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Designing Math Trails-based Hypothetical Learning Trajectory to Promote Students' Numeracy Skill

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Abstract. This study aims to design a Math Trails-based Hypothetical Learning Trajectory (HLT) to promote students' numeracy skill. This research uses design research consisting of three stages: (1) preliminary design, (2) teaching experiments, and (3) retrospective analysis. This research is focused on the preliminary design stage. The HLT component consists of learning objectives that are adjusted to numeracy indicators, learning activities using task designs on MathCityMap, and hypothetical learning process that refers to the steps of mathematical modeling process to solve numeracy problems. The results of this study are HLT in the form of 8 task designs that have been designed, reviewed by experts, and revised according to suggestions and received a score of 4,6 out of 5 from experts. For further research, experimental research can be carried out to examine the increase in numeracy skills through this designed HLT.

Keywords: HLT; Math Trails; Numeracy

INTRODUCTION

Improving the quality of education nationally and the mapping function continues to be pursued by the government. One of the programs implemented is the change of the National Examination into a Asesmen Kompetensi Minimum (AKM) and a Character Survey since 2021. Numeracy skills is one ofthe fundamental competencies measured in AKM. Numeracy is the skills to think using mathematical concepts, procedures, facts, and tools to solve everyday problems in various types of contexts that are relevant to individuals as citizens of Indonesia and the world (Pusmenjar, 2020). Problems in AKM arepresented in various contexts that are expected to be solved by students using literacy and numeracy competencies. The urgency of numeracy skills for students as the current generation is also an effort to increase competitiveness in facing the challenges of the 21st century. A study shows that adults with higher literacy and numeracy skills tend to have higher levels of problem-solving skills (Xiao et al., 2019). The importance of numeracy skills in the world of work and everyday life is becoming an increasingly relevant issue, many university programs require a certain numeracy level as a core aspect of university preparation (Pragati Jain & Rogers, 2019). The urgency of numeration is not directly proportional to the level of students' numeracy skills in Indonesia. The majority of students' numeracy abilities at the primary and secondary levels have not achieved satisfactory results (Anggraini, 2022; Apipatunnisa et al., 2022; Napsiyah et al., 2022). Real condition also show that the skills of teachers to develop student numeracy test instruments is very low, more than 78% cannot develop numeracy skills test instruments because they are considered to be a new thing in the national assessment system (Purnomo et al., 2022). The low numeracy skills of the students are due to several factors, including the lowskills of the teacher to develop numeracy skills instruments, students do not really know questions withthe type of numeracy skills, lack of integration of numeracy questions in learning (Anggraini, 2022; Purnomo et al., 2022; Salim & Prajono, 2018).

Education continues to adapt to technological advances, including in the implementation of learning in schools. Technological developments offer new innovations to expand class activities, supporting learning outside the classroom with Math Trails. Math Trails are student activities in exploring mathematics in the environment by following the tracks that have been made (Cahyono et al., 2015). Learning mathematics using Math Trails media will be implemented using outdoor learning methods. This research will utilize the MathCityMap application which is a Mobile Math Trails (Math Trails on a mobile application) developed by the MATIS I team from Goethe University Frankfurt, Germany. Through Math Trails students can explore mathematics in the environment by following a planned path consisting of a series of stops (Shoaf et al., 2004). Math Trails can help students and teachers to connect with their environment and support the

development of diverse and meaningful mathematical modeling skills (Druken & Frazin, 2018). Mathematical modeling is the main process in numeration (Hera & Sari, 2015). So that the use of Math Trails using the MathCityMap application as a tool in the teaching module is appropriate and supports students' numeracy skills. The characteristics of Math Trails are described as follows: 1) math trails are for everyone; 2) math trails are cooperative, not competitive; 3) math trails are self-directed; 4) math trails are voluntary; 5) math trails are opportunistic; 6) math trailsare temporary (Shoaf et al., 2004). Skortell identified the goals of Math Trails as including facilitating students to be able to apply mathematics in the real world; support students to think critically, communicate, and collaborate; as well as fostering interest in and concern for the environment (Druken & Frazin, 2018).

Hypothetical Learning Trajectory (HLT) is a prediction or conjecture of how students' ways of thinking and understanding develop through a context in learning activities. HLT includes three aspectsin the form of learning objectives, learning activities, and the thinking in which the students might engage (Simon & Tzur, 2004). HLT helps teachers to build structured and sustainable teaching, taking students' abilities into account, providing clear guidance on what needs to be learned, and adapting instruction according to students' individual needs. One important aspect that must be owned by the teacher in teaching students meaningful learning is to design a HLT which contains a series of instructional tasks so that students can understand the concept of learning mathematics (Rezky, 2019). In meaningful learning, students not only learn to memorize facts or concepts mechanically, but also tounderstand the significance and practical application of what they learn. This is in accordance with the principles of Math Trails, mathematics is more meaningful and can be understood better when applied in a real context. This principle emphasizes the importance of associating mathematical concepts with situations and objects in the environment around students. Based on the background that has been described, the purpose of this research is to design Math Trails-based Hypothetical Learning Trajectories (HLT) that are oriented towards numeracy skills.

METHODS

This research uses design research consisting of three stages, namely (1) preliminary design; (2) teaching experiments; and (3) retrospective analysis. This research is focused on the preliminary design stage with data collection techniques by self-assessment and expert review. At this stage, the researcher designed the HLT which consisted of: learning objectives; learning activities: pre-activity, core activity, and post-activity; as well as a hypothetical learning process or conjectures of students' learning process.

RESULTS AND DISCUSSION

HLT that has been designed contains three components that are learning objectives, learning activities and hypothetical learning process.

Learning objectives

Simon (2004) explained that there are two factors that influence the formulation of learning objectives: (1) teacher's knowledge of mathematics, (2) teacher's hypothesis of students' knowledge (Rezky, 2019).The continuous flow of mathematical knowledge makes the teacher's knowledge of mathematics an influential factor in determining learning objectives. In addition, knowledge of the extent to which students' knowledge of the material that has been studied is also a factor that influences the determination of learning objectives and the effectiveness of learning activities. The learning objectives are adjusted to the indicators on numeracy skills, (1) Using various kinds of numbers and symbols related to basic mathematics to solve problems in various contexts of everyday life, (2) Analyzing information presentedin various forms (graphs, tables, charts, diagrams and so on) and, (3) interpreting the results of the analysis to predict and make decisions.

This research is focused on designing HLT for numeracy skills, so it is not focused on one particular topic. The topics used in this study refer to the elements used in AKM, that are numbers, algebra, geometry and measurement, as well as data and uncertainty. The initial competencies needed are topics related to number operations, polyhedron volume, one-variable linear equations, and central tendency.

Learning Activities

The design of learning activities includes Pre-Activities, Main Activities, and Post-Activities. Pre- activity is student preparation to

explore mathematics using Math Trails. At this stage, teacher gives acode to access the trails. In main activities students will be faced with 4 activities in each meeting (consist of 2 meetings) according to the topic (content), context, and certain cognitive level. The context of the problem includes personal (personal self-interest), scientific (issues, activities, and scientific facts that have been carried out as well as futuristic), and socio-cultural (inter-individual interests, culture, and societal issues). The cognitive level includes understanding, reasoning, and application. Post-activity is students activity to discuss the results of mathematical exploration. Students' learning activities overview is presented in Figure 1.

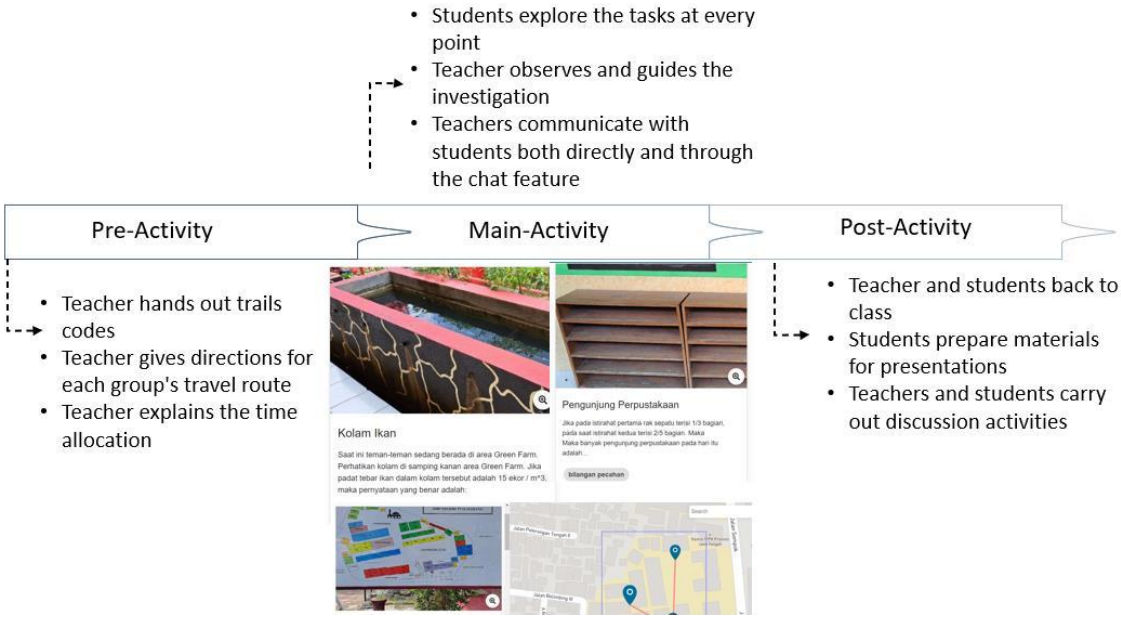

Figure 1. Learning Activities

Hypothetical Learning Process

Hypothetical learning process in each activity refers to the mathematical modelling process to solve numeracy problem (Figure 2).

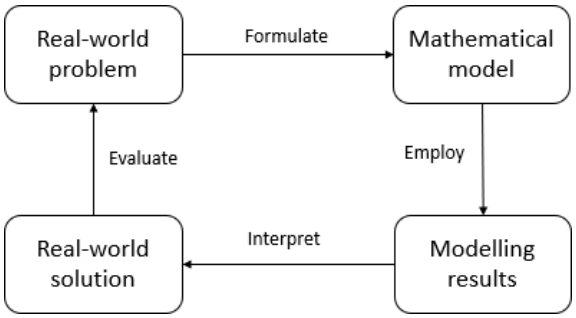

Figure 2. Modelling Process to Solve Numeracy Problem (Fachrudin, 2022)

There are four stages of the modelling process to solve numeracy problems. *Formulate stage*, at this stage students are directed to understand the problem and identify task information by writing down what is known and asked. Math trails involve physical movement and active exploration, making the learning experience more dynamic and engaging. It encourages hands-on activities and promotes a deeper understanding of mathematical concepts through experiential learning. These activities can be found at the formulate stage which allows students to carry out physical activities such as measuring distances, calculating angles, interpreting data from charts or graphs, and interacting directly with the problem object. This is one of the expected benefits of using Math Trails which makes learning more meaningful. In line with English (2010), math trails as a way of promoting mathematics learning by assigning meaningful real task to students outside of the classroom, with a sequence of designated sites also a planned route where students explore math in the environment. *Employ stage*, at this stage students are directed to use mathematical concepts in solving problems. After students carry out the identification process with hands-on activities, then students demonstrate their ability to perform calculations, manipulate, apply known concepts and facts to produce mathematical solutions through systematic problem solving. Learning with math trail can improve students' abilities (Edi & Nayazik, 2019). *Interpret* and *evaluate stage*, at this stage students are directed

to analyze the results of work at the employ stage to interpret the results obtained and draw conclusions and re-examine the results of the answers by re-checking the formula, employ, and interpret stages.

Math Trails-based HLT design has been validated through expert review. The assessment criteria are adjusted to the task criteria on Math Trails. The HLT validation results are presented in Table 1.

Table 1. Expert Review Result

Aspect	Average Score							
	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8
Task context uses understandable question words and commands	4.3	5	4.3	4.3	5	4.7	4.3	4.7
Tasks can be solved using a calculator.tape measure. ruler. stopwatch	4.3	5	4.7	4.7	5	5	4.7	4.3
There is at least 1 hint	4.3	5	4.7	4.7	5	5	4.7	4.7
Authentic assignments	4.3	4.5	4.3	4.7	4.7	4.7	4.7	4.3
Tasks are completed and actively carried out with physical activity. for example. measuring and counting	4.3	5	4.3	4.7	5	5	4.7	4.3
The tasks presented have relevance inthe real world	4.3	5	4.3	4.3	5	5	4.7	4.3
The tasks presented can be solved in a variety of ways	4.0	5	4.0	4.3	4.3	5	4.7	4.0
Compatibility of task design with numeracy ability indicators	4.3	5	4.7	5.0	5	4.7	4.7	4.7
Tasks can only be completed when students come to the location of the object	4.7	5	4.7	4.7	5	5	4.7	4.3
Average Score	4.3	4.9	4.4	4.6	4.9	4.9	4.6	4.4
Total Average Score	4.6							
Percentage	92.5%							

Based on the results of the expert review, valid criteria were obtained for each task design. There are several suggestions provided by the validator. The comparison of HLT before and after the revision is presented in Table 2.

Table 2. HLT Before and After Revision

Aspect	Before	After
Task context	Assignments are presented by true-false question types (in the form of statements)	Assignments are presented by essay or multiple-choice types (in the form of questions), adapted to the operational verbs on the numeracy skill indicator
Hint	There is no hint for circumference of a circle formula in Task 8	Given additional hint for circumference of a circle formula in Task 8
Tasks can only be completed when students come to the location of the object	Taking pictures is not quite right, so that students do not need to come to the location to solve the problem	Adjustment of the shooting angle

The following is an example of task design that has been revised according to the suggestions.

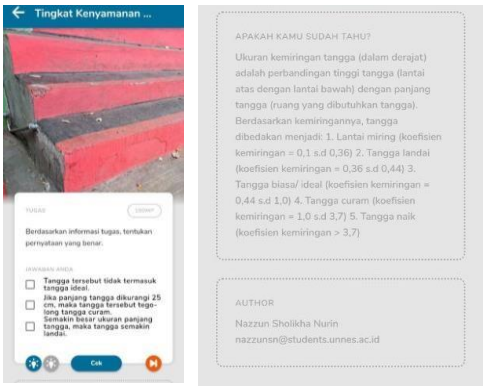

Figure 3. Before revision

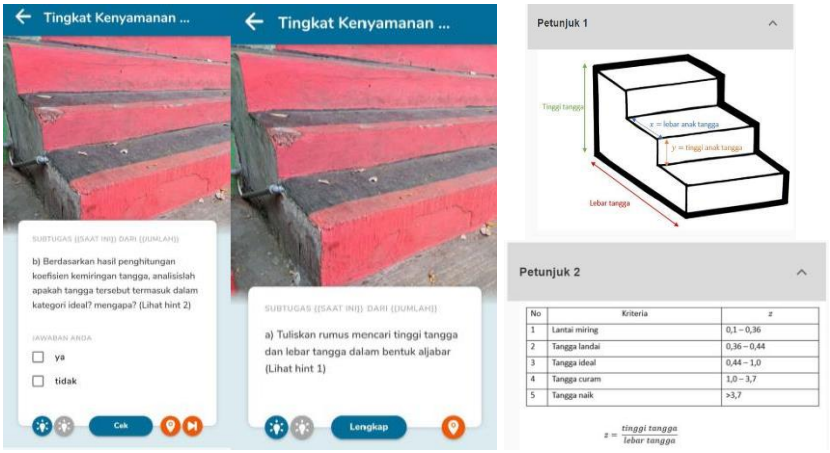

Figure 4. After Revision

The task in Figure 2 is the type of task on number and measurement content before revision. The task does not yet represent the indicator "using various kinds of numbers and symbols related to basic mathematics to solve problems in various contexts of everyday life". The information presented is not presented clearly. Criteria for the slope of the stairs is better if presented in tabular form. This is because representations in the form of graphs, tables, charts, diagrams etc. easier to understand than words (Sri Hartatik, 2020). So that the task also does not yet represent the indicators "analyzing information presented in various forms (graphs, tables, charts, diagrams and so on)" and "interpreting the results of the analysis to predict and make decisions".

The task is revised into 2 sub-tasks that represent 3 indicators (Figure 4). Tasks in point a) include algebraic content and represent indicators of "using various kinds of numbers and symbols related to basic mathematics to solve problems in various contexts of everyday life". Students are givenhint 1 as an aid in solving the problem. Students' ability to make algebraic models is needed in this task. The task at point b) represents the indicators “analyzing information presented in various forms (graphs,tables, charts, diagrams and so on)” and “interpreting the results of the analysis to predict and make decisions”. Students begin the activity by measuring the height and width of the steps. Then from these measurements students can use the formula obtained in task a) to determine the length and height of thesteps, so that the slope coefficient of the stairs can be known. The final step of this task is that students are able to make interpretations of the results that have been obtained to make a conclusion.

CONCLUSION

Based on the results and discussion, a Math Trails-based HLT has been designed that is oriented towards numeracy skills in the form of task designs in the MathCityMap app. The HLT component consists of learning objectives that are adjusted to indicators of numeracy skill, learning activities using task designs on MathCityMap, and hypothetical learning process that refers to the mathematical modeling process to solve numeracy problems. The results of the validation

of each task get an average score 4,6 out of 5. The tasks have been designed, reviewed by experts, and revised according to suggestions. So, this HLT is ready to be implemented. For further research, research experiments can be carried out to examine the increase in numeracy skills through this designed HLT.

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