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Democratic interaction in explorative learning (Model HOTL-DI Type A) About the phenomenon of rainwater falling from the roof

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Abstract
Natural phenomena around form diverse experiences in students. The variety of experiences and perceptions that are formed in the cognitive structure can be integrated with formal learning in the classroom in order to strengthen the relationship between context and concept. This article discusses the part of group democratic interactions from the results of exploratory learning research using the Higher Order Thinking Learning in Democratic Interaction (HOTL-DI) type A model. Collaborative research includes sections exploring contexts and concepts that are individual, and democratic interactions in student groups. Students are directed to explore experiences, impressions and perceptions about the phenomenon of rainwater falling from the roof, discuss democratically to produce common conclusions. The results of the study show a variety of scores for each democratic indicator. Undemocratic attitudes were identified, such as imposing one's own opinion, apathy and waiting for the results of the work of other group members, making unilateral agreements without discussing them, and not having the courage to express opinions. Exploring the phenomenon with the group increases productivity and work efficiency from the beginning of the meeting to the next meeting.

Keywords: explorative learning, democratic interaction, rain phenomena

1. Introduction
Learning in formal schools tends to be rigid because it only comes from books and limits learning creativity. Learning which is dominated by concept development through problem practice in textbooks causes difficulties for students in understanding the basic concepts of physics [1]. Learning can be done anywhere, not only in the classroom but also from the surrounding environment. Such learning makes students more united with nature, because they experience it directly [2]. The surrounding environment can be an optimal learning medium, because experiences in the environment have been formed since childhood. The views and imaginations that shape individual perceptions, experiences and conclusions on facts / phenomena in the environment can be the same or different. Indeed, every opinion that exists can complement each other so that you can see the whole thing about something. Unfortunately what happens, each individual in the group tends to feel that their opinion or view is the most correct.
A democratic attitude is needed in joint learning activities. Dewey in Starkey [3] argues that democracy requires free association and interaction within and between communities, democracy is achieved as a result of consensus on common goals and values rather than through coercion.. Education must promote democracy as a way of life that requires knowledge, skills, attitudes and values[4]. Democratic attitudes and behaviors can be built through learning interactions based on themes about the surrounding environment, where students have experiences (same or different) about these objects [1]. This can be realized through explorative learning.
Explorative learning offers, an alternative way to "make sense" of the world, offering new approaches and angles, and counter-hegemonic alternatives to the act of explaining the world [5]. Pembelajaran eksploratif dapat memfasilitasi kegiatan belajar kelompok untuk menggali fakta-fakta atau fenomena alam. Medellu [6] in 2019 designs a model of explorative learning that used in this study. Explorative Learning (HOTL-DI Type A) is a colaborative research that asseses the individual's ability to think at higher levels, and the process of interaction that occurs in groups. This study assesses the democratic interaction process. Democratic interaction is designed to share experiences, knowledge, and perceptions of individual through gorup interaction[7]. This study is carried out in 3 main stages: exploration by the research team and the preparation of indicators for democratic interaction; explorative learning in democratic interaction of the mentor group (trials); explorative learning in democratic interaction of the target group. This study aims to: (a) explore the concepts and scientific processes of the phenomenon of falling rain, (b) determine the learning process of democratic interaction in groups.

2. Conceptual Framework
Democratic Interaction (DI)
Democratic interaction includes the activities of delivering the learning outcomes of each individual's thinking that can differ in understanding, perceiving objects / phenomena[6]. These differences can be designed as a form of joint learning activities such as discussion, observation, measurement, reference review, analysis and formulation of results and drawing conclusions. Common conclusions can be general descriptions of specific phenomena and characteristics. Democratic attitudes and behaviors can be built through learning interactions based on themes about the surrounding environment, where students have

experiences (same or different) about these objects [1].
Sezer[8] argues that in a democratic educational environment interpersonal relationships must be built on democracy values, including the following characteristics: tolerance, cooperation, mutual trust, interdependence, mutual respect, mutual responsibility, recognition of human dignity, respect for human rights, responsibility, cooperation, care for others, critical thinking, freedom expression, sharing, collaboration, active participation, equality, cooperative learning, cooperative, rewarding loyalty, mutual peace, and human rights, and democratic participation.
Democratic values according to Zamroni [9] include tolerance, freedom of expression, respect for differences of opinion, understanding diversity in society, openness in communication, respect for human values and dignity, self-confidence and not depending on others, mutual respect, ability to self-restraint, togetherness, and balance.
The assessment of democratic attitudes in this study uses indicators formulated by Medellu [6], namely:

1. Courage and freedom of expression,
2. respect the opinions of others,
3. encourage friends to actively participate
4. Giving positive criticism of a friend's opinion or work
5. Appreciate criticism of friends and provide an explanation of the similarities and advantages of personal opinions with those of friends,
6. Discipline and responsibility for collective agreement,
7. Willingness to use private facilities for joint activities.

Explorative Learning Model (HOTL-DI Type A)
The explorative learning used by the research team was formulated by Medellu [6] in 2019, namely the HOTL-DI Explorative Learning Model type A, using the Exploratory Format-1 as a guide for exploration steps.

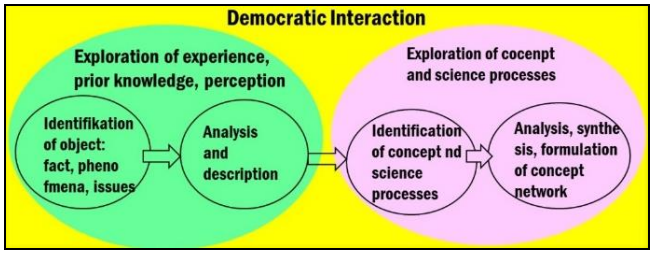


Fig 1: HOTL-DI Model Type A

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

(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. Phenomena/fact identification. This step is filled with phenomena / facts studied. Activities at this step are observation, measurement (if needed), discussion of references, and discussion of relevant experiences.
2. Analyzing facts, phenomena, issues. This step is filled with the results of the analysis factors and a description of these relationships according to the sequence of phenomena.
3. Exploration of scientific concepts and processes. This step is filled with the results of the identification of concepts and processes related to variables, the relationship between variables and factors controlling change, following the contents of step (1) and (2).
4. The analysis-synthesis-formulation step. This step integrates students' real experiences with theoretical / conceptual knowledge acquired in class or through reference. 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.

3. Methods
This research is an exploratory research with the HOTL-DI type A Explorative Learning model by Medellu[6] in 2019, with a mixed method approach, namely qualitative and quantitative. Qualitative data is a process of exploration and democratic interactions that occur in groups. Quantitative data is the score of each indicator achieved. The assessment score for democratic interaction indicators uses a Likert[10] scale of 1-5 with the criteria: very poor (score 1), poor (score 2), fair (score 3), good (score 4), excellent (score 5).
The object being explored is a natural phenomenon, namely falling rainwater on the roof. The research subjects were students majoring in physics. The study is carried out in three main stages:

a. First Stage: Exploration by the research team and drafting of indicators for democratic interaction. Aims to (1) provide experiences to researchers carrying out exploration steps for objects, concepts, and processes (2) produce exploration matrix references, to facilitate exploratory learning activities for groups (3) produce indicators of democratic interaction used as a guide for assessment of learning activities.
b. Second Stage: Exploration and democratic interaction by the trial/mentor group (Semester 3 Students). It aims to (1) provide experience in doing exploration steps in groups (2) produce an exploration matrix (3) assess the learning process in democratic interactions (4) recruit mentors for the next stage.
c. Third stage: Exploration and democratic interaction by the target group (Semester 1 Students). This stage aims to (1) provide experience in doing exploration steps in groups (2) produce an exploration matrix (3) assess the learning process in democratic interactions. This last stage is facilitated by the research team together with

the mentor who directs and assesses the democratic interaction in groups. On this stage the intensity of each democratic indicator is analyzed.

The research subjects were divided into 3-4 people in 1 group, and given an format-1 (exploration process). Researchers and mentors assess the interactions that occur in groups when exploring phenomena, based on 7 existing democratic indicators, with an assessment scale of 1-5. So that it can be assessed a democratic learning process in explorative learning.

4. Results

Explorative learning in groups becomes a place for learning activities where differences in opinions and views of each individual are brought together to produce common conclusions. Each individual in the group has a different view even though they see the same object or phenomenon. Attitudes and behaviors are identified in group learning that do not reflect democratic values. Some students are passive and apathetic, just waiting for group assignments to be done by friends who are considered capable. There are also students who do not give the opportunity or accept their friends' opinions to be discussed together. In terms of exploratory phenomena, deviant answers or misconceptions are accepted without being reviewed. In groups, not all group members are actively involved in discussions. Based on observations during research, the efficiency of discussion in groups should be done with a minimum of 3 people in the group and a maximum of 4 people in the group.

4.1 The Design of Exploration Activities by The Research Team

As an initial step to facilitate exploratory learning activities, the research team together with the supervisors designed exploration material based on the objects, namely the phenomenon of falling rainwater, by focusing on: rainwater falling on the ground; rainwater falling on the grassy ground; and rainwater that falls on the roof. This design for reference only, and is not shown to students.

Table 2: Exploration Matrix of Object 1

Identification of phenomena	Analysis and description	Exploration of concepts and scientific process	Analysis-synthesis-formulation
 (rainwater falling on the open ground)	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
 (rainwater falling on the grassy ground)	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 (s) ▪ Potential energy ▪ Height of grass (x) ▪ Elasticity ▪ • Elasticity 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 $\frac{p^2}{m} = KE$ ▪ $E_{el} = \frac{1}{2} kx^2$

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 $V_0x = V_0 \cos\theta$ $x = v_{0x}\, t = v_0 \cos\theta \cdot t$ $y = v_{0y}\, t = v_0 \cos\theta \cdot t - \frac{1}{2}gt$ $V_0y = v_0 \sin\theta$ $x_{max} = \frac{v_0^2 sin^2\theta}{2g}$ $h_{max} = \frac{v_0\, sin\theta}{g}$ $t_{max} = \frac{2v_0\, sin\theta}{g}$

The indicators used to assess the democratic learning process are arranged based on learning needs, that is attitudes and behaviors that need to be assessed when interacting in groups. The indicators that have been compiled are: (1) Courage and freedom to express opinions, this is necessary so that individuals can express their thoughts without fear; (2) Being able to respect other people's opinions, which is important in order to build good cooperation and avoid chaos in group discussions; (3) Encourage friends to actively participate, so that the discussion will run smoothly if all group members are active in solving problems; (4) Giving positive criticism of the opinion or work of friends, criticism that is positive and constructive will give a sense of being appreciated by fellow group members; (5) Appreciate criticism from friends and provide an explanation of the similarities and advantages of personal opinions with those of friends, this is necessary in order to avoid a complicated debate if it is not accompanied by an explanation; (6) Discipline and responsibility for collective agreement, this reason is an indicator because a good group character is when someone is disciplined with rules and has a sense of responsibility for what has been mutually agreed upon by the group; (7) Willingness to use private facilities for joint activities, giving of oneself totally in groups is needed, for example by providing personal facilities for the needs of the group will form an attitude that is not selfish and like helping each other.

4.2 Exploration Activities and Democratic Interaction by the Trial Group

At the beginning of interacting in groups, research subjects still have difficulty making decisions about the answers they will use in the group. The attitude of imposing one's own answers and also inactivity in the group can be seen in exploration and interaction activities. This stage is carried out in order to get a good overview for the next research stage. The trial group exploration was carried out in 2 meetings (object 1 and object 2). The democratic learning achievement of each indicator are shown in table 5 and table 6.

Table 5: Achievement of Democratic Interaction on Object 1

Exploration Steps	The Average Score of The Democratic Interaction Indicator						
	1	2	3	4	5	6	7
1	4.5	3.9	3.9	3.8	4.1	4.6	4.4
2	4.5	3.8	3.9	4	4	4.4	4.4
3	4.4	3.7	3.9	3.9	4.1	4.7	4.3
4	4.3	4	4.1	4.2	4	4.6	4.6

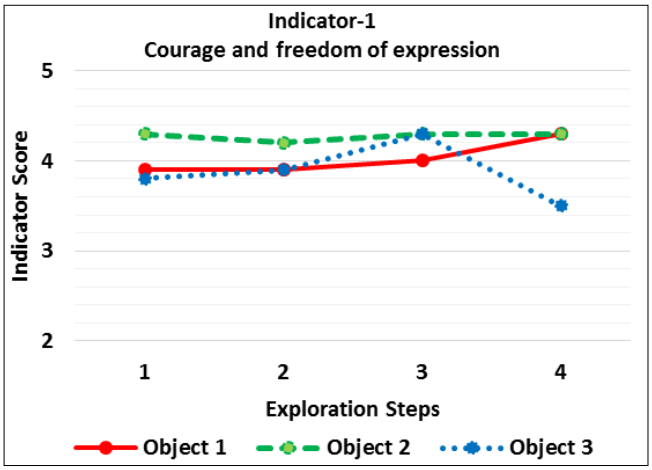
Table 6: Achievement of Democratic Interaction on Object 2

Exploration Steps	The Average Score of The Democratic Interaction Indicator						
	1	2	3	4	5	6	7
1	4.2	3.9	3.8	3.7	3.9	5	3.8
2	4.4	3.7	3.8	4.3	3.8	5	4.1
3	4.1	4	4.4	4	4	5	3.9
4	4.2	4	3.9	4.2	4.1	5	4.1

The column of average score for the achievement of Democratic Interaction is the score achievement of each indicator which has been averaged from the results of each individual in the group. Then, averaged the scores for each indicator of the achievements of all groups for each exploration step. The data presentation in the table shows the achievement of the democratic interaction score at each exploration step. At this stage, mentors are recruited who will direct and assess the democratic learning process on the target group.

4.3 Exploration Activities by The Target Group

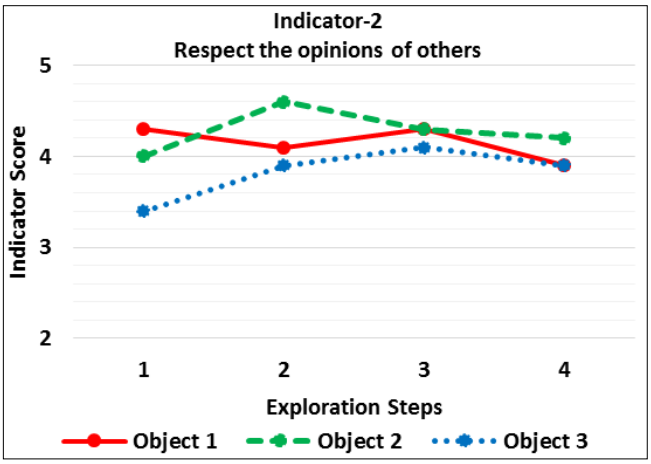
Mentors who have been previously recruited act as guides to encourage, motivate and assess the learning process of democratic interaction by the target group. This is intended to increase cross-level academic interaction. The data on this target group will be analyzed in the learning process of democratic interaction in exploring physics phenomena. The intensity of the democratic interaction of each indicator is shown in the graph. On these graphs, objects are associated with meetings.



Graphic 1: Intensity of Democratic Interaction on Indicator-1

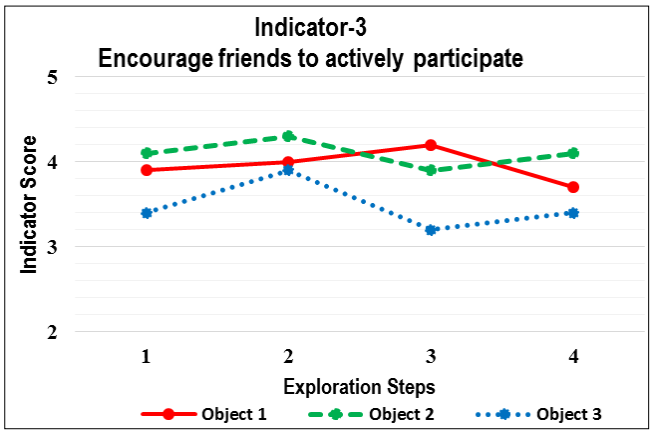
Based on the graph, it can be seen that in the exploration step 1 for the first meeting to the second meeting there was

an increase in this because at the beginning of the meeting or in the first object the students did not have experience exploring in groups so that it was less daring to express opinions and there was still an attitude of fear of being wrong in concluding answer. At the third meeting there was a decrease in the achievement score, this was due to the complexity of the object 3 so that the students hesitated in expressing their opinion about what they knew. The same thing happened in exploration step 2. In exploration step 3 there is a similar increase for objects 2 and 3 from object 1, this is because the students have started to get used to exploring in groups so that they can boldly and freely undertake exploration step 3, namely to express what they know about the concept of physics in rain phenomena. There is a decrease for object 3 in exploration step 4, this is because the attitude of fear of being wrong to formulate the concepts. Courage and freedom to express opinions from the beginning of the meeting to the next meeting are influenced by the experience of exploring phenomena in groups as well as the complexity of the object. Not all group members participate in expressing opinions, this is influenced by the fear of being wrong as well as by ignorance of the related phenomenon. The democratic interaction on indicator 1 is included of the criteria fair to good.



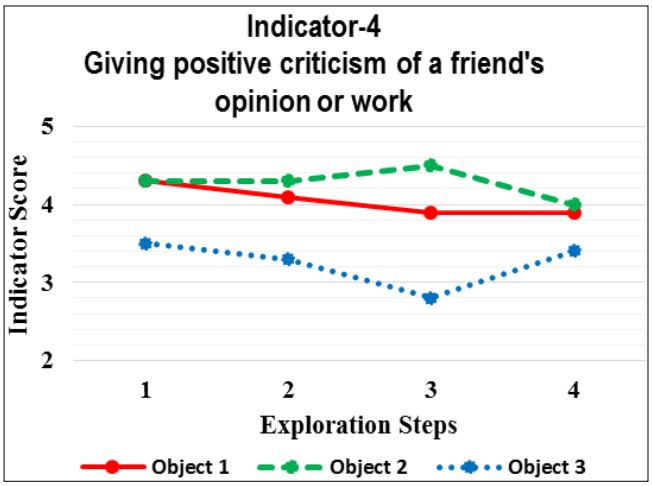
Graphic 2: Intensity of Democratic Interaction on Indicator-2

Judging from the graph, in the exploration step 1, there is a decrease in the score of each meeting or object, this happens because the more the students gets used to identifying the phenomenon, the more individuals impose their own opinion and do not respect the opinions of others. In exploration step 2, namely the description analysis, there is an increase from the first meeting to the second meeting, this is due to the difficulty level of exploration step 2 so that the group members listen to each other and respect the opinions of others to get some answers from various points of view, and there is a decrease in the third meeting because of the complexity of object 3 which makes group members force their own answers which are considered correct. This also happens in exploration step 3 and exploration step 4. Viewed from the initial meeting to subsequent meetings, there is always a decrease in the meeting or object 3. During the interaction process, an attitude of selfishness and disrespect for other people's opinions arises because they respond to the most correct answer, even though there are often some deviant answers or misconceptions. The democratic interaction on indicator 2 is included of the criteria fair to approach very good.



Graphic 3: Intensity of Democratic Interaction on Indicator-3

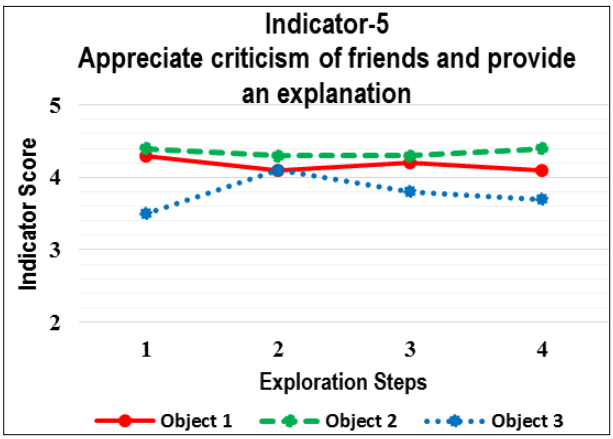
In the exploration step 1 there is an increase from the first meeting to the second meeting because the students already has experience exploring object 1 so that it can encourage other friends to actively participate in object 2, while the decrease that occurs at the third meeting is caused by the complexity of object 3 which makes group members are less sure of their own answers so they are unable to encourage the activity of other friends. The same thing happened in exploration step 2, namely to analyze and describe phenomena. In the exploration step 3 there was a decrease in the score from the beginning of the meeting to the following meeting because step 3 was a step to explore the concepts and processes of physics so that group members were active enough so that no peer encouragement was needed. In the exploration step 4, namely the steps to formulate a concept, things like in the exploration step 1 and the exploration step 2 occur. Judging from the overall object, the lack of mutual encouragement of friends to actively participate occurs in object 3 which is caused by the complexity of object 3 as described above. Some reasons group members do not encourage each other to actively participate, namely because of their belief in their own answers so that they do not need activeness from other fellow group members, as well as an attitude of indifference to others. Group members who encourage other friends to actively participate have the attitude of a leader who wants good interaction in the group. The democratic interaction on indicator 3 is included of the criteria fair to good.



Graphic 4: Intensity of Democratic Interaction on Indicator-4

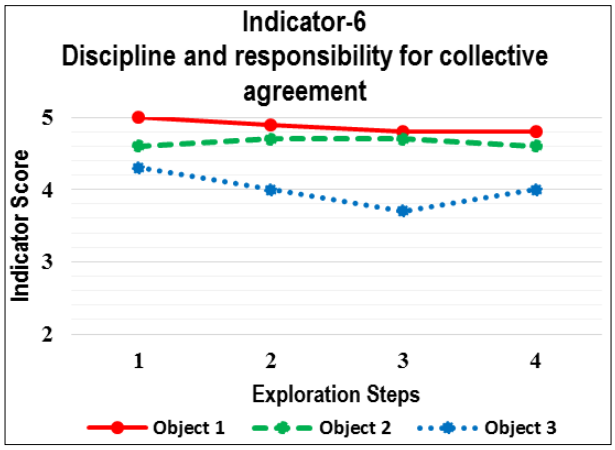
Give positive criticism of a friend's opinion or work, in this

case the work is in the form of an answer as well as an image in the phenomenon identification step. From the graph, it can be seen that based on the meeting to the following meeting or from existing objects, there is an increase in the score from object 1 to object 2 then down on object 3. The increase in score occurs because at the beginning of the meeting, the students already gained experience to explore phenomena in group interactions and are getting used to the second meeting. An attitude of giving positive criticism to a friend's opinion occurs when answers are found that cannot be accepted by most group members but can still be criticized positively by other members. In object 3, the existing democratic interaction is classified as not good to fair, the decrease in the score of object 3 is caused by the complexity of the object, so it is found that fellow group members blame each other's opinions also when there is an image in the exploration step 1, there are groups arguing with the image. The democratic interaction on indicator 4 is included in varied criteria that is fair to good.



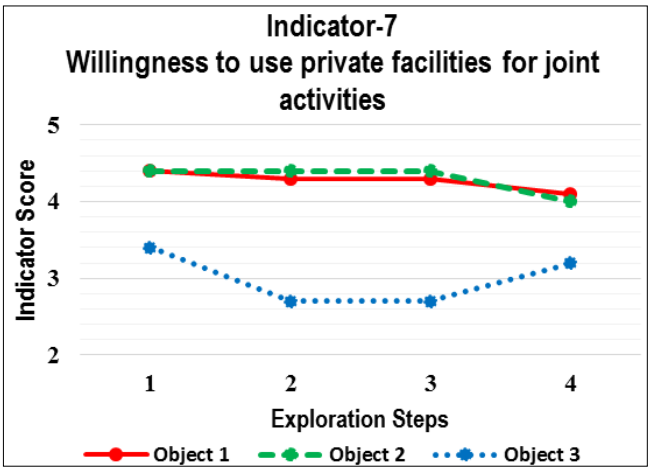
Graphic 5: Intensity of Democratic Interaction on Indicator-5

Good interactions occurred at the first meeting and the second meeting. At the third meeting the indicator score fell, it can be seen in the exploration step 1 which is the lowest score. This occurs when the group identifies the phenomenon and begins to describe it, other group members criticize the image created by giving their opinion but without an explanation of the superiority of the opinion. The democratic interaction on indicator 5 is included of the criteria fair to good.



Graphic 6: Intensity of Democratic Interaction on Indicator-6

Based on the graph, it can be seen that there was a decrease in the score for each meeting. This is due to the complexity of the object, which initially on object 1 is a raindrop that falls on the ground then on object 2 on the grass and on object 3 on the roof. The difficulty level of the objects that exist makes group members hesitate to decide something in the group and become irresponsible for collective agreement. Not responsible in this case cannot explain the reasons for what is done together. The level of difficulty on each object in each meeting makes the group argue with each other on their respective answers, this shows an undisciplined attitude or does not show orderly behavior and is obedient to various existing provisions and agreements. The democratic interaction at the first meeting was very good, at the second meeting it was good, at the third meeting it was fair to good.



Graphic 7: Intensity of Democratic Interaction on Indicator-7

Willingness to use personal facilities for joint activities, such as stationery, cellphones and other personal facilities used when working in groups. In object 1 and object 2 there is a good interaction at each existing exploration step. Whereas for object 3 the indicator score was good at exploration step 1 and exploration step 4, and fair at exploration step 2 and exploration step 3. The unwillingness to provide personal facilities for the common interest occurs due to several reasons, namely because they do not have facilities that can be used as well as because they do not want to lend and occur because they think that other group members can give theirs.

5. Discussion

Based on the data, the score achievement is different for each indicator. The score for each indicator is influenced by differences in the attitudes of each individual when discussing in groups. Exploration skills are continuously built from each meeting so that students have the experience of discussing and exchanging opinions together to analyze a phenomenon. Exploration activities in groups increase learning productivity, namely by filling in the explorative learning format-1. This is consistent with the research conducted by Latifah [11] where the results show that the application of the group discussion method is an effective method in order to maximize the involvement of students so that it can increase the achievement of student learning outcomes.

The results of this study indicate that the interactions during

the group discussion process can result in joint problem solving. This is in line with the research of Lesilolo *et al*. [12] where the results show that democratically independent learning opens spaces for interaction and cooperation among students so as to provide opportunities for finding ideas. Between students there is an effort to complement each other's opinions and ideas so that the flow of students' thoughts can develop.

Paulo Freire in Breault [13] states that to achieve educational democracy it is necessary to create freedom of interaction between educators and students in the learning process in the classroom. This is what the mentors did. Mentors who are senior students direct the interaction process in groups so that the junior students receive guidance but remain within limits (mentors do not provide answers, only direct). Korkmaz and Erden [4] argue that in a democratic environmental education, it must have a feature to individualize instruction; needs and strengths; activate the attention of students in all decisions; simulates real life, encourages active learning, and helps students acquire the knowledge, skills, and attitudes necessary for democratic life and self-improvement.

Undemocratic attitudes were also found during the study such as the attitude of imposing one's own opinion and disrespecting the opinion of group members, the attitude of not wanting to discuss, and the attitude that criticizes negatively. Each individual in the group has their own character, some are active and encourage other friends, but some are passive and indifferent. This is a strong reason that the group learning process must be monitored and facilitated for productive democratic interactions [6].

Differences in experience, prior knowledge, and perceptions of objects can be bridged through democratic interactions [7]. Patterned democratic interaction through study groups is an individual asset in behaving and behaving democratically in a wider and more diverse group. This individual capital is at the same time social capital for a harmonious community life [6].

6. Conclusion

HOTL-DI exploratory learning conducted in groups has the potential to integrate daily experiences in the surrounding environment into formal learning, as well as integrate democratic character education in the learning process. A democratic learning process is formed from the initial meeting to the next meeting. Different opinions and views exist to complement each other so as to find new and comprehensive ideas.

7. Acknowledgment

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