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APPLYING COLLABORATIVE RANKING TASKS TO IMPROVE STUDENTS' CONCEPT MASTERY AND GENERIC SCIENCE SKILLS

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ABSTRACT

The lack of students concept mastery and generic science skills underlying this research. The purpose of this research was to improve the students' concept mastery and generic science skill by applying the collaborative ranking-task model in Earth and Space Science learning. This type of research was a classroom action research, conducted in two cycles. The data were collected by observation technique, test, and questionnaire. The study was conducted on physics students amounted to 25 people (10 male and 15 female). The success of the study was determined by the grade point average which should be at least 70. The obtained data were analyzed descriptively. The results showed that there was an increase in the students' concept mastery starting from cycle 1 to cycle 2 ($\bar{X}_{x1} = 50$, $s_1 = 11.4$ in the 'deficient' category; and $\bar{X}_{x2} = 64$, $s_2 = 8.3$ in the 'sufficient' category). The generic science skills were numerically increased from cycle 1 to cycle 2 ($\bar{X}_{x1} = 58.4$, $s_1 = 13.3$; $\bar{X}_{x2} = 62.8$, $s_2 = 10.2$; in the 'moderate'category). The developed indicators of generic science skills included indirect observation, logic inference, and concept building. The mean score of student response was $\bar{X}_x = 58.6$; $s = 6.7$ which was in the positive category.

Keywords: collaborative ranking tasks, concept mastery, generic science skills

INTRODUCTION

The Earth and Space Science is a subject taught from elementary school to college level. The Earth and Space Science (ESS) has become an interesting subject for many people having either science or non-science educational background (Duschl & Grandy (2013). In Physics Education Department of Universitas Pendidikan Ganesha, ESS is a compulsory subject for physics teacher prospective students. This course aims to provide students with an understanding of concepts of the earth and space science as well as to develop generic science skills. Furthermore, the course is also intended to develop students' thinking skill. Lelliote & Rollnick (2008) obtained that most of the students perceived astronomy subject relatively more difficult than that of earth science. This result was also reflected by the students' learning outcome of astronomy subject was quite low (Hudgin et al., 2008). A preliminary observation showed that only 25% of the students mastered the concept of ESS course in the Physics Education Department of Universitas Pendidikan Ganesha (Pujani, 2013). In addition, the generic science skills students were also not developed optimally (Pujani, 2013).

One of the factors contributing to the low percentage of students was the learning strategy applied by the lecturer. The Earth and Space

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Science's learning was dominated by lecturing methods which did not facilitate the students' participation to develop their thinking skills. The students were less involved in collaborative work, so, there was no sharing of knowledge and discussion. In addition to learning strategies, teaching materials were also seen as the cause of low student learning outcomes. Lecturers lacked teaching materials that encouraged the students to discuss, work collaboratively, and develop reasoning. The above findings indicated that the students' modest concept mastery of ESS was due to the lack of optimal lecturing process, and lack of proper classroom activities. Puspitasari & Permanasari (2012) found that 87.16% of lecturers constantly applied information discussion method and exercise questions in the chemistry courses, although the lab facilities were adequate. The lessons were dominated by lectures, assignments, demonstrations, while lecturers less facilitated the needs of students in class discussions. This is what-so-called the traditional learning (Fraknoi, 2011). Traditional learning focuses more on the transmission of knowledge (subject content) from teachers to students through a passive acceptance process. Students learn through memorization so that the concepts they receive are quickly forgotten. This shows that traditional learning is less effective in maintaining students' concept mastery. Some studies have shown that the traditional learning model is less effective in developing students' understanding that than the constructivist learning (Freeman et al., 2014; Ogan-Bekiroglu et al., 2014). In addition, the traditional learning model emphasizes less on the developing of students' thinking skills, such as generic science skills.

Science learning is an active process where students are physically and mentally active in constructing knowledge. Science education research shows that students' understanding increases if learning strategies involving activities in the learning process are applied. Therefore, the students' active involvement in learning will lead to an increase in students' concept mastery and generic science skills. Some research done by Freeman et al. (2014); Saprudin et al. (2010); Wijaya & Ramalis (2012); Anwar (2014); and Harahan et al. (2017) showed that active learning is effective in developing the concept mastery and generic science skills.

The concept of mastery is the students' mastery level of the materials taught in a subject. There are three criteria of mastery, namely: the coherence of well-defined parts of concepts, the correspondence between a person's internal representation and the conceptual material that can be understood, and the relationship between one's background knowledge with the studied matters (Matlin, 2003).

Generic Science Skills (GSS) are basic skills that future teachers need to have, applicable to a variety of fields, and independent knowledge of a particular domain but lead to cognitive strategies (Gibb, 2002). According to Brotosiswoyo (2000), there are 9 (nine) the GSS indicators; direct observation, indirect observation, scale awareness, symbolic language, principle-based theoretical framework, logical inference, causal law, mathematical modeling and concept building

To address the issues outlined above, there was a need for action interventions that lead to student-centered learning to increase activity and involvement in learning. Such learning should also be able to develop and improve the concept mastery and generic science skills. Learning should be aided by tasks that guide students to develop scientific thinking skills such as; formulating problems, collecting data and testing, testing through experiments, explanatory formulations, and application of concepts. One of the models suitable for the above concern is the collaborative ranking tasks.

The Collaborative Ranking Task (CRT) model is a learning model in the form of conceptual exercises combined with the collaborative activities of students in the classroom (Hudgins, 2008). The constructivism theory underlies this CRT model in which students build new knowledge by connecting the new one with their needs and capacities as well as integrating it to their own cognitive structure (Arend, 2007). There are 5 (five) stages in Collaborative Ranking Task learning; dealing with problems, data collection, experimental testing, explanatory formulation, and application of concepts.

In learning with the collaborative ranking task, teachers insert a task in the form of ranking task exercises to direct students' discussion activities during the lesson. This learning model has been developed by Wambugu (2008) in physics lessons to improve students concept mastery. Henderson et al., (2012) developed a ranking task in physics learning combined with the "Physlet" simulation program. In astronomy, Hudgins (2008) developed a rank task combined with collaborative learning or collaborative ranking task to improve student astronomy. Wijaya (2009) uses the collaborative ranking task in e-learning assisted Earth and Space Science learning to develop students' concept mastery. Aktan & Dinçer (2014) uses ranking task questions in assigning exams to prospective teachers for Kepler's law topics.

Referring to the findings of several studies on the CRT above, it turns out that the CRT model has been proven to offer significant results on the concept mastery, but no one has investigated the development of generic science skills in a CRT learning. Therefore, the researchers applied the CRT model in ESS learning, through classroom action research aimed at improving the students' concept mastery and generic science skills. The scope of the problem was limited to the implementation of collaborative-tasking exercises in ESS lectures for the Phase of the Moon and Kepler's Law. Through this intervention, it was expected that the students' concept mastery of ESS and the generic science skills increased significantly. In addition, it was also expected that this model could foster students to actively and creatively involved, and at the same time make a fun learning. The researchers hoped that the results of these interventions became the foundation for educators to choose the Collaborative Ranking Task as an alternative learning on ESS subject.

METHODS

This research type was Classroom Action carried out to 25 students (10 males and 15 female) in the 6th-semester, Physics Education Department, Universitas Pendidikan Ganesha. The research object was the concept mastery, generic science skills, and students' responses to the model of the implemented learning. The research conducted in two cycles consisting of four stages each: planning, action, observation/evaluation, reflection. The research design adopted the Kemis& Taggart (1982) model as shown in Figure 1.

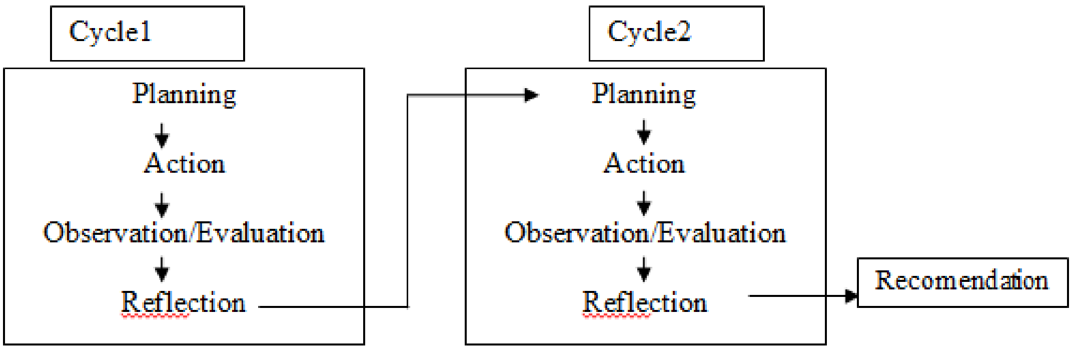

Figure 1. The Research Design

The cyclical determination was also based on the Earth and Space Science materials created in ranking task excercises (RTE) form. The materials in each cycle are shown in Table 1 below.

Table 1. The Earth and Space Science Materials

Cycle	Topic	Materials	Note
1.	Moon Phases	Moon revolution	1 meeting
		Eclipses	1 meeting
		Test of Cycle1	1 meeting
2.	Kepler's Laws	Kepler's Law I	1 meeting
		Kepler's Law II	1 meeting
		Kepler's Law III	1 meeting
		Test of Cycle 2	1 meeting

The data collected in this research were learning activities, concept mastery, generic science skills (GSS), and students' responses. The data types, methods, instruments and time of data collection are presented in Table 2.

Table 2. Data Types, Methods, Instruments, and Data Collection Time

Data Types	Methods	Instruments	Data collection time
Concept mastery	Objective test	Multiple choices	The end of the cycle
GSS	Objective test	Multiple choices	The end of the cycle
Learning activities	Observation	Observation guidance	During the learning process
Response	Questionnaire	questionnaire	The end of the second cycle

Furthermore, the data of Earth and Space Science concept mastery and GSS were analyzed descriptively and the conclusion was drawn based on the criteria in the assessment guidelines set in the Physics Education Department FMIPA Universitas Pendidikan Ganesha, while the qualifications employed are displayed in Table 3.

Table 3. The Guidelines for Students' Conversion Concept Mastery and GSS

Score Interval	Concept Mastery Category	GSS Category
85.0 - 100.0	Very good	Very high
70.0 - 84.9	Good	High
55.0 - 69.9	Sufficient	Sufficient
40.0 - 54.9	Low	Low
0 - 39.9	Very low	Very low

The success was defined as having 'good' concept mastery and 'high' generic science skills.

The students' responses to the implemented learning model were described on the basis of the ideal average score and ideal standard deviation. The questionnaire responses consisted of 15 indicators, 5 maximum score and 1 minimum score each. Moreover, the classification of the students' responses is as in Table 4.

Table 4. The Conversion Score of the Students' Responses

Interval	Score Interval	Qualification
$> (\bar{x}_i + 1.5\ s_i)$	> 60	Very positive
$(\bar{x}_i + 0.5\ s_i) - (\bar{x}_i + 1.5\ s_i)$	50 - 60	Positive
$(\bar{x}_i - 0.5\ s_i) - (\bar{x}_i + 0.5\ s_i)$	40 - 50	Sufficient
$(\bar{x}_i - 1.5\ s_i) - (\bar{x}_i - 0.5\ s_i)$	30 - 40	Negative
$< (\bar{x}_i - 1.5\ s_i)$	< 30	Very negative

$\bar{X}_i$ = mean score; s_i = standard deviation.
The success was defined as having 'positive' responses.

RESULTS AND DISCUSSION

Learning Description

In the cycle 1 and 2, the learning was performed using the collaborative ranking task (CRT) model comprising five phases, which were (1) dealing with problems; (2) testing data collection; (3) testing through experiment; (4) formulation; and (5) concept application. The activities in the five phases were: (1) the lecturer explored the initial ideas of the students related to the topic being studied by asking questions and assigning students to create hypotheses connected to the proposed questions; (2) the lecturer assigned the students to collect information linking with the problems encountered through various sources; (3) the lecturer facilitated the students in conducting testing activities against hypotheses proposed through experiments, demonstrations, and collaborative group discussions, facilitated by ranking task exercises (RTE); (4) the lecturer guided the students to conduct class discussions dealing with the results of the investigation, the students drew conclusions about the results of observations they have done and had reflections on the development of learning; and (5) The students solved the problems in groups.

The Earth and Space Science course with the collaborative ranking task was described by the observation results on the learning activities. The student activities were observed from student-student interaction and student-teaching materials interaction, while the lecturer activities were observed from the student-lecturer interaction and lecturer-teaching materials interaction. The results of student activity observation in the cycle 1 and 2 appear in Table 5.

Table 5. The Student Activities

No	Aspects Observed	Cycle 1		Cycle 2	
		Score	%	Score	%
Student – student interaction					
1	The students discuss in groups	9	75.00	11	91.67
2	The students conduct inter-group discussions	7	58.33	7	58.33
3	The students communicate their analytical results about Ranking Task Exercises(RTE)	8	66.67	10	83.33
4	The studentsrefute the statement expressed by other students	6	50.00	6	50.00
5	The students are self-employed in analyzing RTE	3	25.00	2	16.67

6	The students imitate / rewrite the results of RTE analysis	3	25.00	3	25.00
Student – teaching materials interaction					
1	The students record the material submitted	6	50.00	7	58.33
2	The students use reference books in their learning process	9	75.00	6	50.00
3	The studentsuse multimedia animation in their learning process	6	50.00	10	83.33
4	The students learn the RTE before working on it	9	75.00	11	91.67
5	The students build a pattern of understanding RTE	7	58.33	8	66.67
6	The students express the concepts based on the results of RTE analysis	6	50.00	7	58.33

In the cycle 1, it found that the student activities of group discussion (A1), and learning about the ranking task exercises (B4) obtained the highest score. The students were hectic but rarely found working individually in analyzing the RTE and imitating/rewriting the RTE analysis results. Things lacking in the cycle 1 were then improved, suggesting that the students worked more collaboratively. With these improvements, the students' activities in the cycle 2 for group discussion and RTE prior knowledge showed an increase, while the individual acts in analyzing had the lowest score. The result of lecturer activity observation in cycles 1 and 2 is shown in Table 6 below.

Table 6. The Lecturer Activities

No	Aspects observed	Cycle 1		Cycle 2	
		Score	%	Score	%
Lecturer – student interaction					
1	The lecturer asks questions	3	17.65	4	21.05
2	The lecturer helps the group discussion	3	17.65	3	15.79
3	The lecturer gives appreciation	2	11.76	3	15.79
4	The students pay attention	3	17.65	2	10.53
5	The students answer the question	3	17.65	3	15.79
6	The students ask questions	3	17.65	4	21.05
	Average A	2.83		3.17	
Lecturer – teaching materials interaction					
1	The lecturer informs the materials	2	18.18	2	20
2	The lecturer communicates the materials	3	27.27	3	30
3	The lecturer demonstrates the visual media	3	27.27	3	30
4	The lecturer interpreted the instrument of Ranking Tasks Exercises (RTE)	3	27.27	2	20
	Average B	2.75		2.5	

Based on Table 6, the lecturer activities during the learning in the cycle 1 for lecturer-students interaction aspect has not gone well. The students tended to pay attention to the lecturers' explanations. This was because the students did not understand the tasks pattern presented in the RTE. Therefore, in the cycle 2, the improvement was done by directing the students to work on the provided RTE. With this improvement, in the cycle 2, lecturer-students interactions were likely to be dominated by asking and answering questions. While the students' activity in listening to the explanation of the lecturer tended to decline. This happened because the students focused on the RTE directives. By intensifying the implementation of ranking task based on the weakness in the cycle 1, the lecturer activities in the cycle 2 have improved.

From the results of the learning reflection in the cycle 2, there were several things that still neededimprovement for the next learning, they were: (1) optimizing the planning and implementation of learning model ranking task; (2) emphasizing the concept transferring; and (3) designing contextual ranking task exercises to create a more interesting and easily-understood learning.

Concept Mastery

The Mastery of concepts was excavated using multiple choice tests related to the Phase of the Moon concept and Kepler's Law. The achievement of concept mastery in cycle 1 and 2 is presented in Table 7.

Tabel 7. The Achievement of Concept Mastery

Score Interval	Cycle 1		Cycle 2		Criteria
	f	%	f	%	
85.0 –100	0	0	0	0	Very good
70.0 - 84.9	2	8	7	28	Good
55.0 - 69.9	4	16	14	56	Sufficient
40.0 - 54.9	11	44	4	16	Low
0 - 39.9	8	32	0	0	Very low
Total	25	100	25	100	
Average	50		64		
Standard deviation	11.4		8.3		

f = observation frequency

Seen from the table above, the average of concept mastery in the cycle 1 was 50 and categorized as 'low'. After the cycle 2 learning, the average of the students' concept mastery of the Earth and Space Science increased to 64, or in the 'sufficient' category. This meant that there was an increase in the student achievement of concept mastery after learning using collaborative ranking task but has not reached the established success criteria.

This increase was due to the implementation of the collaborative ranking task exercises model which turned on the learning atmosphere. The RTE made the students organized the clear pattern of the materials, resulting in a regular assimilation and accommodation. This contributed greatly to the students' concept mastery level, as von Glaserfeld (Matlin, 2003) suggested that knowledge does not reflect objects to logical reality, but rather the organization of words derived from the existed experiences. Thus, the RTE could affect the students' concept mastery achievement level.

In addition, the improvement of the students' concept mastery, independent thinking, and social knowledge building were the results of discussions with collaborative RTE. This finding is in line with Vygotsky's (Oakley, 2004) theory of knowledge and the findings of Hadwin & Oshige, (2011), who stated that the result of collaborative learning is the formation of learning societies, where students become more independent, articulate, and mature socially and mentally. Independent thinking is the main goal of transformational learning (Flores et al., 2012). Hence, the RTE could affect the achievement level of college students' conceptualization. The findings of this study are in full agreement to that of Akan & Dinçer (2014).

Generic Science Skills

The generic science skills (GSS) measured in this study comprised 5 (five) types of skills, namely indirect observation, symbolic language, logical inference, principle-based logical framework, and concept building. The GSS profiles achieved in the cycle 1 and cycle 2 are presented in Table 8.

Table 8. Students' Generic Science Skills Profiles

Interval	Cycle 1		Cycle 2		Criteria
	f	%	f	%	
85.0–100	0	0	0	0	Very high
70.0-84.9	4	16	7	28	High
55.0-69.9	12	48	14	56	Sufficient
40.0-54.9	7	28	4	16	Low
0-39.9	2	8	0	0	Very low
Total	25	100	25	100	
Average	58.4		62.8		
Standard deviation	13.3		10.2		

f = observation frequency

Hinge on Table 6, the average score of generic science skills in the cycle 1was58.4 and belonged to '**sufficient**' category.In the cycle 2, the average became 62.8 and still in the same category. Numerically, the average students' GSS score indicated an increase but has not yet reached the established criteria.

The increase of GSS average from the cycle 1 to cycle 2 was due to the lecturing process adopting such model which gave the students' opportunity to interact with the materials presented chronologically. Extensive access to the students interacting with the teaching materials has provided a social environment that plays a major role in their building knowledge process (Oakley, 2004; Freudenberg, *et al.,* 2011).

The failure of GSS set out in the cycle 2 could be elucidated by the findings of the observations during the learning process, in which the learning process in the cycle 2 was not optimally done. It took sufficient time to habituate learning with the CRT model for both students and lecturers. Therefore, the planning and learning implementation required to be optimized. This is in line with the findings of Purwoko et al. (2017); Wijaya (2009); and Pujani (2013), that the improvement of teachers' competence in preparing the learning could significantly enhance students' learning activities and thinking skills. The performance of the GSS indicators is illustrated by the graph in Figure 2.

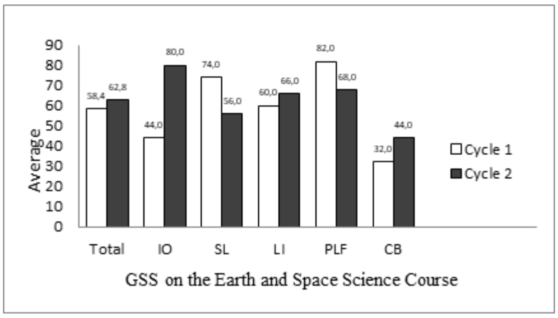

Figure 2. The Performance of the GSS Indicators

Figure 2 indicates that the indirect observation (IO), logic inference (LI), and concept building (CB) have increased from the cycle 1 to cycle 2. However, there were also decreasing indicators from the cycle 1 to cycle 2, which were the symbolic language (SL), and principle-based logical framework (PLF). The highest increase occurred in the indirect observation (IO) and the lowest on the concept building (CB) indicator.

Seeing from the GSS indicators achievement, not all of them were well-developed. Each indicator's accomplishment showed that the increase of GSS only fell on three skills, namely indirect observation, logical inference, and concept building. This was due to the different material characteristics in each cycle, thus, the developed Generic Science Skills also varied. This is aligned with the findings of the research conducted by Mulyani et al. (2016); Wahyuni (2016); and Amida (2017).

The decreasing indicators of the principle-based logical framework and symbolic language were probably caused by the insufficient learning time so that the students were lack of opportunity and flexibility to hone the process of scientific methods in learning. Through the Generic Science Skills, the students would be accustomed to scientific thinking that supports the understanding of their concept and thinking skills (Siswanto et al., 2016 and Brotosiswoyo, 2000). Moreover, the decreasing achievement on both indicators likely occurred because the skills indicator was represented by only a number on the instrument used so that the obtained results cannot be further generalized.

Therefore, the collaborative RTE implementation has provided interaction and cooperation for college students to build knowledge based on personal experience so as to give more meaning to the learning process. This is believed to increase the students' concept mastery and generic science skills. These findings are fully in accordance with that of Maknun (2015); Wahyuni (2016); Mulyani (2016); and Amida (2017).

The Students' Responses

The students' responses to the Earth and Space Science Course with collaborative ranking task model were investigated through questionnaires given at the end of cycle 2. The analysis found the mean response score of 58.6; s = 6.7, having **'positive'** qualification. The distribution of the students' responses is presented in Table 9.

Table 9. The Distribution of the Students' Responses

Score Interval	Frequency	Percentage (%)	Category
> 60	11	44	Very positive
50 - 60	11	44	Positive
40 - 50	2	8	Sufficient
30 - 40	1	4	Negative
< 30	0	0	Very negative

The revealed responses implied how the students adapted to the lecture using the collaborative ranking task. In this case, the ranking task exercises made it easier for students to understand the materials, generated interesting activities, triggered curiosity, facilitated group discussion, and built the students' independence in concept mastery and generic science skills.

Based on the findings and discussions of this study, it is suggested that the teachers/lecturers of the Earth and Space course in the Teacher Training Institutes and Junior/Senior High Schools try to implement the collaborative ranking task learning model as an alternative in Physics learning to vary lecturing activities and improve the concept mastery and generic science skills. The collaborative RTE provided interaction and cooperation for students to earn knowledge based on their personal experiences so as to give signification in the learning process. The positive responses from the students also supported the achievement of these research objectives. Building a positive attitude during learning supported the achievement of the expected goals.

CONCLUSION

Based on the data analysis results and findings in the development of this research, several conclusions could be drawn up. First, the implementation of the collaborative ranking-task model could improve the students' concept mastery of the Earth and Space Science starting from the '**low**' category of ($\bar{X}_1$= 50) to '**sufficient**' category of ($\bar{X}_2$= 64). Second, the generic science skills have numerically increased to the '**sufficient**' category ($\bar{X}_1$= 58.4, $\bar{X}_2$= 62.8).The developed GSS indicators were indirect observation, logic inference, and concept building.

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