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Reducing Misconceptions on the Concept of Vibration and Waves with CCM CCA to Improve Creative Thinking Skills

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Abstract: Education in the 21st century currently requires students to improve higher-order thinking skills (Higher Other Thinking Skills), one of which is creative thinking skills. A good conceptual understanding will support higher-order thinking skills, especially creative thinking skills. This study aims to reduce students' misconceptions about the concept of vibration and waves with CCM CCA and to improve students' creative thinking skills. Subjects in this case amounted to 29 students. Students' creative thinking skills are measured from the results of tests carried out 2 times, namely in the form of an initial test (pretest) and a final test (posttest) which refer to indicators of students' creative thinking skills. Items in both tests are equipped with response answers (reasons for answering questions) and all test items are equipped with several answer choices that indicate the level of certainty of answer responses. The method in this research is descriptive quantitative. The results of the study show that the CCM CCA learning model can reduce students' misconceptions about vibration and wave concepts and improve their creative thinking skills.

Keywords: CCM CCA learning model; Creative thinking skills; Misconceptions; Vibration and harmony

Introduction

Along with the development of science and technology, the government seeks to improve the quality of human resources so they can compete globally (Rahayu et al., 2022). One way is by preparing human resources who have good life skills and the ability to think at a higher level. This is reflected in the demands of 21st century education which are expected to improve higher-order thinking skills, one of which is creative thinking skills (Jamaluddin et al., 2019; Azizah et al., 2021). Fudyartanto (2002) stated that thinking is a complex cognitive process. A good conceptual understanding will support higher-order thinking skills, especially creative thinking skills. Critical thinking skills are the ability to analyze and evaluate information used to draw valid conclusions (Marudut et al., 2020; Solikhin & Fauziah, 2021; Indawati et al., 2021; Ramdani et al., 2020)

The modernization of education puts critical thinking in the top position as the most necessary skill (Bilad et al., 2022; Jang, 2016). Through the world of education, learning activities are designed to realize these four things. Good conceptual understanding will support high-level thinking abilities, especially critical thinking abilities. But in fact, students have not achieved a higher level of critical thinking (Zulkifli and Hasyim, 2020; Hidayanti et al., 2021). This happened because most practical learning has not been oriented towards the attainment of CT skills (Verawati et al., 2022; Bensley & Murtagh, 2012). Critical thinking also improves students' achievement in various school subjects by allowing them to practice a wide range of thinking skills. It urges students to observe and control their thinking, which helps them in making important decisions (Al-Shehri, 2020).

Research on learning has shown that misconceptions hinder student achievement. This

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could be due to many reasons, such as the learner's inability to link what is already present to what is new, misinterpreting the new concepts to match the prior knowledge; or due to the lack of prior knowledge about the concept. In these cases, the learner will resort to sticking to his previous conceptualizations in the light of his conceptual framework (Alkhateeb, 2020). Students who are able to deconstruct and reconstruct knowledge are those who use critical, creative thinking and logical reasoning (Makhrus, 2018). Students need a learning that is able to change the conceptual, so that learning becomes more meaningful. Learning should be emphasized on activities that give students freedom to be involved in activities that can improve creative thinking skills.

In connection with some of the problems above, it is necessary to conduct research that aims to improve 21st-century skills, especially the ability to think creatively. Lailiyah et al. (2018) stated that the ability to think creatively is the ability to generate new ideas that develop into several possible solutions to solve a problem. The ability to think creatively is a student's ability to express new ideas based on existing knowledge to solve a problem from a new perspective. This is in line with the thinking of Suryadi and Herman (2008) who explain that the ability to think creatively is a thought process to express new relationships, see things from a new perspective, and form new combinations of two or more concepts that have been mastered before. The ability to think creatively needs to be developed in the learning process because in everyday life every student must have experienced a problem. These problems certainly require students to choose or make solutions and make decisions quickly, right based on the concepts they understand.

The conceptual change model with a cognitive conflict approach (Conceptual Change Model with Cognitive Conflict Approach) which is abbreviated as CCM CCA is a learning model developed to facilitate concept changes in students/students by providing cognitive conflict stimulation to reduce misconceptions (Makhrus, 2018). The validity of the CCM-CCA learning model has been tested through FGD activities and has been declared valid in terms of content and construct. The CCM CCA learning model is transdisciplinary because it was developed based on the results of studies of various disciplines, such as basic physics, learning theories, conceptual change models, cognitive conflict approaches, and other disciplines which are integrated to solve problems that occur in physics learning and are theories or models. new learning to facilitate conceptual changes in student. Conceptual change is a complex process of knowledge revision that typically does not occur spontaneously, and instruction must be tailored to facilitate this process when needed (Oliver and Troemel, 2022).

Method

The method used in this research is descriptive quantitative. Sugiyono (2012) explains that descriptive research is research conducted to determine the value of an independent variable, either one variable or more (independent) without making comparisons, or connecting with other variables. Arikunto (2013) explains that a quantitative approach is an approach that uses quantitative because it uses numbers, starting from data collection, interpretation of the data, and the appearance of the results. Based on this explanation Jayusman, et al. (2020) concluded that descriptive research is carried out by seeking information related to existing symptoms, clearly explaining the goals to be achieved, planning how to approach them, and collecting various kinds of data as material for making reports.

The test subjects in this study were 29 students taking Basic Physics courses in class E of the Mathematics Education PMIPA FKIP Mataram University study program. The researcher's treatment of the test subjects was by using the CCM CCA model during the learning process. Students' creative thinking skills are measured from the results of tests carried out 2 times, namely in the form of an initial test (pretest) and a final test (posttest) which refer to indicators of students' creative thinking skills. Items in both tests are equipped with response answers (reasons for answering questions) and all test items are equipped with several answer choices that indicate the level of certainty of answer responses. To determine the quality of certainty of the respondent's answers, the CRI (Certainty of Response Index) instrument was used. CRI is usually based on a scale, for example, a scale of six (0 - 5) as in Table 1 (Hasan et al. 1999).

Table 1. CRI Criteria

CRI	Criteria		Kategori
0	Totally guessed answer, If the question is 100% answered by guessing	DUC	DUC
1	(almost guess), If the question is 75% - 99% answered by guessing	DUC	DUC
2	(not sure) If the question is 50% - 74% answered by guessing	DUC	DUC
3	(sure) If the question is 25% - 49% answered by guessing	UC	M
4	(almost certain) If the question is 1% - 24% answered by guessing	UC	M
5	(certain) if the question is answered with no elements of guesswork (0%)	UC	M

With this instrument, researchers will characterize students into categories (1) do not understand the concept (DUC), (2) experience misconceptions (M), and (3) understand the concept (UC) well.

Based on Table 1, four possible combinations of answers (right or wrong) and CRI (high or low) can be determined for each respondent individually. For a respondent and a given question, a correct answer with a low CRI indicates a lack of understanding of the concept, and a correct answer with a high CRI indicates a high understanding of the concept. An incorrect answer with a low CRI indicates a lack of understanding of the concept, while an incorrect answer with a high CRI indicates a misconception. This can be shown in Table 2.

Table 2. Provisions for Distinguishing Between Understanding Concepts, Misconceptions, and Not Understanding the Concept

Answer Criteria	Low CRI (< 2.5)	High CRI (> 2.5)
Correct Answer	Correct answer but low CRI means don't understand Draft	Correct answer and High CRI mean good mastery of the concept
Incorrect Answer	Wrong answers and low CRI means you don't understand the concept	Wrong answer but high CRI means there is a misconception

The test given to students is in the form of 4 test questions which refer to indicators of creative thinking skills. The indicators of a person's creative thinking skills include aspects of fluency, flexibility, originality, and elaboration. Munandar (in Sumarno, 2013) details the four indicators of creative thinking as follows, fluency is the process of someone who can think of many ideas, answers, or solving problems, flexibility is the process of someone generating varied ideas by looking for many alternatives or different directions, originality is the process of someone being able to create new and unique expressions, elaboration is the process of someone being able to detail the details of an object, idea or situation so that it becomes more interesting

Result and Discussion

21st-century learning is a learning transition in which the developed curriculum guides schools or colleges to change the learning approach from teacher-centered to student-centered. This is to the demands of the future where students must have thinking and learning skills. These skills can be developed through various activity-based learning models by the characteristics of competencies and learning materials. As for this study, the thinking skills that the researchers wanted to improve were the creative thinking skills of students who took Basic Physics courses in class E of the Mathematics Education PMIPA FKIP Mataram University study program, totaling 29 people.

A good conceptual understanding will support higher-order thinking skills, especially creative thinking skills. According to research on learning that occurs conceptual errors (misconceptions) can hinder student achievement. Therefore students need a learning that can change the conceptual, so that learning is more meaningful. To reduce misconceptions about vibration and wave material, researchers apply the CCM CCA model in learning activities, and to improve students' creative thinking skills, researchers complement learning activities with LKM which refers to the four indicators of creative thinking skills. Following are student responses to learning activities that use the CCM CCA learning model.

Based on the results of the analysis of student opinions in Table 3 on learning activities and learning tools supporting the model used in learning, it can be seen that the percentage of students who give assessments in the very good category is far greater than students who give assessments in the categories quite good and good, even just a little students who assess the category is not good. The results of the analysis above show that learning carried out with the CCM CCA model can be carried out very well in classroom learning. This also shows that the problems presented in the student worksheets are indeed problems that can improve creative thinking skills and can show students that the conceptions that have been believed so far are wrong and conceptual changes must be made towards newer ones correct conception.

Not only through the percentage of student responses, researchers also analyzed student N-gain scores to determine the effectiveness of the CCM CCA model in learning activities. Based on the analysis, the percentage of N-g <g> for all students is 80% or 0.8. The percentage of N-g <g> is very high because <g> ≥ 0.7 (Hake, 1998). The N-g value indicates that the use of the CCM CCA model in learning activities is said to be effective. Students' creative thinking skills are known to be included in the very high category. This is shown in Table 4.

Table 3. Percentage of Student Responses to Learning Activities and the CCM CCA Model Support Learning Device

Indicator	Percentage Of Student Opinion			
	1		1	
	Not Good		Not Good	
Learning Activities with the CCM CCA Model				
What do you think about the CCM CCA learning model	0	3	13	83
Explaining learning material (delivering information or demonstrating examples that contradict students' initial conceptions)	0	0	17	80
Appearance of the lecturer and the way of teaching	0	3	13	83
Investigative activities to test student ideas	3	10	17	70
New knowledge being taught	0	3	10	87
Can study independently	0	10	20	70
Can discuss (get lots of opportunities to speak, express opinions, ask lecturers/friends).	0	0	20	80
How to acquire knowledge/application of learning materials in everyday life.	0	3	17	80
Can challenge students to confront their current thoughts through collaborative experiences that challenge students' preconceptions	3	7	13	77
Offers a detailed discussion of this puzzling phenomenon	0	0	7	93
What is the atmosphere of the class during teaching and learning activities.	0	0	10	90
What if this learning model continues in the next material/semester.	0	0	10	90
Student Worksheets and Teaching Materials				
Ease of understanding goals	0	0	7	93
The concept of physics that becomes problem	0	0	0	100
Demonstration activities carried out lead to problem solving	0	7	13	80
Facilitating the development of student thinking creativity	0	0	0	100
The attractiveness of the question that becomes the problem	0	0	3	97
How to understand the language used.	0	3	7	90
How to apply the material in everyday life.	0	10	13	77
Linkage pre-conception with the latest information to be achieved	0	0	7	93
The results of the activity lead to changes in opinion regarding the truth of the concept that is believed	0	0	0	100
Ease of doing practice questions	0	3	10	87

Table 4. Creative Thinking Skills Level

Class	The Meeting	Creative Thinking Skills Level				Average	Category
		A	B	C	D		
Experiment	1st	92.76	88.82	84.87	96.05	90.62	VH
	2nd	91.45	76.32	88.82	93.42	87.50	VH
	3rd	88.82	100	84.21	67.11	85.04	VH

Note:
A: Fluency, B: Flexibility, C: Originality, D: Elaboration, VH: Very High, V: High.

Based on Table 4 it can be seen that for the ability to think creatively in terms of each indicator. Students have fluency in expressing ideas and producing meaningful responses, flexibility in providing changes to ideas that move from one category to a different category, originality in generating rare and rare ideas, and elaboration in the ability to develop, embellish, and enrich ideas with details. This is in Surya's opinion (2016) which states that creative thinking is a thought process for (1) many possibilities; (2) delaying the scales; (3) new and unusual possibilities; (4) using imagination and intuition; (5) developing and selecting alternatives; (6) many ways and using different points of view on something.

Student learning outcomes shown from the results of students' creative thinking ability tests show that students have understood abstract concepts and have experienced conceptual changes to misunderstood conceptions or even misconceptions. Learning by using the CCM-CCA model and learning tools supporting the model has made students from the beginning of learning admit that there is a cognitive conflict (disequilibrium) against their initial conceptions. This recognition motivates students to try to resolve the conflict. Demonstrations that have been carried out by researchers/lecturers are very effective for creating cognitive conflict because they are simple so that students can easily understand the situation and questions submitted by the model lecturer related to

demonstrations. This situation gives students have the potential for high enthusiasm and motivation to try to solve problems and try to reorganize the knowledge they already have. In addition, students are more challenged to prove the truth of new information conveyed by lecturers through literature studies, discussions, and verification through experiments. Based on the following analysis the level of certainty of student responses can be seen in Table 5.

Table 5. Level of Certainty of Student Responses

Item of Test	Category (Student)					
	TPK		M		PK	
	U1	U2	U1	U2	U1	U2
1	15	0	14	4	0	25
2	18	0	11	3	0	26
3	10	0	19	6	0	23
4	11	1	17	9	1	19
Average	13.5	0.25	15.25	5.50	0.25	23.25

Note: TPK: Does not understand the concept; M: Misconceptions; PK: Understand the concept

Based on Table 5 it can be seen that the results of the initial test (pretest) were that almost all students did not understand the concept. Most students do not understand the concept and most of them experience misconceptions. In each item, most students experienced misconceptions during the pretest, even in the 3rd item about the energy of objects in karmonic vibrations and the 4th about wave velocity, most students experienced misconceptions and few did not understand the concept.

In the posttest results, students experienced an increase in their ability to think creatively, this was indicated by the increase in students who understood the concept and the decrease in students who did not understand concepts and misconceptions. Figure 1 below is a comparison of the level of certainty of student answers on the pretest (U1) and posttest (U2) for the categories of not understanding the concept (TPK), misconceptions (M), and understanding the concept (PK) in each item.

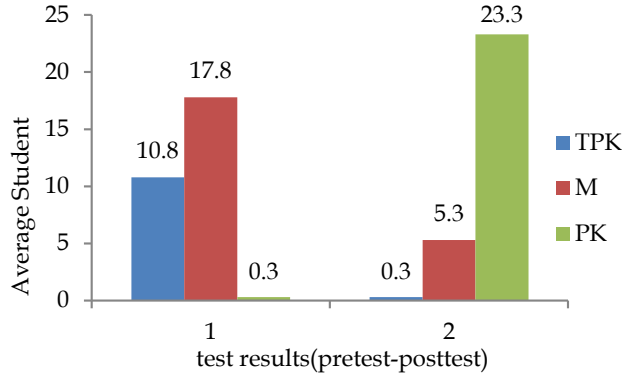

Figure 1. Comparison of the Certainty of Response (TKR) Student Answers

Based on Figure 1, it can be seen that the results of the initial test (U1) of students experiencing the categories of not understanding concepts (TPK) and misconceptions (M) are far greater than the number of students in the final test results (U2). Whereas in the category of understanding the concept the opposite occurs, namely the results of the final test are much greater than the results of the initial test. This shows that learning with the CCM-CCA model is effective in reducing the occurrence of incomprehension of concepts and misconceptions and vice versa is effective in increasing the occurrence of understanding of concepts in students after participating in learning.

Learning that has been done using the CCM-CCA model has been able to reconstruct the knowledge possessed by students so that students do not understand concepts and misconceptions about the concept of vibration and waves can be reduced. The phases of CCM-CCA learning have been able to reveal students' lack of understanding of concepts and misconceptions and then provide solutions (problem testing) to existing problems with a detailed discussion of confusing phenomena, and show how scientific conceptions can apply. This causes students to finally be able to understand the concept and be able to do well on the learning outcomes test. Learning must involve demonstrations and activities that create counter-evidence (counter) and plausible conceptual alternatives to dispel misconceptions (Smith et al. 1993).

Conceptual changes that occur in students are indicated by a reduction in students who experience misconceptions and a significant increase in students who understand concepts indicating that learning using the CCM-CCA model is effective for reducing misconceptions and increasing students' creative thinking skills.

Conclusion

Student learning outcomes shown from the results of students' creative thinking ability tests show that students have understood abstract concepts and have experienced conceptual changes to misunderstood conceptions or even misconceptions. This proves that the CCM CCA model can reduce misconceptions about vibrations and waves and can improve students' creative thinking skills.

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Author Contributions
All authors contributed to research design, instrument preparation, research implementation, data collection and analysis, and article writing.

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Conflicts of Interest
The authors declare no conflict of interest.

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