Integrating HOTS activities with GeoGebra in Pre-Service Teachers’ Preparation

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**Introduction**

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A comparison of Bloom's taxonomy, Newcomb-Trefz learning model and two levels of thinking skills
C. Edwards, and G. Briers, 2000
Introduction

- High order thinking skills (HOTS) are suggested today as essential for the cognitive development of students and as preparing them for real life skills.
- Teachers are encouraged to use HOTS activities in the classroom to help their students develop higher order skills and deep thinking.
Introduction

• It is essential to prepare pre-service teachers to write and use HOTS activities for their students.

• This paper describes a model for integrating HOTS activities with GeoGebra in pre-service teachers’ preparation.
Introduction

- The paper describes the pre-service teachers' difficulties in preparing and working with HOTS activities.
- As well as their perceptions regarding the use of these activities and GeoGebra in the mathematics classroom.
- The paper also describes the contribution of a HOTS activity to pupils' learning of mathematics.
Research Participants

- The present paper describes an experiment with 12 pre-service teachers in their third year of study, who specialize in mathematics and technology teaching in the middle school.

- The participants were part of a program for students who excelled in their secondary school study. In the frame of this program, the pre-service teachers are requested to perform a special personal project in their third year of training.
Research Process

- In the academic year 2013-2014, the project involved activities that put emphasis on higher order thinking skills (HOTS).
- The pre-service teachers, collaborating with their training in-service teachers and their pedagogical supervisors, built mathematical activities that emphasized higher order thinking skills.
Research Process

- pre-service teachers taught these activities to grade 9 pupils in the frame of their practical training.
- The pre-service teachers brought their laptops to the classroom and used a mobile overhead projector to present the activities to the pupils who investigated them with GeoGebra.
Research Process

The pupils' investigation process was composed of:

- Working with GeoGebra
- Searching for mathematical relations
- Putting and verifying conjectures, and justifying them.
**Principles of the Experiment**

- HOTS activities would **support the professional development** of the pre-service mathematics teachers and prepare them to use such activities in the classroom as future mathematics teachers.

- Engaging with HOTS activities would **enhance** the pre-service teachers **as learners of mathematics** and give them **new approaches** when coming to work with mathematical problems.
Principles of the Experiment

- Working with HOTS activities, with the supervision of the pedagogical supervisors, the pre-service teachers experience being innovators, and, as a result, they are encouraged to become innovative teachers in their future work in schools.

- Technology assists students in developing higher order thinking skills.
The Preparation Process

- To carry out the preparation process of the pre-service teachers, we utilized a document of the ministry of education about using HOTS activities in the schools.
- We also introduced GeoGebra to our pre-service teachers, and encouraged them to write HOTS activities that utilizes GeoGebra, and collaborate with the training in-service teachers to carry out these activities in the mathematics classroom.
The Suggested Model

- To guarantee the assimilation of higher order thinking skills among middle school mathematics pupils, we developed a model for integrating HOTS activities with GeoGebra in pre-service teachers’ preparation.
The Suggested Model

This model describes four aspects of HOTS activities and working with them:

- Activity components
- Preparation procedure
- Strategies and processes used in writing a HOTS activity
- Types of the HOTS activities
The Suggested Model

The Activity Components:

- Description of the activity
- Pedagogical instructions for the teacher
- Technical description of the GeoGebra applet
- Link to the GeoGebra applet in the GeoGebra Tube

- A table that categorizes the questions according to the various higher order cognitive skills
- Description of expected pupils' answers
- Instructions to the teacher of possible responses and actions

A worksheet detailing the questions of the activity
The Suggested Model

The Preparation Procedure:

- Write a HOTS activity
- Reflect on it
- Rewrite it
- Implement it in the classroom
- Reflect on the implementation
- Rewrite the activity
The Suggested Model

Strategies and Processes:

- Investigating & Exploring
- Constructing a Concept
- Discussing
- Analyzing
- Planning
- Taking Decisions
- Problem Solving

- categorizing
- identifying components and relations
- conjecturing
- raising different points of view
- pupils asking questions
- comparing
- concluding
- combining
- using different representations
- claiming
- reasoning and evaluating
The Suggested Model

Types of the HOTS Activities:

The HOTS activities are basically of two types, depending on the used strategy:

- **Explorative activity** that can be performed with technology (GG), where the teacher can investigate with the pupils mathematical concepts or relations.

- **Constructive activity** where the teacher constructs with a technology (GG) mathematical concepts or develops mathematical objects.
Assessment

To study the process of the pre-service teachers’ training, as well as their experience to prepare and teach HOTS mathematical activity, we interviewed the pre-service teachers twice in the academic year (at the end of the first semester and at the end of the practical training year), asking them about the experiment.
Assessment

The interviews included questions about:

- The activity *writing* process
- The teaching process
- The pre-service teachers’ perceptions of HOTS
- The pre-service teachers’ perceptions of GeoGebra as a helping technological tool to perform HOTS activities
Assessment

The activity writing process:

- The pre-service teachers emphasized the importance and benefits of the ministry of education document about HOTS.
- The pre-service teachers reported that they consulted the pedagogical supervisors regarding the correctness, adequacy and appropriateness of the questions, and as a result improved the questions.
Assessment

The teaching process:

- Began with following the prepared worksheet questions’ text verbally
- It advanced to follow the text more freely according to the advancement of the mathematical investigation and discussion with the pupils
- Afterwards to instinctively improvise additional questions that fitted the mathematical situation and discussion.
Assessment

Perceptions of HOTS:

- The pre-service teachers perceived HOTS activities as contributing to teaching and learning mathematics and
- Improving teachers’ own thinking.
Assessment

Perceptions of HOTS:

- They described teaching with HOTS activities as encouraging pupils' creativity
- Giving them freedom of thinking and behaving
- Improving their thinking
- Helping pupils internalize the mathematical concepts and relations
- Helping them connect between different mathematical concepts and
- Inquiring about alternative ways of solution.
Assessment

Perceptions of HOTS:

- They claimed that the actual practice of writing HOTS activities following the suggested model, including all the activity components; especially the categorization of the questions according to the HOTS, resulted in their professional development.
Assessment

Perceptions of HOTS:

- This professional development included improvement in their content knowledge as well as technological pedagogic content knowledge (TPACK).
Assessment

Perceptions of GeoGebra as a helping technological tool to perform HOTS activities:

- The pre-service teachers perceived GeoGebra as a helping technological tool to develop and perform HOTS activities.
- Especially when raising conjectures and verifying their correctness, and performing the thinking processes involved in HOTS.
Assessment

Perceptions of GeoGebra as a helping technological tool to perform HOTS activities:

- The pre-service teachers perceived GeoGebra as an illustrative dynamic interactive tool that supports them in discovering, with their pupils, the mathematical relations because of manipulating the mathematical objects, which also supported them in applying successfully the strategies and processes that they used in the HOTS activities.
Assessment

To describe the contribution of HOTS activities to pupils' learning of mathematics, we videoed the performance of a HOTS activity, where this activity was prepared and taught by one pre-service teacher.

Analyzing this performance, we noticed that pupils' mathematical behavior included the following learning processes when carrying out the HOTS activities with GeoGebra:
Assessment

- Manipulating mathematical objects

- making conjectures and verifying them through the use of the measurement tools in GeoGebra

- using GeoGebra geometrical tools to extend the mathematical situation when answering ‘what if not’ questions

- Using the illustration and dynamic tools in GeoGebra to discuss mathematical relations and giving various correct answers to open questions
Conclusions

- **GeoGebra** was practiced and conceived by our pre-service teachers as a tool that helps pupils perform the processes that **HOTS activities** are involved with, especially:
Conclusions

- Asking questions
- Conjecturing
- Using different representations
- Claiming
- Reasoning
- Raising different points of view
- Identifying relations

These processes are in the heart of doing mathematics
Conclusions

- Participating in writing and teaching HOTS activities with GeoGebra improved pre-service teachers’ different types of knowledge, especially their technological pedagogical content knowledge (TPACK).

This improvement is one of the main targets of teacher training colleges for preparing pre-service teachers towards the twenty-first century skills.
Conclusions

- Participating in writing and teaching HOTS activities with GeoGebra, the pre-service teachers are encouraged to be:

  Innovative teachers, who try new methods in their teaching, without the fear of working with new ideas and implementing them in the classroom
Thank you for your attention

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