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Developing MAP for integrating mathematical applets in teaching sequence

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In this paper, we present the way in which the math teacher proceeds to select an applet, and especially its main considerations when preparing for the lesson or preparing the study unit. In addition, this study examines what the teacher's meta-data should be in order to make a knowledgeable select of applets and integrate them into the teaching sequence. This study aims to help the teachers cope with the heavy load of the Open Educational Resources (OER) and help them in their day-to-day management of the study units. Therefore, qualitative research was carried out to examine the teachers' choices and considerations regarding their goals and sequence of teaching. The present study offers a way to deal with this difficulty by means of a Map that will link the teacher's pedagogical-content considerations. This map may be used by the teacher as a tool for intelligent choice of applets.

Keywords: Mathematical applets, Map, Meta-data, teaching sequence.

Introduction

A well-informed integration of technology in teaching and learning at school positively affects students regarding cognitive features and effective ones (emotional and motivational), as well as features connected with the teachers' choices in the classroom and outside of it. Using technological tools for the purpose of teaching is very common nowadays (Stehr, He, & Nguyen, 2018). These tools are often used for the sake of innovation, and for introducing a fresh aspect to increase students' motivation (Horzum, 2015; Smith, Shin, & Kim, 2017). This occasionally leads to the development of new technological tools that are not always best fitted to the students, and do not attach importance to mathematical content. Thus, if mathematical content is not taken into account, the choice of using certain technology for the purposes of teaching and studying does not grant any educational benefits, and may indeed miss the actual goal (Dębowska et al., 2013).

The recent development of various educational resources containing digital learning materials for the use of teachers is especially relevant to this study (Cohen, Kalimi, & Nachmias, 2013). These educational resources - most of which are free for use (such as the Israeli Ministry of Education's "Educational Catalogue") - offer various activities and material and in varying formats, from short texts, videos, and applets up to full lesson plans. Hence, teachers are given a chance to make use of existing learning materials in order to optimize and improve their work. Among these educational resources there is specifically a major supply of game-based applets, interactive web utilities (Pejuan, Bohigas, & Jaén, 2016), aimed at various subjects in Mathematics and for a broad age-range. It is a well-known fact that using these applets has a positive impact on students (Hershkowitz, Tabach, & Dreyfus, 2017), and that using the applets through a guided model can

provide better outcomes in the acquisition of language and of mathematical terminology (Dijanić & Trupčević, 2017).

Despite the potential for teaching and learning encompassed within existing learning materials, and their many benefits, studies suggest that their usage, as well as their combinations to match the specific user's needs, are relatively low (Hilton, Lutz, & Wiley, 2012; Pirkkalainen, Jokinen, Pawlowski, & Richter, 2014; Bernstein, 2015). One argument is that many educators are not aware of these growing educational resources, or that they are not entirely convinced of their effectiveness (Cannell, Macintyre, & Hewitt, 2015). Furthermore, there is a concern that the abundance of displayed information might lead to confusion, discrepancies and wasting time when searching for information - due to the lack of a single unified system which would license and catalogue learning material (Nash, 2005). It could also lead to difficulties in evaluating the quality and reliability of information and its management (Clements, Pawlowski, & Manouselis, 2015; Gurung, 2017).

There are two significant challenges facing those teachers who are interested in using mathematical applets and making informed usage of them. The first is related to the stage of searching and selecting the materials that will best suit the goals of their specific teaching subject; and the second is regards to the optimum usage of those materials within the teaching process in class during a lesson, or during a few consecutive lessons.

Main research goals and questions

Three main goals for this research (1) Understanding what data is needed for teachers to integrate applets within their teaching sequence; (2) Identifying specific features within applets that will enable an informed integration within the teaching sequence; (3) Creating a Map based on meta-data fields that teachers can choose an appropriate applet and integrate it within the classroom's teaching sequence. In order to achieve these goals two questions were asked: (1) What are the main considerations that teachers operate in order to integrate applets into teaching sequence? (2) What is the meta-data that can help teachers to make decisions about using those applets? Meta-data in educational aspects (pedagogic - content) and, Meta-data in technological aspects.

Methodology

The research was conducted in three main stages. The first stage included a review of various meta-data models connected to the world of studies and education. A theoretical framework was built based on these models (e.g Dublin Core and LOM) including the meta-data of existing mathematical applets. The meta-data was divided into educational dimensions and technical-technological dimensions. The educational dimension contains the teachers' pedagogical requirements and contents, and the technological dimension describes the applets (Figure 1).

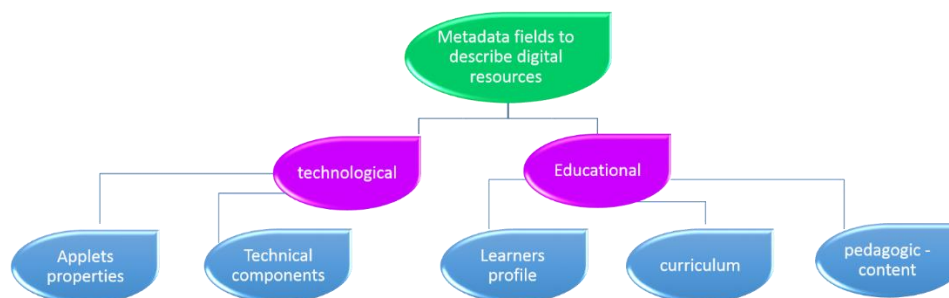


Figure 1: The theoretical framework

The meta-data fields which describe the Mathematical applet in each dimension are grouped into different categories of metadata. The branching of these metadata categories shows a comprehensive view of all the characteristics that can be considered when examining applets.

The second stage included semi-structured interviews with 12 mathematics teachers who use applets in elementary schools. The interviews aimed to establish the theoretical framework, and to examine the teachers' perception of integrating applets within their teaching sequence in accordance with their teaching goals. The interviews were divided into four stages in accordance with the stages the teacher faced when implementing the applets: applet searching, locating, using, and feedback. The interviews were conducted as one-off sessions with each teacher. This qualitative stage draws its data from the natural system, in which the researcher and the interviewees are on the same communication level, and the research output is created from opportunities in their interaction.

The third stage dealt with analyzing the findings, and developing a tool in the form of a Map for applets integration. This stage of analysis and tool-building placed emphasis on the teachers' answers concerning their ways of choosing applets and integrating them into their math class teaching sequence. This research was based on Grounded Theory, in which data collection was carried out before the study is fully understood (Shkedi, 2003).

Preliminary findings

The findings' analysis was divided into two levels: addressing the teachers' considerations regarding the integration of applets within their teaching sequence, and addressing the meta-data they would find useful for their decision making process. Based on these, a comprehensive Map was constructed.

Teachers' considerations

A number of considerations arose regarding the teachers' select of an applet and planning of their teaching sequence - mainly pedagogical and technological considerations. From the teachers' point of view, the main considerations were pedagogical considerations which included mainly the teaching goals, the pedagogy, the mathematical content, the location and time frame. Moreover, it was found to be important to consider their teaching experience and professional knowledge, their teaching style and even their personality. The technological considerations include mainly authorizations, certification (Figure 2).

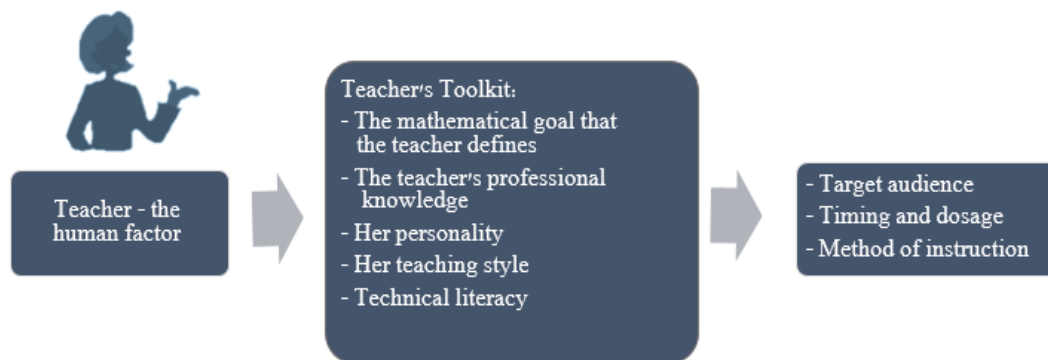


Figure 2: The teacher's considerations for integrating applets

Meta-data

Beyond the considerations that the teachers must use when choosing an applet, there is also the matter of the specific data that is required from the applet or database they are examining. The teachers defined the meta-data from pedagogical aspects as well as technological ones. Pedagogical aspects included mainly the teaching sequence in relation to the objective of use, the way of studying, acquired skills, students' profiles in relation to difficulty levels, timeline, mediation levels, the student experience evoked by motivational factors and configuration. In accordance with the findings' analysis, a set of Metadata fields was created for the purpose of assisting the teachers in an optimal search for the applet most suitable for their teaching sequence. Figure 3. presents the main meta-data fields that can assist the teachers in their decision-making process while constructing their teaching sequence with the use of applets (Figure 3).



Figure 3: Pedagogical and technological metadata fields

A map for applets integration in teaching sequence

The pedagogical and technological considerations as well as the set of metadata are presented by process map. This map shows the teacher's way of thinking in making the choice in four stages: the search stage, the detection stage, the use stage, and the feedback stage. At each stage the teachers referred to a number of different categories. In the search phase, the teachers referred mainly to the availability of information, pedagogical considerations and a structural model. At the point of identification, the teachers referred mainly to the data they had in the applet and to the superlative information that still did not exist, when they referred mainly to the information they knew and their experience. At the point of use, the teachers referred to their meta-goals, motivational factors, and time and place of use of the applet. In the fourth and final stage, the teachers referred to the effectiveness of feedback, the type of feedback required, feedback interactivity, and feedback as a learning too.

According to the map (Figure 4), the teacher can filter out the considerations that lead her to decide whether to select an applet. The integration applet Map is presented in four main steps: filters, properties, receipt of products and choice of characteristics and in the end decision-making, from the search stage to reaching the desired applet. The filter stage includes all the pre-requisite knowledge the teacher needs when choosing an applet that includes her professional knowledge, her personality, her mathematical goal, and more. At this stage, the teacher also defines her target audience, the method of instruction and the timing of her teaching sequence. The properties stage includes the different characteristics of the applet and its target audience. The third stage, which is

defined as the receipt of the products and the examination of characteristics, is from a stage in which all the knowledge that the teacher has is integrated into this stage and it examines the continuation of the process in order to select the applet. In the fourth and final stage, the teachers arrive at a crossroads where they have to make a choice: Should they choose the current applet, or should they go back to the second and third stages, and re-examine other applets.

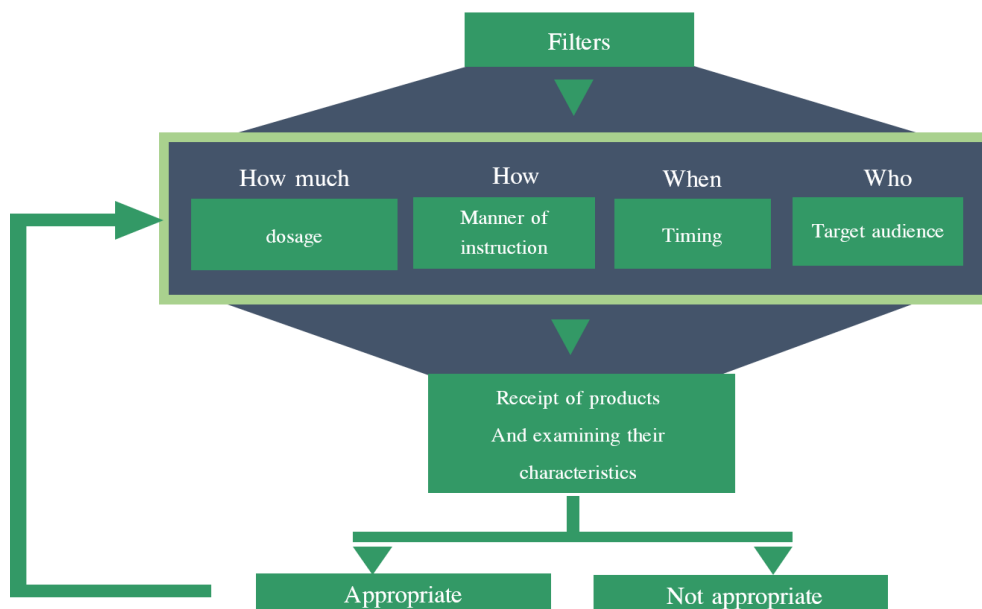


Figure 4: A map for applets integration in teaching sequence

In conclusion, this research looked at the considerations and the metadata which would influence teachers when choosing applets and integrating them into the teaching sequence. The interviews indicated great significance attached to the teacher’s personality, needs and authority. Another issue that emerged through the interviews was the students’ needs - the teacher’s understanding of what the student needs to get; how the students will connect to the applet; and how we get the students to understand mathematics by using the right applet. Another issue which is just as important as the teacher and student’s needs, is the teachers’ learning process during their search for the desired applet. During the interviews, the teachers explained how they approached searching and choosing the applet, as well as how they integrated it within their teaching sequence, and these led to conclusions regarding their method of learning.

Discussion and conclusions

In this research, the pedagogical consideration was the main one for choosing applets. According to the pedagogical consideration, teachers choose the applet most suited to their teaching sequence. Since the mathematical content is highly significant in building up the students’ mathematical knowledge (Kimeswenger, 2017), the teachers will first search for an applet appropriate for that content. Most of the teachers interviewed stated that without that element of information they would not be able to begin the search, hence - this is a primary filter when choosing a database or applet. Similarly, Namukasa, Gadanidis, Sarina, Scucuglia, and Aryee in their research (2016) found that among the most important considerations were the pedagogy and content that the teachers wanted to

teach in their mathematics lessons. They also stated that mathematical terms or “mathematical thinking” would be the most critical when choosing a digital object. This issue was addressed as well by Kotsopoulos et al. (2017), who explained the importance of the students’ computational mathematical thinking, which should take precedence.

The study found that technical components such as installation instructions and necessary hardware and software programs were not essential elements when choosing an applet. Most teachers, when asked about the technical aspect of choosing an applet, answered that they do not attribute much importance to those aspects when choosing to use an applet. The teachers stated that the only factor impacting on their choice would be the hardware or program’s digital license - as defined by Green (2017) during his OER license research, where he examined how they influence studying. The teachers stated they are already used to the “wonders of technology” and that they know how to handle anything that comes their way. Much to our surprise, the technical aspect that we had emphasized at the beginning of the research did not end up being a hindrance or even a consideration when choosing an applet. This surprised us a great deal, since some populations find study-suitability very difficult during times of technological advancements (Göthe, Oberauer, & Kliegl, 2007).

During this research, we mapped out the considerations and information the teachers would need when choosing an applet or mathematical resources. Then, similar to Kimeswenger (2017) we recognized the need for developing a tool, which will help teachers to navigate in the heavy load of resources and to assess learning materials. Thus, we built a Map for integrating applets in teaching sequence. The Map consists of the knowledge the teachers will need for choosing the applet and for integrating it into the teaching sequence. We believe that the Map we have created may assist in developing a technological tool with which teachers may integrate all the elements necessary for their teaching. Beyond the teacher’s familiarization with the educational resources and applets, it is necessary to develop a tool in the form of Google, consisting of mathematical educational resources and applets, with the added option of feeding it criteria that would make it possible to obtain the desired product, and which could assist the teachers’ choice of an applet, and shorten search duration.

Since this research did not deal with the construction of lesson units by teachers, it is vital for future research to deal with that subject in greater depth and regarding the following influencing factors: How long it takes the teachers to learn the usage of applets; how long it takes to build a lesson plan - whilst relating to pedagogical components as well as to the teacher’s teaching goals; the chronology of lesson building; and how the applets assist the teachers.

In an age of rapid and frequent changes, we must pay attention to the fact that teachers are required to implement new technologies on a daily basis as part of their lesson structure. Hence, the main importance of this research is in assisting teachers integrate mathematical applets within their teaching sequence in the classroom. Teachers nowadays are laden with a huge amount of applets and resources (Peralta, Alarcon, Pichara, Cano & Bozo, 2017) which is why we developed the presented Map. Teachers are expected to have an extremely high level of literacy due to current usage of many technological tools. Therefore, it is important for future research to address the way

in which the teachers learn how to use technological tools, and to actually implement them in the classroom.

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