The Role of Hots-Oriented Creative Inquiry Model for Improving Self-Efficacy and Physics Problem-Solving Ability In Gender Perspectives

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Abstract--- *The purpose of this research was to describe the roles of HOTS-oriented creative inquiry learning model in improving self-efficacy and solving problem ability in physics problems to be seen from the gender of senior high school students in Lampung province, Indonesia. This research used the static-group pretest-posttest design. One hundred sixty-five students from five public Senior High Schools in Lampung province, Indonesia, were taken as samples by using random cluster sampling. Problem-solving ability data were obtained from the essay test by using a problem-solving ability survey (PSA), while data of students' self-efficacy level toward physics subjects were collected by using the physics self-efficacy scale (PSES). The percentage of n-gain average determined the improvements of self-efficacy and problem-solving ability, differences between pretest and posttest, and differences between male and female students' abilities were determined by using the Wilcoxon test. The correlation between self-efficacy and problem-solving ability was determined by using Spearman's' coefficient of correlation test. The research result showed that there were significant improvements in self-efficacy and problem-solving ability in physics problems at a significance level of 0.05. The self-efficacy and problem-solving ability of male students were higher than female students. There was a correlation between students' self-efficacy and problem-solving ability in physics.*

Keywords--- *Creative-inquiry, Self-efficacy, Problem-solving*

I. INTRODUCTION

In general, physics subject areas are divided into two parts, namely classical and modern physics. Classical physics contains mechanics, dynamics, temperature and heat, wave, optic, electricity, and magnetics, whereas modern physics includes quantum theory, relativity theory, electron radiation, gas kinetic theory, electromagnetic wave, atom physics, and core physics. The characteristics of materials in physics subjects are mostly abstract and complex [1]; [2]. Based on these characteristics, the physics learning process should satisfy 5M aspects; Mengamati (observing), Mencoba (trying), Menanya (asking), Menalar (reasoning), and Mengkomunikasikan (communicating). However, learning must be fun, and in this research, the proposed term is PAKEM (Aktif (active), Kreatif (creative), Efektif (effective), and Menyenangkan (fun) learning), so that students would not be bored. The learning by having aspects of 5M and PAKEM uses a scientific approach, and it is following learning in 21 century referred to as 4C; the creative and innovation, critical thinking, and problem-solving, collaboration, and communication.

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The final objective of learning physics is problem-solving. The abstract and complex problem-solving in physics requires students to have higher-order thinking skills (HOTS). Therefore, physics learning needs a combination of learning models that can lead students towards higher thinking levels to improve self-efficacy and problem-solving ability. The HOTS-oriented learning model combination to improve self-efficacy and problem-solving ability is creative inquiry. A creative process model emphasizes motivations to produces creative ideas and thinking logically. Motivation is a process that involves energy, lead, and maintain behaviors [3], while inquiry more emphasizes on critical, creative, and logical thinking processes [4]. Learning physics is a complex process. Physics teachers have to develop attitudes of curiosity, being honest, responsible, logical, critical, analytical, and creative by composing hypothesis, designing and conducting experiments, analyzing concepts, principles and laws, and creating simple products. Each learning undertaken by a teacher must be able to train students to think logically, critically, analytically, and creatively. Furthermore, learning physics by merely implementing inquiry or creative process is less practical and effective so that it needs to combine two models or strategies that would able to improve both self-efficacy and problem-solving ability. HOTS-oriented creative inquiry learning model more emphasizes enhancing efficiency and effectiveness in obtaining graduate competences, but its learning process still refers to Regulation of the Indonesia Ministry of Education No. 65 in 2013 concerning interactive, inoperative, fun, challenging learning by motivating learners to participate actively and providing enough spaces for the initiative, creativity, and autonomy [5]; [6].

AI. Literature Review

Knowledge and skill have essential roles for an individual in solving a problem, but they are not enough to obtain performance [7]. An individual with proper knowledge and skill would not certainly be able to decide by using strategies in problem-solving and finishing assignments if the individual is not sure about his/her self-ability. Self-efficacy is a predictor in determining attitude to make a decision, to be able to handle a particular task practically and effectively [8]. Research results by [7] showed that self-efficacy is very influential to a student's ability, effort, gender, and personality temperament. A strong self-efficacy can drive or generate motivation to overcome spectacles or challenges [9]. A low self-efficacy would tend to reduce efforts and easy to give up so that an easy problem would be a difficult one.

In solving complex and complicated physics problems, students tend to be lazy and easy to give up, even though the problems are not that difficult. Still, because of lower students' self-efficacies, students are easy to give up and not believing their self-abilities. Students with higher self-efficacies would be better and able to overcome difficulties and more confidence [10]. Higher self-efficacy would reach good performances because an individual has a strong motivation, clear goal, and stable emotion [11]. Therefore, self-efficacy is essential for students to generate self-confidence to overcome problems. Self-efficacy is an attitude or feeling to believe upon self-ability so that a student with higher self-efficacy would not anxious and fear failure in solving problems. Male student's self-efficacy tends to be different with female student's self-efficacy [12]; [13] so that their abilities in physics problem solving would also be different [14]. Self-efficacy level of an individual would also be depending on alma mater [15]; [16] and success level of an individual in the academic field [10].

Albert Bandura's concept of self-efficacy is used to express an individual's assessment. In this context, the student's assessment of self-confidence is essential to reach success in complicated problem-solving. Self-efficacy influences performance and motivation [17], and only teachers with high self-efficacies can conduct inquiry learning [18]. Scientific inquiry implementation has been a trend in science learning in all over the globe [19], including in Indonesia. Explicitly, an inquiry is designed to develop scientific reasoning skills and to provide training that is related to scientific concepts, representations, and modeling for real-world phenomena [20]. The inquiry is an active learning model where students are active to pose questions, think critically and creatively (HOTS) so that they can solve abstract and complex problems. The inquiry learning model can improve the student's motivation and talent [21]. Research results by Mulyeni, Jamaris, and Supriyati [22] found that the inquiry learning model can improve science process skills. There are four inquiry types commonly used in science learning; the demonstrated inquiry, structured inquiry, guided inquiry, and self-directed inquiry [23]. The inquiry is described as an active learning process where students actively did investigations, posing questions, and answering their questions [24]. Barron and Darling-Hammond [25] defines inquiry as one of the active learning models centering on students and is based on questions, critical thinking, and problem-solving.

In physics learning, implementing one of four inquiry levels without using other models would make not all students active in a learning process because, in one classroom, there are students with different behaviors and abilities. Physics learning will mostly involve mathematics so that physics problems become complex and complicated. Students must be able to use mathematics as a language to solve problems. The same notion is suggested by [26], that mathematics has an important role in solving a physics problem from primary school to higher education.

Students in solving physics problems tend to imitate solution examples provided in textbooks, and they will have difficulties when the physics problems to solve are different from the ones in textbooks. This is because learning pattern implemented by teachers only emphasizes learning result than its scientific process [27]. The HOTS-oriented creative inquiry learning model is student-centered learning that provides opportunities for students to develop their creativity, to be innovative, and critical to taught materials. HOTS-oriented creative inquiry learning is under curriculum demand in Indonesia to create autonomous learning, collaborative learning, and group learning. In the HOTS-oriented creative inquiry learning, students are guided to be actively observing, questioning, experimenting, discussing and making analyses, so that students will be critical; such as doing interpretation, analysis, inference, explanation, and self-regulation, and be creative; such as fluency, flexibility, originality and elaboration [28].

BI. DATA COLLECTION

This research used the quasi-experiment method with pretest and posttest design [29]. This research involved 165 public and private senior high school students in Lampung province, Indonesia. Samples were divided into five learning groups; groups A, B, C, D, and E. Each sample group was taken with random cluster sampling by using a lottery system.

Before learning, each group filled scale tests for self-efficacy and physics problem-solving ability. All groups were taught electricity and magnet materials by implementing a HOTS-oriented creative inquiry learning model. After that, all groups were given posttests.

Data on students' self-efficacy levels toward physics subjects were obtained with the physics self-efficacy scale (PSES), containing 12 questions following a test developed by Tezer and Asiksoy [10] with necessary adjustments. The PSES used a Likert scale with four options; very disagree, disagree, agree, very agree [30]. The lowest and highest scores were 12 and 48. Problem-solving ability (PSA) data were collected by using an essay test that was developed by Savage and Williams [31] containing: setting up model, analyzing a problem, interpreting, and validating. PSA instrument contained six essay problems. PSES and PSA had been tested to 25 senior high school students to see their reliabilities and validities before they were used.

The validity test was estimated by using a product-moment correlation, while reliability was estimated by using the Cronbach alpha formula. The validity and reliability test results for PSES and PSA are presented in Table 1 and Table 2.

Table1. PSES Validity and Reliability Test Results

Self-efficacy	SE1	SE2	SE3	SE4	SE5	SE6	SE7	SE8	SE9	SE10	SE11	SE12
Validity	0.508	0.737	0.421	0.632	0.465	0.674	0.574	0.597	0.683	0.758	0.782	0.595
Reliability						0.836						

SE = physics self-efficacy scale number
Correlation is significant at 0.05 level

Table 2. PSA Validity and Reliability Test Results

Problem-solving	P1	P2	P3	P4	P5	P6
Validity	0.663	0.871	0.532	0.861	0.516	0.871
Reliability			0.828			

P = test of problem-solving ability
Correlation is significant at 0.05 level

Table 1 and Table 2 show that PSES and PSA instruments are both reliable and valid.

Students filled PSES instruments before and after learning. Obtained data were estimated for their averages and then converted hundreds scale. The PSES averages of male and female students of each group were separated. The same thing was done in problem-solving test results. N-gain estimation for male and female students in each group was done by using the following equation [32]:

$$< g >= \frac{\% \ of \ posttest\ scores - \% \ of \ pretest\ scores}{100 - \% \ of\ pretest\ scores}$$

Score interpretation $<g>$: $<g>$ high, if $<g> > 0.70$; $<g>$ moderate, if $0.30 < <g> \leq 0.70$; $<g>$ low, if $<g> \leq 0.30$.
N-gain difference between male and female students was estimated by using paired-sample t-test. The correlation between self-efficacy and problem solving ability was analyzed by using correlation test with SPSS V.22.

IV. DATA ANALYSIS

Self-efficacy

There were five learning groups; group A (Public Senior High School 7 in Bandar Lampung), group B (Public Senior High School 1 in Kota Bumi), group C (Public Senior High School 15 in Bandar Lampung), group D (YP Unila Senior High School), and group E (Public Senior High School 2 in Kalianda), that were taught by implementing HOTS-oriented creative inquiry learning model. Students' self-efficacy data in groups A, B, C, D, and E are presented in Table 3.

Table3. The average scores of pretest, posttest, and n-gain of students' self-efficacies in physics subject

Group	Self-efficacy		
	Pretest	Posttest	<g>
A	18.91	35.39	0.78
B	21.09	35.55	0.76

C	19.03	33.79	0.69
D	19.88	37.31	0.86
E	22.92	37.17	0.83
Average	20.36	35.84	0.78

Table 3 shows that group C has the lowest posttest score of 33.79, with the lowest n-gain score of 0.69, and this belongs to the moderate category. Average scores of groups A, B, D, and E are higher than group C with n-gain scores between 0.76 and 0.86, and they belong high category. Overall, the average n-gain of students' self-efficacies in HOTS-oriented creative inquiry learning is 0.78, and this belongs to a high category.

The pretest, posttest, and % <g> of students' self-efficacies results in physics subject to be seen from gender are presented in Table 4.

Table 4. Pretest, posttest, and % <g> of students' self-efficacies results in physics subject to be seen from a gender

Group	Male			Female		
	Pretest	Posttest	<g>	Pretest	Posttest	<g>
A	19.94	36.17	0.81	17.67	34.47	0.75
B	21.09	35.55	0.76	21.48	34.74	0.72
C	18.38	34.88	0.75	19.65	32.76	0.63
D	19.88	37.31	0.86	17.41	35.59	0.79
E	22.92	37.17	0.83	20.24	35.90	0.80
Average	20.44	36.22	0.80	19.29	34.69	0.74

Table 4 shows that male students in all groups have high category n-gains, and only in group C female students have moderate n-gain. The highest and lowest n-gains for self-efficacy are obtained by male students in group D with n-gain 0.86 and by female students in group C with n-gain 0.63.

The normality test results of pretest and posttest of groups A, B, C, D, and E derived asymp. Sig. (2-tailed) < 0.05. It means that data of the self-efficacy pretest and posttest were not distributed normally. Therefore, differences between pretest and posttest of groups A, B, C, D, and E could be obtained by the Wilcoxon test. The estimation result by using the SPSS V.22 program of asymp. Sig. (2-tailed) of each group is presented in Table 5.

Table 5. Difference test results between self-efficacy pretest and posttest

Self-efficacy	Group				
	A	B	C	D	E
Asymp. Sign. (2-tailed)	0.00	0.00	0.00	0.00	0.00
Rejection area (Z)	-5.017	-5.020	-5.015	-5.016	-5.017

Asymp. Sign. (2-tailed) < 0.05

SPSS estimation result (Table 5) shows that asymp. Sign. (2-tailed) < 0.05 in all groups. It means Ho is rejected and Ha is accepted so that there is a significant difference between pretest and posttest averages.

Students' self-efficacies in physics learning differ significantly between male and female students. Male students' self-efficacies are higher compared to female students. Wilcoxon statistic test result of self-efficacy difference between male students and female students is presented in Table 6.

Table 6. The difference test result of self-efficacy between male and female students

Self-efficacy	Male and female student groups				
	A	B	C	D	E
Asymp. Sign. (2-tailed)	0.015	0.00	0.005	0.000	0.010
Rejection area (Z)	-2.438	-4.075	-2.817	-3.621	-2.590

Asymp. Sign. (2-tailed) < 0.05

Table 6 shows that asymp. Sign. (2-tailed) < 0.05, so that Ho is rejected. It means that there is a significant difference in self-efficacy between male and female students. Male students' self-efficacies are higher than female students.

Problem Solving

The average results of pretest, posttest, and n-gain of problem-solving abilities of groups A, B, C, D, and E are presented in Table 7.

Table 7. Average results of pretest, posttest, and n-gain of physics problem-solving abilities

Group	Problem-solving		
	Pretest	Posttest	<g>
A	37,61	79,18	0,66
B	35,94	76,82	0,63
C	28,48	79,09	0,70
D	28,79	80,30	0,72
E	28,18	80,00	0,72
Average	31,80	79,08	0,69

Table 7 shows that groups A and B obtain n-gain averages in the moderate category, while groups C, D, and E obtain n-gain averages in the high category.

The average results of pretest, posttest, and n-gain of problem-solving abilities of students in physics learning to be seen from gender are presented in Table 8.

Table 8. Results of pretest, posttest, and n-gain of problem-solving abilities of students to be seen from a gender

Group	Male			Female		
	Pretest	Posttest	<g>	Pretest	Posttest	<g>
A	33.90	79.60	0.69	43.31	78.54	0.62
B	35.94	76.82	0.63	38.36	77.27	0.63
C	25.63	82.50	0.76	31.18	75.88	0.64
D	28.57	84.29	0.78	28.95	77.37	0.67
E	26.67	81.67	0.75	29.05	79.05	0.70
Average	30.14	80.98	0.72	34.17	77.62	0.65

Table 8 shows that n-gain scores of male students' physics problem-solving abilities belong to high category except for groups A and B, while n-gain scores of female students' physics problem-solving abilities belong to moderate category except for group F that has high category n-gain score.

Hypothesis Test

Normality test results of pretest and posttest of groups A, B, C, D, and E showed asymp. Sign (2-tailed) < 0.05. It indicated that pretest, posttest, and n-gain data of problem-solving abilities were not distributed normally. The differences between pretest and posttest of groups A, B, C, D, and E were then estimated with the Wilcoxon test. The estimation result by SPSS V.22 program derived asymp. Sig. (2-tailed) of each group that is presented in Table 9.

Table 9. Difference test results between pretest and posttest of problem-solving abilities

Self-efficacy	Group					
	A	B	C	D	E	F
Asymp. Sign. (2-tailed)	0.00	0.00	0.00	0.00	0.00	0.00
Rejection area (Z)	-4.374	-5.014	-5.020	-5.015	-5.016	-5.017

Asymp. Sign. (2-tailed) < 0.05

The SPSS estimation results in Table 9 shows that asymp. Sign. (2-tailed) < 0.05 in all groups. These results mean that Ho is rejected and Ha is accepted so that there is a significant difference between averages of pretest and posttest of problem-solving abilities.

N-gain f students' problem-solving abilities in physics learning differ significantly between male and female students, where male students' problem-solving abilities are higher than female students. Statistic test results by Wilcoxon test of differences between male and female students' problem-solving abilities are presented in Table 10.

Table 10. Difference test results of n-gains between male and female students' problem-solving abilities

Problem Solving Ability	Group					
	A	B	C	D	E	F
Asymp. Sign. (2-tailed)	0.000	0.140	0.018	0.002	0.008	0.002
Reecion area (Z)	-4.198	-1.475	-2.374	-3.127	-2.654	-3.137

Asymp. Sign. (2-tailed) < 0.05

Table 10 shows that asymp. Sign. (2-tailed) < 0.05, meaning that Ho is rejected and there is a significant difference between male and female students' problem-solving abilities except for group B. male and female students' problem-solving abilities in group B do not differ significantly, but quantitatively male students' problem-solving abilities are higher than female students. Spearman's test result on the coefficient of correlation shows that there is a significant correlation between self-efficacy and problem-solving ability with sig. (2-tailed) the score of 0.001.

HOTS-oriented creative inquiry-based learning was conducted to five senior high school student groups in Lampung province, Indonesia. Each group contained of 33 students learning in grade 12. Physics Self-efficacy Scale (PSES) and problem-solving ability (PSA) instruments were tested for their validities and reliabilities before they were used. Table 1 and Table 2 above show that the instruments are valid and reliable so that they are used to measure self-efficacy and problem-solving ability of the physics problem of students in Grade 12. Before HOTS-oriented creative inquiry-based learning was conducted, the average student's self-efficacy was 20.36, and it belonged to a low category. This might be because there were many assignments that the students were unable to solve. After all, students were not confident in their abilities.

Male and female students' self-efficacy scores before learning were 20.44 and 19.29, respectively, and they were not significantly different. After learning by using the HOTS-oriented creative inquiry learning model, students' self-efficacy scores improved significantly in all groups (see Table 5). The average n-gain score of student's self-efficacy was 0.78, and it belonged to a high category. The lowest and highest self-efficacy n-gain scores were 0.69 in group C and 0.86 in group D, respectively. Significant self-efficacy improvement was because HOTS-oriented creative inquiry learning was able to generate students' motivation and talent [21], and students were able to formulate questions and to seek for their answers. The learning model was also able to develop students' activities [33].

Inquiry learning is designed to develop scientific reasoning and provide training related to scientific concepts, representations, and modeling for phenomena in the real-world [20]. In learning, the creative process emphasizes motivations to produce creative ideas and to think logically. The combination of inquiry learning and the creative process that is HOTS-oriented can improve students' self-efficacies in learning physics. Students' self-efficacy improvements in learning physics are because students are confident to their abilities in finishing academic assignments, such as experimenting, analyzing, and solving physics problems provided by teachers. Results of research support these findings by [14], where a combination of inquiry learning models with other models could improve students' critical thinking compared to using inquiry model alone.

However, there are some factors influencing students' self-efficacies in learning physics, including gender. The average of male student's self-efficacy is 0.80 compared to female student's self-efficacy, which is 0.74 (see Table 4). Gender causes significant different self-efficacies between male and female students (see Table 6). Some researchers found that gender difference in inquiry learning influences students' thinking skills [14]. In HOTS-oriented creative inquiry learning, students do not only pose questions, do explorations to lead them to question, test ideas, and find answers, but students are also guided to be more creative and critical in solving abstract and complex physics problems through activities of studying problems, solving problems, and communicating them to their peers. Students then do reflection and follow-up. By reflection activity, students become very confident in their own abilities. With high self-confidence, students would be able to solve physics problems properly.

The physics problem-solving in electricity and magnet materials before learning was low by 31.80 (see Table 7). In the beginning, students were less confident with their abilities, because they found difficulties to solve physics problem assignments given by teachers. After receiving HOTS-oriented creative inquiry learning model, students' physics problem-solving abilities improved into a high category with an average score of 79.08. Students' problem solving n-gain average was 0.69, and it belonged to the moderate category. HOTS-oriented creative inquiry learning model was able to improve students' physics problem-solving abilities significantly (see Table 9). This is because the creative inquiry learning model is more effective and fun. The creative inquiry learning relates curiosity to situations that lead us to respond with new ways (original). Research results by Mumford [34] about effects of creative process implementation in problem-solving suggest that: (a) processing activity is a mediation between ability and creative skill of problem-solving; (b) every process provides a unique contribution to predict the creative performance of problem-solving; (c) problems of produced construction, conceptual combination, and idea are effective predictors for problem-solving performance; (d) creative processes predict problem-solving performances in some domains such as public policy and education. HOTS-oriented creative inquiry learning model implementation affected male and female students' problem-solving abilities. Average n-gain scores of problem-solving abilities were 0.72 (high category) for male students and 0.65 for female students (moderate category). This result was confirmed because male students are more focused and had better self-confidence compared to female students. This finding is in line with the finding by [13] that female students have a higher anxiety level in physics learning. It is also supported by a result of research by [7] that male students' self- efficacy is higher compared to the female student.

The self-efficacy level refers to the students' success level in obtaining academic objectives. The same finding is suggested by [10] that a student with a higher academic success level has a higher and significant self-efficacy compared to the one with a lower academic success level. A similar result is also suggested by [35] that relating between self-efficacy and academic ability. Self-efficacy is a determining factor in the learning process, and it correlates to students' confidence levels toward their abilities. Students with low self-efficacy would find difficulties in completing assignments given to them, and vice versa. A similar finding is suggested by [36] that a high self-efficacy would make a student be more optimistic about his/her own learning ability. Self-efficacy has an important role in improving problem-solving ability. Therefore physics teachers have to scaffold students on how to learn and apply problem-solving strategies effectively in the classroom [37]. One alternative that can be taken by the teacher to promote creativity in building students' physics problem solving skills is physics open-ended worksheets [38].

V. Study Results, Summary And Contribution

HOTS-oriented creative inquiry learning can generate students' motivations and talents. Students would be able to formulate questions, review problems, and seeking answers. HOTS-oriented creative inquiry learning is designed to develop scientific reasoning skills and to provide training related to scientific concepts, representations, and modeling for phenomena in the real world so that it is able to convince students on their own abilities in completing assignments given by their teachers. Before the implementation of HOTS-oriented creative inquiry learning, students' self-efficacies and problem-solving abilities were low. After its implementation, students' self-efficacies and problem-solving abilities improved significantly. Students' self-efficacies improved into a high category, while students' physics problem-solving abilities improved into the moderate category. There is a significant correlation between self-efficacy and problem-solving ability.

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