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Research article

Education

METACOGNITIVE SKILLS FOR THE INTEGRATED PROBLEM BASED NUMBERED HEAD TOGETHER LEARNING

基於綜合題頭編號學習的元認知技巧

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Abstract

This quasi-experimental study aimed to examine the effectiveness of four learning models, namely Problem Based Learning; Numbered Heads Together; their combination; and conventional in improving students' metacognitive skills. The study employed a pretest-posttest non-equivalent control group with the design of a 4 x 2 factorial pattern. The study population consisted of 1.050 tenth graders from all public senior high schools spread in Jeneponto Regency. A random sampling method was used to select 198 students: 87 (43.94%) were males, and 111 (56.06%) were females. Students' metacognitive skills were measured by performance on an essay test conducted in the beginning and at the end of research activities. Data analysis was performed using descriptive and inferential statistics. The results showed that students' metacognitive skills could vary when they were exposed to different learning models. The students' metacognitive skills were also affected by their academic abilities. Findings of the present study suggested that the integrated PBL and NHT was the best combination of learning models that can be used to improve upper academic ability students' metacognitive skills.

Keywords: Learning Models, Upper Academic Ability, Students, Factorial Pattern, Jeneponto Regency

摘要 這項準實驗研究旨在檢驗四種學習模型的有效性，即基於問題的學習；基於問題的學習；基於問題的學習；基於問題的學習。一起編號的元首；他們的組合；和傳統的提高學生的元認知能

力的方法。該研究採用了 4 x 2 階乘模式設計的前測後測非等效對照組。研究人群包括來自耶內蓬托攝政區所有公立高中的 1.050 年級學生。隨機抽樣方法選擇了 198 名學生：男生 87（43.94%），女生 111（56.06%）。通過在研究活動開始和結束時進行的作文測試來衡量學生的元認知技能。使用描述性和推斷性統計數據進行數據分析。結果顯示，當學生接觸不同的學習模式時，他們的元認知能力可能會有所不同。學生的元認知能力也受到他們學習能力的影響。本研究的結果表明，PBL 和 NHT 的整合是學習模型的最佳組合，可用於提高高學歷學生的元認知能力。

关键词: 学习模式，高级学术能力，学生，析取模式，简内蓬托摄政

I. INTRODUCTION

Life in this era is becoming more challenging. Globalization factors have contributed to making education more and more demanding. Students are required to possess high-order thinking to help them compete with others in the real world. Students' thinking ability is one of the determining factors to deal with life challenges in the 21st century. Greenstein explains that 21st century thinking skills involve critical thinking, creative thinking, problem-solving, and metacognitive skills [1].

Students' metacognition and self-regulation are the keys to the improvement of their thinking ability [2]. Metacognitive skills play an essential role in enhancing students' thinking ability. Metacognitive skills are realized in excellent cognitive and affective self-regulation [3]. Metacognition is a determining component of students' academic success [4]. It is essential in promoting students' critical thinking (Ku & Ho, 2010) and problem-solving skills [5].

Metacognitive skills are also crucial in problem-solving [6]. Metacognition involves cognitive processes that may affect learning and behaviors [7]. To improve students' metacognitive skills, metacognition learning is required. According to Kramarski, Mevarech, and Arami, teaching students to work in a small group is the main element of metacognition when it focuses on formulating and answering a set of problems or metacognitive tasks [8]. Azevedo states that students' metacognitive skills can be maintained through proper settings of learning [9].

There are two categories of students: students with upper academic (UA) ability and students with lower academic (LA) ability [10], [11]. The discrepancy between the upper and lower academic ability students' metacognitive skills can be controlled by giving students enough time to explore themselves based on their needs and ability [12]. Despite the differences, according to Corebima, every student has unique potentials to develop [13].

One thing that can be done to synchronize the diversity is to implement an appropriate learning model in the classroom. Teachers can improve Learning and students' motivation by applying learning methods to suit students' competence and needs [14]. Varying learning models do not only help to promote students' achievement but also help in assisting students to be actively involved in a fun learning environment [15].

Research has reported that learning in public senior high schools (SMAN) Jeneponto regency is more focused on teachers than on students. Many teachers ignore students' academic ability differences and thus fail to improve students' critical thinking skills and metacognition. This phenomenon reflects poor learning activities [16].

Teachers need to possess adequate knowledge and skills to design and implement a learning model. They need to ensure that the learning model can provide students with new learning experiences. Teachers also have to give students space to think and learn from their mistakes. Teachers should also remind students of things that they should or should not do [17].

One of the alternatives to overcome the problem is to employ problem-based learning (PBL), which emphasizes student-centered Learning and students' active participation in the classroom. PBL allows students to identify new knowledge and use particular skills to apply the knowledge to a unique situation to achieve learning goals [18]. As is suggested by Williams & Beattie, students need to discover a new method to help them combine prior knowledge or principles with new knowledge they obtain during the problem-solving process [19].

PBL has been proven effective in improving students' metacognitive awareness and positive attitudes with poor scientific backgrounds [20]. Similarly, findings by Erdogana dan Senemoglub; Bachtiar, Zubaidah, Corebima, and Indriwati; Husamah; Ranjanie and Rajeswari, have suggested that the implementation of PBL could improve students' metacognitive skills [21], [22], [23], [24]. PBL can help students to learn high-order skills and concepts. The benefits of

PBL can be enhanced through the empowerment of students' metacognitive skills [25].

Numbered Heads Together (NHT) also has the potentials to empower students' metacognitive skills. NHT is a learning model in which steps include numbering, questioning, thinking together, and answering [26]. Zulkarnain and Ishabu found that the implementation of NHT could improve students' achievement [27], [28]. NHT creates a situation where students can discuss in groups so that the upper academic ability students can feel comfortable sharing their knowledge with the lower academic ability students. Domination can be avoided since students become more tolerant towards others [29], [30], [31].

This study highlights the prospective outcomes from the implementation of both learning models (PBL and NHT). It attempts to examine the differences in students' metacognitive skills when they were exposed to four different learning models, namely PBL; NHT; integrated PBL and NHT; and conventional models.

II. METHODS/MATERIALS

A. Research Design

This quasi-experimental study employed a pretest-posttest non-equivalent control group design with 4 x 2 factorial pattern [32], [33], [34]. The study included learning models (PBL; NHT; integrated PBL and NHT; and conventional) as the independent variable, students' academic abilities (lower academic (LA) ability and upper academic (UA) ability) as the moderating variable, and students' metacognitive skills as the dependent variable. The research design is presented in Table 1.

B. Sample of Research

The study population consisted of 1.050 tenth graders (aged between 15-16 years old) from 11 senior high schools (SMAN) spread over the Jeneponto regency. Random sampling technique was used to select 198 students as the samples: 87 (43.94%) were males, and 111 (56.06%) were females. There were eight classes: two PBL classes, two NHT classes, two integrated PBL and NHT classes, and two conventional classes. A data grouping test was used to determine the homogeneity of the sample classes. The students' academic abilities were categorized based on their test scores written on the 2014/2015 semester report. Thus, the student's intellectual skills fell into three categories: upper, medium, and lower. Every treatment class consisted of 33.3% students with upper academic ability and 33.3% lower academic ability.

Table 1.
Treatment classes

Pretest	Treatment classes	Post-test
O1	S1K1	O2
O3	S1K2	O4
O5	S2K1	O6
O7	S2K2	O8
O9	S3K1	O10
O11	S3K2	O12
O13	S4K1	O14
O15	S4K2	O16

Note:
S1K1 = PBL upper academic ability
S1K2 = PBL lower academic ability
S2K1 = NHT upper academic ability
S2K2 = NHT lower academic ability
S3K1 = integrated PBL and NHT upper academic ability
S3K2 = integrated PBL and NHT lower academic ability
S4K1 = conventional upper academic ability
S4K2 = conventional lower academic ability
O1, O3, O5, O7, O9, O11, O13, O15 = pretest scores
O2, O4, O6, O8, O10, O12, O14, O16 = post-test scores

C. Instrument and Procedures

Before the post-test administration, Learning was conducted as the research activity. Four lesson subjects were given in 12 meetings. After that, students' metacognitive skills were measured using an essay test which consisted of 12 items. The test was developed based on the revised version of Bloom's taxonomy. The experts had confirmed the validity and reliability of the test. Students' answers would be analyzed using a rubric [13] composed of 7 scales (0 – 7). There were five criteria considered in assessing the students' answers to the test: (1) the originality of the answers, (2) the organization, systematics, and reasoning of the answers, (3) the language used, (4) the reasons (analysis/evaluation/creation), and (5) the answers (correct/less appropriate/incorrect/unanswered).

D. Data Analysis

Data analysis was performed using descriptive statistics to show profiles of students' metacognitive skills. The hypothesis of a difference was tested using inferential statistics ANCOVA two paths (level of significance 5%). Data were analyzed using an SPSS program. The importance indicated by the results of the ANCOVA test would be further examined using the Least Significance Difference (LSD). Before the ANCOVA analysis, the normality and homogeneity of the data had been confirmed using one-sample Kolmogorov-Smirnov and

Levene's test of equality of error variances, respectively.

III. Results

The combination of NHT's upper academic ability achieved the highest average score in the pretest (34.37). In contrast, the lowest average score was obtained on the variety of PBL and lower academic ability (18.95). Differently, the highest average score in the post-test was achieved by the combination of PBL, NHT, upper academic ability (59.77), and the lowest score was from the combination of traditional and more insufficient theoretical knowledge (34.79) (Table 2).

Table 2.
Pretest and post-test average scores, and differences: metacognitive skills

Learning models	Academic abilities	N	Average		Improvement (%)
			Pretest	Post-test	
PBL	UA	25	27.71	59.15	113.46
	LA	25	18.95	38.36	102.43
	Total	50	23.33	48.75	108.96
NHT	UA	24	34.37	61.24	78.18
	LA	24	25.94	44.32	70.86
	Total	48	30.16	52.78	75.00
PBL + NHT	UA	25	23.73	59.77	151.88
	LA	25	19.75	42.16	113.47
	Total	50	21.74	50.96	134.41
Conventional	UA	25	24.65	43.26	75.50
	LA	25	22.66	34.79	53.53
	Total	50	23.65	39.03	65.03

Table 2 shows the average scores achieved by the participants in the pre and post-tests. It also presents the improvement of students' metacognitive skills after being exposed to the four learning models. The integrated PBL showed the most significant improvement, and NHT group of students (134.41%) while the smallest was performed by the conventional group of students (65.03%). The scores also suggest that the integration of PBL, NHT, and upper academic ability could improve students' metacognitive skills significantly (151.88%). Meanwhile, the combination of conventional Learning and lower theoretical knowledge did not significantly affect students' metacognitive skills, indicated by the lowest percentage (53.53%).

Table 3.
The results of the ANACOVA test

Source	Sum of squares	Df	Mean Square	F	Sig.
Corrected value of Model	22969.637[a]	8	2871.205	18.032	.000
Intercept	20368.077	1	20368.077	127.916	.000
Average Score	3771.828	1	3771.828	23.688	.000
Model	4839.803	3	1613.268	10.132	.000
Academic Ability	6983.830	1	6983.830	43.860	.000
Model * Academic Ability	567.306	3	189.102	1.188	.316
Error	30094.555	189	159.230		
Total	506081.255	198			
Total average score	53064.192	197			

[a] R Squared = .433 (Adjusted R Squared = .409)

Table 3 indicates a difference in students' metacognitive skills (F calculated= 10.132, *p-value* = 0.000. *p-value* < α (α=0.05)). Thus, table 4 presents the result of the LSD test conducted to examine the significance.

Table 4.
The result of the LSD test

Learning models	Pretest	Post-test	Difference	Average	LSD notation

Conventional	23.65	39.86	16.21	39.60	A
PBL	23.33	48.75	25.42	49.51	b
NHT	30.16	52.78	22.63	49.69	b
PBL+NHT	21.74	50.97	29.23	52.62	b

As is suggested by Table 4, the lowest average score of metacognitive skills was obtained by students who learned using the conventional learning model (39.60). Meanwhile, the highest score of metacognitive skills was achieved by the PBL and NHT student. No significant difference was found between the combination of PBL and NHT group and the PBL or the NHT group alone.

Table 3 previously suggested that academic abilities had an effect on students' metacognitive skills (F calculated =43.860, *p-value* = 0.000 *p-value* < α (α=0.05)). The average scores of students' metacognitive skills are depicted in Table 5.

Table 5.
The average scores of metacognitive skills of students with different academic abilities

Academic abilities	**Pretest**	**Post-test**	**Difference**	**Improvement**	**Average scores**
Upper Academic Ability (UA)	27.71	59.15	31.44	113.45%	54.19
Lower Academic Ability (LA)	18.95	38.36	19.41	102.38%	41.51

Table 5 indicates that the improvement of the upper academic ability students' metacognitive skills is 61.98% higher than that of the lower academic ability students. The difference between the pretest and post-test scores of the UA students is 31.44, which is considerably higher than that of the LA students (19.41).

However, based on data recorded in Table 3 (F-calculated = 1.188, *p-value* = 0.316. *p-value* > α (α=0.05)), it can be concluded that the interaction between learning models and academic abilities had no effect on students' metacognitive skills. The result of the LSD test, which indicates the interaction between learning models, students' academic abilities, and students' metacognitive skills are presented in Table 6. Table 6 shows that the combination of PBL, NHT, and lower theoretical knowledge had a more significant effect on students' metacognitive skills than the combination of conventional and lower academic ability and PBL and lower intellectual ability. However, the impact of the variety of PBL, NHT, and lower academic ability on students' metacognitive skills is reported similar to that of the combination of conventional and upper academic ability or NHT and lower academic ability (b and b). The integrated PBL, NHT, and lower academic ability have obtained the highest value of metacognitive skills (44.93), 3.84% higher than that of the conventional upper academic ability, and 25.08% higher than that of the conventional lower academic ability.

Table 6.
The result of the LSD test on the interaction between learning models, students' academic abilities, and students' metacognitive skills

Learning models	**Academic abilities**	**Pretest**	**Post-test**	**Difference**	**Average scores**	**Improvement (%)**	**LSD notation**
Conventional	Lower	22.66	34.79	12.13	35.92	53.53	a
PBL	Lower	18.95	38.36	19.41	41.58	102.43	a b
Conventional	Upper	24.65	43.26	18.62	43.27	75.53	b
NHT	Lower	25.94	44.33	18.39	43.61	70.89	b
PBL+NHT	Lower	19.75	42.16	22.40	44.93	113.42	b
NHT	Upper	34.37	61.24	26.87	55.77	78.18	c
PBL	Upper	27.71	59.15	31.44	57.43	113.46	c
PBL+NHT	Upper	23.73	59.77	36.05	60.30	151.92	c

IV. DISCUSSION

The present study results had suggested a difference in students' metacognitive skills when they were exposed to four distinctive learning models: PBL; NHT; integrated PBL and NHT; and conventional. These findings were corroborated with those suggested by Demirel and Arslan; Palennari; Yusnaeni, and Corebima, who reported that learning models had the potentials to empower students' metacognitive skills. These results also indicate that students' metacognitive skills can be enhanced through learning, training, and habituation [35], [36], [16].

The integrated PBL and NHT learning model has been proven to contribute to the improvement of students' metacognitive skills. These self-regulation skills are essential for students [37]. Shetty and Bachtiar found that PBL effectively improved students' metacognitive awareness and metacognitive skills [38], [39]. More specifically, they proved that PBL was able to help students extend their procedural knowledge, cognition knowledge, and planning and information management skills. On a different occasion, Leasa and Corebima also showed the importance of applying NHT in Learning. They reported that students' academic abilities could be accommodated in NHT [14]. Therefore, the integrated PBL and NHT learning model can be assumed as the best combination of learning models that can improve students' metacognitive skills despite the differences in their academic abilities (upper and lower).

The combination of PBL and NHT provides a stimulus for students' behavior construction. This learning model can help promote students' classroom interaction and attitude development [34]. PBL is an innovative learning model that is also useful in students' metacognition development, while NHT emphasizes students' active contribution in discussion [40], [41]. In NHT, every student is responsible for presenting their knowledge as an individual [42].

The potentials of the integrated PBL and NHT in improving students' metacognitive skills are also reflected in the learning steps. The syntax of PBL and NHT encourages students to do an investigation either individually or in groups through discussion. Problem-based learning activities, needless to say, can motivate students to independently process their cognition before attempting to solve the given problems [43], [44].

Metacognition generates an ability to understand and monitor self-thoughts and assumptions which imply one's activities. It can be assumed that the mastery of metacognitive skills can facilitate the formation of a confident attitude which means that if students have possessed excellent metacognitive skills, they will develop more positive attitudes towards Learning. As a result, the improvement in students' metacognitive skills will result in students' better scientific attitudes and cognitive achievement. Therefore, metacognitive skills are crucial in learning [6]. Metacognitive skills also contribute significantly to students' academic achievement [45], [46].

Metacognition allows students to become independent learners because they can regulate and evaluate their learning activities [47]. According to Flavel and Miller, metacognition influences students' thinking process. Through metacognition, students can maintain, plan, and control their thoughts [48]. Metacognition is one of the essential aspects of humans' intelligence, making them able to think critically. Critical thinking is thinking while 'metacognitive is considered more than just cognitive' [49]. Some experts believe that metacognition is not a mere personal internal activity; it is a social process [50]. However, an independent student needs to be aware, observant, reflective, and analytic towards problems [51].

Besides metacognitive skills, some other factors might influence students' academic achievement. Nevertheless, metacognitive skills still need to receive more attention because students' mastery of metacognitive skills reflects their capacity to learn other skills [52], [53]. Dunning et al. state that metacognition is a strong independent variable of a successful academic life [54]. Livingston also points out that metacognitive activities such as planning, task completion, knowledge monitoring, and progress evaluation can actively control students' cognitive processes [55]. Therefore, students whose metacognitive skills are trained well will have better academic achievement. According to Nurisya and Corebima, the empowerment of students' metacognitive skills and critical thinking will impact the students' ability in a positive way [56].

Unlike conventional learning models, cooperative learning models have been proven able to improve students' academic achievement. Cooperative learning models can also minimize the discrepancy between students with upper academic ability and lower academic ability [57]. One of the aims of the cooperative learning models is to work in teams [58]. Working in a team to solve problems also helps students develop collaborative and cooperative learning skills [59]. Therefore, the integrated PBL and NHT can assist students in learning new knowledge and skills relevant to their daily life issues.

The ANCOVA test results revealed a difference found between high ability students' and low ability students' metacognitive skills. Livingston has guaranteed that students with upper academic knowledge will have excellent metacognitive skills because metacognition makes students more independent in managing and planning their learning activities [55]. Metacognition needs to be studied [60]. Studying metacognition means learning to be independent, honest, and brave enough to try something new [61].

The findings of this research also suggested that academic abilities affected students' metacognitive skills. Therefore, these results have confirmed related previous findings on the relationship between metacognitive skills and intellectual skills [33]. In line with that, Corebima state that students with upper academic ability possess better prior knowledge than students with lower academic ability. This situation makes the high-ability students feel more confident in learning [62].

V. CONCLUSION

The present study results suggested a difference in students' metacognitive skills when they were exposed to PBL, NHT, PBL and NHT, and conventional learning models. The PBL and NHT group of students were reported to be the ones who could achieve the highest score in metacognitive skills. Findings also indicated that academic abilities affected students' metacognitive skills. The average metacognitive score of upper academic ability students transcended that of lower intellectual ability students. However, the results did not significantly affect the interaction of learning models (PBL; NHT; integrated PBL and NHT; conventional) and academic abilities on students' metacognitive skills. It was only found out that upper academic ability students who were put in the integrated PBL and NHT classes could obtain the highest score of metacognitive skills compared to other groups of students.

Based on the research results and the discussion presented in the previous section, some suggestions can be offered. It is recommended for senior high school teachers to implement the integrated PBL and NHT learning model in their classrooms as an alternative to cooperative learning models introduced earlier, such as PBL and NHT. The teachers also need to pay more attention to students' academic abilities to minimize the academic gap among students.

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