Athens Institute for Education and Research
ATINER

ATINER's Conference Paper Series
MAT2013-0474

Development of Logical Think among Students

Gohar Marikyan, PhD
Associate Professor/Mentor
State University of New York Empire State College
USA

Athens Institute for Education and Research
8 Valaoritou Street, Kolonaki, 10671 Athens, Greece
Tel: + 30 210 3634210 Fax: + 30 210 3634209
Email: info@atiner.gr URL: www.atiner.gr
URL Conference Papers Series: www.atiner.gr/papers.htm

Printed in Athens, Greece by the Athens Institute for Education and Research.

ISSN **2241-2891**
31/07/2013

An Introduction to ATINER's Conference Paper Series

ATINER started to publish this conference papers series in 2012. It includes only the papers submitted for publication after they were presented at one of the conferences organized by our Institute every year. The papers published in the series have not been refereed and are published as they were submitted by the author. The series serves two purposes. First, we want to disseminate the information as fast as possible. Second, by doing so, the authors can receive comments useful to revise their papers before they are considered for publication in one of ATINER's books, following our standard procedures of a blind review.

Dr. Gregory T. Papanikos
President
Athens Institute for Education and Research

This paper should be cited as follows:

Marikyan, G. (2013) "**Development of Logical Think among Students**" Athens: ATINER'S Conference Paper Series, No: MAT2013-0474.

Development of Logical Think among Students

Gohar Marikyan, PhD
Associate Professor/Mentor
State University of New York Empire State College
USA

Abstract

I teach a vast range of courses in mathematics, computer science and interdisciplinary courses to a diverse student population in one-on-one, blended, online, and in-group modalities. As a math logician I appreciate the process of logical thinking and reasoning. That is why for all of my courses I develop methodology to nurture analytical thinking and problem solving skills. My main research topic is in mathematical logic. I also conduct research in the art of teaching mathematics. My third closely related research topic is the historical roots of teaching mathematics. My research in math education led me to identifying the cause-and-effect of math anxiety among students. How can I use my knowledge in mathematical logic to address this issue? What can we learn from the history of math education that can be used in the contemporary diverse classroom? Is there any connection between teaching mathematics and development of computer science? Can we incorporate all these in our teaching? How to devise strategies for development of analytical thinking through teaching mathematics? Finally, how to foster student learning of higher level mathematics?

Keywords: Mathematics education, teaching mathematics, development of analytical thinking, math anxiety, teaching strategies, learning higher level mathematics, new trends and experiences, student learning assessment.

Corresponding Author: Gohar Marikyan, Ph.D., Associate Professor, Empire State College State University of New York, Gohar.Marikyan@esc.edu, www.GoharMarikyan.com.

Main Aspects to Learning Mathematics

There are two main aspects to learning mathematics: problem solving, and development of analytical thinking. These two aspects run parallel in the process of learning, contributing to each other. The second aspect, the development of analytical thinking is more important than the first one. Without analytical thinking capabilities problem solving becomes weaker when advancing to more complex topics of mathematics. Often the second aspect is missing in the way mathematics is being taught. I have observed among my students that they have learned mathematics mainly through memorization. Learning mathematics through understanding develops analytical thinking skill. The earlier a person starts learning mathematics, the earlier the person develops logical thinking skills, a useful skill not only for learning mathematics, but also for learning other subjects, for any career and for life.

From the above we conclude that it is imperative to nurture analytical thinking skills among our students.

Contributing Expertise for Devising a Methodology to Nurture Analytical Thinking and Problem Solving Skills

Let us discuss the following expertises that contribute to the development of a methodology to help students learn mathematics more effectively and to gain life long lasting knowledge:

- Diversity of courses taught,
- Diversity of student population,
- Diversity of teaching modalities,
- Good knowledge of the subject matter.

Through teaching various courses the instructor gets exposed to different courses. This develops better knowledge of mathematics and helps to connect the topics of various math courses. Connecting different topics helps the instructor to present each topic in various more interesting and more effective ways, connecting the current topic with previously covered topics.

Teaching in a classroom with student population of wide age range, diverse backgrounds, races, ethnicity, and knowledge level is challenging, but also a thought-provoking experience. It is challenging because they had studied mathematics in different ways, their comprehension level varies and there is a large spectrum in the processes of reasoning. All these, and especially the last one, make this experience interesting, and help to master teaching skills.

Teaching modalities, such as classroom lecturing, study group discussions, one-on-one instructions, online, and blended teaching make the instructor a more skillful and rounded teacher.

Good knowledge of the subject matter helps the teacher to easily identify students' weaknesses and existing gaps in their knowledge. It also helps the instructor to be flexible in presenting the topic in various ways to strengthen the weaknesses and to cover the knowledge gaps.

An instructor gains more skills and good knowledge through teaching various courses to a diverse student population in different teaching modalities. All these contribute to becoming a well-rounded mathematics teacher, and in devising individual strategies to develop analytical thinking skills among students.

Observations

Let us discuss a few observations that need to be considered in developing a methodology to nurture analytical thinking skills among our students.

In New York State all bachelor's degree students are required to have credits in mathematics. Therefore, often students study mathematics unwillingly. In my observation 55% of our students unnecessarily suffer from math anxiety[1]. The existence of math anxiety among our students makes mathematics classes less desirable. I also teach computer and business related classes. In my observation students are usually interested in those subjects, and are more prepared to study the material. Subsequently, students are more hesitant to participate in mathematics classes than in computer or business related classes. Therefore, it requires more effort to engage students in mathematics classes than in classes they are more interested and often have sufficient knowledge to conduct their learning.

Students' reasoning processes and learning styles vary depending on their ethnic background and age. In some cultures mathematics is being taught through emphasizing its philosophical aspects. These students usually seek philosophy it each topic, and problem solving is a secondary task. In other cultures students are taught to solve problems using the steps provided in the textbook. The only necessary skill is to identify which numbers should be used for each step. This process is similar to old computing when computers would follow a sequence of instructions (written in a programming language) to solve a particular problem[2]. Another example is learning mathematics through understanding. In this case students comprehend concepts of mathematics and they learn topics through understanding, vs. memorization. This develops reasoning skills, and problem solving for these students usually is to put to use their logic thinking and reasoning skills. This method of problem solving is parallel to the historic development of computer science that has traveled from algorithmic programming to artificial intelligence[3].

Students' learning styles and their level of comprehension vary depending on teaching modalities.

---

[1] Marikyan, G. (2009). 'Notes on Math Anxiety Among Students: Cause-and-Effect, Pro-and-Con.' *The International Journal of Learning* 16: p. 213.

[2] Marikyan, G., (2011). 'Notes on Mathematical Model of Decision-Making Process.' *Revisiting Boyer* 1: p. 76.

[3] Marikyan, G., (2011). 'Notes on Mathematical Model of Decision-Making Process.' *Revisiting Boyer* 1: p. 77.

In classroom lecturing students follow the reasoning presented in the lecture. The questions students usually ask are mainly addressed to clarify some part of a lecture. This is passive learning.

In online teaching students use computer in their learning process, and computer becomes the main teaching tool. The level of comprehension heavily depends on the technology used in teaching, on set up tasks in modules, and on the structure of the course.

In one-on-one instructions students have the opportunity to get answers to their questions accumulated between the sessions. The level of comprehension heavily depends on students' self-studying skills.

In study group discussions students have the opportunity to get answers to their questions immediately, to discuss the topic with their classmates, and to follow other students' reasoning processes. This group learning fosters a higher level of comprehension.

In blended modality students have the opportunity to use computer to assist them in the learning process. In this case technology becomes an additional tool when the instructor is not available. Its effectiveness mainly depends on how they are integrated into the teaching and learning processes.

Sources for Developing the Methodology

Valuable sources for structuring a methodology to develop logical thinking skills are:

- Mathematical logic,
- Historical roots of teaching mathematics,
- Observation of reasoning processes,
- Research on math education.

How to nurture analytical thinking and problem solving skills using mathematical logic, historical roots of teaching mathematics, observations of reasoning processes, and through research on math education?

Using Mathematical Logic

From Mathematical Logic we understand that mathematics is an abstract subject[1]. Therefore, for better learning of mathematics abstract thinking skills are essential. Although mathematics can be applied to solve problems in natural sciences, in social sciences, in business, in life, etc., applications of mathematical topics should not be used in explanation of mathematical concepts. This will develop students' abstract thinking. After full comprehension of the concept students can be instructed about the ways the topic can be used to solve real life problems.

How to use Mathematical Logic in structuring a teaching methodology?

---

[1] Kleene, S. C. (1971). *Introduction to Metamathematics. Vol 1.* Wolters-Noordhoff Publishing and Noth-Holland Publishing Company, p. 25.

From Mathematical Logic we learn that to set up a formal system means to define the following parts of the formal system. This is an inductive definition of a formal system.

1. The list of formal symbols.
2. Formal expressions that are constructed of finite sequences of formal symbols.
3. Terms and formulas built up from 0 and variables by application of defined steps.
4. Axioms or postulates.
5. The set of formally provable formulas or formal theorems[1].

Mathematics is a formal system. Therefore, the above shown inductive steps of defining mathematics should be used to teach mathematics. That is, following the same steps in teaching will enforce the learning of mathematics and will develop students' mathematical thinking.

The list of formal symbols of mathematics is similar to the alphabet of a language. Therefore, full comprehension of all symbols of mathematics is required for learning mathematics. Parenthesis and variables are formal symbols. In my observations some students have problems with these symbols. They have not learned the importance of parenthesis and its proper use. Also, students struggle to fully comprehend the notion of variables. Not understanding the notion of variables is an evidence of weak abstract thinking skills.

The next step is to understand how to build formal expressions. Students who do not understand the notion of variables and struggle with proper use of parenthesis will have problems in constructing expressions. Difficulties with variables and expressions make challenging understanding of terms and how to work with formulas. This entails difficulties with problem solving. Axioms and theorems are missing in the textbooks of introductory mathematics courses, and are not being taught at all.

Learning from Anania Shirakatsi

Mathematics, as a science, is one of the pillars of civilization. Mathematics, most probably, started with prehistoric man just as soon as he could think. When it comes to teaching mathematics every nation, or even groups of people, have their own unique method that has been developed through their own history. One such nation is Armenia and one particular person in the history of that nation is Anania Shirakatsi, a 7th century Armenian mathematician and scientist. His manuscript *Tvabanutiun* (Arithmetic) is the world's oldest extant manuscript on teaching arithmetic.[2] In his manuscript Shirakatsi describes methods he had developed and used in teaching arithmetic to first grade children. I find him to be fascinating because the man, in fact, has a genius

[1] Kleene, S. C. (1971). *Introduction to Metamathematics. Vol 1.* Wolters-Noordhoff Publishing and Noth-Holland Publishing Company, pp. 69-85.
[2] Hewsen, R. H., (Spring, 1968). 'Science in Seventh-Century Armenia: Ananias of Širak.' *Isis, The University of Chicago Press* 59(1), p. 42

approach to teaching mathematics to children[1]. After reviewing a number of elementary arithmetic textbooks I find Anania Shirakatsi's teaching methodology more effective than those described in the textbooks. I am of the opinion that Anania Shirakatsi's methodology can be as effective in the contemporary diverse classroom as it has been since the 7th century.[2]

I have used my research done on teaching methodology of Anania Shirakatsi, an Armenian 7th century mathematician, to develope a teaching methodology that uses the construction steps of the formalization of number theory. After detecting the week loops in student learning I address them in my teaching by emphasizing their importance and discussing the common mistakes students do. My methodology allows students to strengthen their analytical thinking and reasoning skills without making them spend long hours on repetitious practice. In my opinion students learn through understanding not by rote.

I continue my research on Anania Shirakatsi's teaching methodology. There is always more to learn from the history.

Bibliography

Kleene, S. C. (1971). *Introduction to Metamathematics. Vol 1.* Wolters-Noordhoff Publishing and Noth-Holland Publishing Company.

Hewsen, R. H., (Spring, 1968). 'Science in Seventh-Century Armenia: Ananias of Širak.' *Isis, The University of Chicago Press* 59(1): 32-45.

Marikyan, G. (2011). *Anania Shirakatsi's Tvabanutiun: World's Oldest Manuscript On Arithmetic, Part 1: Addition*, New York.

Marikyan, G., (2011). 'Notes on Mathematical Model of Decision-Making Process.' *Revisiting Boyer* 1: 75-78.

Marikyan, G. (2009). 'Notes on Math Anxiety Among Students: Cause-and-Effect, Pro-and-Con.' *The International Journal of Learning* 16: 211-221.

[1] Marikyan, G. (2011). *Anania Shirakatsi's Tvabanutiun: World's Oldest Manuscript On Arithmetic, Part 1: Addition*, New York, p. 27-36.

[2] Marikyan, G. (2011). *Anania Shirakatsi's Tvabanutiun: World's Oldest Manuscript On Arithmetic, Part 1: Addition*, New York, p. 28