

How the Effects of the 21st-Century Learning Model on Higher Level Thinking Ability and Mathematical Learning Creativity Viewed from Student Mathematical Disposition

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Abstract: 21st-century education requires students to communicate, collaborate, think critically, do problem-solving, creativity, and innovation. This can be measured based on high-level thinking skills and student learning creativity. However, the reality is that the current learning model of mathematics learning does not support this, which makes students' high-level thinking skills and learning creativity not increase. Therefore, the main focus of this study is to apply the challenge-based learning model and see how the effects of the challenge-based learning model are viewed from the students' mathematical dispositions towards high-level thinking skills and students' learning creativity in mathematics. The methodology used is quantitative research with quasi-experimental type of research, subjects of VIII grade students of SMP Negeri in Surakarta, data collection techniques using test instruments, questionnaires, and observations. The method of data analysis in this study uses multivariate variance analysis with unequal cell lines. The results of the study prove that the 21st-century learning model and mathematical disposition have a significant influence on HOTS and student learning creativity and the Challenge Based Learning model is very appropriate in increasing HOTS abilities and student learning creativity.

Keywords: 21st-century education, challenge-based learning, HOTS, creativity, mathematical disposition

INTRODUCTION

21st Century education is a challenge for educators because 21st-century education prioritizes activities and direct learning for students. The reality of education today is still not much different from previous education is too focused on how students can answer, but students can not understand the concept well. Education must now evolve to adapt to an increasingly fast-paced era because students must have the ability of 4C, which can make students able to compete in the 21st century that is increasingly fast-thinking ways to evolve. Because of this, the question arises how do educators teach students in the 21st century? How do educators prepare their students to be able to compete in the 21st-century era? In this article, researchers will try to answer that question.

The Challenge Based Learning model is the right model applied in 21st-century education because one of the attributes of Challenge Based Learning focuses on developing 21st-century skills, the Challenge Based Learning model also supports learning by doing learning. In line with the opinion (Apple, 2008) that Challenge Based Learning is a framework for learning while completing real-world challenges. This framework is collaborative and direct, involving all participants (students, teachers, families, and community members) to identify big ideas, ask right questions, find and solve challenges, gain in-depth subject knowledge, develop 21st-century skills, and share their thoughts with the world. (Nawawi, 2016) Challenge Based Learning learning models include the use of problems in the real world, where students can apply knowledge and problem-solving skills. Challenges that are designed expertly for learning can successfully include students to formulate intuition about challenges based on their

fundamental knowledge and experience. Challenges are designed to help students find essential relationships about applying knowledge and bringing relationships into several concepts to help students distinguish how concepts are used and the relationships between one another to build deep and lasting knowledge (Swiden, 2013). According to (Johnson, 2009) Challenge Based Learning learning model is a model that combines essential aspects such as problem-based learning, project-based learning and contextual learning (CTL) which is focused on real problems in the world. Continue (Johnson, 2009) This learning makes problem-solving a significant concern, giving access to 21st-century equipment, requiring students to work collaboratively and manage time under the guidance of the teacher. (Nawawi, 2016) added the advantages of integration of the Challenge-Based Learning learning model, among others, active students in learning because students think how to solve problems faced, problems that arise in everyday life and are rooted in global issues, and planning is done to address them. (Argaw, Haile, Ayalew, & Kuma, 2016) PBL is a learning method where relevant problems are introduced at the beginning of the teaching cycle and are used to provide context and motivation for learning that follows. This definition requires operating conditions and is usually (but not necessarily) collaborative or cooperative. This involves a large amount of self-learning on the part of students.

How do we measure that the model is said to be successful in improving the quality of capabilities needed in the 21st century? Before we discuss this, 21st-century capabilities can be measured by seeing how students can communicate, collaborate, think critically, do problem-solving, have creativity and innovation. The ability to communicate, collaborate, think critically, do problem-solving, have creativity, and change can be measured by seeing how the students' high-level thinking skills value in mathematics. By learning mathematics, these abilities can be easily measured because mathematics is learning that needs the ability to think critically. The ability to think higher or commonly known as HOTS is a thought process that requires students to manipulate information and ideas in specific ways that give them new insights and implications (Gunawan, 2012).

HOTS is a process of thinking students in higher cognitive levels developed from various concepts and cognitive methods and taxonomy of learning such as problem-solving methods, bloom taxonomy, and taxonomy of learning, teaching, and assessment (Saputra, 2016). HOTS is a way of thinking that is no longer just verbalistic memorization but also means the essence of what is contained, among other things, to be able to interpret the meaning that is integralistic thinking by analyzing synthesis, associating to concluding creating creative ideas and productive (Ernawati, 2017). HOTS involves problem-solving skills, creative thinking skills, critical thinking, argumentation skills, and the ability to make decisions guided by truth ideas that each have meaning.

Based on the description above, it can be concluded that HOTS in this study is a high-level thinking ability that is not just remembering, restating, or referring without doing processing, but high-level thinking skills to critically analyze information, transfer one concept to another, creative, creative and able to solve problems based on ideas or ideas that are constructed from within the students themselves based on real issues.

The most common taxonomy of learning in the cognitive domain is the taxonomy of bloom. In the Table. 1. (Anderson & Krathwohl, 2010) classify the dimensions of the thinking process as follows.

Table. 1. Dimensions of the Thinking Process

HOTS	Creative (C6)	<ul style="list-style-type: none"> • Create your ideas/ideas • Verbs: construct, design, create, develop, write, formulate
	Evaluate (C5)	<ul style="list-style-type: none"> • Make your own decisions • Verbs evaluate, judge, refute, decide, choose, support
	Analyzing (C4)	<ul style="list-style-type: none"> • Specify aspects / elements • Verbs: compare, examine, criticize, test

Based on the classification the level of reasoning is the HOTS level, because to answer questions at the level of reasoning students must be able to remember, understand, and apply factual, conceptual, and procedural knowledge and have high logic and reasoning to solve real problems. The level of reasoning includes the dimensions of the thinking process of analyzing (C4), evaluating (C5), and creating (C6).

Some of the abilities that can improve HOTS are the ability of student learning creativity. (Munandar, 2009), creativity is the result of interactions between individuals and their environment. Someone affects and is influenced by the context in which he is located. Thus, both change in individuals and the environment can support or hinder creative efforts. From this statement, it can be interpreted that creative action in mathematics consists of creating new things about mathematical concepts, finding an unknown relationship, and reorganizing the structure of the mathematical theory. Mathematical creativity is not only related to further work in mathematics but also finds something new and strange.

Some things are the reasons why creativity is essential to develop in children as expressed by (Munandar, 2009), namely:

- By creating people, they can manifest themselves, and the realization of themselves is one of the basic needs in human life.
- Creativity as the ability to see a variety of possible solutions to a problem is a form of thinking that until now still lacks attention informal education.
- Creative self-busy not only benefits the individual and the environment but also gives satisfaction to the individual.
- Creativity is what enables humans to improve their quality of life.

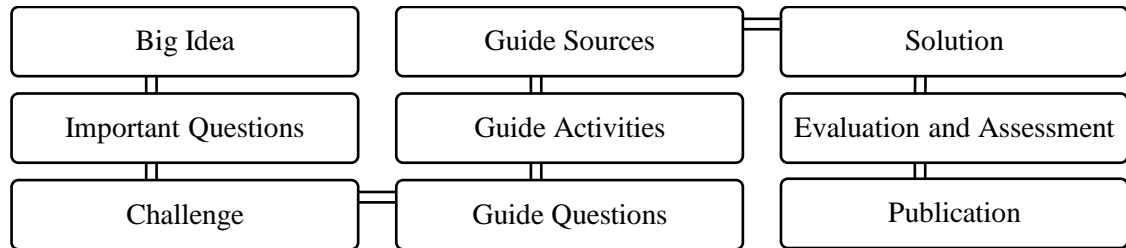
In addition to the Challenge Based Learning model, the supporting factors in improving high-level thinking skills can be seen from the students' mathematical disposition abilities. NCTM (Mahmudi, 2010) defines precise disposition as a tendency to think and act positively. Sumarmo (Ristanti, 2017) says that mathematical distributions are desires, awareness, dedication, strong inclinations in students to think, and do mathematically in a positive way and are based on faith, loyalty, and noble character. Grootenboer (Annajmi, 2018) states that "mathematical disposition related to her beliefs about and attitude toward mathematics may be important as content knowledge for making informed decisions in knowledge in everyday life." From this statement, it can be interpreted that the disposition of student learning towards mathematics has the opportunity to be a factor that determines student success in improving students' high-level thinking skills

NCTM (Annajmi, 2018) someone who has a mathematical disposition means having seven components, which include:

- confidence in using mathematics
- flexible in doing precise work (accurate)
- persistent and resilient in working on mathematical tasks
- have curiosity in mathematics

- e) reflect on the way of thinking and performance on yourself in learning mathematics
- f) appreciate mathematical applications
- g) understand the role of mathematics

The work steps of the Challenge-Based Learning (Premsmith, Wannapiroon, & Nilsook, 2016) learning model that follow Apple inc as follows:



1. Big Idea

Big problems begin by working with students to identify significant problems in everyday life. The big problem in question is an essential issue on a global scale, and students can work together to gain knowledge and in-depth understanding of the problem needed by students to solve problems in daily life.

2. Important Questions

Based on the problem in the big idea, it is then given essential questions to help students in revealing the truths that exist.

3. Challenge

After getting a critical question, the critical question is constructed into a challenge that can describe the central ideas or ideas of students to find solutions based on real action. The challenge consists of 3 activities:

a. Guide Questions

Students can create their own guide questions identifying the knowledge they need to understand to develop solutions to these challenges.

b. Guide Activities

Students identify and engage in guide activities including simulations, research, games, calculations, expert interviews, surveys, and other activities that help them obtain the knowledge needed to answer guide questions (Guiding Resource) and to carry out innovative, broad-minded development, and realistic solutions.

c. Guide Sources

Students conduct research using books, class notes, papers, the internet, and expert opinions to develop solutions to guiding questions.

4. Solution

They must choose a solution through prototyping, experimentation, or other means. Then, they thoroughly research, document, and develop the solution and then identify the steps for implementing their implementation plan.

5. Evaluation and Assessment

The CBL model presents a variety of opportunities for assessment. Informative assessment of content and skills built along with challenges and solutions to challenges provide the best opportunity for summative assessment. Traditional assessment methods are used at many points throughout the process.

a. Publication

The final results are published to provide information that they have developed to other groups and outside the classroom, by publishing in-wall magazines and others.

METHOD

The main objective of this study was to assess how the effects of the 21st-century learning model and students' mathematical dispositions on high-level thinking skills and student learning creativity. In this study the experiments were applied in 6 classes, with the division of CBL learning models applied to 3 classes with a total of 94 students determined based on the category of students' mathematical disposition ability levels, while the PBL learning model experiments were applied to 3 classes with a total of 91 students determined based on the categories of disposition ability levels mathematically students. The distribution of samples can be seen in table 2.

Table 2. Sample Categorization

Class	Mathematical Disposition Rates	CBL	Class	Mathematical Disposition Rates	PBL
1	High	43	4	High	17
2	Moderate	30	5	Moderate	41
3	Low	21	6	Low	33
	Total	94		Total	91

Before experimentation, it is necessary to do a balance test on high-level thinking skills and learning creativity to see how early students are because one of the requirements of this test is that the sample must have the same or balanced ability. The balance test was carried out to find out the high-level thinking abilities of students using test instruments in the form of multiple choices which included HOTS indicators and questionnaire observation sheets in determining the ability of students' creative learning. After a balance, a test is carried out, and the population has the same balance, the initial conditions are met. After the balance test then a mathematical disposition questionnaire was given to determine the disposition level of each student, after that the challenge-based learning model experiment and other models were carried out for four months in the study sample, at the end of the HOTS test and the learning creativity data questionnaire. Will be tested. Data analysis was performed using multivariate analysis with unequal paths.

RESULTS AND DISCUSSION

Research data will be summarized in the table, which will be shown below. Balance test data, analytical disposition summary data, HOTS summary data, and mathematical creativity.

Table 3. Balance Test Data

		HOTS		Creativity	
		Equal var assumed	Equal var not assumed	Equal var assumed	Equal var not assumed
Levene's Test for Equality of Variances	F	.017		.974	
	Sig.	.898		.325	
t-test for Equality of Means	T	-.032	-.032	-.349	-.350
	Df	183	182.946	183	182.952
	Sig. (2-tailed)	.975	.975	.727	.727

Mean Difference		-.04793	-.04793	-.45590	-.45590
Std. Error Difference		1.52073	1.52035	1.30482	1.30378
95% Confidence Interval of the Difference	Lower	-3.04835	-3.04760	-3.03032	-3.02828
	Upper	2.95249	2.95174	2.11852	2.11648

Based on table 3. Levene's Test for Equality of Variances values on HOTS variables and creativity $Sig > 0.05$. Therefore, H_0 is accepted which means because the probability value (significance) of HOTS with equal variance assumed (assumed to be the same two variants) is 0.898 greater than 0.05, then H_0 is accepted. So, is the probability value (significance) of creativity with equal variance assumed (assumed to be the same variant) is 0.325 greater than 0.05 then H_0 is accepted, so it can be concluded that the two options are the same (variant HOTS variable and class group creativity CBL and PBL classes are the same). With this, the use of the t-test uses equal variance assumed (assumed to be the same two variants).

Table 4. Normality Test

Lilliefors Test					
		CBL-H	CBL-K	PBL-H	PBL-K
N		94	94	91	91
Normal Parameters ^{a,b}	Mean	76,97	76,62	65,55	71,65
	Std. Deviation	9,87	9,85	9,44	9,62
L Hitung		,090	,079	,088	,091
L Table		,091	,091	,093	,093
Keputusan		H_0 accepted	H_0 accepted	H_0 accepted	H_0 accepted
Kesimpulan		Normal	Normal	Normal	Normal

Based on table 4. Because the value of $n \geq 50$, we only see it based on the Lilliefors test provided that if $L < L \text{ table}$ then H_0 is accepted. In table 3. with the use of the Lilliefors test the value, $090 < 0.91$, means that H_0 is approved, and the other data is also thus normal distribution.

Table 5. Final HOTS Data and Learning Creativity

Tests of Between-Subjects Effects						
Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	HOTS	29474.927 ^a	5	5894.985	144.764	.000
	Creativity	17604.503 ^b	5	3520.901	149.957	.000
Intercept	HOTS	789013.477	1	789013.477	19375.902	.000
	Creativity	858984.437	1	858984.437	36584.714	.000
Model	HOTS	3304.399	1	3304.399	81.147	.000
	Creativity	281.466	1	281.466	11.988	.001
Mathematical Disposition	HOTS	17797.092	2	8898.546	218.523	.000
	Creativity	12910.115	2	6455.058	274.925	.000
Model * Mathematical Disposition	HOTS	322.111	2	161.055	3.955	.021
	Creativity	528.842	2	264.421	11.262	.000
Error	HOTS	7289.127	179	40.721		
	Creativity	4202.799	179	23.479		
Total	HOTS	936975.000	185			
	Creativity	1005152.495	185			
Corrected Total	HOTS	36764.054	184			
	Creativity	21807.303	184			

Value $FA_{(0.05;2,178)} = 3.047$, $FB_{(0.05;4,356)} = 3.047$, $FA_{(0.05;4,356)} = 3.047$.

Based on table 5. Then it can be concluded several things as follows:

- (1) There are differences in effects between learning models on HOTS ability with $F_{obs} = 81.147$, with $p = 0,000$ because of $F_{obs} > FA$ and $p < 0.05$, H_0 is rejected. There are differences in effects between the learning model on Creativity with the value of $F_{obs} = 11,988$, with $p = 0.001$ because of $F_{obs} > FA$ and $p < 0.05$ then H_0 is rejected.
- (2) There are differences in the effect of high, medium, and low mathematical dispositions on HOTS ability with $F_{obs} = 218,523$, with $p = 0,000$ because of $F_{obs} > FA$ and $p < 0.05$, H_0 is rejected. There is a difference in effect between high, medium, and low mathematical dispositions on Creativity with the value of $F_{obs} = 274,925$, with $p = 0,000$ because of $F_{obs} > FA$ and $p < 0.05$ so H_0 is rejected.
- (3) There is an interaction between the model and mathematical disposition on HOTS ability with the value $F_{obs} = 3.955$, with $p = 0.021$ because of $F_{obs} > FA$ and $p < 0.05$ then H_0 is rejected. There is an interaction between the model and mathematical disposition on Creativity with the value $F_{obs} = 11,262$, with $p = 0,000$ because of $F_{obs} > FA$ and $p < 0.05$ so H_0 is rejected.

Tabel 6. Tabel Descriptive Statistics

Descriptive Statistics					
	Mathematical Disposition	Model	Mean	Std. Deviation	N
HOTS	High	CBL	87.7907	6.10448	43
		PBL	77.0588	2.53650	17
		Total	84.7500	7.21492	60
	Moderate	CBL	71.6667	4.42043	30
		PBL	66.4634	8.67784	41
		Total	68.6620	7.60440	71
	Low	CBL	61.1905	2.18218	21
		PBL	50.3030	7.80018	33
		Total	54.5370	8.19966	54
Creativity	High	CBL	86.0781	4.29001	43
		PBL	79.7447	1.52956	17
		Total	84.2837	4.69242	60
	Moderate	CBL	72.0417	3.70640	30
		PBL	74.0098	4.96612	41
		Total	73.1782	4.55440	71
	Low	CBL	62.0248	3.21029	21
		PBL	58.5618	7.50290	33
		Total	59.9085	6.38603	54

In this study, the experiments were carried out only on two learning models, so they could not use post-manova follow-up tests for the learning model. A comparison of the mean on the dependent variable was made to find out a better model. Based on table 6. Then it can be concluded:

- (1) The CBL model and PBL model are different results if imposed on children who have high mathematical dispositions. By looking at the average ability of the HOTS, the CBL model is more effective than the PBL model.

- (2) The CBL model and PBL model are different results if applied to children who have moderate mathematical dispositions. By looking at the average ability of the HOTS, the CBL model is more effective than the PBL model.
- (3) The CBL model and PBL model are different results if applied to children who have a low mathematical disposition. By looking at the average ability of the HOTS, the CBL model is more effective than the PBL model.
- (4) The CBL model and PBL model are different results if imposed on children who have a high mathematical disposition. By looking at the average creativity capability of the CBL model, it is more effective than the PBL model.
- (5) The CBL model and PBL model are different results if imposed on children who have moderate mathematical dispositions. By looking at the average creativity capability of the CBL model, it is more effective than the PBL model.
- (6) The CBL model and PBL model are different results if applied to children who have low mathematical dispositions. By looking at the average creativity capability of the CBL model, it is more effective than the PBL model.

Tabel 7. Tabel Descriptive Statistics Total

Descriptive Statistics					
	Mathematical Disposition	Model	Mean	Std. Deviation	N
HOTS	Total	CBL	76.7021	11.97114	94
		PBL	62.5824	12.56898	91
		Total	69.7568	14.13523	185
Creativity	Total	CBL	76.2248	10.52988	94
		PBL	69.4791	10.21524	91
		Total	72.9066	10.88659	185

Based on table 7. Then it can be concluded:

- (1) The CBL model of the average value of HOTS capabilities is better than the PBL model.
- (2) The CBL model of the average ability of Creativity is better than the PBL model.

Tabel 8. Tabel Descriptive Statistics Total

Multiple Comparisons							
Dependent Variable	(I) Mathematical Disposition	(J) Mathematical Disposition	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
HOTS	High	Moderate	16.0880*	1.34349	.000	12.7723	19.4038
		Low	30.2130*	1.43708	.000	26.6662	33.7597
	Moderate	High	-16.0880*	1.34349	.000	-19.4038	-12.7723
		Low	14.1249*	1.38335	.000	10.7108	17.5391
	Low	High	-30.2130*	1.43708	.000	-33.7597	-26.6662
		Moderate	-14.1249*	1.38335	.000	-17.5391	-10.7108
	High	Moderate	11.1055*	.91106	.000	8.8570	13.3540
		Low	24.3751*	.97453	.000	21.9700	26.7803
Creativity	Moderate	High	-11.1055*	.91106	.000	-13.3540	-8.8570
		Low	13.2697*	.93809	.000	10.9544	15.5849
	Low	High	-24.3751*	.97453	.000	-26.7803	-21.9700
		Moderate	-13.2697*	.93809	.000	-15.5849	-10.9544

Based on observed means.

The error term is Mean Square(Error) = 26.992.

*. The mean difference is significant at the .05 level.

Based on table 8. Then it can be concluded:

- (1) Between moderate mathematical dispositions with high mathematical dispositions have a mean difference of -16.09. This shows that HOTS capabilities with high mathematical disposition abilities are better than moderate mathematical dispositions.
- (2) Between moderate mathematical dispositions and low mathematical dispositions have a mean difference of 14.1249. This shows that HOTS capabilities with mathematical disposition abilities are better than low mathematical dispositions.
- (3) Between moderate mathematical dispositions with high mathematical dispositions have a mean difference of -11.11. This shows that creative ability with high mathematical disposition ability is better than moderate mathematical disposition.
- (4) Between moderate mathematical dispositions and low mathematical dispositions have a mean difference of 13,2697. This shows that creative abilities with moderate mathematical disposition abilities are better than low mathematical dispositions.

Based on several explanations above, it shows that the challenge-based learning model is successfully implemented and has a positive impact on high-level thinking skills (HOTS) and student learning creativity. Furthermore, the level of mathematical disposition also has a significant influence on high-level thinking skills (HOTS) and learning creativity.

Indirectly, the research model of challenge-based learning on HOTS in mathematics learning is still not much done. However, several studies and theories say that the challenge-based learning model is very appropriate in improving the ability of 4C, which can be measured based on students' HOTS abilities. (Apple, 2008) Challenge Based Learning is a framework for learning while completing real-world challenges. This framework is collaborative and direct, involving all participants (students, teachers, families, and community members) to identify big ideas, ask right questions, find and solve challenges, gain in-depth subject knowledge, develop 21st-century skills, and share their thoughts with the world. Based on the results of the research the challenge-based learning model has been applied in several lessons, (Rådberg, Lundqvist, Malmqvist, & Svensson, 2018) The results of the study indicate that students feel that they have developed deep skills in problem formulation and sustainable development, as well as working across disciplines and with various stakeholders interests. (Nufus & Bahrin , 2018) in his research, concluded that the creative abilities of students taught with the Challenge Based Learning model had a positive effect. (Marin, Hargis, & Cavanaugh, 2013) The challenge-based learning model adds valuable and process-based assessment feedback to the English learning process. (Santos, Sales, Fernandes, & Nichols, 2015) The results of his research show that a teaching-learning environment based on practical experience that combines a challenge-based learning framework with the Scrum process is a useful model to teach students how to become successful mobile application developers immediately. (Kastner & Kukreti , 2014) The model of challenge-based learning increases the activeness of students in asking questions, and students can feel that the model helps the project being done, students get all the information from the material, students can express things that are confusing very well.

CONCLUSION

The 21st-century learning model is very appropriate to be applied in learning, especially the challenge-based learning model because based on this study, high-level thinking skills and student creativity have a significantly better value than other models. Therefore, educators need

to know the application of appropriate learning models is very important in the 21st century because if there is no suitable learning model, future generations will have difficulty facing the development of the 21st century. In addition to that, educators also need to pay attention to the mathematical disposition of students, because mathematical dispositions also significantly influence the ability of high-level thinking and student learning creativity. If necessary, do research again to find out how and what factors can improve students' mathematical disposition skills ?.

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