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Explorative learning (Model HOTL-DI Type A) about the phenomenon of rainwater falling from the roof

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Abstract
This article describes the results of explorative learning using the model: Higher Order Thinking Learning in Democratic Interaction (HOTL-DI) type A, regarding the phenomenon of rainwater falling from the roof onto the ground. Exploration activities are carried out in three stages. The first stage is the exploration of objects, concepts and scientific processes by the research team as a reference to facilitate learning activities for students. The second stage is exploration by semester 3 students (trial group). Stage III exploration activities for 1st semester students (target group). The results showed that at the beginning of the exploration process students experienced difficulties at each exploration step. This difficulty is caused by the lack of experience in exploring physical concepts and processes about natural phenomena. This difficulty shows that the mastery of physical concepts and processes is still lacking and not comprehensive, so that students find it difficult to formulate a network of concepts and physics processes. The ability to explore phenomena continues to increase at each meeting, so that it has the potential for the development of higher-order thinking ways to integrate experiences about the context in the environment with classroom learning.

Keywords: explorative learning, higher order thinking, rain phenomena

1. Introduction
Physics is a branch of science that studies the nature, symptoms, natural phenomena and all their interactions. Some students find physics difficult because they had to compete with different representations such as experiments, formulas and calculations, graphs, and conceptual explanations at the same time [1]. Learning which is dominated by concept development through question exercises in textbooks causes difficulties for students in understanding the basic concepts of physics [2]. Students can be trained to understand the concepts of physics through the real world around them [3]. Experiences about natural phenomena experienced by individuals in their environment must be integrated with classroom learning in order to obtain a thorough understanding. The environment becomes a potential, factual and functional learning medium for students in achieving the expected learning abilities. In fact, learning in schools makes minimal use of the surrounding environment as a learning context that has shaped experiences since students see the world around them.

The integration of everyday experiences in the environment with classroom learning can be carried out through explorative learning. Explorative learning is a learning that aims to explore ideas, arguments and different ways from students through a number of open questions and commands so that it can lead students to understanding a concept and solving problems [4]. Explorative learning provides broad opportunities for students to build knowledge through the process and skills of linking initial knowledge with learning experiences [5]. Explorative research instead aims at applying new words, concepts, explanations, and theories to reality with the expectation of offering new ways of seeing and perceiving how this segment of reality works, or more specifically how and in what way different factors relate to each other causally [6]. Explorative learning provides a different learning atmosphere and makes students explorers and can discover for themselves, thereby mastering concepts and having critical thinking skills. Rain is a natural phenomenon that contains physics concepts in it.

The exploration process formulated by Medellu (2019) [7] in Explorative Learning (HOTL-DI Type a Model) consists of 4 steps: (1) Identification of facts / phenomena, (2) analysis of descriptions of facts / phenomena (3) exploration of concepts and scientific processes / physics (4) formulation of concept networks / formulations. Explorative learning (HOTL-DI Type A Model) is carried out in 3 main stages: exploration by the research team, explorative learning to the mentor group (trials), and explorative learning to the target group. The model is applied in research to Physics Department students. This research is a collaborative study that assesses the individual higher-order thinking learning process and the democratic process in group discussions (HOTL-DI). Specifically in this study, assessing the higher order thinking learning process. This study aims to: (a) explore the concepts and physical processes of the phenomenon of falling rain, (b) determine the learning process of higher order thinking in exploring the concepts and physical processes of the rain phenomenon.

2. Conceptual Framework
Higher Order Thinking Learning (HOTL)
The ability to learn higher order thinking is a very important outcome for education. Higher-order thinking is more than just memorizing and understanding, and involves a variety of cognitive processes, such as making judgments, generating ideas, exploring consequences, reviewing

options, monitoring progress, and so on [8]. Higher-order thinking as thinking at a higher level rather than memorizing facts or explaining them again [9]. Higher order thinking will occur when someone associates new information with information that is already stored inside memory and connect and / or rearrange and develop the information to achieve a goal or find a solution to a situation that is difficult to solve [10]. Critical thinking as "intelligent thinking" which includes reasoning, questioning and investigating, observing and describing, comparing, and connecting, finding complexity and exploring points of view [11]. Higher-order thinking requires that individuals do things with facts, understand them, draw conclusions, relate to other facts and concepts, categorize them, manipulate them, put them together in new ways, and apply them when looking for new solutions to new problems.

Explorative Learning Model (HOTL-DI Type A)

The explorative learning used by the research team was formulated by Medellu in 2019) [7], namely the HOTL-DI Explorative Learning Model type A, using the Exploratory Format-1 (HOTL Process) which directs higher-order thinking learning activities.

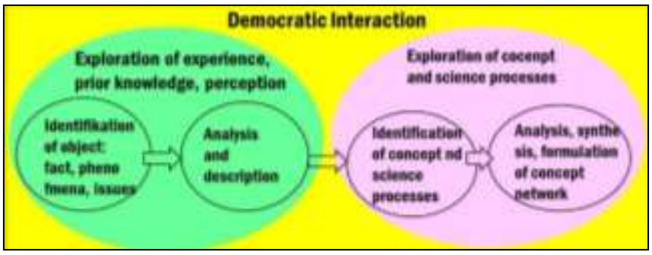

Fig 1: HOTL-DI Model Type A

This explorative learning model is used for learning objects that emphasize facts and natural phenomena around. The assumptions of this model are: the surrounding environment builds empirical experiences and impressions that attract or challenge individuals to understand them based on scientific concepts and processes. This model emphasizes two interactive components, namely the individualistic process of higher order thinking (HOTL: Higher Order Thinking Learning), and democratic interaction (DI: Democratic Interaction) as a process of sharing (opinions, experiences, perceptions) and collaboration between individuals in groups.

Format-1 (exploration process) includes two main parts, namely exploration of experiences, impressions and perceptions (blue column) and exploration of scientific concepts and processes (pink column).

Table 1: Fomat-1 Exploration (HOTL Process)

(1) Identify facts, phenomena, issues	(2) Analysis of facts, phenomena, issues	(3) Exploration of scientific concepts and processes	(4) Analysis-synthesis-formulation of scientific concepts and processes

Explanation of column contents:

1. Step to identify learned facts, phenomena, issues. This column is filled with facts / phenomena / issues, their limitations, distribution and changes, changing elements and influencing factors. Activities at this step are observation, measurement (if needed), discussion of references (association, comparison of phenomena / issues), and discussion of relevant experiences.
2. The step of analyzing facts, phenomena, issues. This column is filled with the results of the analysis of the relationship between sections, the relationship between variables and controlling factors and a description of these relationships according to the sequence of phenomena.
3. The step of exploration scientific concepts and processes. This column is filled with the results of the identification of concepts and processes related to variables, the relationship between variables and factors controlling change, distribution etc., following the contents of columns (1) and (2). Activities at this step are to record the results of concept identification and process descriptions, review references to get reinforcement, formulate scientific networks of concepts and processes so that scientific descriptions of phenomena / issues are obtained, formulate and carry out validation / testing referring to references and consistency of results, and consultation / ask for expert correction.
4. The analysis-synthesis-formulation step. This column is filled with the results of concept and process exploration, which are linked back to the analysis results (column-2). The data in this column describes the relationship between phenomena / issues (context) with scientific concepts and processes. This step integrates students' real experiences with theoretical / conceptual knowledge acquired in class or through reference. Activities at this step are to formulate and carry out validation / testing referring to references and consistency of results, seminars, and consulting / asking for expert corrections.

3. Methods

This study is an explorative research using the model of Explorative Learning HOTL-DI type A by Medellu in 2019, using a mixed-method design with both qualitative and quantitative data. This study explores natural phenomena, namely falling rainwater, and explores to reveal the thought process of the research subject, namely the process of higher thinking in exploring concepts or physical phenomena. The research subjects were students majoring in physics, who were prospective educators. This study was conducted in three main stages:

a. First Stage: Exploration by Researchers

This first stage aims to (1) gain experience carrying out exploration steps for objects, concepts, and processes (2) produce an exploration matrix reference used by researchers to facilitate exploratory learning activities for trial / mentor and target groups. In the first stage the research team also identified and formulated choices of learning activities used by the trial and target groups. The first stage of this research team was facilitated by the supervisor.

b. Second Stage: Exploration by Trial Group (Semester 3 Students)

This stage aims to (1) provide experience in conducting individual exploration stages (2) produce an exploration matrix (3) recruit mentors for the next stage, according to the target group's facilitation needs in order to increase cross-level academic interaction. In this second stage the researcher acts as a mentor who directs the trial group in exploring steps. The format results found misconceptions were straightened out by giving reflective questions. The format that was filled in by the trial group was reviewed by the research team as revision material for the next matrix reference. The completed format results are used as an assessment reference for the target group.

c. Third stage: Exploration by Target Group (Semester 1 Students)

This stage aims to (1) provide experience with individual exploration steps (2) produce an exploration matrix. The format results found misconceptions were straightened out by giving reflective questions. This last stage is facilitated by the research team together with the mentor who directs the target group in exploring steps.

The research data collection was carried out by providing the Exploration Format-1 (HOTL Process) to the research subjects to be filled in according to their higher-order thinking skills in exploring the phenomenon of falling rainwater. The filled format is then assessed using an assessment rubric that has been compiled based on existing material indicators. Qualitative analysis is in the form of an exploratory framework or the results of filling in format-1 from the research subject, variations in the variety of answers, consistency of answers and misconceptions of answers, as well as from the results of interviews. Quantitative analysis, among others, relates to the process of achieving scores and the achievement of exploration activities (assessment using a rubric) according to the level of conformity with reference material, as well as the development of exploration skills from the initial meeting to the next.

4. Results

The application of the HOTL-DI type A exploration learning model by Medellu (2019) to explore the higher-order thinking skills of physics students in exploring the concepts and physical processes of the phenomenon of falling rainwater, resulting in various answers. Overall, the exploratory step of phenomenon identification is answered by describing the phenomenon of each object. The description analysis step is often incompatible with the identification of the phenomenon in the previous step. Exploration of conceptual understanding and scientific processes as well as the formulation of concept networks is still lacking, and there are often deviant answers or misconceptions.

The new answers that deviate are rectified by reflective questions, some are changing and some are not. Only the few who understood then had the will to correct their mistakes. The cause can be from several things, namely the unwillingness of other subjects to find out the truth that exists, also because they do not understand the material and the application of the concept. The new correct answer is used as a revision of the material design.

4.1 The Design of Exploration Activities by the Research Team

The results of the exploration by the research team together with the supervisors resulted in a material design that was used as a reference for exploratory learning activities for research subjects. The design of the material consists of three objects based on the phenomenon of falling rainwater, namely: rainwater falling on the open ground; rainwater falling on grassy ground; and rainwater that fell on the roof. The design is flexible and open, it does not rule out new answers outside the design.

Table 2: Exploration Matrix of Object 1

Identification of phenomena	Analysis and description	Exploration of concepts and scientific process	Analysis-synthesis-formulation
 (ground on which the raindrops fall)	Holes lined up on the ground are caused by the collision of rainwater falling onto the ground	▪ Mass (m) of raindrops ▪ Velocity (v) ▪ momentum (p) ▪ Coefficient of restitution (e) ▪ Collision ▪ Kinetic energy ▪ Time (t) ▪ Gravity (g) ▪ height (h) / distance (s) ▪ • Potential energy	• Momentum p = mv • Inelastic collision $v = \frac{(m_1 v_1 + m_2 v_2)}{(m_1 + m_2)}$ • Kinetic Energy = $\frac{1}{2}mv^2$ • Potential Energy = mgh • relation of momentum and kinetic energy KE = $\frac{1}{2}mv^2$ p = mv $\frac{p^2}{m} = KE$

Table 3: Exploration Matrix of Object 2

Identification of phenomena	Analysis and description	Exploration of concepts and scientific process	Analysis-synthesis-formulation
 (grassy ground on which the	Raindrops fell on the grassy ground will cause the grass to have elasticity due to the collision of raindrop onto the grass. grass will reduce the amount of collision to the ground.	▪ Mass (m) of raindrops ▪ Velocity (v) ▪ momentum (p) ▪ Coefficient of restitution (e) ▪ Collision ▪ Kinetic energy ▪ Time (t) ▪ Gravity (g) ▪ height (h) / distance	▪ Momentum p = mv ▪ Inelastic collision $v = \frac{(m_1 v_1 + m_2 v_2)}{(m_1 + m_2)}$ ▪ Kinetic Energy = $\frac{1}{2}mv^2$ ▪ Potential Energy = mgh ▪ relation of momentum and kinetic energy

raindrops fall)		(s) ▪ Potential energy ▪ Height of grass (x) ▪ Elasticity ▪ Elasticity potential energy	▪ KE = $\frac{1}{2}mv^2$ ▪ p = mv ▪ $\frac{p^2}{m} = KE$ ▪ $E_{el} = \frac{1}{2}kx^2$

Table 4: Exploration Matrix of Object 3

Identification of phenomena	Analysis and description	Exploration of concepts and scientific process	Analysis-synthesis-formulation
 (rainwater falling on the roof)	Rainwater falling from the roof forms a projectile motion	Mass (m) of raindrops Velocity (v) Momentum (p) Collision with roof elevation angle (θ) Distance (s) of roof to ground / height (h) Time (t) Gravity (g) Projectile Motion (x-axis horizontal velocity) / uniform linear motion Projectile Motion (y- axis vertical velocity) / accelerated linear motion	▪ P = mv ▪ $V_0x = V_0 \cos\theta$ ▪ $x = v_{0x}\, t = v_0 \cos\theta \cdot t$ ▪ $y = v_{0y}\, t = v_0 \cos\theta \cdot t - \frac{1}{2}gt$ ▪ $V_0y = v_0 \sin\theta$ ▪ $x_{max} = \frac{v_0{}^2 \sin^2\theta}{2g}$ ▪ $h_{max} = \frac{v_0 \sin\theta}{g}$ ▪ $t_{max} = \frac{2v_0 \sin\theta}{g}$

4.2 Exploration Activities by the Trial Group

The exploration of scientific concepts and processes by the trial group / prospective mentor in this case the 3rd semester physics students at the first meeting (the first object) still experienced difficulties, because they had never explored phenomena before. Various answers exist such as in the phenomenon identification step, there are subjects who answer with sentences, some describe them, and some draw and include information. One of the research subjects added that a rainbow was formed, but this answer was not in accordance with what was directed by the research team. There were deviant answers, such as answering that the rain falling on the ground was caused by pressure, even though it was because of the momentum between the rainwater and the ground. There are also answers that emphasize the hydrological cycle when it rains so that it is not in accordance with the identification of existing phenomena. Answers also emerged which were still based on the general public's understanding and did not use good Indonesian. At the second meeting (the second object) the research subject had experienced an increase when identifying the phenomenon, but understanding of the concept and formulation was still lacking due to the complexity of the object. At the end of the meeting (the third object) exploration ability continues to increase, due to the habit of doing phenomena exploration activities.

The results of the exploration score achievement of the trial group are shown in table 5.

Table 5: Exploration Score of Trial Group

Object	Exploration Steps			
	1	2	3	4
1	8,26	3,26	3,44	2,19
2	8,33	2,5	1,52	0,31
3	10	8,75	5,31	9,76

Exploration scores range from 1-10 based on the scoring rubric.

4.3 Exploration Activities by The Target Group

The target group's exploration activities were facilitated by mentors who had been previously recruited, namely the 3rd semester physics students as senior students. Format-1 has been filled in by the target group directed by the mentor, resulting in a variety of answers. In the phenomenon identification step, there are research subjects who describe correctly, some are not right, there are also research subjects who answer incorrectly by describing the hydrological cycle and some are describing rainwater falling in the ocean. There is an answer to object 3 which answers correctly by describing the motion of the parabola when the rain falls onto the roof then on to the ground, other research subjects only describe rainwater falling onto the roof. Various answers also appear in the description analysis step, there are research subjects who are able to describe the phenomenon accurately and many do not get an exploration score. Some of the deviant answers exist such as: pressure, error in the formulation of momentum, and explaining the contents of the image, not explaining phenomena. New appropriate answers were identified, such as several formulations for parabolic motion. The answers are then used as a revision of the material design.

The development of the target group's exploration ability is shown in figure-2.

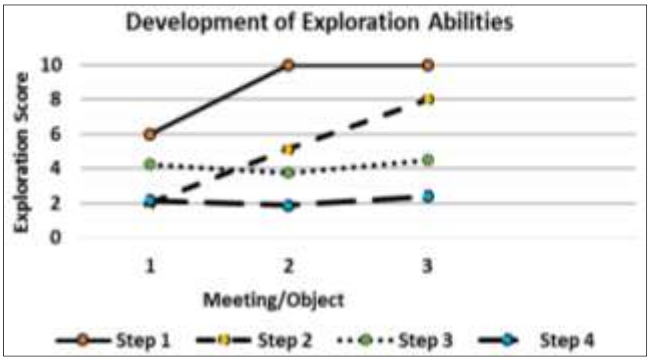

Fig 2: Development of Exploration Abilities

Exploration scores range from 1-10 based on the scoring rubric. The object in this case is associated with the meeting. There are developments and improvements in exploration capabilities from the initial meeting to the next meeting. Judging from step 1 of exploration, at the beginning of the meeting or on object 1 the research subject is less able to identify existing phenomena, this is due to a lack of experience to identify phenomena in the natural surroundings. At subsequent meetings, namely object 2 and object 3, the research subject has increased, meaning that they have been able to identify the phenomenon because they already have experience at the beginning of the meeting.

Step 2 of exploration describes a gradual increase in each object or encounter. This shows that the experience of exploring increases the ability of research subjects to think at higher levels. Exploration of concepts and processes or step 3 is influenced by the complexity of the object. For a simple object, namely object 1, the third step is higher than the more complex object, namely object 2. Likewise for the fourth exploration step, which is a step to formulate. Judging by each object (meeting), at object 1 or the initial meeting the research subjects experienced difficulties in the exploration step 2, namely the description analysis and in the exploration step 4, namely formulation. At object 2 or the second meeting there is a decrease in each exploration step. Likewise with object 3.

The results of the graph analysis of the development of exploration abilities can be concluded that the factors that influence exploration ability are the experience of exploring the object's complexity.

5. Discussion

Based on the data of the results, it can be seen that the ability to explore increases at each meeting. This means that explorative learning has the potential to improve the ability to explore physical phenomena as well as the ability to learn higher order thinking.

Rahayu[12] found that explorative learning strategies can provide a new learning atmosphere for students because students are led to be creative through exploration activities and have an impact on visualization skills and conceptual understanding.

In line with Reiter's[6] findings, the exploratory research conducted has become an instrument of expanding knowledge, awareness, and conceptual and intellectual expansion. It has emancipatory potential and is in the best sense a process of raising awareness, and of education.

Wang and Wang[8] suggest that there are many terms for composing higher-order thinking in literature, such as critical thinking, reflective thinking, integrative thinking, good thinking, deep thinking. Based on the assessment during the learning process, exploration activities familiarize research subjects to think critically in solving problems, namely exploring natural phenomena. Reflective thinking is formed when knowing and correcting mistakes through reflective questions. When connecting everyday experiences in nature with existing learning forms integrative thinking. Good and deep thinking goes hand in hand with exploration activities.

6. Conclusion

The HOTL-DI type A explorative learning model has the potential to improve students' higher-order thinking ability in exploring physics phenomena in the surrounding environment. This explorative learning provides a new learning atmosphere so that it can increase initiative and motivation to learn. The learning process is shown by students from beginning to end doing exploration activities, where at the beginning of exploring, they still experience difficulties so that they need more assistance from mentors. The ability to explore continues to increase to the next meeting. Students are able to identify phenomena, describe them, understand scientific concepts and processes, and formulate comprehensive concept networks.

7. Acknowledgment

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