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Formation of Thinking and Scientific Language in the Primary Classes

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Abstract.

Purpose: This study examines the preferences of elementary school students in using inductive considerations when given arithmetic claims, and when they review inductive reasoning as a mathematical proof to an arithmetic claim, as well as teachers' attitudes toward types of reasoning.

Methodology: A survey in which participated 267 pupils from the Arabic sector in three different elementary schools in Israel, in grades 4 to 6. The survey, based on the math reasoning tasks by Healy and Hoils (1998), is comprised of Algebra and Geometry reasoning tasks. Alongside the task, a semi-constructed interview was administered to 12 math teachers in these schools.

Results: The study findings support the research hypotheses that (a) There will be a difference in the students' preferences towards the types of thinking, between grades 4 and 6; (b) Sixth graders will be less likely to accept tautologic and inductive reasoning than fourth graders; (c) Elementary school pupils tend to prefer empirical arguments (such as inductive and example) as their approach rather than the arguments that they believe will receive the highest scores from their teachers. However, findings do not support the hypothesis that there will be a difference in teachers' preferences towards different types of thinking. The research findings and their practical implications are discussed together with recommendations for teachers and educators in the field of mathematics and teacher training.

Introduction

While studying mathematics at school, pupils are often required to formulate and test assumptions, to explain and justify conclusions and to prove general theorem or claims. The proof is the mathematical tool through which, by argumentation, the correctness of a mathematical claim is established and given universal validation, or the opposite confirming that the claim is false thus refuting it (Hanna, 1989).

An argumentation, the building block of the proof, is a daily act that is naturally faced in everyday life. For example, we know how to explain why we chose to learn a certain subject, why to close the door when going out, and why we buy at a certain shop and so on. A claim is a series of hypothesis (namely, information from which we can make conclusions), along with a conclusion that we can make in one or more deduction procedures. An argumentation comes in order to persuade ourselves and others about the correctness of a hypothesis.

An argument consists of a claim and a conclusion. A claim is a statement that the addresser asks the recipient to accept as a truth or a modus operandi, and the addresser must prove it (Toulmin, 1969). Claims refer to the discursive methods of science and include the expression and justification of the claims, observation in opposite attitudes and evidences, and the social negotiation about data and theories (Sadler & Fowler, 2006). The text of the claim is bound to lead to a conclusion, and therefore presents assumptions that lead to it (Antaki, 1994, p. 140). This text differs from the expository text, because it presents facts and ideas - interprets historical events and explains social phenomena (Makar, Bakker & Ben-Zvi, 2015).

The argument structure represents a variety of ways (Makar, Bakker & Ben-Zvi, 2015). According to the logical structure of the thinking processes, the argument helps the claimant to present his words logically: to express his opinion, to prove it, and sometimes even to end it with a solution proposal. Moreover, a high level of argument expresses a high level of literacy (Glassner & Schwartz, 2001). Students in the elementary schools apply external justification methods, empiric techniques of justification and an analytic justification technique (Flores, 2002).

A few definitions

At this point a few definitions are required:

A Claim is an assertion with arguable justification, correctness, verity or validation. A claim might be determining attitude, opinion, certain decision, assumption, conclusion, command, theory or certain solution for a problem (Neuman, Glassner & Weinstock, 2004).

Reasoning is an assertion brought to support and establish a claim. For example, **A reasoning of the kind "evidence"** answers the question: "how do I know that the claim is true?" whereas **a reasoning of the kind "explanation"** answers the question: "what are the factors, justification or reasons for the claim?" (Glassner & Schwartz, 2001).

Simple argumentation is an assertion composed from a claim and the reasoning that supports it (Toulmin, 1969).

Wide argumentation is an argumentation that contains two discrete argumentations or more contradicting one another (Toulmin, 1969).

Reserved or conditioned argumentation is an argumentation that its claim is reserved or conditioned (for example, "this theory is correct only if condition A is met") (Toulmin, 1969).

Developing critical thinking

One of the elementary school's curriculum goals is to foster critical thinking skills in students. Critical thinking is a balanced reflective thinking focused on the decision what to believe and how to operate. The argumentation is usually involved with identifying relevant conclusions and hypothesis of a given problem. Moreover, very often it involves identifying conflicts and consequently, the need observe advantages and disadvantages of certain conclusions (Flores, 2002).

Developing critical thinking skills is a condition for consuming information and significant processing of it that enables implementing the knowledge. Argumentation skills are part of the critical thinking skills set and constitute preliminary and essential background for activating a process of decision making. Young students can develop mathematical claims of high potential to be called proofs in elementary grades (Stylianides, 2007b). Each time they are asked to reason, explain, validate, claims and make conclusions, we are fostering and optimizing their thinking abilities. Unfortunately, many times, students' replies to these questions are poor due to a variety of reasons. Some of which originate from the development process of verbal and lingual skills and others stem from cognitive and intellectual development processes that are age dependent.

Nevertheless, the more we empower this essential skill among students, the better we provide them with tools for coping with innovative information and for understanding new data technology which are abundant in our society. The involvement and experience in proving methods can also empower elementary students to probe mathematical assumptions, thus providing them with a strong base for conceptual understanding (Stylianides & Ball, 2008).

Furthermore, the argumentation activities require both criticism and independence, thus learning while applying different skills leads to significant learning. Argumentation activities engage the learner, channel the teacher's desires with the learner's desire (and vice versa), expose the goals of learning and enable them to be understood.

In my opinion as a teacher for several years in elementary schools in Israel, resources need to be invested in developing teacher's ability and a systematic ongoing approach for teaching that uses proofs in the elementary school. I think that this approach must include support for pupils in order to examine the available declaration definitions, and try to prove and refute assumptions in the classroom by using legal and appropriate claim means and representation of claims in a correct way in accordance with their knowledge level in the elementary school. Furthermore, teachers' educators must encourage them to focus on different characteristics of thinking ways that encourage pupils to evaluate and use correct and proper terms, in order to train their pupils for the examination (to prove/refute) of a certain claim correctly.

In addition, it is very important to inform teachers of pupils' inductive tendency and their reliance on examples when asked to prove or give reasoning to a claim. According to this, it is very important for teachers to develop more generic as well as visual examples that will suit the thinking and cognition capacities of pupils in elementary school. These teaching methods will serve as the basis in more advanced grades later on for deductive proofs, and for relations between different proofs that were provided for the same assumption.

In my opinion, seminars and collages for teachers' training, as well as new teachers' educators must be aware of the challenges facing teachers in the subject of mathematical proofs. They need to assume the main role in assisting teachers to develop an ability to evaluate different kinds of thinking among pupils in order to develop appropriate tools to learn this important subject already in the elementary school. An emphasis must be put as well, on pupils' false perceptions concerning this subject and how to fix these false perceptions.

Conclusion

The importance of this study is in examining the inductive tendency of elementary school pupils in the Arab sector in Israel, in an effort to shed light on the developmental process of argumentation and reasoning in these ages. This research differs from prior researches in two aspects: the first is the student's population age. This paper will include elementary school pupils in grades 4-6, whereas most researches in Israel included only high-school students. Second, it will examine students in the Arab sector exclusively, which were not included in prior researches. It is expected that this research's findings will contribute to teachers' training as well as the formulation of teaching methods and materials, in light of new information regarding the thought process of proof and reasoning.

Summary

Introduction. Mathematical studies as early as elementary school require students to validate assumptions, general theorem or claims, by means of proving or refuting them through a series of arguments. While these tasks demand a high level of literacy, argumentation and logic, elementary school students most frequently use deductive and empirical reasoning when asked to prove or refute a claim. This gap between potential and practice originates from age dependent development process of verbal and lingual skills as well as cognitive and intellectual development processes.

Rational. The purpose of this study is to examine the inductive tendency of elementary school pupils in the Arab sector in Israel, in an effort to shed light on the developmental process of argumentation and reasoning in these ages. According to the research literature in the field, the study's hypotheses are that there will be a difference between the preferences of fourth and sixth graders when they are required to explain mathematical arguments, so that the younger students are based on empirical arguments and examples. We also hypothesized that there would be a fundamental difference in the arguments they provided and the consistency of their thinking.

This research adds to prior studies by including elementary school pupils in grades 4-6, while most prior studies in Israel included only high-school students. In addition, this study examines only students in the Arabic sector, which were not included in prior researches. In order to provide a comprehensive account on the issue, the study also included a qualitative analysis of teachers' attitudes and perceptions about the abilities and preferences of elementary school students when they are required to prove mathematical and geometric claims. This study's findings contribute to teacher-training as well as the formulation of teaching methods and materials.

Methodology. This research is comprised of two studies conducted in three different elementary schools in the Arabic sector in Israel. The first is a quantitative study, based on the math reasoning tasks by Healy and Hoils (1998), in which 267 in grades 4 to 6 participated. The pupils were asked to perform algebra and geometry reasoning tasks of explaining and proving mathematical claims. The second study was qualitative study, based on a semi-constructed interview which was administered to 12 math teachers of the participants of the first study.

The analysis of the quantitative data in Study 1 was carried out using the Kai-square test, while the information collected through the semi-structured interviews in Study 2 was analyzed using qualitative methods of textual analysis. Study 3 contains further statistical analysis designed to test the validity of a scheme that describes the evolution of thinking.

Results. The study findings support the research hypotheses that (a) There will be a difference in the students' preferences towards the types of thinking, between grades 4, 5 and 6; (b) Sixth graders will be less likely to accept tautologic and inductive reasoning than fourth graders; (c) Elementary school pupils tended to prefer empirical arguments (such as inductive and example) as their approach rather than the arguments that they believe will receive the highest scores from their teachers. However, findings do not support the hypothesis that there will be a difference in teachers' preferences towards different types of thinking.

The qualitative findings suggest that teachers are aware of their student's difficulties in performing mathematical reasoning tasks. The research findings and their practical implications are discussed together with recommendations for teachers and educators in the field of mathematics and teacher training. In order to improve the teaching of mathematical critical thinking and logic, it is necessary to adapt the teaching methods in elementary school curriculum and in the training of teachers so that they become aware of the developmental, cognitive and linguistic process that underlies the development of the skills to prove and refute claims.

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