafted onto traditional classroom practice, raise several intriguing research questions: How do students respond to and perform with this novel on-line, collaborative QPA? How does the on-line question-posing and peer-assessment activity relate to students' traditionally conceptualized learning outcomes? And what are the students' attitudes towards the use of systems such as QSIA and the on-line QPA? In the following we report on a field test that investigates the implementation of such a set of tools and practices.

1.1. *Web-based testing and on-line assessment*

The evaluation of learning outcomes is evolving in both methodology and technology. The methodology of evaluation is shifting from a "culture of testing" to a "culture of assessment" (Birenbaum and Dochy, 1996; Sluijsmans et al., 2001). Emphasis is placed on integrating assessment and instruction. Assessment addresses the process of learning rather than just the evaluation of products and individual progress. The role of students has also been changing from passive subjects to active participants who share responsibility in the process, practices self-assessment and collaboration.

Technologically, the environment is shifting from paper and pen to computerized adaptive testing. Computerized administration of tests is attractive for a variety of reasons. Computerized tests offer convenience, efficiency, aesthetic and pedagogic improvements (Rafaeli and Tractinsky, 1989, 1991). Computerized testing has traditionally been a very centralized, closely guarded and tightly controlled enterprise. An artefactual expression of this centralization is evident in the reliance of most computerized adaptive testing systems on closed, mainly multiple-choice

format questions. More recent developments in interface design allow a relaxation of some of this rigidity and an enrichment in test types.

The role of information technology in educational assessment has been growing rapidly (Beichner et al., 2000; Hamilton et al., 2000; Barak, 2003). Several well-known computer-based tests are now administered on the web, including the Graduate Record Exam (GRE), the Graduate Management Admissions Test (GMAT), and the Medical Licensing Examination (MLE). The high speed and large storage capacities of today's computers, coupled with their rapidly shrinking costs, makes computerized testing a promising alternative to traditional paper-and-pencil measures. Web-based testing systems offer the advantages of computer-based testing delivered over the Internet. The possibility of conducting an examination where time and place are not limited, however time and pace can still be controlled and measured, is one of the major advantages of web-based testing systems (Rafaeli and Tractinsky, 1989, 1991; Rafaeli et al., 2003). Other advantages include: the easy accessibility of on-line knowledge databases and the inclusion of rich multimedia, and interactive features such as color, sound, video, and simulations.

Modern on-line assessment systems offer considerable scope for innovations in testing and assessment as well as a significant improvement of the process for all its stakeholders, including teachers, students and administrators (McDonald, 2002). This paper presents a new approach for web-based testing. We use the term 'on-line assessment' to emphasize the shift from a culture of testing to a culture of assessment and from paper and pen to web-based administered examinations. This study describes a new on-line mode of learning and evaluation that includes question-posing integrated with multi-modes of assessment:

1. *Self-assessment*: Students conduct self-assessment by completing an independently run test followed by immediate feedback.
2. *Peer assessment*: Students are required to contribute items to a joint pool and are encouraged to read and review questions developed and contributed by others—their classmates.
3. *Achievement assessment*: Knowledge acquisition is assessed via an on-line final examination.

All modes of assessment were administered by QSIA—an on-line system for assessment and knowledge sharing (Rafaeli et al., 2003).

1.2. Question-posed by students

There is a recent increase in recognition given to the importance of student's questions in the teaching and learning process (Dori and Herscovitz, 1999; Marbach-Ad and Sokolove, 2000). The realization that questions and information seeking are central to meaningful learning dates back to Socratean thought (Bohlin, 2000). Challenging students to assume an active role in posing questions can promote independence in learning (Bruner, 1990; Marbach-Ad and Sokolove, 2000).

Although the essence of thinking is asking questions, most students perceive learning as the study of facts (Shodell, 1995). This may relate to acquired experience

with questions as something teachers impose on students, using fact-demanding questions rather than thought provoking queries. During their years of education, students are schooled at answering questions but remain novices at asking them (Dillon, 1990). Questions, in the traditional teaching, are privately owned and displayed by the teachers. Dillon (1990) suggests that questions should come from both teachers and students. Similarly, studies of novel teaching approaches stress the importance of the student's questions. These studies suggest that the central role of education should be to develop in students an appreciation of posing questions (Shodell, 1995; Dori and Herscovitz, 1999). In the study reported here, students were asked to develop questions relating to the course learning contents. Using QSIA as the web-based technology they were asked to share these questions with their peers, use the questions as a form of preparing for the final test, and evaluate questions posed by their classmates.

1.3. Peer-assessment

Innovation in assessment practices has accelerated in recent years as well. Assessment systems that require students to use high-order thinking skills such as developing, analysing and solving problems instead of memorizing facts are important for the learning outcomes (Zohar and Dori, 2002). Two of these higher-order skills, are reflection on one's own performance—self-assessment, and consideration of peers' accomplishments—peer assessment (Birenbaum and Dochy, 1996; Sluijsmans et al., 2001). Both self- and peer-assessment seem to be underrepresented in contemporary higher education, despite their rapid implementation at all other levels of education (Williams, 1992). Larisey suggested that the adult student should be given opportunities for self-directed learning and critical reflection in order to mirror the world of learning beyond formal education (Larisey, 1994). Experiencing peer assessment seems to motivate deeper learning and produces better learning outcomes (Williams, 1992).

Peer assessment tasks include rating of individual and group presentations, artwork, or posters (Zevenbergen, 2001); marking classmates' problem solving performances; and rating classmates' contributions while carrying out different group assignments (Conway et al., 1993; Sluijsmans et al., 2001). Our study describes a new mode of peer assessment task. In this study, students were asked to review instructional questions developed by their classmates' and conduct peer assessment by rating the questions. This peer assessment task was available throughout the learning period as it was conducted via a web-based on-line assessment system.

2. Research settings

Our study explored a novel educational methodology and technology implemented in a postgraduate E-business course. The students participating in the course carried out an on-line QPA (Question Posing Assignment) administered by

QSIA—an on-line system for assessment and knowledge sharing. This section describes the E-business course, The QSIA system, the on-line QPA, and the way students were graded on their assignment.

2.1. E-business course

E-Business is a required, advanced course given in the latter half of an MBA (Masters in Business Administration) curriculum, at a major Graduate School of Business Administration, in an Israeli university. The E-Business course introduces applications of IT (information technology) in markets, organizations and individual use. The course includes both technical and conceptual topics such as: HTML, XML, ASP, business frameworks and models, packet switching, cryptography, security, payment mechanisms and digital money, auctions, Java, Javascript, cookies, knowledge management, and the like. This is a three credit, 9 week (“mini-semester”) course.

As part of the course’s tasks, students were asked to pose questions and perform peer assessment via QSIA—a web-based on-line assessment and knowledge sharing system, described in the following.

2.2. The QSIA system

Knowledge sharing and community building is at the core of many on-line systems design (Carroll et al., 2003; Robertson and Reese, 1999; Rafaeli and Ravid, 2003). This research presents an on-line system that was designed to share the authoring of knowledge items and the process of constructing assignments and tests—QSIA.

QSIA is acronym for Questions Sharing and Interactive Assignments but also a Hebrew eponym for “question”. QSIA was designed to serve instructors in providing a web-based platform to share the authoring of knowledge items, the management of collections of such items and the accumulated history of the psychometric performance. The system was designed to harness the power of groups and communities to improve the process of constructing assignments and tests (Rafaeli et al., 2003). From a student and classroom perspective, QSIA enables the administration of assignments and tests under a variety of contexts. Tests and assignments can be completed on-line or off-line, in proctored or individual settings, with or without time limits, allowing open or closed book or internet connections, etc. Creation of the database of items and assignment templates is, however, only the first tier of the system usage. A second tier allows the collection of knowledge items ratings and the provision of recommendations. Participants in the system are given tools that allow them to respond and rank the items. QSIA provides aggregation of such ranking for future sifting and selection. Actual use of the system in a learning capacity enriches the collected history and available logs. Thus, this system is designed to learn, not just teach. QSIA can be viewed at: <http://qsia.info>. Fig. 1 presents a screen shot of the interface to QSIA’s knowledge items database, folders, search and recommendations.

2.2.1. QSIA's technology architecture

The basic idea of sharing which initiated QSIA, also stands behind its technology. The system is based on open source technology and contributes back to the open source community. The system uses an open source application server (Apache Tomcat), and an open source database (MySQL), based on an open source operating system (Linux). Some of the software infrastructure built for QSIA is shared with the open source community under the GNU public license.

The system is built around open and acceptable standards, both in the software engineering aspect and in the functionality aspect. The system is based on Java technology, using JSP as the presentation layer and object oriented Java Beans technology as the business logic layer. These foundations enable the system to operate in any standard operating system and application server environment. The relational MySQL database serves as a data repository for the system. Because of the seamless SQL support, the database could be switched easily to any SQL database, and the content can be easily imported or exported.

In order to communicate with an external learning system, and in order to assimilate the system in the world of educational systems, QSIA supports the Question and Test Interoperability (QTI) specification developed by IMS Global Learning Consortium, Inc. (2003). The IMS Question and Test Interoperability Specification provides proposed standard XML language for describing questions and tests. The specification has been produced to allow the interoperability of content within assessment systems.

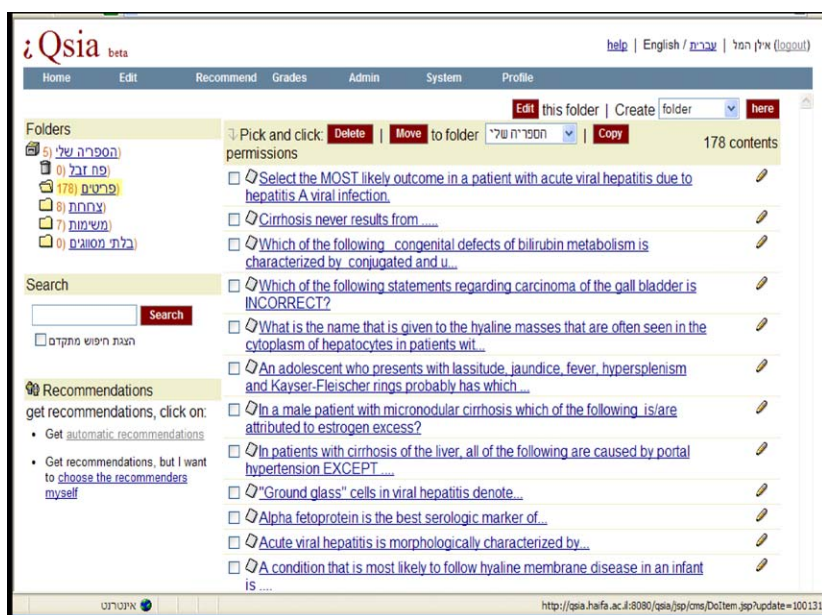


Fig. 1. QSIA's knowledge items database, folders, search and recommendations.

2.2.2. *QSIA's conceptual architecture*

The design of QSIA was based on four conceptual pillars: Knowledge Generation, Knowledge Sharing, Knowledge Assessment, and Knowledge Management.

- Knowledge Generation—QSIA enables users to create and edit different knowledge items such as questions or learning tasks. The system includes a variety of question types such as open ended, numerical responses, multiple-choice, matching, true/false questions and the like.
- Knowledge Sharing—QSIA focuses on knowledge sharing among participants, while maintaining a secure and private working environment for subgroups and individuals. One of QSIA's sub-tasks is 'matching mates': the capability to make matches among recommenders and those seeking recommendations.
- Knowledge Assessment—QSIA can be used both as a formal and informal evaluation of the students' learning outcomes. Formal evaluation is carried out by quizzes or examinations given to the students simultaneously but not necessarily in the same place. Informal evaluation is represented by self-tests. Students' may use subsets of the item collections designated by instructors to perform self-tests on-line, any time and any place. Such self-directed use can aid diagnosis and detection of specific difficulties or misunderstanding.
- Knowledge Management—QSIA allows individual and shared management of educational content using hierarchical information storage and classification policies and tools, search facilities and editing tools. It enables users to create and manage a set of folders that includes all of the content owned by them.

QSIA enables web-based support for many of the traditional modes of testing and assignments. However, in this paper we attempt to document a novel mode of students' 'knowledge assessment' that includes self-, peer- and achievement-assessments. We report here on an investigation of the relations between 'knowledge assessing' and 'knowledge sharing' made feasible via QSIA. Development, contribution and assessment of knowledge were merged in a novel assignment described in the following.

2.3. *The on-line question-posing assignment (QPA)*

Graduate students in the E-Business course were required to author questions and present possible answers relating to topics taught in class. The students were required to share these questions on-line with their classmates. They were also asked to read and review their classmates' contributions and perform peer-assessment by ranking items authored by others on a 1 (poor)–5 (excellent) scale. Some motivation for participation and attention to this process was based on the indication that the final examination may include items generated in this process. Students also received a differential bonus grade, up to 10 additional percentage points on the course final grade, depending on their performance in this assignment. The on-line QPA required students to be actively engaged in constructing instructional questions, testing themselves with their classmates' questions, and assessing questions contributed by their peers.

The purpose of the on-line QPA was three-fold. The first goal was to enhance meaningful learning by implementing construction of knowledge through construction of questions and answers. Secondly, we intended to encourage knowledge sharing by distributing the students' questions and answers on the web. The third goal was to enhance peer-to-peer assessment, an initial step for generating a community of learners.

Students were advised of seven components that determined their grade on the on-line QPA. The grading components included the cognitive level of the questions; the cognitive level of the distracters; the type of questions; the type of multimedia features employed with the questions; the number of questions contributed; the persistence of uploading questions throughout the study period (measured as frequency); and the number of questions authored by others, that were ranked by the student. Students were encouraged to author "objective", closed questions such as multiple-choice and true/false. This is due to two reasons. First, in closed questions the students need to compose not only the question but also several distracters that reflect the possible correct answer. The cognitive investment in authoring such items is higher compared to open ended questions (Tamir, 1996). Second, closed questions allow immediate feedback by the computer. Students were required to contribute at least five questions to qualify for a minimum grade on the on-line QPA. Students did not receive instructions on how to evaluate their peers' questions. Each student had to generate his own rules and criteria. Fig. 2 presents an example question that was developed and contributed by one of the students.

2.4. Grading the on-line QPA

Determining the score earned on the on-line QPA involved both content analysis and the usage of access logs. Qualitative components such as the 'cognitive level of the questions' and the 'cognitive level of the distracters' required content analysis of each question and distracter. Whereas quantitative data such as the number of questions contributed, the persistence (frequency) of uploading questions and the number of questions ranked were extracted from the servers' logs.

2.4.1. Grading the 'Knowledge Development' components of the on-line QPA

Questions may be rank-ordered by the level of thought they require. The most common hierarchy for ranking knowledge items is the Bloom taxonomy (Bloom et al., 1956) that consists of six levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. In this study we analysed the content of 597 questions developed by 71 students. Each question was rated on a 0–3 scale. To validate the content analysis and rating of the questions, five experienced instructors of E-Business were asked to rank a random sample of 30 questions, about 5% of the questions developed by the students. The instructors were asked to indicate the cognitive level of the questions using the following three categories:

1. *Knowledge* (low-order thinking skill)—A question that requires recalling details from memory, from a textbook, or from any other source of information.

Qsia

Home Assignments Recommend Grades Edit

Item

Mark the true sentences concerning switch packet technology

☐ The technology reinforces centralization

☐ The information path is not known in advance

☐ It emphasizes information security problems

☐ It allows fast growth of the net

Packet routing through WAN/Internet

Check item >>

Rankings and Comments

Rank the Item above (between 1 to 5)

1 2 3 4 5

Add your comment:

Fig. 2. Question on packet switching that was developed by one of the students.

2. *Understanding* (intermediate order thinking skill)—A question that requires implementation of a new concept and connecting it to other concepts.
3. *Evaluation* (high-order thinking skill)—A question that requires implementation of critical thinking and evaluation of phenomena.

These three categories are a modification of Blooms' taxonomy (Bloom et al., 1956). Eighty percent consent on the categories for each question was accepted. The experts added remarks and comments such as: "overlapping alternatives"; "OK, too few options"; "bad spelling"; and more. The experts' remarks and comments provided the researchers benchmarks for analysing and categorizing the rest of the questions.

Each question was analysed using four qualitative components and graded on a 0–3 scale, as presented in Table 1. These four components determined the students' Knowledge Development performance.

The scores for the four components of Knowledge Development presented in Table 1, were produced for each question separately. An average of these components was calculated to determine the students' grades.

2.4.2. Grading the 'Knowledge Contribution' components of the on-line QPA

Quantitative components for evaluating the students' Knowledge Contribution were collected through the servers' access logs. The number of questions contributed,

Table 1
Grade components for evaluating students' Knowledge Development

Question-posing assignment components		No performance (0 points)	Low performance (1 point)	Intermediate performance (2 points)	High performance (3 points)
Knowledge Development	1. Cognitive level of question	Wrong or irrelevant question	Requires recall of details from memory	Implementing learned concepts and interconnection	Implementing critical thinking and evaluation of phenomena
	2. Cognitive level of Distracter	Wrong or irrelevant answers	Simplistic—the correct answer is obvious	All distracters are feasible, the best answer has to be chosen	Critical thinking and addition of explanations
	3. Type of question	No questions	True/false	Multiple-choice	Matching
	4. Multimedia features	Text only	Colored fonts	Added hypertext links	Added pictures or animation

Table 2
Grade components for evaluating students' Knowledge Contribution

Question-Posing assignment components		No performance (0 points)	Low performance (1 point)	Intermediate performance (2 points)	High performance (3 points)
Knowledge Contribution	5. Number of questions contributed	No contribution	5–7 questions	8–10 questions	More than 10 questions
	6. Persistence of uploading questions	All questions uploaded at the same day	1–5 days gap	More than 9 days gap	6–8 days gap
	7. Number of questions ranked	No questions were ranked	1–5 questions ranked	6–20 questions ranked	More than 20 questions ranked

the persistence in uploading questions throughout the study period, and the number of questions ranked, determined the students Knowledge Contribution performance as presented in Table 2.

The students' final grade on the on-line QPA was, then, a linear function of the seven components. Each student was accorded a differential grade, for up to 10 points.

3. Research objective and methodology

This study is an investigation of a novel mode for on-line assessment and knowledge sharing. Our objective was to explore student's learning and knowledge

sharing while engaged in an on-line question-posing and peer-assessment activity. QSIA system was used as a platform for this study.

When we harness the capabilities of web-based testing mechanisms to go beyond just the administration of on-line tests and include knowledge sharing by on-line QPA, we encounter three interesting research questions:

1. How do students perform in on-line QPA?
2. How does the on-line QPA relate to students' traditionally conceptualized learning outcomes?
3. What are the students' attitudes towards the use of systems such as QSIA and the on-line QPA?

3.1. Research population

The subjects in this experiment were 71 students who participated in an E-Business course, offered as part of an MBA (Masters in Business Administration) program at a Graduate School of Business Administration, in a major university in Israel. Most of the subjects were males (69%), and their average age was 33.

As the student body was heterogeneous with students rooted in different cultures, academic backgrounds, and levels of work experience, their GMAT scores were used to determine their prior educational background and capabilities. The GMAT is an internationally known required test of general skills and abilities. Students are required to take the GMAT before enrolling the MBA program. GMAT measures basic verbal, mathematical, and analytical writing skills (Johnson, 2000). The GMAT scores were used as the control variant of the statistical analysis procedures (Mean = 655.92, s.d. = 51.09). No significant difference was found between GMAT scores for male and female students in this group.

3.2. Research instruments

The research instruments were selected in order to best measure student's learning and sharing outcomes while engaged in an on-line question-posing and peer-assessment activity. The research tools assessed a variety of variables for indicating students' performances in the social, cognitive and affective domains as presented in Table 3.

In the social domain, content analysis of the students' contributed questions and data from QSIA's access logs were used for determining the score of each student on his question-posing and peer-assessment activity. The content analysis of the contributed questions determined not only social but also cognitive abilities. It was defined under the social domain since the students shared their questions by contributing them to the benefit of the learning community. The exact procedure of analysing the contributed questions and calculating the students' grades is detailed in the research settings section. The content analysis investigated the students' Knowledge Development.

Table 3
Research instruments, assessed variables and explored domains

Instrument	Assessed variable	Domain
Content analysis of contributed questions and QSIA access logs	Question-posing and peer-assessment activity	Social
Final examination	Conceptual and phenomenon understanding	Cognitive
Feedback questionnaire	Attitudes towards the on-line QPA and QSIA	Affective

Web access logs provided information on the students' behavior while contributing knowledge. Accesses to web servers are recorded meticulously. Every request by a "client" results in a record of the date and time of the request, the transmission protocol, the amount of information sent, and the address of the client (Rafaeli and Ravid, 1997). In this study, the number of questions uploaded by each student, the frequency of using the QSIA platform, and the number of questions ranked were recorded on the web servers' logs, and were provided on QSIA for monitoring purposes. The access logs were tools for investigating the students' Knowledge Contribution.

In the cognitive domain, the students' grades on their final examination were investigated. The final examination was composed by the instructor. The examination was 90 min long, and included 80 questions, 72% were multiple-choice questions, the remainder in true/false format. About 15% of the questions were interdisciplinary and integrated numerous topics taught in class.

In the affective domain, a feedback questionnaire for evaluating attitudes towards the on-line QPA and the use of QSIA was administered at the end of the course, after the students experienced developing questions and contributing them to QSIA, performing peer-assessment and responding to an on-line self-test and an on-line examination. The feedback questionnaire contained 12 statements concerning the usage of QSIA during the semester as a learning environment and 4 statements concerning the usage of QSIA as an on-line assessment tool. The statements were presented on a Likert-type 5-point scale response (5-strongly agree to 1-strongly disagree). Five experts in science and computers education validated the questionnaire. The questionnaire's internal reliability, Cronbach's Coefficient Alpha, was 0.85.

4. Results

The results section consists of three parts. Each part relates to a certain research question and presents data for its answer. Each part is also associated with one or two explored domains—social, cognitive and affective. The first part reports the results of the students' performance on the on-line QPA. The second part reports the

relationships between the students’ on-line QPA grades and their final examination grades. Both parts explore the relationships between the social and cognitive domains of on-line knowledge sharing. The third part reports the students’ attitudes towards the use of on-line systems such as QSIA and explores the affective domain.

4.1. *Students’ performance on the on-line QPA*

During the mini-semester the students developed and contributed 597 questions on QSIA platform, as part of the on-line QPA. The students’ grades on the on-line QPA were standardized on a 1–3 point scale in order to reduce the differences within each component and allow statistical analysis. The results show that the average grade students receive on the on-line QPA was around 5 points (5.44 ± 0.76) and the maximum grade was 6.67 points (out of 10). The average grades of the seven components composing the on-line QPA are presented in Table 4.

Spearman ρ correlation test, among the seven components of the on-line QPA components indicated a statistical significant correlation between three pairs as presented in Table 5.

Table 5 presents a statistically significant correlation between the ‘cognitive level of the questions’ and the ‘cognitive level of the distracters’ components. In other words, students who developed high cognitive level questions also developed high cognitive level distracters.

The ‘cognitive level of the distracters’ and the ‘type of question’ components were also statistically significant correlated. This means that students who developed high cognitive level distracters chose also to write complex type items such as matching or multiple-choice questions.

A third significant correlation was found between the ‘number of questions contributed’ and the ‘persistence in uploading questions’ components. This means that students who developed many questions tended to upload them more frequently—about once a week.

Table 4
Average grades of the seven components of the on-line QPA

On-line question-posing assignment components		Mean	S.D.
Knowledge Development	1. Cognitive level of question	2.03	0.61
	2. Cognitive level of distracter	1.89	0.43
	3. Type of question	1.95	0.23
	4. Multimedia features enclosed	1.02	0.12
Knowledge Contribution	5. Number of questions contributed	1.75	0.63
	6. Persistence of uploading questions	1.65	0.61
	7. Number of questions ranked	1.15	0.47

N = 71, Minimum = 1, Maximum = 3.

Table 5
Spearman ρ correlations of the on-line QPA's components

$N = 71$	Cognitive level of question	Cognitive level of distracter	Type of question	Multimedia features enclosed	Number of questions contributed	Persistence of uploading questions
Cognitive level of distracter	0.334*	—				
Type of question	0.110	0.517*	—			
Multimedia features enclosed	0.194	0.034	0.029	—		
Number of questions contributed	0.021	0.174	0.094	0.059	—	
Persistence of uploading questions	0.099	0.180	0.054	0.082	0.441*	—
Number of questions ranked	-0.098	-0.128	-0.120	-0.043	0.230	1.57

* $p < 0.01$.

Table 6
Students' performance on the on-line QPA and the final examination

Research instrument	N	Minimum	Maximum	Mean	S.D.
On-line QPA	71	3.33	6.67	5.44	0.76
Final examination	71	40.00	90.00	65.10	7.98

4.2. The relationships between the students' on-line QPA grades and their final examination grades

The second research question was: How does the on-line QPA relate to students' traditionally conceptualized learning outcomes? This question aimed at investigating relationships and the mutual influence of the social and cognitive domains of the on-line question-posing and peer-assessment activity. Table 6 presents descriptive analysis of the students' performance on their on-line QPA and the final examination. The on-line QPA grades are on a scale of 1–10 and the final examination grades are on a scale of 100 points.

The relationship between the students' grades on their on-line QPA and their final examination grades is of central interest. A linear regression analysis was performed to investigate whether the on-line QPA grades predict the final examination grades. The on-line QPA grades were defined as the independent variable and the final examination grades were defined as the dependent variable. The statistical analysis showed a significant relationship ($\beta = 0.38$, $p < 0.01$). This result indicates that

students who performed well on their on-line QPA—developed and contributed high quality questions in high quantity, had greater success on their final examination compared to their counter peers.

Since the on-line QPA grades were composed of seven components, we further investigated each component for its contribution to the relationship presented above. A stepwise multiple regression analysis of the seven components indicated that only the ‘Cognitive level of questions’ component contributes significantly to the prediction of the final examination ($\beta = 0.69$, $p < 0.01$). Moreover, the ‘Cognitive level of questions’ component explains about 50% of the final examination scores.

The relationship between on-line QPA scores, especially the ‘cognitive level of questions’ component, and the final examination grade might have an alternative explanation. It can be argued that this finding is just an artefact of students with high cognitive abilities succeeding in both the on-line QPA and the final examination. To further refine the analysis we therefore proceeded with a more detailed examination. A partial correlation coefficient was calculated using the students’ GMAT scores (MBA program entering requirement) as a surrogate control variable for representing prior knowledge and cognitive abilities. The results show a statistical significant correlation ($r = 0.36$, $p < 0.01$). This indicates that even beyond the effects of students’ prior knowledge or abilities, students who were actively engaged in on-line question-posing and peer-assessment activity, received higher scores on their final examination compared to their counter peers.

4.3. Students’ feedback regarding the use of QSIA as a web-based learning and assessing environment

In this study, students were actively engaged in question posing as well as self-, peer- and achievement-assessment, all administered by QSIA. In order to evaluate the use of QSIA and to answer the third research question, a Likert-type 5-point scale feedback questionnaire was administered at the end of the semester. The feedback questionnaire contained 12 statements concerning the use of QSIA during the semester as a learning environment and 4 concerning the usage of QSIA as an on-line assessment tool. The questionnaires were administered at the beginning of the following semester and only 46 students (65% of the research population) responded. The feedback results concerning the use of QSIA as an on-line learning environment are presented in Table 7 (5-strongly agree, 1-strongly disagree).

On average, students reported moderate attitudes towards QSIA as a web-based learning environment. They indicated enjoying the use of QSIA during the course and noted they would like to use the system in other courses. When asked about the learning aspects of QSIA, students indicated a variety of opinions. Students agreed to the statement that while using QSIA they were engaged in active learning, they also agreed that QSIA encourages individual learning. The students moderately agreed that the use of QSIA improved their learning and conceptual understanding. The students disagreed with the statement that the use of QSIA encouraged team learning. By their reports, students were not concerned with data security issues, but did note that they had encountered some technical problems.

Table 7

Feedback questionnaire results concerning the use of QSIA as an on-line learning environment

Statements concerning the use of QSIA as a learning environment	Mean	S.D.
1. I enjoyed using the QSIA during the course.	3.54	0.91
2. I was engaged in active learning while using the QSIA.	3.35	1.12
3. I encountered technical problems while using the QSIA.	3.30	1.09
4. I would like to use QSIA in other courses.	3.24	0.87
5. QSIA encouraged individual learning.	3.11	1.04
6. Using the QSIA improved my learning.	3.04	1.07
7. My conceptual understanding improved while using QSIA.	3.04	1.17
8. QSIA encouraged critical thinking of the learning material.	2.87	1.09
9. Using QSIA improved my understanding of the learning material.	2.80	1.11
10. I became aware of my misconceptions while using the QSIA.	2.43	0.93
11. The QSIA system encouraged team learning.	2.04	0.89
12. I was concerned about Security issues when I used QSIA.	1.61	0.80
Total feedback	2.87	0.59

 $N = 46$.

Table 8

Feedback questionnaire results concerning the use of QSIA as an assessment tool

Statements concerning the use of QSIA as an assessment tool	Mean	S.D.
1. After taking a test, I would like to receive an immediate feedback on my performance and my final grade.	4.46	0.72
2. I enjoyed using QSIA as an assessment tool.	3.78	0.92
3. I would like to use QSIA in other courses as an assessment tool.	3.41	0.93
4. I encountered technical problems while using the QSIA as an assessment tool.	3.26	1.25
Total feedback	3.72	0.56

 $N = 46$.

The feedback results concerning the use of QSIA as an on-line assessment tool are presented in Table 8 (5-strongly agree, 1-strongly disagree).

Table 8 shows positive attitude towards QSIA as a web-based assessment tool. The students expressed a strong interest in receiving self-monitoring. Receiving an immediate feedback and observing grades are important aspects of on-line learning and testing, as perceived by the students. The students enjoyed the use of QSIA as an assessment tool and noted they would like to use the system in other courses. These two statements received here higher means compared to the same statements on the previous table. Encountering technical problems received a similar mean as in the previous table. Over all, the total feedback mean of this section (3.72 ± 0.56) is much higher than the total feedback mean of the previous section—QSIA as a learning environment (2.87 ± 0.59). This indicates

that the students perceive QSIA more as an assessment tool than as a learning environment.

No significant differences were found between genders regarding their attitudes towards the use of QSIA as a web-based environment for learning and assessing, and no significant correlation was found between the students' attitudes towards the use of QSIA and their final examination scores.

5. Summary and discussion

Some instructors expect learning to remain unchanged from the forms it had when they were students. However, both technology and teaching paradigms are evolving, and so should the learning environment (Dillon, 1990). This paper describes a new approach to assessment that we believe holds promise for reshaping the way learning outcomes are measured in higher education. This approach includes question-posing as well as self-, peer- and achievement-assessments, all administered by QSIA—a computerized on-line system for assessment and sharing of knowledge. This study provides evidence that question-posing and peer-assessment can serve as both learning and assessment tools in higher education by encouraging students to carry out active learning, constructive criticism and knowledge sharing. We propose the On-line QPA (Question Posing Assignment) as a methodology and QSIA as a tool to serve as an alternative learning and assessing process in higher education.

Question-posing capability can be used effectively as an alternative evaluation tool for assessing the extent to which students understand and analyse a topic (Dori and Herscovitz, 1999). Using web-based on-line tools such as QSIA can be implemented efficiently on a large scale with large numbers of students. We report a significant correlation between the cognitive level of questions developed by students and their performance on an independent, objective and separately administered traditional final examination. Students who contributed higher-level questions received higher grades on their final examination.

Rafaeli and Ravid (2003) found a relation between information sharing and team profit. This project indicate a similar strong connection between the social behavior—contribution of knowledge, and the cognitive benefits for the students. On-line sharing of information or knowledge has a positive impact on learning outcomes. Findings indicated that even controlling for the students' prior knowledge or abilities, those who were highly engaged in question-posing and peer-assessment activity received higher scores on their final examination compared to their counter peers. The research findings support the claim made by other researchers that question posing can be regarded as a component of high level thinking skills and as a stage in the problem-solving process (Ashmore et al., 1979; Shepardson and Pizzini, 1991). The major contribution here is the demonstration of an on-line method of doing this.

This research suggests that on-line question-posing activity may enhance meaningful learning and that on-line peer-assessment activity may enhance communities of learners. These activities support both development of the individual

learner and a community of learners by enabling knowledge sharing. Knowledge sharing was supported in this study by the two components of the on-line QPA: *Knowledge Development* and *Knowledge Contribution*. We suggest that these are the two components of which knowledge sharing is comprised. To share knowledge one has first to develop it and then to consent and act on contributing it for the benefit of others. The QSIA on-line system supports such knowledge sharing process.

Our approach expands the notion of ‘web-based testing’ to the broader ‘on-line assessment’. The system described here goes beyond on-line testing and evaluation of students’ performances to the creation and use of a platform that allows various modes of assessment (self, peer and achievement) and supports knowledge sharing.

The students who participated in the research noted positive attitudes towards QSIA as a web-based learning and assessing environment. The students enjoyed using the QSIA system during the course and noted they would like to use the system in other courses. They pointed out QSIA as a system that enhances active and individual learning. These findings are in contrast to Dabbagh’s findings (Dabbagh, 2000). In her research she received negative comments on on-line quizzes from her students. While Dabbagh found that on-line quizzes were perceived as anxiety producing and cumbersome in terms of on-line requirements, we have shown here that an on-line system can yield better responses.

Although students were actively engaged in contributing knowledge and sharing information, they did not note QSIA as a system that encourages team learning. This indicates that students still see team learning in the traditional way of working in small groups and conducting face-to-face meetings. This notion is supported by Tang who noted that when people work collaboratively, but not face-to-face, many interaction resources are disrupted (Tang, 1991). On-line educational systems that are developed in collaboration between computer science researchers and educational researchers can support interactions and enhance collaboration (Carroll et al., 2003; Rafaeli et al., 2003).

In this study, most students actually contributed more questions than the minimum required. The students were willing to share knowledge with their classmates in this aspect. However, students were less active in providing rankings. Only a few students participated in ranking their peer questions. They were not willing to assess or criticize their classmates work. This result echoes results reported by Williams (1992). Students in Williams’ study felt that peer assessment might be construed as inappropriate criticism of one’s friends and colleagues. Students’ reaction to peer assessment is not always positive, therefore, the adoption of peer assessment needs to be tempered with recognition of its virtues and limitations.

In the quest for improving learning in higher education, and in accordance with the trends of integrating on-line systems in higher education, further use of the on-line QPA administered via on-line testing mechanisms such as QSIA may provide intriguing opportunities. On-line assessment holds promise for educational benefits and for improving the way achievement is measured. This is especially so if knowledge sharing is harnessed to aid the process.

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