Computer-Based Interactive Tasks:
A New Approach in Mathematics Evaluation

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Abstract

Computer-based evaluation (CBE), especially with interactive tasks, is appropriate for the math domain, given its diverse teaching-learning goals: conceptual knowledge ideas and processes, procedural knowledge, problem-solving and inquiry processes.

First, CBE can be used to evaluate student problem-solving and inquiry processes and not only products (i.e., the correct answer). Computerized labs designed according to principles in the domain can present phenomena, processes and connections between attributes. . Students can use labs to demonstrate their abilities to solve problems, make predictions and observations, record data and draw appropriate conclusions. Interactive tasks can assist in documenting processes and gathering information which could not be otherwise collected.

Second, CBE can be used not only for summative but also for formative purposes. CBE can capture student strategies and inquiry skills, determine if they are systematic or random and identify student misconceptions. This data can be used by teachers to improve their teaching of diverse learners, and by students to help avoid repeating their errors.

Third, CBE helps to neutralize student dependency on verbal skills, especially for populations with special needs (e.g., second-language learners and students with learning disabilities). Interactive tasks, which invite students to demonstrate practical skills not readily mediated by verbal expressions, can promote such improved measurement.

Most importantly, the assessment tasks can be integrated onto the digital text-book.

Key words: Mathematics; computer-based evaluation; interactive tasks

Theoretical Background

A great shift has occurred in the approach to assessment since the 1990s. The shift was from a summative type of assessment to a formative or educative one (Henning, McKeny, Foley & Balong, 2012). The assessment moved from testing at the end of a subject just learned to new and alternative forms, like peer assessment, co-assessment and self assessment. Nowadays, this shift continues and moves towards e-assessment.

The rationale behind this shift was to try and find forms of assessment which would provide a more accurate reflection of the learners' abilities and which would help teachers and learners to deal with a broader spectrum of content and thought processes (Schoenfeld, 2002).

This shift followed the change in how the role of learner was viewed - from passive to active - so opening the way for the learners to participate in the process of evaluation (Dochy, Segers & Sluijsmans, 1999).

In the 21st century, assessment began to benefit from the penetration of computers into education. The underlying idea is that the learner should not only acquire knowledge, but also the skills needed to acquire, apply and transfer schematic knowledge in new contexts. These skills include the ability to form, use, evaluate and revise the learner's own mental models of phenomena in a process which results in more complete, accurate and useful mental models (Gobert & Buckley, 2000).

The computer becomes an important part of evaluation, presenting learners with interactive tasks which enable them to demonstrate practical skills. The computer can also help the learner to improve mental models and to enhance performance on more complex cognitive tasks (Norman, 1993). The use of computers can also help learners who are not able to cope with a regular curriculum to find new motivation and challenge by learning how to cope with computer-based tasks. Other advantages of these interactive tasks are: they can be divided into levels, e.g. "novice – apprentice – expert"; they can reveal a student's "submerged talent" not apparent in the classroom; task they do not require above-average curriculum knowledge (Pead, 2012); they reduce language demands, thus helping learners who are verbally-challenged (Quellmalz et al., 2012).

The use of interactive and inquiry tasks for evaluation can enable teachers to better assess their students' problem-solving skills in a way not possible in a conventional paper and pencil test. The computer-based tasks also benefit teachers in that they do not have to focus on a wide curriculum, but on smaller portions of it, for example, at the end of a unit, and even in the middle of it. This may lead teachers to form a more balanced assessment of their students (Pead, 2012).

Computer-based assessment tasks can also be used for another kind of assessment – a formative one. As Sadler wrote (1998), this is a form of "assessment that is specifically intended to provide feedback on performance to improve and accelerate learning". Black & William (1998) also agree that such an assessment can contribute to the improvement of learning. All agree that the quality of feedback is crucial in that respect. Nicol & MacFarlane-Dick (2006) formulated seven principles of good feedback, including: feedback should be prompt, frequent and regular; it should be of a high quality; it should clarify what is expected of the student; it should enable students to improve their performance. These principles are better answered when the e-learning and assessment tasks are embedded in the course (Turney et al., 2009)

The use of animation and labs embedded in the digital text-book task can make the assessment more dynamic and more accessible to a wider range of students (Pellegrino et al.,

2001). Such use can benefit teachers too, in that it affords them more flexibility regarding where and when to administer an assessment, whether in the classroom or as a homework assignment. It also facilitates the collection of data about students' performance, whether at home or school, thus giving teachers a fuller view of their students' strengths and weaknesses.

Notwithstanding the extensive literature in the field of computer-based evaluation, little is known about the pedagogical potential of evaluation based on computerized tasks in general, and interactive tasks like labs in particular.

Computer-Based Assessment Tasks

The main objective of the present paper is to expose the pedagogical value of computer-based evaluation tasks, especially interactive tasks like labs, integrated in a digital math text-book.

We chose to focus on **two examples of computerized evaluation tasks** embedded in a digital math text-book. Each of the examples will be briefly discussed with regard to its pedagogical value to the teacher and to the learner, and the value of being embedded in the digital text-book.

We chose examples that highlight three important features for a computer-based task:
a. The task involves interactive activities.
b. The task would be difficult to accomplish with paper and pencil, or with paper and scissors.
c. The solving process enables the teacher to know more about the student's ability.

Example 1 - Tricks with numbers

The first example deals with numerical insight in long multiplication exercises. Each time, the activity presents a long multiplication exercise with missing numbers which the learner has to drag into suitable places. The activity includes a variety of tasks, of different levels of thinking and reasoning, e.g., completion of numbers in order to achieve the maximal/minimal product. The system records the student's performance and enables the teacher to fully follow the student's progress. In addition, it affords the teacher the opportunity to allow the students to perform the task and to feel free to try again and again until they succeed.

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The added value of this task, as a computerized evaluation task in general and as one that is integrated in the digital text-book in particular, can be seen on several levels as follows.

Immediate feedback: One of the prominent advantages in computerized evaluation is the ability to afford the learner an immediate feedback, not only with the completion of the task, but also during its execution. The feedback indicates not only right or wrong but allows the student to check his answer in a kind of "intellectual mirror" (Schwartz, 1989) so that he can analyze his assumption and try a new answer or approach to his solution. The great advantage of the task being in the digital book is in the opportunity to create for the learner an intimate evaluation environment, in which she can train herself at an appropriate rate and level.

Differentiation in assessment: The teacher can assign the task to students according to their level and to the rate of their personal progress. It is reasonable to assume that high-achieving students may address the task in the early stages of learning long multiplication, and will find it a challenge, whereas students with difficulties will meet this task nearer the end of the learning process.

An adaptive system with tasks similar to the above is now in advanced stages of development. Adaptive systems provide tasks suitable to the learner's level of performance. If the learner succeeds, the system will provide a more difficult task, if the learner struggles, the system will provide an easier task.

In the right place and time: The presence of such evaluation tasks in the digital text- book, in the relevant chapter and page makes it easier for the teacher to plan a continuous formative evaluation during the school year. Assigning the task to learners also becomes easier due to the technology, thus encouraging more and more teachers to use this tool.

Harmony between learning and evaluation: An additional value of formative evaluation tasks in the digital text-book is the relationship between learning and evaluation, or the harmony between them. The student approaches the task in the text-book which is a familiar learning environment, and thus learning and evaluation become one entity in the learner's mind.

Example 2 - Investigating the area of the parallelogram

The second example relates to geometry, and deals with area and perimeter of parallelograms. This task is integrated in a laboratory embedded in the digital geometry text-book for Grade 5, appearing in the chapter on the area of a parallelogram. The laboratory enables locking (keeping constant) various components of the parallelogram, such as the lengths of sides, the perpendicular, the perimeter, or the area, and dragging the vertices of the parallelogram to investigate the effect on its other components. For example, locking two adjacent sides and dragging the vertices will cause the area to change but the perimeter will remain constant (although

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it is not locked). The students are required to explain their observations.
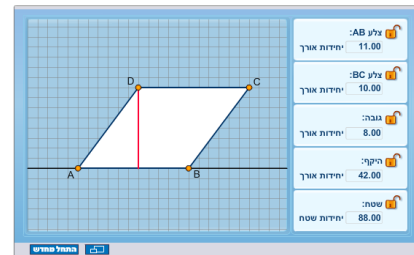
The integration of such interactive laboratories into the digital text-book broadens the potential for assessing the learner.

In comparison to computer-based evaluation tasks in which the teacher does not have the opportunity to be involved in the development and design of the task, the laboratory affords the teacher flexibility in shaping the task according to her needs, to the current phase of teaching and/or to the students' level.

For example, questions at the basic level of understanding, concerning the area of the parallelogram: "Lock two sides and move the vertices of the parallelogram. Observe what changes and what does not. Explain your observation". And on a higher level of understanding: "What happens when you lock both the perimeter and the area? Investigate and check. Formulate your conclusions."

The added value of using math laboratories for tasks integrated in digital text-books can be discussed on various levels as follows.

Viewing a process: Often teachers are unable to follow students' reasoning processes, even when they have requested them to explain their methods. They can see the final answer but not how it was reached. To illustrate this we will use the example of the parallelogram laboratory. Let us assume that the teacher asks her students to find the minimal number of components which should be locked in order to get a parallelogram whose components will stay constant under any dragging. In the case of a paper and pencil test, we might receive a right or wrong answer, without knowing the stages the student underwent on the way to the written answer. The laboratory documents the process which the student undergoes. For example, the student might at first conjecture that locking the lengths of the sides might produce the required parallelogram. He can check his conjecture by dragging the parallelogram's vertices and the immediate feedback will reveal that his conjecture is not correct and that he needs to search for an alternative strategy. From this point on, it will be interesting to follow the documented process and to see whether the student will conjecture that locking only the perimeter or locking both sides produce the required parallelogram. If the student checks each of these conjectures, which are equivalent and wrong, this indicates that he is struggling to understanding the equivalence of situations.

Neutralizing the language component: Often investigative tasks require considerable language ability, and present added difficulties to students who might otherwise have no difficulty with a math task. The example of the laboratory may ease the process in such cases, because it enables the learners to investigate the relationships among the various components of the parallelogram and to characterize their findings with minimal use of language. It is important to stress that we do not presume to eliminate all tasks which require extensive verbal reasoning, but desire to give students a chance to experience investigative tasks without the language component being an obstacle to their performance.

Various forms of representation: One of the best advantages of the laboratory is the possibility to observe the measure of change of each of the components at the same time. This cannot be done at all with paper and pencil. This advantage allows teachers to ask questions which demand various skills and different levels of thinking.

Potential for co-assessment and collaborative learning: The laboratory being embedded in the digital text-book might have extra value due to the opportunity given to the teacher to lead a discussion among the learners, via the use of a forum, for example. Opening up such a forum, allows for the disclosure of the learners' reactions to the task, thus encouraging them to evaluate their colleagues' answers (peer assessment), exposing them to various methods of solution, and even discussing solution space (Leikin, 2007) for the given problem. Another advantage is in exposing students' mistakes and dealing with them.

The present example of the use of the parallelogram laboratory for creating an evaluation task can definitely be a part of a formative assessment program which spans teacher's instruction. The integration of the laboratory for different kinds of evaluation tasks enables the teacher to vary the questions asked, and the laboratory itself serves as a tool to assess the students' answers and to test their conjectures, thus encouraging them to continue the process of learning. We intentionally chose to end with this example so as to negate the myth that computerized evaluation must be a pre-dictated task which cannot be changed at all.

The use of interactive evaluation tasks as presented in the two examples also fits the challenges mentioned by Pead(2012):

a. Requesting students to give a written explanation in the form of a description or a justification.
b. Challenging students, e.g. by a "Beat the computer" task.
c. Logging the interactions between student and computer and analyzing this data.
d. Heuristic inference – based only on the best results of the student. This does not lend itself to all tasks.
e. Extension problems – further tasks to demonstrate understanding.

Summary and Future Challenges

The main goal of the present paper was to expose those who deal with math education in particular and those who deal with assessment in general to the pedagogical value of computerized evaluation tasks using interactive tasks and labs, and to the added value of assessment tasks when integrated onto the digital text-book.

We have shown that these evaluation tasks have important attributes which contribute to the assessment process. The added value of the computerized assessment tasks, as presented in this paper, can be seen on two levels: the teacher's and the learner's.

On the teacher's level, these evaluation tasks may lead to viewing a process and not just the product at a certain point in time. This is accomplished by finding an efficient way of diagnosing thought levels by using tasks which include and encourage deep understanding, by analyzing situations and posing conjectures, and by planning an experiment to test those conjectures. Viewing it as a process enables the teacher to adapt the evaluation to the student's level at a certain time and place, and thus to achieve differential assessment (Pead, 2012).

On the learner's level, computerized assessment tasks enable him to receive immediate feedback about his performance, which rarely happens with the traditional way of evaluation using paper and pencil. Moreover, "intellectual mirror" feedback can help the student analyze and refine his solution. Computerized assessment tasks existing in the digital text-book enable the learner to proceed and exercise at a comfortable rate and at a convenient time, thus creating an intimate environment for evaluation and for learning and encouraging maximal performance; all this usually does not happen in a regular class, in which some of the students are afraid to ask questions or to share their solutions (Quellmalz et al., 2012).

Nowadays there are exercise generators in the digital text-books, which make it easy to get a variety of exercises according to the demands of the learner. Another important advantage is the neutralization of the language component through the computerized evaluation tasks. We often skip over inquiry tasks in math because of their demands for verbal reasoning. Computerized assessment tasks can enable the learner to perform investigations, and receive reports about their performance. This advantage can make it easier for the learner to reflect on her knowledge, whereas in a paper and pencil task this would not necessarily have happened (Quellmalz et al., 2012).

There is no doubt that the technological value concerning different representation forms, the use of labs, interactive tasks, etc., helps with building evaluation tasks which integrate more interest, curiosity, creativity and connection to the learner's world, thus enabling the assessment of unorthodox questions, like analysis of situations and posing conjectures.

We see great importance in the evaluation tasks integrated into the digital text-book, because they create a continuance between learning and evaluation, both for teachers and students. In the same text-book, in which they find instruction and exercises, students also learn to assess and improve their knowledge, whether the achievements are reported to the teacher, or

whether the students get the feedback directly. The integration of computerized formative assessment tasks in the digital text-books creates harmony between learning and evaluation. Long-term thinking in the application of digital assessment at the right time may improve the teacher's "hand on the pulse", so she will be aware of the rate of progress of every learner at all times (Turney et al., 2009).

Considering all the positive aspects presented in this paper, and in the wide literature in the field of computerized evaluation, we see great importance in continuing research into the potential of computerized assessment tasks for furthering learning, by quantitative and qualitative research. Such research can also shed light on the question of whether the vast investment needed for the development of such computerized task is justified.

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