Re-Imaging Learning Environments
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DO OUR MOOC'S WORK? CREATIVE WAYS TO ASSESS INNOVATIVE E-LEARNING PROGRAMS

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Introduction

Assessment of learners is important. Not only can we learn about the individual achievements of the learners, we can also assess the effectiveness of the learning scenario, be it the teacher, the curriculum, the learning environment etc. In this paper, we focus on the latter, in an attempt to assess some aspects of two, highly irregular online learning programs in math and science. Assessment of the learners before and after taking part in these programs can give us valuable information about the programs themselves (Boekaerts & Minnaert, 2003).

The programs, *Math By Mail (MBM) Online*, and, *Science By Mail (SBM) Online*, are e-learning courses (Jacobson & Archodidou, 2000; Welsh et al., 2003) in recreational math and popular math (respectively), for K-8 students, worldwide (Elran, Bar-On, & Elran, 2012). The main goals of these programs are to develop high-order learning skills and *out-of-the-box* thinking, and to boost curiosity and affinity to math and science – and it is this that we want to measure (Bar, Elran, & Elran, 2013).

They were developed and are managed by the Davidson Institute of Science Education, the educational arm of the Weizmann Institute of Science. Through a unique learning platform within a MOOC (Massive Open Online Course) -like scenario, thousands of young scientists and mathematicians, learn from, and collaborate with leading scientists and mathematicians (Shulamit & Yossi, 2011; Kotzer & Elran, 2012).

The courses are unique in many parameters:

- Each course facilitates diverse learning settings, blending synchronous and asynchronous learning: a series of e-booklets with many interactive tasks, quizzes and multiple question types, released every two months, weekly challenges with open questions, forum discussions and monthly synchronous face-to-face lessons.
- Participation in the course is elective. Still, the participants mostly have a homogeneous profile. Typically, they are high achievers interested in math or science. Albeit, they are highly dispersed geographically and differ culturally.
- The topics learned are non-curricular and, given the goals of the courses, the tasks are unusual and irregular.
- Over 4,500 learners participate in the programs.

It is extremely important for us to assess the added value of our programs, and learn whether or not they achieve their goals. In general, with regards to MBM and SBM, we want to know what unique knowledge, skills etc. do the students learn. We narrowed our focus to one specific question for each course:

1. Do the students who finish an annual MBM course, grasp the much broader concept of math being a vast body of knowledge and skills, hinging on philosophical, reflective thinking?
2. Does SBM enhance the individual student's *meaningful question asking* abilities?

In order to answer these questions, a new model based on performance assessment tasks (Boekaerts & Minnaert, 2003) was designed and implemented to identify the learning and thinking skills that were acquired during the year within the unique framework of MBM and SBM (Dalgarno, 1998). The rest of this paper describes the model and its application to MBM and SBM.

Math by Mail

Method

The assignment: We designed an assignment to test the way the learner grasps the concept of *math*. Participants were asked, at the beginning and end of the course, to compose a mind map of his or her answer to the question "What is math?".

The analysis: We compared the mind maps of the beginning and the end of the course with regards to four main aspects:

1. The number of associated ideas connected to the main concept in the mind map: A larger number of associated ideas represent a deeper acquaintance and broader understanding of the student with the main concept.
2. The diversity of representations in the mind map. Mind maps allow for different representations of ideas: text, images, symbols etc. A more diverse representation suggests a broader mental representation of the main concept.
3. The contents of the map: we tested the quality of the associated ideas represented in the map based on the following possibilities:
   - A higher level:
     - Ideas that indicate concrete mathematical thinking – such as a collection of arithmetic operators or descriptions of components and fields of math
     - Ideas that indicate abstract thinking or complex understanding of math
     - Ideas that indicate the broader concept of math as thinking processes

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- A lower level:
  - Examples ("Math for example is…")
  - Insignificant answers

4. The visual nature of the description. A more sophisticated description (i.e. complex vs. simple drawing) may correspond to the complexity of the thinking about the field.

Main results

Following are some of the main findings in our study:

- At the end of the year the participants used many more concepts than at the beginning of the year. 60% of the participants at the end of the year mentioned 10-28 concepts as opposed to only 33% that did so at the beginning of the year (Figure 1).
- Many more participants drew a mind map at the end of the year (92%) compared with the beginning of the year (15%)
- Less students wrote only lists of words or drew images that are not maps (9% of the participants at the end of the year compared with 85% at the beginning)
- When we compare the contents of the mind maps we see a significant difference between the periods with respect to the comprehension of math as a *domain of thinking* (42% at the end of the year compared with 0% at the beginning)
- At the beginning of the year the typical description was a list (54% of the participants) and at the end of the year this kind of description became negligible (6%) and the description with the highest frequency was what we termed a *sun description* – the main concept written in the centre of the map with *rays* extending to the associated ideas (86% at the end of the year as opposed to 19% at the beginning).

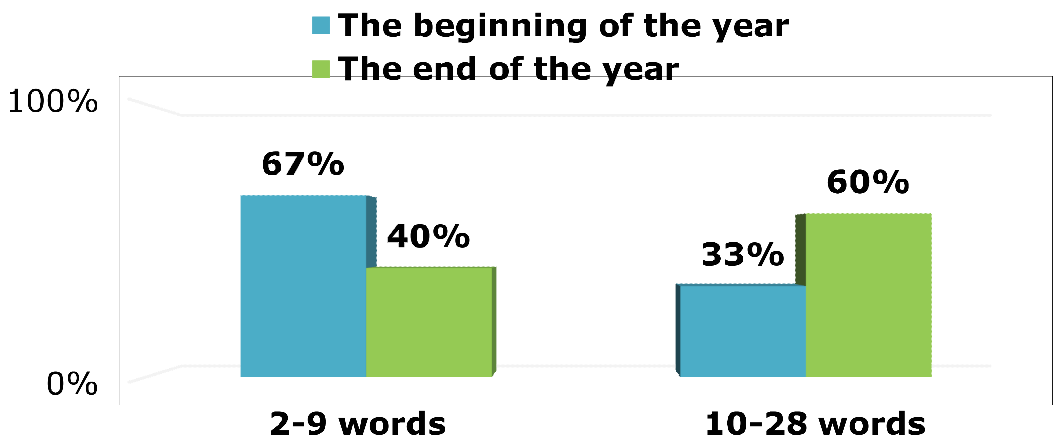

Figure 1. The number of concepts used by participants (grades 3-4) in their mind maps (comparison between the two periods)

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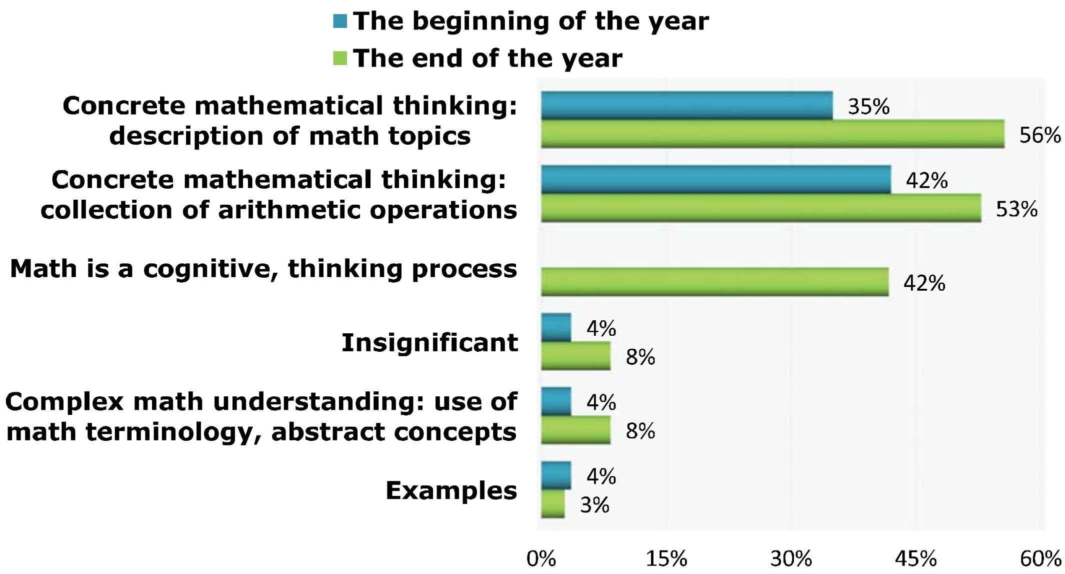

Figure 2. The content of the mid map created by participants (grades 3-4) (comparison between the two periods)

Figure 3 shows a mind map created by a grade 5 participant at the end of the year. The student drew complex connections between the ideas and expressed his understanding that math involves a cognitive thinking process by using phrases such as: *thinking out of the box* and *creative thinking*.

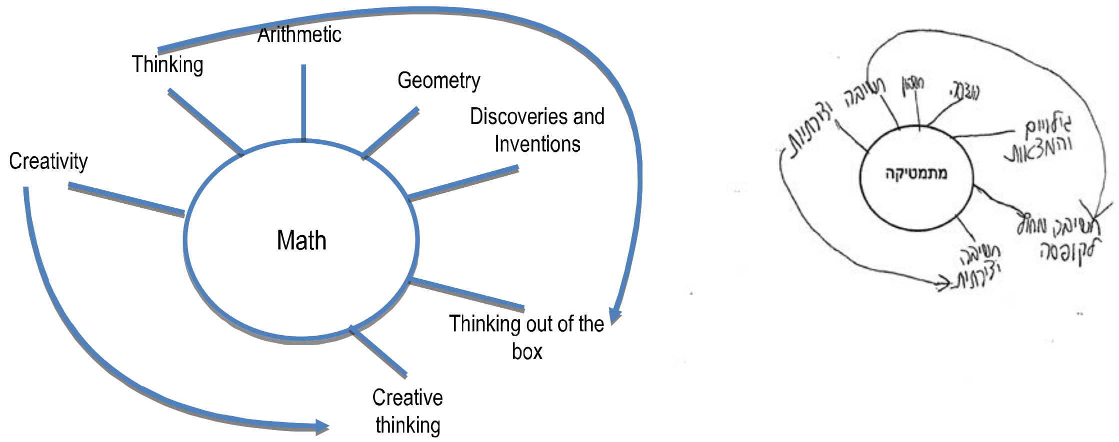

Figure 3. A mind map created by a Grade 5 MBM student (translated from original)

We conclude that in MBM, the program reaches its goals in respect to cultivating thinking and learning skills. At the end of the year the students that participated in the programs expressed richer concepts in their mind map, the structure of the map was much more complex and the possibility to connect between different concepts was more sophisticated.

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Science by Mail

Method

The assignment: We designed an assignment to assess the improvement in students' *meaningful question asking* skills. Both at the beginning and the end of the year, we presented the participants an illustration taken from a recent research. The illustration was accompanied by a short written text. The participants were asked to write as many questions as they could about the illustration.

The analysis: We compared the findings at the beginning and the end of the period with respect to two main aspects:

1. The number of questions asked – this indicates the level of confidence the participants have to ask questions and the legitimacy they feel they have to find as many answers as they can.
2. The quality and nature of the questions. We analyzed the contents of the questions asked by the participants and these questions were divided into different groups according to the level of thinking they indicated.

Main Results

At the end of the year we found substantial improvement in the students' *meaningful question asking* skills: they were willing to ask more questions (Figure 4), and the content of the questions indicated higher thinking levels (Figure 5).

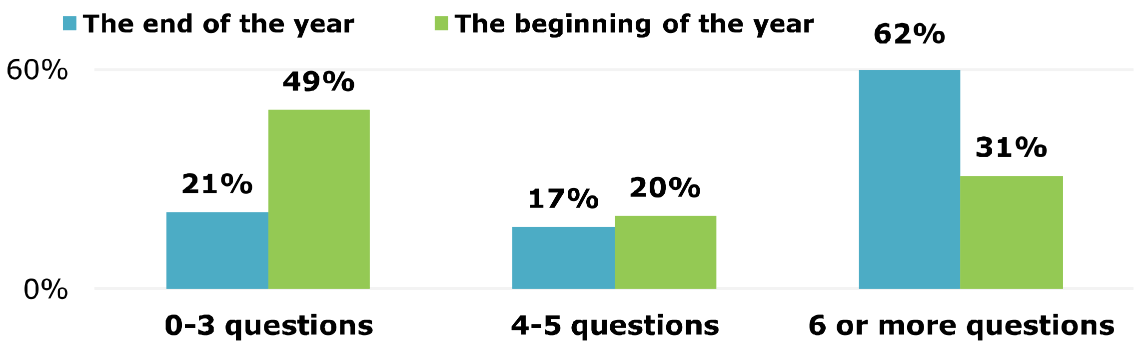

Figure 4. The number of questions asked by grade 3-4 participants (comparison between the two periods)

Regarding the quality of the questions, we found that the questions at the end of the year were of a higher standard than the questions at the beginning of the year. They were related more to the essence of scientific phenomena and less to historical information or research methods and techniques. For example, we saw more questions such as: "Why is that range of temperatures specifically those that sustain life on Earth?" as opposed to: "Are there more or less germs as we go deeper into earth?"

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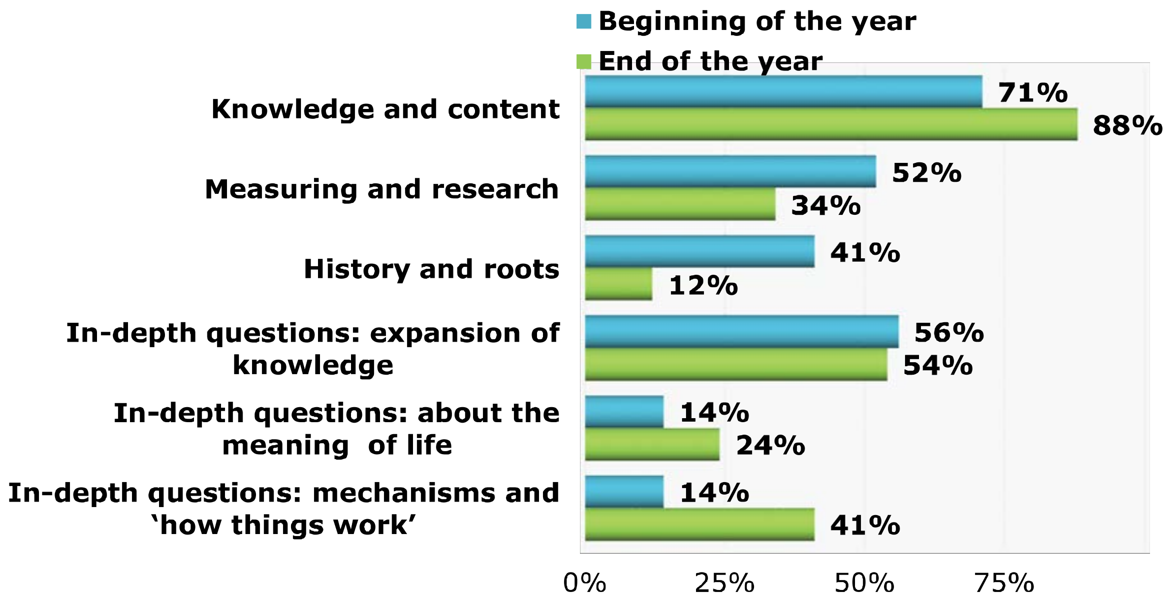

Figure 5. The types of questions asked by grade 3-4 participants (comparison between the two periods)

The findings show that SBM reaches its goals in the aspect of development of high-level, meaningful question asking skills: participants ask more questions and the content of the questions indicate higher thinking levels.

Summary and Conclusion

In this paper, we presented the innovative methods we developed to assess two extracurricular programs for high achievers and showed how these methods were applied. In particular, we found that the performance assessment tasks developed and delivered online to the participants, answered questions we had about the effectiveness of the programs, such as: Do the students who finish an annual MBM course, grasp the much broader concept of math being a vast body of knowledge and skills? (yes!), and, does SBM enhance the individual student's *meaningful question asking* abilities? (yes!).

Rather than focus on the individual results specific to MBM and SBM, we believe that the model suggested here can be adopted for many online scenarios (i.e. Azmon et al., 2012; Bar, Elran, & Elran, 2013). Performance assessment tasks of the type presented in this paper, are helpful to assess the effectively of programs for a large, homogeneous group of learners. They are easy to deploy online, especially for a large body of learners and hence are also useful for evaluating MOOCs. More research is required to form a larger body of tests that can be used to gain insight into similar learning environments. Perhaps we can develop a standard set of tasks that can be used to answer other important questions regarding the effectiveness of online and distant learning in general. The direction proposed can apply to other MOOC's and similar learning environments. Work along these lines is in progress.

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