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Multidisciplinary and Multimodal Approaches in Teaching and Learning Mathematics, Music and Language Based on the Flipped Classroom Model

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Abstract
Digitalization and multidisciplinary approach are the new trends in Teaching and Learning theory and practice. The article lays emphasis on mathematics teaching and learning knowledge, based on Action Research Theory, New Learning Theory and Variation Theory. Preservice early elementary school teachers created audiovisual video films (AV) and Podcasts (PD) lessons integrating Mathematics, Music and Language during a university course in teacher education. These multidisciplinary lessons were used as intelligent tutors in a flipped classroom model. The lessons are dealing with proportionality, one of the most difficult items in elementary school mathematical curriculum. For explaining proportionality, the preservice teachers have used multiple representations such as manipulatives, fiction stories, videogame Minecraft, “Smash up” in tennis table, musical intervals, self-composed, self-written and self-performed songs about mathematical rules in easy to remember rap-style. Preservice teachers have shown their AV or PD lessons to elementary school students followed by joint discussions
and exercisers in solving of mathematical problems. Preservice teachers analyzed their work in an essay-form report describing creation of their intelligent tutors for elementary school students’ knowledge development in mathematics, music and language, including pronunciation, explanation and understanding of mathematical terminology. The multipart flipped classroom approach promoted prospective teachers’ professional growth. For future analysis the described multipart flipped classroom model can be further developed in international collaboration.

Keywords: flipped classroom, preservice teachers, elementary school mathematics, music, language, multidisciplinary, multimodal

Introduction

Digitalization and subjects’ integration are new trends in Teaching and Learning theory and practice. The article is based on the multidisciplinary and multimodal approaches for teaching and learning prospective teachers. They are being equipped with new methodology for teaching elementary school and kindergarten subjects of mathematics, music and language, based on Action Research Theory, New Learning Theory and Variation Theory. While the Action Research theory is using a descriptive approach for understanding the educational practices from the perspectives of research participants [20], the New Learning Theory [10, 13] and Variation Theory [18] are emphasizing multidisciplinary and multimodal approaches to education for stimulating preservice teachers’ creativity. It is described here how the prospective teachers are being equipped during their university studies in teaching and learning mathematics with modern educational tools, the semiotic resources in which image, text, speech and music correlate. It has been shown earlier that preservice teachers enrolled into university courses of teaching and learning mathematics often bring with them preconceptions and common concepts about certain difficulties of the subject of mathematics all the way from kindergarten to university, which negatively influence their ability to teach mathematics [12]. To teach mathematics is considered by many elementary school preservice teachers to be a difficult task and they often develop a mathematics anxiety and negative appraisal of the subject [3, 4, 7]. Preservice elementary school teachers who attend our university’s Teacher Education programs are also showing these tendencies. To overcome these problems, we offer the prospective teachers to try in our courses a variety of new educational methods for teaching elementary school mathematics [2]. Described earlier multidisciplinary and multimodal approaches of integrating mathematics with music [3] and a flipped classroom model [8] are
two of them. According to Clark, in many of the secondary classrooms in the USA, students are passively engaged in the mathematics content, but it can be improved by implementation of the flipped classroom model in which the lecture-like instruction is moving outside the classroom via technology while moving homework and exercises with concepts inside the classroom via learning activities, as opposed to a traditional format [8]. The flipped classroom model is usually used with students of secondary and higher educational levels [8, 11]. The application of the flipped classroom model has been shown to have a variety of positive features in mathematics education at the university level [11, 14, 23]. We became interested in whether the flipped classroom model can be also offered to preservice teachers as a new methodology of teaching and learning elementary school and kindergarten mathematics. Therefore, we modified flipped classroom method to be applicable for kindergarten and early elementary school levels and included flipped classroom approach in our courses of teaching and learning elementary mathematics. We designed our modification of the described earlier flipped classroom model based on such advantages of a flipped classroom intelligent tutor’s instructions as 1) a possibility for a student to watch the instructions repeatedly as many times she or he wants, 2) to watch them at any convenient time and on that 3) these instructions should be relatively short (about 6-7 minutes) and consist, attracting students’ concentrated attention. Here we describe using the flipped classroom model in one of such courses when the participating prospective teachers applied the flipped classroom model using an audiovisual video filmed (AV) instructions for teaching mathematics and mathematical language at the kindergarten and early elementary school level in combination with music. Using this approach preservice teachers were encouraged to place emphasis on student-centered learning strategies and students’ investigations of mathematical ideas, to improve students understanding and learning mathematics. When it comes to the mathematical content of the AV films described here, we present how preservice teachers were using our modified flipped classroom model and applied it in teaching and learning about proportionality. We have chosen to work with proportionality due to two reasons. Firstly, because proportionality is one of the most difficult items in the elementary school mathematical curriculum [24] and is therefore most interesting for preservice teachers to work with. The core content of the curriculum has the following instruction when it comes to proportionality:” Relationships and changes. Different proportional relationships, including doubling and halving” (page 59) [24]. Secondly, because elementary school students of the third-grade had achieved the worse results in solving mathematical problems connected to proportionality in a recent country-wide test organized by Swedish Ministry of Education [25]. It was shown
earlier, that using computer games which are popular among elementary school students, serves as an intrinsic motivator for students’ elementary school studies in mathematics, as well as it improves their mathematical and language learning outcome [15]. In this study we use the computer game Minecraft created by Mojang AB computer games company [21]. This game is created in Sweden and the bulk of elementary school students are familiar with it since they have tried it at home, with friends och during free time hours at school. The idea of Minecraft is that it involves players to interact with the game world by placing and breaking various types of blocks in a three-dimensional environment, which allows to train the knowledge of mathematics and various mathematical skills.

We suggested that combination of a modified flipped classroom with music will provide the preservice teachers with a new method of teaching elementary mathematics, music and language, which will stimulate their creativity, and their interest in teaching these subjects. We present here an example of three cases of our preservice teachers integrating mathematics with music in a modified flipped classroom setting. All preservice teachers received the permissions of the guardians of elementary school students and kindergarten children and the permissions of the principals of respective school or kindergarten. All work was made according to ethical guidance of the European Code of Conduct for Research Integrity and according to the Swedish Research Council. Science-Ethical Principles for Humanistic-Social Science Research [1, 26].

Results
Before starting to plan their work in a flipped classroom model style the preservice teachers had received the instructions summarized in Table 1.

Table 1. An Assignment in a Flipped Classroom Model Style
- You plan and create a short (about six min) video lesson that integrates music in teaching of mathematics.
- You try this video lesson in an elementary school class or at the kindergarten and analyze students experience with it.
- You describe the milestones of you work in a short memo before the oral presentation.
- You present at the university seminar your video lesson and hold an oral discussion about your findings.
You describe students’ experience and your own experience of working in a flipped classroom model style in a written report submitted after your oral presentation.

Preservice teachers in our teaching and learning elementary mathematics course were assigned to work in pairs to fulfill the task presented in Table 1 above. They designed and created a six to seven minutes long audiovisual video films (AV) as educational tools. One of the pairs has combined the AV-film with a Podcast (PD) as it will be described below. A Podcast presentation is like a small radio program. These AVs and PD were shown to the students through a computer as an intelligent tutor in elementary school classroom setting during prospective teachers practice of teaching mathematics. Preservice teachers performed observations and formative assessments to describe the process of making their AV and PD, their thoughts and ideas. Before and during they were working with the described tasks in the course in teaching and learning mathematics the preservice teachers had received the following support and have read the following literature: 1) an earlier course in filmmaking; 2) philosophical and historical overview of mathematical education and its connection to music and motivation [16, 19, 22]; 3) theoretical knowledge about making video [8]; 4) the assessment of students’ mathematical achievements [5, 6].

In the first presented here case, the preservice teachers pair combined musical segments of their AV film and PD with elementary school students’ everyday experiences. Figure 1 A is showing a screen short of the AV film which uses the computer game Minecraft, described in the Introduction. When it comes to a PD format, it lacks visual images. Therefore, working with this format one should direct an extra focus on the language. Designing efforts of preservice students’ pair were concentrated in this case on making sure that the examples which are conveyed to elementary school students as radio PD intelligent tutors were understandable without visual images. The prepared script included examples of students’ everyday life, one of which was dealing with purchasing of candy, since shopping is a familiar experience for the bulk of elementary school students.
A.                                B.                                C.

Figure 1. The screen shorts of: A. *Minecraft*, B. “Smash up” in tennis table and C. Musical notes. See details in the text.

The musical part of the exercise was designed to stimulate students’ *auditory* and *kinesthetic* senses. While the listening students were investigating a well-known melody and ranking the value of the notes, they were encouraged to keep an even stomping rhythm as a reference to the melody. This preservice students pair presented the rationale behind their design as following. Music is something that most people can relate to, therefore it can improve almost every student’s learning process. The idea is that students themselves are active agents in getting the information, which we, preservice teachers, are conveying information to them. In this case’s AV film the music was also visualized as images of notes (Figure 1 C). The rhythms and melodies which are raised, have rhythmic notation with the timeline that was also shown to the listeners on the screen during intelligent tutor mathematical and musical performance. The use of music as a mathematical example in the PD and on the screen is beneficial for elementary school students’ learning mathematics since music is presented both with the help of a sound and a visual image, respectively. The computer game *Minecraft* was chosen because of its popularity, but also because it is a very promising educational tool, as house building in the game is a good way to visualize the proportional relationship. The example with *Minecraft* in presented intelligent tutor AV film is the following. With the help of cubes, we built houses of various sizes. Large cuboid is a visual picture, which is also explained orally in the film. The film is presenting a correlation between the two events that have a proportional relationship: one grows proportionally to the other. We have chosen to compare shoot arrows in *Minecraft* with "smash up" in table tennis (Figure 1 B). In both trails, one of the two competitors managed to score a half. Using this combination of the *Minecraft*, music, images and audio PD explanations turned out to be the one easiest to understand for elementary school students.

We, the first pair of the preservice teachers, have chosen the following sequential approach of presenting this example for the third-grade elementary school students. From the beginning they received an information that they would first have to listen to a sound clip, and then take part in AV film. Therefore, the students have listened to the explanatory radio-like PD first. Then they were given time to talk with their neighbors about each other’s experience and to verbalize their thoughts, to present and to listen to the arguments. Then they could hear PD with video support and again reflect around it together. This order of events has been chosen
because it can provide prospective teachers with an opportunity to examine the role the video film of whether it “helps or hurts” and if it could stand alone without the audio PD. After these exercises, students discussed the presented material with preservice teachers. Preservice teachers followed the rule, which says that when conducting field studies, it is important to remember not to put words in the mouth of the respondents with leading questions. Therefore, preservice teachers developed a set of open questions to have a discussion with the students and to observe their reaction to the AV. Preservice teachers collect the information about students’ thoughts and reflections after seeing the AV. The students were asked about what they sensed as well as what they have gotten out of the radio PD, the first discussion, watching the AV film and the second discussion among the students. Some of the questions were as follows:

- Can you tell me what you heard / saw?
- Were there anything/ any examples that you felt better about?
- Can you explain what is proportionality, double, half, etc.?

When students were prompt to explain the meaning of proportionality, it was noticeable that it was difficult for them. Students did not manage to formulate a clear understandable explanation. Students have shown that they did not feel secure in what the proportionality is if they have an access only to an audio PD file, although they said that they understood the visual AV computer game Minecraft explanations with houses and building blocks as well as with “smashing up” in table tennis. Therefore, students had shown more understanding with AV film-support. One of the respondents answered after seeing the film that now he/she has understood how "mathematics is linked to proportionality”.

In the second case, another pair of preservice teachers have chosen to make an intelligent tutor which is using proportionality and Alistair McIntosh idea of four representations [17]. This AV film was presented to the students of the first grade of an elementary school. As it is illustrated in the Figure 2, this example is dealing with a mathematical exercise describing how ten children were eating twelve muffins of two different colors at a birthday party, which is also a very familiar situation for elementary school students. The preservice teacher pair have chosen the following four representations: 1) one of the preservice teachers is singing, dancing and showing with body language the theoretical rules with proportionality (Figure 2 A); 2) the other prospective teacher explains the mathematical exercise orally and in a written form with words and numerical representations (Figure 2 B); 3) the same exercise is presented with drawn
pictures and with an audio explanation (Figure 2 C); 4) the same exercise is illustrated with manipulatives and an audio explanation (Figure 2 D).

These two preservice teachers presented their song in a simple rap-style (Figure 2 A), for which they themselves composed the music and had written the words. It was a kinesthetic explanation in which music and song were combined with dancing movements and mathematical signs of minus and multiplication were shown with gestures, explaining the meaning the terms proportionality, double and half. The sequence in which different parts of the explanation were presented in the AV film is presented in Figure 2. After watching the AV film, the students were given a possibility to discuss the film and its mathematical content with each other and then with preservice teachers. Students liked the song and asked the preservice teachers a permission to repeat and to sing this song themselves. They were of cause allowed, repeated the song and this created a positive and relaxed atmosphere at this mathematical lesson. After singing and discussing, the students got to answer some questions like the previous case (see above). At the end of the lesson the reaction of the students was very positive.
Figure 2. Four representations of a mathematical exercise with muffins. A. Singing a mathematical song in a rap-style and illustrating mathematical terminology with the body language. B. An exercise written as words and numerical representations, as well as explained orally. C. An exercise presented with drawn pictures and an oral explanation. D. The same exercise illustrated with manipulatives and an oral explanation. See details in the text.

Therefore, this preservice teachers’ pair have also seen that this *flipped classroom* style approach motivates students to study mathematics and the four representations combined with music, song and dance help students to remember and to understand the issue of proportionality.

The third case illustrates the work of two preservice teachers who had chosen to make their AV intelligent tutor for children of a kindergarten, 4-5 years old (Figure 3).
This pair of prospective teachers has made a short AV movie about a strange place where this kindergarten’s toy-pony Alice has disappeared recently. The children could see in the AV movie that in this strange place happens it that things disappear, doors open on their own, books move on the shelves, when nobody is moving them, and a glove is flying in the air. The movie has a beautiful musical background which helps to create a fairy tale atmosphere. At the end of the movie, children could hear a mathematical task, which they had to fulfil to save and get back their toy-pony Alice. They had to solve a mathematical problem of drawing a square in the kindergarten’s yard and placing by each side of the square the number of things which was two times higher than the number at the previous side. Solving of this mathematical problem will open the gate for Alice and she will be able to come back.

Initially, were children a bit scared with this story, but intrigued and curious. They watched and discussed the AV movie with their ordinary teachers and with preservice teachers. Children and teachers discussed disappearance of the pony and the mathematical problem. They discussed what kind of a measuring instrument they can use to draw the exact evenly long sides of the square. They also decided to start with placing one ball at the first side of the square, two balls at the second, four toy-buckets at the third and finally eight toy-shovels at the fourth. The sequence in which children were solving this problem is presented in Figure 3, from A to D. Children decided to use a stick-brush as a measuring instrument for equal length of the sides. It has also arisen a question among children: “What if we will also disappear as pony Alice..."
when we will finish solving the mathematical problem. The Alice will come back, but we will disappear instead. Can it be so?”. This discussion gives a good representation about the type of a questions that can bother children when they can solve the mathematical part of an exercise, but there is something else which could trigger the difficulties. The prospective teachers could insure children that they will be safe. After that the children went out and stared to work with solving their problem. They continued to discuss their solving strategies and using mathematical terminology throughout the whole process. This gives also a good illustration in which way the flipped classroom model can be modified and applied in a kindergarten setting. It illustrates how can flipped classroom model help to develop children’s’ mathematical knowledge, develop their lexicon and ability to discuss, predict and analyze the circumstances. Children received visual instructions of how their square should look like when they were outside in the kindergarten's yard (Figure 3D). Children discussed and decided themselves which instruments and manipulatives to use when they will be solving the problem, as it is shown in Figure 3, A-D. All the discussions, finding the solution and the whole process of solving the mathematical problem were performed by children in presence of their ordinary teachers and two preservice teachers. When the problem was sold, pony Alice came back.

Summary
The modified flipped classroom model was used by preservice teachers from the university course in teaching and learning elementary school mathematics. Three different cases of preservice teachers’ work with the model are presented here. They have applied this approach as a new educational tool for children of kindergarten and for first and third years of elementary school education. All three cases are using their own creative ideas of applying the model and all three ones include designing and creating an intelligent tutor as AV film. The first case includes also a radio-style PD. All presented intelligent tutors are explaining proportionality and are combining elementary mathematics with music and other esthetical representations, like dance, drawings and toy-manipulatives. In presented here cases, the preservice teachers created their intelligent tutor lessons to teach elementary school students of the first grade, third grade and kindergarten children 4-5 years old. These lessons are focused on developing students’ and children’s knowledge in mathematics, music and language. Preservice teachers evaluated whether their flipped-style lessons stimulated elementary school students’ and kindergarten children knowledge development about proportionality, and if it also stimulated students’ and preservice teachers’ intrinsic motivation for studies in mathematics. Preservice teachers analyzed elementary school students’ and kindergarten children’s responses to this
new approach, which implied that it promoted students’ joy in studies using modern technologies combined with music, mathematics and language teaching and learning.

The flipped classroom methodological approach is a new way of helping preservice elementary school teachers in developing their theoretical and practical skills in teaching mathematics, language and music and developing their professional confidence. Working creatively with AV and PD is expected to stimulate preservice teachers’ interest in teaching mathematics, music and language and leave more time to direct interaction with students in the classroom for solving mathematical problems, working with terminology and listening to students’ argumentation.

In the future, we plan to study further whether this new methodology of designing, creating and practicing with flipped classroom model, which integrates mathematics, language and music, can be also useful for prospective teachers and teachers in other universities inside and outside Sweden.

References


