Development of innovative problem based learning model with PMRI-scientific approach using ICT to increase mathematics literacy and independence-character of junior high school students

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Development of innovative problem based learning model with PMRI-scientific approach using ICT to increase mathematics literacy and independence-character of junior high school students

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Abstract. This research is very urgent in relation to the national issue of human development and the nation's competitiveness because of the ability of Indonesian Junior High School students' mathematics literacy results of the Programme for International Student Assessment (PISA) by OECD field of Mathematics is still very low compared to other countries. Curriculum 2013 launched one of them reflect the results of PISA which is still far from the expectations of the Indonesian nation and to produce a better quality of education, PISA ratings that reflect the nation's better competitiveness need to be developed innovative, interactive learning models such as innovative interactive learning Problem Based Learning (PBL) based on the approach of Indonesian Realistic Mathematics Education (*PMRI*) and the Scientific approach using Information and Communication Technology (ICT).The research was designed using Research and Development (*R&D*), research that followed up the development and dissemination of a product/model. The result of the research shows the innovative interactive learning PBL model based on *PMRI-Scientific* using ICT that developed valid, practical and effective and can improve the ability of mathematics literacy and independence-character of junior high school students. While the quality of innovative interactive learning PBL model based on *PMRI-Scientific* using ICT meet the good category.

1. Introduction

Indonesia as a developing country to be able to compete in global competition with other countries then its citizens must have the ability of mathematics literacy equivalent to the ability of other country's mathematics literacy. In fact the ability of PISA mathematics literacy of Indonesian students is still low compared to other countries.

Based on the Program for International Student Assessment (PISA) report 2003, Indonesia was ranked 39th out of 40 countries, in 2009 Indonesian students were ranked 61 out of 65 participating countries, in 2012 Indonesian students were ranked 64th out of 65 countries, while in PISA 2015, Indonesia was still ranked 63 out of 70 countries [1]. The ability of mathematics literacy is defined as the ability to understand and apply basic knowledge of mathematics in everyday life [2,3].

Curriculum 2013 that is and will be implemented one of the reasons for the launch of the 2013 curriculum because the results of PISA students Indonesia is still low compared to other countries. The 2013 curriculum recommends some learning approaches that lead to student habituation in solving problems independently such as learning base problem learning model, project base learning, realistic

with daily contextual solving problems, scientific approach. etc. One effort that can be done by educators to improve the ability of students' mathematical literacy PISA in solving a problem is to innovate the learning of mathematics and develop the instrument of assessment of learning. Innovation of learning mathematics is done by choosing the method of learning in accordance with the material and characteristics of students and can build the character of students so as to improve student motivation in learning mathematics. One of the mathematics learning that can give positive impact to the students' literacy ability in problem solving and can build student character is PBL Learning with Approach of Indonesian Realistic Mathematics Education (PMRI), hereinafter referred to as realistic learning by using ICT and character Independence.

The Problem Based Learning model is a learning model with student learning approaches on authentic and meaningful problems to students who serve as the basis for students to investigate and investigate, so that students can develop their own knowledge, develop more skills High and inquiry and can make students confident and students more independent [4]. PBL is a student-centered learning model [5-8]. Furthermore, PBL as a learning model that empowers students to conduct a study, integrate theory and practice, and apply knowledge and skills to develop solutions of defined problems [5]. PBL is an effective learning to condition the students to be actively involved in meaningful learning [8].

The Learning of Indonesian Realistic Mathematics Education (PMRI) is a learning approach whose starting point is derived from "real" or real things for learners. PMRI in its learning process emphasizes the insinuation of "process of doing mathematics" through discussing and collaborating activities, and berargmentasi with classmates so that they can find their own essence of a material and ultimately use that math to solve the problem both individually and in groups [9]. Broadly speaking, students will be introduced to real phenomena related to the material that will be developed. The phenomenon is then observed and examined based on the guidance provided by the teacher. PMRI combines what mathematics is, how students learn math, and how math should be taught. PMRI was developed based on Hans Freudhental thinking that mathematics is a human activity and must be related to daily reality [10]. Based on that thinking, mathematics learning with PMRI approach has characteristics, among others, that in the learning process students should be given the opportunity to reinvent mathematics through teacher guidance, and reinvention of ideas and concepts must be mathematical Starting from exploring various situations and "real world" issues [11]. There are three RME principles: (a) Guided reinvention and progressivemathematiza- tion, (b) didactical phenomenology, and (c) from informal to formal (from informal To formal mathematics; model plays inbridging the gap between informal knowledge and formal mathematics) [11]. PMRI (Indonesian Realistic Mathematics Education) is an adaptation of RME, the principle of PMRI is the same as RME but in some ways differs from RME, that is its context, culture, social system, and nature. The PMRI team is aware to support the success of PMRI implementation, teachers and students need an appropriate and contextual curriculum of Indonesia [9]. There are three formulates of RME principles: (a) Guided reinvention and progressive mathematical reactions, (b) didactical phenomenology, and (c) from informal to formal (from Informal to formal mathematics; model plays in bridging the gap between informal knowledge and formal mathematics) [11]. While [12] formulated there are four principles in PMRI learning that are 1) Principle of activity, 2) Principles of reality, 3) Tiered principles, and 4) Principles of interwoven. In order to be more easily implemented in class, the above four principles are spelled out into five characteristics of *PMRI* which include: (1) the use of context as the starting point of learning; (2) the development of mathematical tools to lead to formal mathematics; (3) student contribution through free production and reflection; (4) learning interactivity in social activities; And (5) interwining. Through social interaction based on the virtues of a number of values, morals and norms in learning mathematics with PBL *PMRI*-Scientific model using ICT and independence character education will be able to develop a character that by the government has formulated 18 values of cultural education and character of the nation [10].

Learning with a scientific approach is a learning process designed in such a way that learners actively construct concepts, laws or principles through observing stages, formulating problems, filing

or formulating hypotheses, collecting data with various techniques, analyzing data, drawing conclusions and communicating concepts, laws or a "found" principle. Scientific approach is intended to provide understanding to learners in knowing, understanding the various materials using a scientific approach, that information can come from anywhere, anytime, not dependent on the teacher's direction. Therefore, the expected learning conditions created directed to encourage learners in finding from various sources through observation, and not just be told. The learning objectives with the scientific approach are based on the advantages of the approach; 1) to improve intellectual ability, especially students' high-order thinking; 2) to shape the students' ability to solve a problem systematically; 3) the creation of learning conditions where students feel that learning is a necessity; 4) obtaining high learning outcomes; 5) to train students in communicating ideas, especially in writing scientific articles; 6) to develop student character.

Learning in this research will utilize ICT to provide maximum benefit to students in accordance with the development of the era in the era of information and communication technology high by using the internet. ICTs utilized in this research are Google Drive, Quipper School, e-Learning Edmodo and Schoology.Google Drive is a cloud computing-based service that can be used to create, share, collaborate and store data up to 1 terabyte (TB). According to Google representative, Sundar Pichai, Drive allows users to upload and access various files such as videos, photos, Google Docs and PDF. All can be done. You can access files from anywhere. At home, work, or even away from your device, with this cloud-based storage medium. One of the beneficiaries of e-learning is the use of Quipper School is a personal social networking platform that is claimed to provide secure learning platform for learners and educators [13]. Quipper School is a learning media with e-learning system based on the latest open source output and launched in January 2014 which began accessed September 25, 2014 [14]. Quipper School is a liaison between students and teachers in the distribution of subject tasks online and In accordance with the subjects adapted from the curriculum applied in Indonesia, namely mathematics.

Edmodo is a social network for learning-based Learning Managent System (LMS). Edmodo provides facilities for teachers, students a safe place to communicate, collaborate, share content and learning applications, homework (homework) for students, virtual classroom discussions, online replicates, grades and more will be discussed below. In essence edmodo provides everything we can do in class with students in learning activities plus facilities for parents can monitor all activities of children in edmodo as long as it has a parent code for his son. Edmodo is a site dedicated to educators to create virtual classes. The site is free and easy to use as long as a teacher and student can connect to the internet. E-Schoology is one of the innovative platforms built on the inspiration of facebook social media for the purpose of education. Platform was developed in 2009 in New York. Schoology assists teachers in enabling wide-ranging communication opportunities for students to take part in discussions and teamwork. In addition Schoology is also supported by various forms of media such as video, audio and images that can attract students' interest. Schoology directs students to apply the use of technology in learning.

The development of Indonesian students' math skills in PISA during the last 4 periods shows unstable movement, Indonesian students are only able to answer PISA questions of level 1, 2 and 3, and some students can break level 4 [15]. The structure of the PISA mathematical framework can be characterized by a mathematical representation: ML + 3C. ML stands for mathematics literacy, and 3 Cs stands for content, context, and competence [15]. According to PISA 2012, literacy or mathematical literacy is defined as the ability of an individual to formulate, use, and interpret mathematics in various contexts [16]. Explains that PISA includes three major components of the mathematical domain, namely context, content, and competence [17]. The new definition of PISA on mathematical literacy will recognize the important role of information technology by noting that more individual mathematical literacy will make one more capable of using mathematics and mathematical tools to make judgments and decisions well [18].

The 2009 PISA report states that students "who reach the level of all levels can be considered a 'world class' potential for knowledge workers for tomorrow, making comparisons of a country's

students reach this level relevant for future economic competitiveness [19]. Indonesian 15-year-olds have not reached this level [18]. In mathematical literacy, it is important that one can identify mathematics relevant to the context experienced and then be able to use this mathematics as one means of contributing to the attainment of one's goals in context [20]. Teachers themselves need to develop a positive experience of using mathematics in context, as described above. After teachers develop their experience of mathematical literacy, they will reflect on their teaching and learning process [20]. The level of teacher math skills is an important determinant of success in the program. But also that the lack of math skills is not the only barrier to success [20]. Mathematical literacy has a cultural component: "It is not possible to promote the concept of mathematical literacy without at the same time - implicitly or explicitly-promoting certain social practices. Self efficacy of mathematical literacy of mathematics and physics teacher candidates is below average [21] Self-efficacy is an important part of shaping the lives of students, so it is important for teachers and educators to Develop self-efficacy in the classroom [21]. There is a positive correlation between students' literacy scores and Arithmetic Performance scores [22]. Improve students' mathematical literacy skills, preferably those presented in real life [23], need to build meaning with symbols, context, graphs, diagrams, and other models [24]. The need to improve science knowledge, technology and mathematical literacy among students has been a major focus for learning science, technology and mathematics in schools [25].

Character that implanted in this research is characteristic attitude of independence (affective domain). Attitude of independence is the attitude/behavior is not easy to depend on others in completing tasks. Student independence is an individual's readiness and able to learn by own initiative, without the help of others to achieve learning goals. The characteristics of the individual have the readiness of self-study characterized by: (1) love of learning, (2) self-confidence as students, (3) openness to learning challenges, (4) curiosity, (5) self-understanding in learning, (6) accepting responsibility for learning activities [26]. The attitude of independence would be even better if developed with a high base of concern for others, this is called modern humans. This opinion is in line with the description that modern humans have a tendency to accept new ideas, a willingness to express opinions, time sensitivity, and more concerned with present and future time than past time, better sense of timeliness , Greater concern for organizational planning and efficiency, the tendency to view the world as something that can be counted, to appreciate the power of science and technology. Meanwhile, learning independence is characterized as follows: (1) independence with others, (2) confidence / self, (3) trying to meet learning needs, (4) learning is based by Initiative itself, and (5) trying to exercise self-control. The creative character towards the creation of independence for children can be established by developing a learning cycle covering five aspects of the learning experience as follows (1) Exploring (2) Planning (3) Doing / acting (4) Communicating and (5) Reflecting [27].

Based on the background of the problems and theoretical review mentioned above formulated the following issues; (1) How is the innovative interactive learning tool of PBL based on *PMRI*-Saintific approach using ICT with self-reliant character education that will be implemented in some junior high schools in Semarang whether valid and practical?, (2) Is the quality of innovative interactive learning PBL based on PMRI-Saintifik approach using ICT with autonomous character education that is implemented in some junior high schools in Semarang meets the minimum category of good?; (3) Whether implementing learning tools and innovative interactive learning models of PBL based on PMRI-Saintific approach using ICT with independent character education can effectively improve students' mathematical literacy skills in some junior high schools in Semarang; (4) Is interactive learning innovative PBL based on PMRI-Saintific approach using ICT with self-reliant character education that implemented in some junior high schools in Semarang can improve the character of student self-reliance better ?, (5) How description of ability of junior high school student literacy in Semarang ?

2. Methods

This research includes the type of Research and Development. Device development and learning model refers to the 4-D development model Thiagarajan; (1) the defining phase consists of the final preliminary analysis, student analysis, subject matter analysis, task analysis and formulating specific learning objectives; (2) stage of device design and learning model; (3) development stage consists of validation steps, device trials and learning models; (4) the implementation phase of the device and the learning model in the two junior high schools.The development carried out is the development of an innovative interactive learning tool based on PMRI-Saintific approach using ICT with creative character education with self-assessment based on PISA assessment on junior high school students. The tools developed include the Syllabus, Learning Implementation Plan (RPP), Student Worksheet (*LKS*), and PISA Mathematics Literacy Test (PMLT) and the development of this learning model. While the instrument of study in the form of validation sheet of learning device that includes: syllabus, lesson plan, *LKS* validation sheet, device validation sheet PMLT similar test PISA, teacher management observation sheet, student attitude sheet in learning, student response questionnaire, teacher response questionnaire, implementation validation sheet Learning model, learning quality observation sheet, student character observation sheet.

The research done by quantitative research on improving the ability of mathematical literacy and the character of student's independence after implementing innovative interactive learning of PBL model of ICT-based Realistic-Scientific approach. Research is also conducted qualitatively to describe the ability of students' mathematics literacy on JHS model of PBL approach of Realistic-Scientific with ICT. Quantitative research requires population and sample. The population of quantitative research was the students of class VII SMP N 4 Semarang, while the samples were obtained through random sampling technique. This technique is chosen because of the limitations of the researchers' authority in a wide range. The samples were selected randomly regardless any particular criteria in the population. Out of all grade VII classes in SMP N 4 Semarang, 2 classes were selected as the research sample in accordance with research design. The population for grade VII and VIII of SMP N 4 Semarang and SMPN 15 Semarang, with 3 classes randomly selected as the research samples. The subjects of the qualitative research were 6 students from each level of student's TKLM based on the respective questionnaire results. Non-probability sampling technique was used in the qualitative research, where each object of research was carried out. The technique used is purposive sampling, that is taking the subjects to be used based on certain considerations.

The research variables are; (1) variable of learning device; (2) variable ability of mathematics literacy, 3) learning quality variable and (4) variable of student independence characteristic. Data were collected by tests, interviews and observations. Quantitative data were analyzed by descriptive statistics and inferential statistics with the help of SPSS, while the qualitative data were analyzed by qualitative descriptive analysis

3. Result and Discussion

3.1. Interactive Innovative Learning Model PBL With PMRI-Scientific Approach Using ICT

Assessment or validation of learning devices aims to assess the extent to which the feasibility of learning tools can be used in the learning process. Validation is performed by a competent expert, the validator. Validator consists of 6 experts, namely 1 expert evaluation and education, 2 mathematics literacy experts, 1 mathematical process expert and 2 experts of learning and mathematics education. In general, the validation of learning tools by the three validators is presented in Table 1.

Table 1. Results of validation of learning tool

	Aspect	Validator						Mean	Validity	Description
		1	2	3	4	5	6			
1	Syllabus	4,67	4,35	4,89	4,20	4,25	4,65	4,50	Valid	Very good
2	LP	4,57	4,65	4,71	4,50	4,60	4,60	4,61	Valid	Very good
3	WS	4,40	4,60	4,80	4,55	4,35	4,40	4,52	Valid	Very good
4	Material	4,60	4,70	4,75	4,65	4,45	4,60	4,63	Valid	Very good
5.	TAML	4,60	4,40	4,25	4,70	4,65	4,60	4,53	Valid	Very good

Based on Table 1 can be explained about the quality of learning device development results as follows. (1) The result of validation of syllabus in this research is valid with very good category. The average total valuation of the three validators for the syllabus is 4.50. (2) Average overall assessment of expert validator for *RPP* of 4.61. *RPP* can be said to be valid and included in the category very well. (3) Average overall assessment of expert validators for *LKS* of 4.52. *LKS* can be said to be valid and included in the category very well. (4) Average appraisal of expert validators for Materials Teaches of 4.63. Teaching Materials can be said to be valid and included in the category very well. (5) Average assessment of expe validator for *TKLM* of 4.53. *TKLM* can be said to be valid and included in the category very well. The results of validation of learning tools by these experts show that learning tools are valid with very good categories, with little revision required. *TKLM* after going through several revisions and tested to students and analyzed resulted that *TKLM*-oriented PISA has been valid by content, every item used is valid, reliable, significant difference and normal difficulty level. Learning device development results can be said to be practical, because after being tested on the students get the following results. (1) Positive student response, this can be seen based on questionnaire obtained that students give a positive response of 82.25% (above 75%). (2) Teachers respond well, this can be seen from the average result of questionnaire of teacher response to learning device equal to 4,26 and can be categorized very good; And (3) The ability of teachers to manage learning well with the average total ability of teachers in managing learning amounted to 4.34 and can be categorized very good.

3.2. *Innovative interactive learning qualities of PBL PMRI-Saintifik approach using ICT have character education Independence*

The results of data analysis with descriptive statistics on the quality of innovative interactive learning PBL *PMRI*-Scientific approach using ICT containing character education independence obtained average learning quality 83.5% with good category.

3.1. Results Quality of learning in SMPN 4 Semarang

The results of data analysis with descriptive statistics on the quality of innovative *PMRI* learning character education characterized by PISA obtained average learning quality of 84.6% with Good category

3.2. Results The quality of learning in SMPN 15 Semarang

The results of data analysis with descriptive statistics on the quality of innovative PMRI learning character-educated character PISA obtained average learning quality 82.4% Good category

3.3. Improving the Ability of Mathematical Literacy by Implementing Innovative Interactive Learning Based on PMRI-Scientific Approach Using ICT

The results of the effectiveness test of Learning model in SMPN 4 Semarang for Classical Exhaustiveness Test Calculation using the formula z obtained value of $z_{arithmet}$ = 1.780. With a real level of 5% obtained $Z_{table} = Z_{(0,5\ -0,05)} = Z_{0,45}$ = 1,64. Because $Z_{arithmetic} > Z_{0,5-0,05}$ then H_1 accepted. Thus, it can be concluded that the proportion of students on learning has reached classical mastery of 75%. The calculation using the formula t in excel, obtained t_{count} value of 3.46. With a real level of 5% obtained t_{table} of 1.67. Because t_{count} (3.39)> t_{table} = 1.67 then H_1 accepted. Thus it can be concluded that

the average student's mathematical literacy on the learning is better than the average mathematical literacy ability of the control group. So the result of the development of learning tools can be said to be effective, because after tested in experimental class results obtained. (1) The results of the students' experimental class mathematics literacy are thoroughly classical and (2) The mean mathematical literacy of students with innovative interactive learning PBL PMRI-Scientific approach Using ICT Character Education Education Independence is better than the mean of the expository class math literacy (control) students. While the results of the test of the normality test showed an increase of 0.39 in the medium category. Meaning of Mathematics Literacy of students in innovative interactive learning class PBL PMRI-Scientific approach Using ICT Character Education Character of Independence is increasing from the ability of previous students' mathematical literacy.

The results of the effectiveness test of Learning model in SMPN 15 Semarang to Test Exhaustiveness Classical calculation using the formula z obtained z count = 1.81. With a real level of 5% obtained z table = 1.64. Since Zhitung> Z table then H1 is accepted. Thus, it can be concluded that the proportion of students on learning has reached classical mastery of 75% Calculation using the formula t in excel, obtained t value = 2.57. With a real level of 5% obtained t table = 1.67. Because t count> t table then H1 accepted. Thus it can be concluded that the average student's mathematical literacy on innovative interactive learning PBL PMRI-Scientific approach Using ICT Load Education Character Independence is better than the mean of mathematics literacy expository class (control) students. So the result of the development of learning tools can be said to be effective, because after tested in experimental class results obtained. (1) The results of the students' experimental class mathematics literacy are thoroughly classical and (2) The mean mathematical literacy of students with innovative interactive learning PBL *PMRI*-Scientific approach Using ICT Character Education Education Independence is better than the mean of the expository class math literacy (control) students. While the results of the calculation of the normality test showed an increase of 0.36 in the medium category. Meaning of Mathematics Literacy of students in innovative interactive learning class PBL PMRI-Scientific approach Using ICT Character Education Character of Independence is increasing from the ability of previous students' mathematical literacy. This is consistent with research conducted by [28] that PMRI learning with media Schoology can lead to formal student reasoning and can establish informal and formal mathematical representation relationships. This is also in accordance with Wardono's research [29] that learning with a realistic approach can increase the students' literacy skills that PISA refers to. This is consistent with the same results of research from PBL approaches of PMRI with media Edmodo can improve the ability of mathematics literacy and research PMRI or RME can improve the ability of mathematics literacy [30,31].

3.4. Improving the Character of Independence By implementing Innovative Interactive Learning PBL PMRI-Saintifik Approach Using ICT

The result of data analysis with descriptive statistics about the character of student independence in SMPN 4 Semarang mean the percentage of students' independence character continuously increased consecutively from the 1st to 4th learning that is 68,4% (good enough), 72,8% Good), 82.5% (Good) and 87.6% (Very Good).

While the results of data analysis with descriptive statistics about the character of student autonomy average percentage of student autonomy character continuously increased consecutively from the 1st (P1) to 4th (P4) learning that is 67,5% (Good Enough), 71 , 6% (Good Enough), 83.7% (Good) and 86.8% (Very Good). The results of two schools is presented in Figure 1.

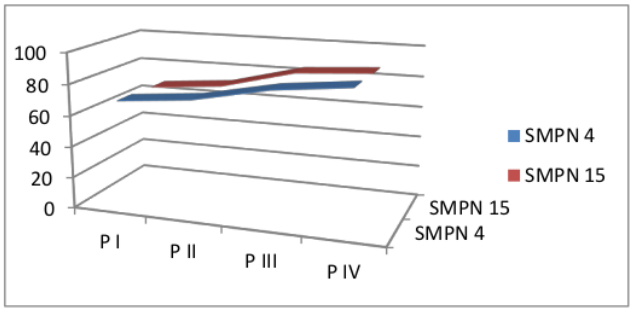

Figure 1 Average percentage of student independence

3.5. Description The Ability of Mathematics Literacy of Junior High School Students in Semarang City

Qualitative descriptions literacy skills math junior high school students with innovative learning interactive PBL approach PMRI-Scientific use ICT charged character education independence of subjects Group Top Identified meet all indicators of literacy mathematics, namely Communication, Mathematising, Representation, Reasoning and Argument, Devising Strategies for Solving Problems, Using Symbolic , Formal and Technical Language and Operations and Using Mathematics Tools. The identified Central Group subjects meet the mathematical indicators of Communication, Mathematising, Representation, Reasoning and Argument, Using Symbolic, Formal and Technical Language and Operations and Using Mathematics Tools. While the subject of the Bottom Group identified the Indicators of mathematical literacy, some Mathematising, Representation, Reasoning and Argument, and Using Mathematics Tools.

4. Conclusion

Based on the analysis of research results and discussion are drawn the following conclusions; (1) The innovative learning interactive PBL based approach to PMRI-Scientific use ICT charged character education of independence that has been implemented in several junior high schools in the city of Semarang valid and practical, (2) quality innovative learning interactive PBL based approach to PMRI-Scientific use ICT charged character education Independence that has been implemented in some junior high schools in Semarang meets the minimum category either; (3) Implement learning tools and innovative interactive learning model PBL PMRI based approach to using ICT charged Scientific independence of character education can effectively improve the literacy skills of students at several junior high school math in Semarang; (4) Implementation of innovative learning interactive PBL based approach to PMRI-Scientific use ICT charged character education autonomy of some secondary schools in the city of Semarang can improve the character of the independence of the student better, (5) Description of the literacy skills of mathematics students of SMPN 4 and SMPN 15 Semarang with learning innovative interactive PBL approach PMRI-Scientific use ICT charged character education independence of subjects Group Top identified meet all indicators of literacy mathematics, namely Communication, mathematising, Representation, Reasoning and Argument, Devising Strategies for Solving Problems, using Symbolic, Formal and Technical Language and Operation and using Mathematics Tools. Subjects Central Group Identified meet math literacy indicators Communication, mathematising, Representation, Reasoning and Argument, Using Symbolic, Formal and Technical Language and Mathematics Operation and Using Tools. While the subject of the Bottom Group identified the Indicators of mathematical literacy, some Mathematising, Representation, Reasoning and Argument, and Using Mathematics Tools.

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