Editors

Dian Kurniati

Rafiantika Megahnia Prihandini

University of Jember
Mathematics Education
Jl. Kalimantan No. 37 Sumbersari
Jember, 68121
Indonesia

Email: dian.kurniati@unej.ac.id
rafiantikap.fkip@unej.ac.id

Ridho Alfarisi

Universitas Airlangga
Mathematics
Jl. Mulyorejo
Surabaya, 60114
Indonesia

University of Jember
Primary School
Jl. Kalimantan No 37
Jember, 68121
Indonesia

Email: alfarisi.fkip@unej.ac.id

Student's Open-Mindedness Behavior In Solving Math-Based Problem With Contradictory Information And Problem With No Specified Universal Set

Arik Hariati[1, a], Didik Sugeng Pambudi[1], Dian Kurniati[1],
Dimas Danar Septiadi[2], Hari Gantiyani[1]

[1]*Department of Mathematics Education, University of Jember, Jl. Kalimantan No. 37 Jember, Indonesia*
[2]*Study Program of Islamic Primary School Teacher Education, IAIN Madura, Jl. Raya Panglegur Km. 4 Pamekasan, Indonesia*

[a] *Corresponding author: arikhariati01@gmail.com,*

Abstract. The purpose of this research is to describe students' open-mindedness behavior in solving math-based Problems With Contradictory Information (PWCI) and Problems with No Specified Universal Set (PWNSUS). This qualitative descriptive study uses the steps of (1) giving math-based questions Problems With Contradictory Information (PWCI) and Problems with No Specified Universal Set (PWNSUS) to three groups, each group consisting of 3 students, (2) direct observation by noting and recording research subjects when solving problems, (3) describing students' open-mindedness behavior based on video recordings and direct notes during research along with the subject's answer sheets, (4) triangulating with interviews, and (5) concluded the students' open-mindedness behavior in solving problems. The results of this study are Open-mindedness behavior of students when completing about math-based *problems with Contradictory Informat* and *Problem with no specified universal set* that is, some students conduct discussions with other friends to determine the right conclusions, accept logical arguments and evidence from friends so that they can think again in the completion process. Meanwhile, they also confirmed to the mathematics teacher for the answers to the conclusions they had discussed together However, on the other some of them haven't behaved yet Open-mindedness. They worked on the questions individually, did not discuss with other friends, and did not conformm with the mathematics teacher even though they felt confused when working on the questions. They choose silence with the answers they have written.

INTRODUCTION

Disposition is a person's habit of thinking or attitude when facing a problem (Lai, 2011) [1]. Facione (2000) defines the tendency to think critically as a consistent internal motivation to act critically on an event or environment[2]. In this case, people with a tendency to think critically are always based on critical thinking when taking action (As'ari, Mahmudi, & Nuerlaelah, 2017)[3]. Before taking certain actions, people can think critically and tend to consider everything related to the action to be taken. Critical thinking is one of the abilities that must be possessed and developed by both students and teachers. This is based on the goals of education in the 21st century, which explains that four abilities must be developed, namely creative thinking, critical thinking, communication and collaboration, which are commonly referred to as 4Cs. According to Facion, Sánchez, Facione, & Gainen (1995), there are 7 (seven) scales on the CCTDI (California Critical Thinking Tendency Scale) tool to determine a person's critical thinking tendencies (1) truth-seeking, (2) open-mindedness, (3) analyticity, (4) systematicity, (5) self-confidence, (6) inquisitiveness and (7) cognitive maturity[4].

But in reality the disposition of critical thinking is still very low. This happens both among students and students. The truth-seeking and open-mindedness components are still very low for students in mathematics (Akgun & Duruk, 2016; As 'ari, Mahmudi, & Nuerlaelah, 2017; Biber et al., 2013; Facione et al., 1995; Lampert, 2007) [5][[3][6][4].

Among students, both at the junior high, high school, and vocational level, critical thinking behavior is still very low. This can be seen when they work on the ANBK (Computer-Based National Assessment) simulation questions, especially on math problems. Mathematics problems in the ANBK (Computer-Based National Assessment) simulation are non-routine questions. In working on the ANBK (Computer-Based National Assessment) questions, students look very confused and work on questions with original answers. This happens because in learning students are rarely given non-routine questions to foster student thinking. Therefore, it is necessary to make an effort to familiarize students with critical thinking dispositions, especially open-mindedness.

Open-mindedness is a person's tendency to allow others to express their opinions that others may not agree with(Insight Assessment, 2017)[7]. *Open-mindedness* is a tendency to allow differing views. This open-minded person tends to listen carefully to other opinions that may not be in line with his current thinking. He always tries to understand the rationale used in expressing his opinion. As long as the different opinions can be justified, he will gladly accept it. He does not force others to follow the thoughts he builds. He is receptive and tolerant of other people's different opinions. The familiarize a person's critical thinking disposition, it is necessary to conduct a search related to his behavioral tendencies (Ajzen, 1991a; Arsal, 2017)[8][9] and the factors that cause low critical thinking disposition (Akınoğlu & Karsantık, 2016; Facione, 2000)[10][2].

One of the math problems that can train students' critical thinking, especially on the indicator o*pen-mindedness* is math-based questions *problems with Contradictory Information* and *problem with no specified universal set. problems with Contradictory Information*oru PWCI is a math problem or problem that contains conflicting information. Problems like this arise because the question maker may not be careful, make a typo, or just miscalculate it. Problems like this can be considered as problems with false premises. Skeptic students usually realize if there are irregularities in the questions and will check the correctness of the information provided before they believe the information (Primiero, Raimonde, Bottone, & Tagliabue, 2017)[11].

Meanwhile, a problem with no specified universal set or abbreviated as PWNSUS is an algebraic problem or problem (a problem containing variables) but the universe of discussion of the variables is not defined with certainty. PWNSUS is one of the divergent questions that can see students' understanding in transferring knowledge because the answers to questions require analysis, synthesis, or evaluation using the knowledge they have (Bulent et al, 2016)[12]. The custom so far, if the universe of speech is not written down explicitly, the universe of speech is defined as the set of all real numbers. Problem with no specified universal set is a good form of a question because questions like this can stimulate students' thinking and responses (Lewis, 2007)[13].

The purpose of this study is to classify the critical thinking disposition of prospective mathematics teachers, especially for the truth-seeking and open-mindedness components in solving non-routine questions. The non-routine questions in question are math-based questions *problems with Contradictory Information* and *problem with no specified universal set*. Furthermore, the formulation of the problem in this study is (1) how is the behavior of *Open-mindedness* students in solving problems math-based *problems with Contradictory Informat*and *problem with no specified universal set.*?

METHOD

This research is a qualitative descriptive study, which describes the open-mindedness behavior of students when solving problems math based *problems with Contradictory Informat*and *problem with no specified universal set*. This is following with the statement that the purpose of qualitative descriptive research is to describe, combine, analyze, and interpret a situation from an individual, institution, and group(Akınoğlu & Karsantık, 2016)[10].

The subjects in this study were ten (10) eleventh-grade students at SMK Ainul Yaqin. The ten subjects were chosen because (1) they had studied the material of spatial structure and matrices, (2) had fluent and good communication skills when doing think-aloud based on the recordings, and (3) were willing to be used as research subjects.

There are five stages in this research. First, the provision of non-routine questions (mathematical questions based on *problems with Contradictory Informat*and *Problem with no specified universal set*). The first question is a based on math problem *with Contradictory* and question number two is a math-based problem with no specified universal set. The questions are as follows:

1. Determine the volume of the lantern in the form of a combination of cones and spherical hemispheres, if the length of the lantern is 28 cm, the diameter is 14 cm and the cone painter's line is 25 cm as shown in the following figure 1 below:
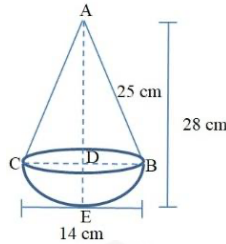
FIGURE 1. Lantern

In question number one, there are steps to solving the problem with the aim that students are aware or not that the questions presented are questions that contain conflicting information. The steps are as follows:

1) Read the following questions and think about how you plan to solve them. "Determine the volume of the lantern in the form of a combination of a cone and a half-sphere, if the length of the lantern is 28 cm, the diameter is 14 cm and the cone painter's line is 25 cm as shown in the following picture.
2) Specify length BD, DE, and AD using the properties of the diameter, radius, and the Pythagorean theorem on the triangle ADB.
3) Count the length AE by adding the length AD and the length of DE.
4) Compare length AE with long Existing AE on picture.
5) Take a decision about whether or not to measure the volume of the lantern above.

2. Determine the values of x and y, given the following matrix equation:

$$[2\ x\ 4\ 5] + [7\ -9\ y\ 13] = [9\ -5\ 2\ 18]$$

In question number two there are steps for solving the problem with the aim that students are aware or not that the problem presented is a problem whose solution depends on the universe of conversation that has been determined in the problem. The steps are as follows:

1) Read sthe following questions and think about how you plan to solve them.
2) Specify the value of x and y if the universe is the set of real numbers.
3) Specify the value of x and y if the universe is the set of rational numbers.
4) Specify the value of x and y if the universe is the set of integers.
5) Specify the value of x and y if the universe is the set of natural numbers.
6) Specify the value of x and y if the universe is the set of prime numbers.
7) Write down your conclusions in determining the values of x and y

The second stage is a direct observation by noting and recording research subjects when solving problems. Researcher recorded directly each subject and also by recording directly every activity of research subjects when solving non-routine questions based on observation sheets to classify open-mindedness tendencies. The third stage, analyzing the two components of the critical thinking disposition that emerged on each research subject based on the results of direct observations and video recordings. The results of the analysis are in the form of conclusions about the behavior of the research subject, namely whether the subject is open-minded or not. The fourth stage, triangulated the data to confirm the results analysis, namely by conducting in-depth interviews (indept interviews). interview guidelinesused is a structured and open format. Meanwhile to interviews, data reduction is also carried out which is not needed after in-depth interviews are carried out. The last stage is concluding the results of the analysis of the two components of students' thinking dispositions based on the results of observations, video recordings, and interviews so that data on the classification of open-mindedness of prospective mathematics teachers can be obtained when solving non-routine questions.

The open-minded indicators used in this study are:

TABLE 1. Indicator of Open-mindedness in Solving Non-routine Problems

About math based *problems with Contradictory Informat*	About math based *problem with no specified universal set*
1. Discuss with other friends who have the same or different answers and decide on the right answer	1. Discuss with other friends who have the same or different answers and decide on the right answer 2. Accept the logical opinion of friends or teachers even though they are different

About math based *problems with Contradictory Informat*	About math based *problem with no specified universal set*
2. Accept the logical opinion of friends or teachers even though they are different	

RESULTS AND DISCUSSION

Students' open-mindedness behavior in completingabout math based *problem with Contradictory Information*

The research subjects were given the first question, namely about math based *problems with Contradictory Information*. There are 2 students working by the steps for solving the problems that have been determined. First, they read question number one and try to understand the meaning of the problem, then they can determine the length of BD by dividing the length of BC into equal lengths of 7 cm. Their next step is to determine the length of DE (the radius of the ball), where the length of DE is equal to the length of BE which is 7cm. After they determine the lengths of BD and DE, then they determine the length of AD using the Pythagorean formula which is 24 cm. In determining BD, DE, and AD these two students worked alone without discussing with other friends. then they continue the next command, which is to determine the length of AE by adding up the lengths of AD and DE, namely $24 + 27 = 31\ cm$. Then they compared the AE length they obtained with the AE length in the image. From this, comparison they found something strange, the AE length they got with the AE length in the picture had the same length, but they found a 28:31 ratio. Not sure about the answer they got, they discussed it with other friends. it turns out that these two students experienced the same thing. After they discussed it, they concluded that most likely the problem presented was the wrong question because of the difference in the length of the AE they got with the length of the AE in the picture. Not satisfied with the conclusions they got, they immediately confirmed it to the teacher. They listen carefully to the explanation of the math teacher, then the teacher asks do you need to find the volume of the lantern? one of them answered it was not necessary because the question given was the wrong question.An example of an answer from one of these students is shown in Figure 2 below:

FIGURE 2. An example of one of two student answers to question number one

Based on the explanation above, the two students had a discussion when they found something odd about their answer. They also confirmed to the math teacher and listened carefully to the teacher's explanation. Unlike the other eight subjects. They work on question number 1 according to the steps instructed in the problem. But the answer they wrote was the wrong answer. First, when they were asked to determine the length of BD they wrote down the length of BD = 11cm. They wrote the wrong answer, actually what they wanted to write was BD = 14 cm. So that it greatly affects the next steps. Next, they wrote down the length of DE = 22 cm, AD = 22 cm, where the answers they wrote were not quite right. In the first and second steps they worked individually without asking other friends. Then in determining the length of AE they add $28 + 22 + 22 = 72\ cm$. They wrote the answer because they were confused about how to determine the length of AE and finally added up the numbers, and their answer was the wrong answer. Then they compared the AE length they got with the AE length in the picture, namely $72 : 28$. Even though they know the AE length they get with the AE length in the picture is different, they don't ask or discuss it with other friends. Finally, they wrote the conclusion that it was necessary to measure the volume of the lampion, because they did not realize that the questions presented contained conflicting information. An example of an answer from one of these students is shown in Figure 3 below:
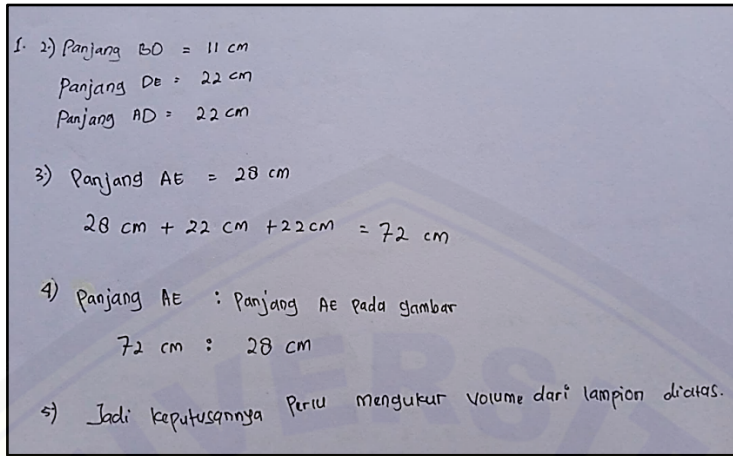
FIGURE 3. An example of one of eight students' answers to question number one

Based on the explanation above, the eight students did not have discussions with other friends when completing theabout math based *problems with Contradictory Information*. After finishing their work also did not confirm to the math teacher, they immediately collected the answer sheets. It happened because they didn't realize that the question presented wascontains conflicting information.

Students' open-mindedness behavior in completing about math based *problem with no specified universal set*

The research subjects were given the second question, namelyabout math based *problem with no specified universal set*. There are 4 students working in accordance with the steps for solving the problems that have been determined. They write if the universe of conversation is a Real number then $x = 4 \, dan \, y = -2$, If the universe of speech is a Rational number then $x = 4 \, dan \, y = -2$, If the universe of conversation is an Integer then $x = 4 \, dan \, y = -2$, if the universe of conversation is a natural number then $x = 4 \, dan \, y$ cannot be determined, if the universe is a prime number, then the value of $x \, dan \, y$ value cannot be determined. They also write the conclusion that the value can be determined depending on the universe of the conversation. In determining the value of $x \, dan \, y \, x \, dan \, y$ with different universal set, they work individually. However, when they were asked to conclude, one of them asked the opinion of another friend, because the student was confused about what conclusion he would write. An example of an answer from one of these students is show in Figure 4 below:
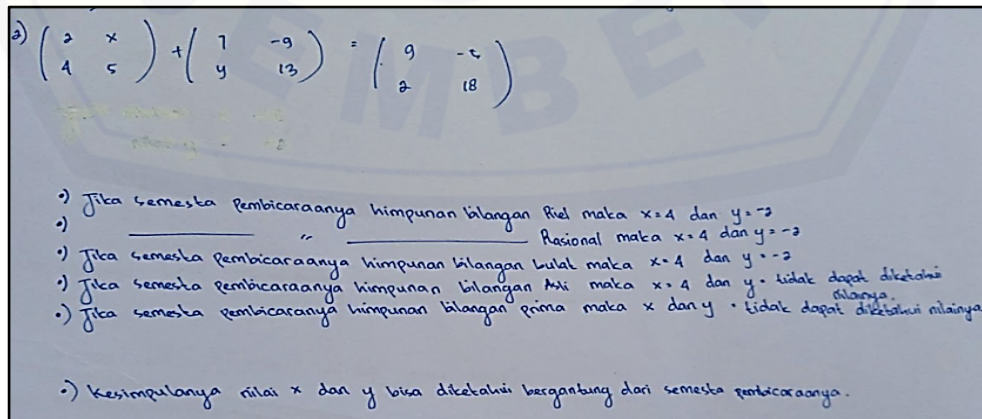

FIGURE 4. An example of one of four student answers to question number two

Based on the explanation above, the four students had discussions with other friends when completing the about math based *problem with no specified universal set*. I they discussed to determine the right conclusion. After finishing their workalso confirm to the mathematics teacher, whether the conclusions they discuss are correct or not. In addition, they listen to the teacher's explanation that the math problem is a math problem based *problem with no specified universal set* namely a question that allows many answers because the universe of conversation is not determined.

This is in stark contrast to the other six students. They work on question number two according to the steps instructed in the problem. But the answer they wrote was the wrong answer. They do not understand the command in the matter well. They wrote down the set of real numbers = positive and negative numbers, the set of rational numbers $= 0, 1, 2, 3, 4, 5, ...$, integer set $= 0, 1, 2, 3, ...$, set of natural numbers $= 1, 2, 3, 4, 5, ...$, set of prime numbers $= 2, 5, 7, ...$ and value $x = 4 \, dan \, y = -2$. The answers they wrote were wrong because they did not match the questions in the questions. The question in the problem is that students are asked to determine the value if the set of conversations is the set of rational numbers, the set of integers, the set of natural numbers, and the set of prime numbers. However, on the answer sheets they write down are members of each set.$x \, dan \, y$An example of an answer from one of these students is shown in Figure 5 below:
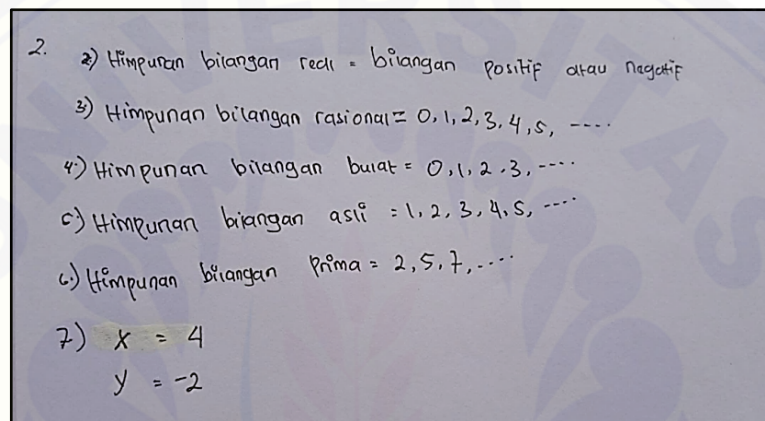

FIGURE 5. An example of one of six student answers to question number two

From Figure 4 it can be seen that students work on the questions according to the previous explanation. Based on the results of interviews and video recordings of students working on individual questions without asking other friends' opinions. even though from the interviews it was found that they were still confused about the meaning of the questions they were doing. They only mention the members of each set and cannot determine the values of x and y according to the problem order. They determine score $x = 4 \, dan \, y = -2$ by trying to enter it by operating the existing matrix without considering the universe of the conversation. In determining the conclusion, the students did not ask either other friends or the mathematics teacher. They thought the questions were too difficult because the students had never done this kind of problem before.

Based on the results obtained, it can be said that the disposition of critical thinking, especially the behavior of open-mindedness when solving problems math-based *problems with Contradictory Informat*and *problem with no specified universal set* has not appear in the students of SMK Ainul Yaqin Jember. Most students are used to always assuming that the questions given are always correct and can be done easily and directly without exploring the truth of the questions. In each step of solving the problem, it is done individually without asking other friends or confirming the math teacher. In addition, they also do not try to look for arguments and other evidence to convince them that the questions given to them are the right questions. The results of this study are by Akgun et al (2016) which states that everyone's truth-seeking and open-mindedness have not developed optimally and do not even appear in that person..

This is very contrary to the opinion of Ennis (1996) which states that someone who thinks critically always has the characteristics of a critical thinker who always demands accuracy and analyzes and assesses what he has to do[14]. In this researh, students tended not to check the correctness of the questions at the beginning before they were done and did not conduct analysis based on evidence and logical arguments. So that the open-mindedness of a student when completing about math based *problems with Contradictory Informat*and *problem with no specified universal set* is unable to change the views and positive opinions of any given problem.

Based on the discussion, it is necessary to do learning that focuses on developing the critical thinking disposition of prospective open-minded mathematics teachers so that prospective mathematics teachers become critical thinkers.

Several ways that can be done to develop critical thinking dispositions, namely by explicit (infusion) and implicit (immersion) learning and a combination of the two (Aizikovitsh-Udi & Cheng, 2015)[15]. In addition, it can also be applied learning that focuses on problem-solving with the provision of non-routine problems and traditional learning methods (Temel, 2014)[16].

CONCLUSION

Open-mindedness behavior of students when completing about math-based *problems with Contradictory Informat*and *Problem with no specified universal set*t hat is, some students conduct discussions with other friends to determine the right conclusions, accept logical arguments and evidence from friends so that they can think again in the completion process. Meanwhile, they also confirmed to the mathematics teacher for the answers to the conclusions they had discussed together. However, on the other some of them haven't behaved yet Open-mindedness. They worked on the questions individually, did not discuss with other friends, and did not conformm with the mathematics teacher even though they felt confused when working on the questions. They choose silence with the answers they have written.

The suggestions given in this study are teachers can apply continuous mathematics learning that focuses on developing critical thinking dispositions, especially open-mindedness by applying infusion, immersion, combined infusion and immersion learning, and problem solving. In addition, it can also be done habituation of giving non-routine questions in every mathematics lesson so that students get used to thinking critically in solving problems.

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REFERENCES

1. ER. Lai, Critical Thinking: A Literature Review Research Report. Pearson's Research Report, (2011).
2. P.A. Facione, The Disposition Toward Critical Thinking: Its Character, Measurement, and Relationship to Critical Thinking Skill. *Informal Logic*, **20**(1), (2000)
3. AR. As'ari, A. Mahmudi, & E Nuerlaelah. Our Prospective Mathematical Teachers are not Critical Thinkers Yet. *Journal on Mathematics Education*, **8**(2), 145–156 (2017)
4. PA. Facione, CA. Sánchez, NC. Facione, & Gainen, J. The Disposition Toward Critical Thinking. *Source: The Journal of General Education*, **44**(1), 1–25 (1995)
5. A. Akgun, & U. Duruk, The Investigation of Preservice Science Teachers' Critical Thinking Dispositions in the Context of Personal and Social Factors. *Science Education International*, **27**(1), 3–15 (2016)
6. AC. Biber, A. Tuna, & L. Incikabi. An investigation of critical thinking dispositions of mathematics teacher candidates. *Educational Research*, **4**(2), 2141–5161 (2013)
7. Iinsight assessment. California Critical Thinking Dispositions Inventory: A Measure of the Critical Thinking Mindset User, User Manual and Resource Guide. (See August, Ed.). San Jose, (CA: California Academic Press, California, 2017)
8. I. Ajzen. The Theory of Planned Behavior. Organizational Behavior and Human Decision Processes, **50**, 179–211 (1991)
9. Z. Arsal. The impact of inquiry-based learning on the critical thinking dispositions of pre-service science teachers. *International Journal of Science Education*, (2017)
10. O. Akınoğlu, & Y. Karsantık. Pre-Service Teachers' Opinions on Teaching Thinking Skills 1. *International Journal of Instruction*, **9**(2), 1694–609 (2016)
11. G. Primiero, F. Raimonde, M. Bottone, & J. Tagliabue. Trust and Distrust in Contradictory Information Transmission. Applied Network Science, **2**(1), 12–41 (2017)
12. D. Bulent, B. Erdal, A. Ceyda, T. Betul, C. Nurgul, & D. Cevahir. An Analysis of Teachers Questioning Strategies. *Educational Research and Reviews*, **11**(22), 2065–2078 (2016)
13. K. Lewis. Developing Questioning Skills. In Teachers and Students - Sourcebook (2007), pp. 1–7.
14. RH. Ennis. Critical Thinking. United States of America: Prentice-Hall (1996)
15. E. Aizikovitsh-Udi, & D. Cheng. Developing Critical Thinking Skills from Dispositions to Abilities: Mathematics Education from Early Childhood to High School. Creative Education, **6**, 455–462 (2015)
16. S. Temel. The effects of problem-based learning on pre-service teachers' critical thinking dispositions and perceptions of problem-solving abilities. (South African Journal of Education, Africa, 2014)