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Cognitive apprenticeship in vocational students mathematical decision making skills

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ABSTRACT

Exploring the decision-making abilities of undergraduate students, including students from vocational education backgrounds, is the main priority in the achievement of mathematics learning in general and in Calculus courses particularly. Decision-making processes require cognitive guidance through activities describing in detail the systematic steps of each process. It is implicitly said as part of a cognitive apprenticeship procedure. There are claims that students with a vocational education background can develop their academic and practical potential more through a cognitive apprenticeship model. In addition, using video as visual media learning allows students to sharpen their skills. Therefore, the study aims to explore the distinction in achievement and improvement of mathematical decision-making skills between undergraduate students who learn with a Video-assisted Cognitive Apprenticeship approach (CAV), and they are who receive Cognitive Apprenticeship learning (CA) with conventional learning. A quantitative study with the Static-Group Pretest-Posttest Design was employed as a methodology in the research. Based on the research stage, there are differences in achievement and improvement of student decision-making skills with a review of the type of vocational school between undergraduate students.

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INTRODUCTION

The expected students' competencies from Calculus course, in general, is understanding not only the elements of mathematics, algorithms, and the complexity of computational systems but also the ability to apply these concepts and theories to overcome various real-life problems. In solving the problem effectively, the procedures of finding, developing, analyzing, selecting, implementing, and evaluating alternative solutions from various possibilities are needed quickly, precisely, and accurately (Heidari & Shahbazi, 2016; Mitchell & Reiter-Palmon, 2017). These processes by Bruch and Feinberg (2017) are categorized in a realm of thinking activities, namely judgment (the stage of deciding a solution).

Dörner and Funke (2017) and Meyer (2018) emphasize that the decision-making stage of choosing a solution is critical in solving a problem because it is related to determining and justifying the strategies. These activities are challenging since it belongs to the cognitive domain of high-level thinking, and the process also involves an important affective area that accepts responsibility for each choice and its consequences (Kim et al., 2018; Turkan & Jong, 2018). This ability is part of an individual's life in dealing with uncertainty on each aspect of diversity which is generally understood as the interaction and processing of complex information from high-level thinking processes. Hence, it is not excessive if Haupt (2018) and Rabe et al. (2019) recommend improving decision-making abilities in individuals as early as possible to support problem-solving, a consistent personal shaper and ready to face various future challenges. Thus, exploring and optimizing the potential decision-making abilities of undergraduate students is the main priority in the achievement of mathematics learning in general and in calculus courses particularly.

The development of students' decision-making abilities is determined by many factors, including the learning experience (Ramos et al., 2016; Weir & McAvinue, 2013). The learning experience is the crystallization of the forging process of cognitive, affective, and psychomotor competencies received by students in previous high school education (Wismath et al., 2014; Zhan et al., 2013). In addition, the learning experience relates to how often students carry out the trial-and-error process in mathematical exercises (Amidei et al., 2016). Corresponding to this situation, first-level students of the FKIP Mathematics Education Study Program at Universitas Serang Raya come from heterogeneous high school graduates with different learning experiences.

In general, students come from Senior High School (SMA), Vocational High School (SMK), Madrasah Aliyah (MA), and Vocational School of Madrasah Aliyah (MAK), both public and private schools, which are then simplified into two main parts, namely Senior High School (SMA), including MA, and Vocational High Schools (SMK), including MAK. The categorization of undergraduate students based on the performance of mathematical decision-making abilities for calculus courses, especially chapter limits, and functions, for the last three years from 2019 to 2021.

The achievement results in the period showed that students with a high school education background had higher average achievement scores than students with a vocational education background. Besides the lower achievement score, the students from vocational education backgrounds have decreased achievement from year to year, as seen in Figure 1.

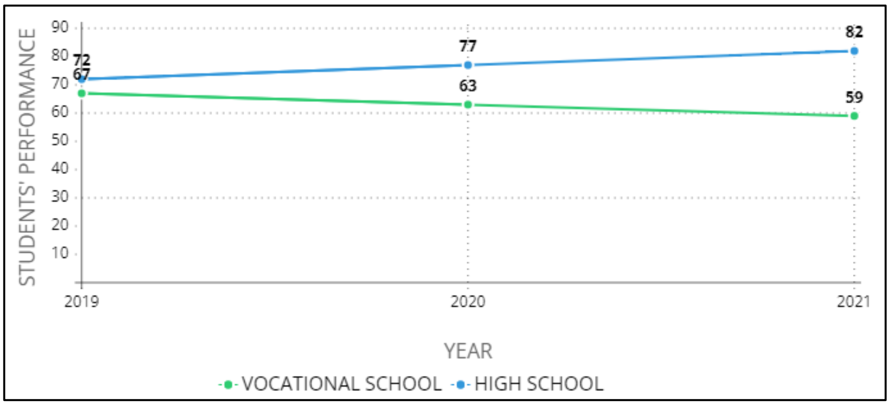


Figure 1. The Data Performance of Undergraduate Students' Decision-making Ability of Calculus

Furthermore, more than 70% of undergraduate students from vocational education background yield on thinking activities that involve a logical analysis and argumentation process in choosing the most appropriate, minimal risk and accountable problem-solving alternatives (R. Oktaviyanthi & Dahlan, 2018). If this condition is sustained, it could inhibit the achievement of the instructional purpose of the course. Furthermore, the preliminary study's results reveal that the instructor's learning process in the three-year interval uses a conventional approach assisted slide PowerPoint. Responding to this, Zeynivandnezhad et al. (2012) stated that the characteristics of vocational schools have learning patterns that focus on procedural abilities.

Meanwhile, the characteristics of calculus courses, particularly limits, and functions, involve formal definitions emphasizing the analysis process (Juter, 2005; Liang, 2015). The analytical expertise needs to be stimulated in various ways, such as providing proper instruction through modeling activities, directing the framework of thinking through guided training activities, and accompanying learning through structured activities starting from the basic to the high level (Brennan

& Resnick, 2012; Collins et al., 2018). However, there needs to be more alignment between the abilities formed in the vocational school. It should fulfill the cognitive abilities of factual learning outcomes at the university level.

Meanwhile, the teaching model in higher education has yet to explore and elaborate on the undergraduate students' abilities that have been mastered. Therefore, there is a significant need to apply other learning approaches to accommodate mastering and optimizing mathematical decision-making abilities. Decision-making is classified into three parts, namely strategic level, tactical level, and operational level, in which individuals require cognitive guidance through activities describing in detail the systematic steps of each process (Bertoni, 2017; Louis & Dunston, 2018).

The cognitive guidance is implicitly said by Lyons et al. (2017), and Oktaviyanthi and Dahlan (2018) as part of a cognitive apprenticeship procedure. In line with previous thought, Tompkins (2016) and Huang et al. (2019) revealed that determining the options in making decisions is most likely developed through a cognitive apprenticeship approach. Collins et al. (2018) emphasized that cognitive apprenticeship in developing decision-making skills stimulates finding as many of the existing options in solving a problem or dealing with certain situations.

Stefaniak (2018), Brown et al. (2019), and Miyauchi et al. (2020) revealed that cognitive apprenticeship in a learning context serves as a driving force for developing students' cognitive skills and abilities through the observation of an expert when responding to situations or dealing with problems by fulfilling the learning stages of modeling, coaching, scaffolding, articulating, reflecting, and exploring. Rina Oktaviyanthi (2019) formulated the first three stages, namely modeling, coaching, and scaffolding, related to the decision-making ability for Limit and Function materials. These stages focus on directing students to find alternative solutions, developing the alternatives, and analyzing the alternative of solving the limit value of the function f(x) in c.

Further, the second three stages, namely articulation, reflection, and exploring. These stages are devoted to students' activities to choose the best alternative for solving the limit value, applying the selected alternatives, and evaluating the application of the alternatives. Whereas, the individual decision-making abilities in vocational education must be developed in a balanced manner to enable the transition from school to the working because, during education, they are more directed at practice-oriented implementation that emphasizes procedural (Golsteyn & Stenberg, 2017; Hampf & Woessmann, 2017). Therefore, the cognitive apprenticeship learning approach is the potential to be implemented to support empowerment and develop the potential decision-making abilities of students with a vocational education background, particularly in clculus for limit and function materials.

Meanwhile, the decision-making process requires clarity of judgment to optimize the visibility of the problems (Nyathi, 2018). The optimization process of the appearance of problems can be accommodated by three main cognitive apprenticeship activities: modeling, coaching, and scaffolding (Minshew et al., 2021). Cakmakci et al. (2020) emphasize that those three main activities are critical stages of exploring the central idea or primary focus of a concept or problem. Furthermore, Brame (2016) claims that visual media help adds almost half the understanding of individuals in observing an idea or problem.

Moreover, audio-visual media significantly impact exploring a concept (Fiorella & Mayer, 2018). The integration of video in learning as a form of audio-visual media provides clarity for students in defining an idea or problem, guides students to construct solutions, and choose the right solution that is most likely to be taken (Knight, 2019; Nilsson & Karlsson, 2019). Since one of the characteristics of vocational school students is that they build skills through strategic work plans (Hu et al., 2018). Therefore, the transfer of knowledge and expertise can work better through demonstrations that display information visually (Babb et al., 2019). Thus, the integration of video in cognitive apprenticeship learning becomes a recommendation that supports the development of students' decision-making skills, particularly in the calculus course.

There are several research that has focused on the application of cognitive apprenticeship learning approaches recently, particularly for concepts that require high-level cognitive exploration. Yusepa et al. (2018) focused on implementing the cognitive apprenticeship approach to improve the mathematical representation ability of junior high school students.

Meanwhile, de Bruin (2018) focused on the perspectives of teachers and students in using the cognitive apprenticeship approach. Further, Ibrahim et al. (2020) focused on the impact of using cognitive apprenticeship modules on the ability to higher order thinking. Moreover, Khudhair (2021) raised mathematics achievement and mathematical proficiency in students who received learning with the cognitive apprenticeship approach.

Using the cognitive apprenticeship model, Pinto and Zvacek (2022) showed student perspectives on mechanical computational learning. The conclusions of the five studies state that there are differences in the average value of experimental classes that implement learning using the cognitive apprenticeship approach with the control class. Considering these findings, applying the cognitive apprenticeship learning approach can improve the results, interests, and motivation of learning or cognitive abilities such as problem-solving and reasoning.

Furthermore, the collaborative research on cognitive apprenticeship approaches with multimedia such as computer applications, websites, or other technologies has been done by several research J. A. S. Brown (2018), Davis (2020), García-Cabrero et al. (2018), Holmberg (2019), and Lin et al. (2021) shows that the learning stage is more visible in uncovering abstract material concepts or ideas. However, many studies related to the implementation of cognitive apprenticeship, whether with multimedia integration or not, it has yet to be done to empower students' decision-making abilities, especially in the background of vocational education in calculus courses, especially limit and function materials.

Therefore, the study aims to explore the differences in achievement and improvement of mathematical decision-making skills between undergraduate students who learn with a Video-assisted Cognitive Apprenticeship approach (CAV) and receive Cognitive Apprenticeship learning (CA) with conventional learning. The findings are expected to provide information about the appropriate learning model for students with a vocational background and serve as input for teachers in designing teaching materials that consider differences in character and experience of students from various educational backgrounds.

METHODS

To achieve the research objective, the study used quantitatively as a collection process approach and analyzed numerical data. A quasi-experiment is a temporary design study that implements quantitative methods. The study includes four variables. This consists of three independent variables and one dependent variable. The independent variables in this study are (1) Video-assisted Cognitive Apprenticeship (CAV) learning; (2) Cognitive Apprenticeship (CA) learning approach; and (3) Conventional learning. At the same time, the dependent variable of research is decision-making ability. There are three research classes: experimental class 1 (E1), which implements the Video-assisted cognitive apprenticeship learning approach; experimental class 2 (E2), which implements the cognitive apprenticeship learning approach; and control class, which uses conventional learning.

The research population is all Universitas Serang Raya undergraduate students, with the research sample being second-level students who take calculus courses. Three sample classes were selected based on the grouping of students studying limits and functions. The distribution of the sample is presented in Table 1.

Table 1. Characteristics of Sample

Research Class/ Number of Students	**High School Type**	
	High School/vocational school	**Total**
Experiment 1/ 32 people	High School	20 people
	Vocational school	12 people
Experiment 2/ 35 people	High School	25 people
	Vocational school	10 people
Control/ 31 people	High School	24 people
	Vocational school	7 people
Total	**98 people**	

The research instruments for gathering and measuring the data were the pretest and posttests on decision-making abilities, student worksheets designed according to the Cognitive Apprenticeship (CA) learning approach, observation sheets, and interviews. Experts, revised and piloted, have validated these research instruments. The questionnaire grids and interview points used in this research can be seen in Table 2, while the math test grids can be seen in Figure 2.

Table 2. The Grid of Questionnaires and Interview Points

No.	Aspect Observation		Evaluation				
A. Students' Activity om Respond Hints/Questions from Lecturer							
Introduction Activities							
1	Take note of the lecturer's explanation of the importance of the material, as well as the objective learning.		1	2	3	4	5
2	Respond to the lecturer's question about basic ability and initial knowledge.		1	2	3	4	5
Care Activities							
3	Modeling	Take note of the depiction-assisted lecturer video narration about material from a simple example, including the use of properties, rules, and theorems.	1	2	3	4	5
4		Observe the steps for answering a variety of questions that are neither exemplified by the lecturer nor shown in videos.	1	2	3	4	5
5	Coaching	Pose the question-related material, questions, or task, along with possible solutions.	1	2	3	4	5
6		Disclose difficulties encountered in finishing the problems.	1	2	3	4	5
7		Inform us of what you should do to finish the problems.	1	2	3	4	5
8		Examine instruction settlement questions carefully, both from the lecturer and from videos.	1	2	3	4	5
9		Train do question tiered with help instruction lectures and video playback.	1	2	3	4	5
10	Scaffolding	Solving problems step by step, guided by the lecturer's instructions, until it can be completed in an independent manner.	1	2	3	4	5
11		Watching videos for assistance in gradually completing the question with increasing complexity.	1	2	3	4	5
12	Articulation	Create draf material or intermediate knowledge processes based on your understanding and language.	1	2	3	4	5
13		Respond to the lecturer's question or contribute to making a verbal comment about current ideas, thoughts, knowledge, and understanding.	1	2	3	4	5
14		Play related video content to gain a thorough understanding of the subject.	1	2	3	4	5
15	Reflection	Join another student in the group in accordance with the lecturer's instructions.	1	2	3	4	5
16		Discuss ideas and compare results according to the lecurer's instructions.	1	2	3	4	5
17		Play-related video content for discussion purposes.	1	2	3	4	5
18		Discuss with lecturer.	1	2	3	4	5
19		Results should be expressed in thinking groups and discussed with the entire member class.	1	2	3	4	5
20		Write the discussion of the results on the whiteboard write or in notebooks.	1	2	3	4	5
21	Exploring	Slove the problems on the developing material.	1	2	3	4	5
22		Play-related video material as additional reference in solving the problems.	1	2	3	4	5
Closing Activities							
23	Take note of the lecturer's explanation of the main points of the material and clarify any incorrect concepts (if any).		1	2	3	4	5
24	Understandable questions about unfinished material.		1	2	3	4	5
25	Writhe review results form today's learning.		1	2	3	4	5

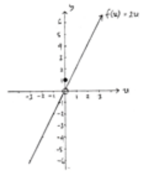
<table>
<tr><th>Mathematical Ability</th><th colspan="2">Indicator</th><th colspan="2">Question</th><th>Answer question</th></tr>
<tr><td rowspan="6">Decision Making</td><td>B11</td><td>Look for an alternative solution</td><td rowspan="6">7</td><td rowspan="6">Please specify whether the function's limit at point c exists from the functions listed below. If so, how do you explain that the limit value is correct?
$f(x) = \begin{cases} 2x, x \neq 0 \\ 1, x = 0 \end{cases}, c = 0$</td><td>a. Use the concept of left limit and right limit
$\lim_{x \to c} f(x) = \lim_{x \to c^-} f(x) = \lim_{x \to c^+} f(x)$
b. Use graphic method
c. Use table approach through calculation in a manner numeric</td></tr>
<tr><td>B12</td><td>Develop altemative solution</td><td>a. Write down the left limit and right limit function that is known
b. Draw a sketched graphic from existing information available
c. Enter any x values in the function For get mark function f(x)</td></tr>
<tr><td>B13</td><td>Analyze alternative solution</td><td>Detail and complete choice solution both in form algebra, sketch neither graphic nor numeric table.
a. Left limit $\lim_{x \to 0^-} 2x = 0$ and right limit $\lim_{x \to 0^+} 2x = 0$
b. Sketch the graph
c. Numeric table calculation
<table>
<tr><th>x</th><th>$f(x)$</th><th>$(x, f(x))$</th></tr>
<tr><td>-3</td><td>-6</td><td>(-3, -6)</td></tr>
<tr><td>-2</td><td>-4</td><td>(-2, -4)</td></tr>
<tr><td>-1</td><td>-2</td><td>(-1, -2)</td></tr>
<tr><td>0</td><td>0</td><td>(0, 0)</td></tr>
<tr><td>1</td><td>2</td><td>(1, 2)</td></tr>
<tr><td>2</td><td>4</td><td>(2, 4)</td></tr>
<tr><td>3</td><td>6</td><td>(3, 6)</td></tr>
</table>

</td></tr>
<tr><td>B21</td><td>Choose the best alternative</td><td>Choose a solution as believed correct</td></tr>
<tr><td>B22</td><td>Apply alternatives in solving the problem</td><td>Finish the question with use the selected solution</td></tr>
<tr><td>B23</td><td>Evaluate application alternative</td><td>a. Based on argument
b. Based on calculation algebra
c. Based on proof with a formal definition that involves ε and δ</td></tr>
</table>

Figure 2. The Grid of Mathematical Test

To determine the magnitude of the achievements and the increase in the ability of the research sample, the quasi-experimental static-group pretest-posttest design proposed by Creswell (2013) was used, as shown in Figure 3.

O	X_1	O
O	(X_2)	O
O		O

Figure 3. Quantitative Research Design

Notes:
X1: Video-assisted Cognitive Apprenticeship learning approach (E1)
X2: Cognitive Apprenticeship learning approach (E2)
O: Decision-making ability test
Dashed line: The selection of research sample was not randomly choosen

The three classes were given a pretest regarding decision-making abilities that experts, revised, and tested had validated. After that, each class was treated differently, which ended with the post-test that was the same as the pretest. The assumption test consisting of normality and homogeneity test on the data was carried out first to determine the statistics used in the average equivalence test between the three research classes. The data homogeneity test analysis results can be seen in Table 3, while the results of the data normality test can be seen in Table 4. The analysis of data homogeneity and normality tests was carried out with the help of SPSS software.

Based on the normal distribution and data homogeneity tests, to measure the difference in the average achievement and improvement in decision-making ability of undergraduate students among three research classes used, the One-Way ANOVA test.

Table 3. Levene Statistic Homogeneity Test Results

Type of Data	Sig.	Test Results
Reach_ Making_Decision	.948	the data variance is Homogeneous
N_Main_Making_Decision	.803	the data variance is Homogeneous

Table 4. Kolmogorov-Smirnov Normality Test Results

Data Reach of Decision Making Capabilities							
Type_School_Middle_And_Class		**Sig.**	**Test Results**	**Type_School_Middle_On_ Merge_Class**		**Sig.**	**Test Results**
Reach_Making_ Decision	CAV Class High School	.071	Data is normally distributed	Reach_ Making_ Decision			
	CAV Class Vocational School	.200*	Data is normally distributed		High School	.103	Data is normally distributed
	CA Class High School	.052	Data is normally distributed				
	CA Class Vocational School	.200*	Data is normally distributed				
	Conventional Class High School	.060	Data is normally distributed		Vocational School	116	Data is normally distributed
	Conventional ClassVvocational school	.200*	Data is normally distributed				
Data for Improved Decision Making Capabilities							
Type_School_Middle_And_Class		**Sig.**	**Test Results**	**Type_School_Middle_On_M erge_Class**		**Sig.**	**Test Results**
N_Gain_ Making_Decision	CAV Class High School	.077	Data is normally distributed	N_Gain_ Making_ Decision			
	CAV Class Vocational School	.099*	Data is normally distributed		High School	.070	Data is normally distributed
	CA Class High School	.188	Data is normally distributed				
	CA Class Vocational School	.060	Data is normally distributed				
	Conventional Class High School	180.	Data is normally distributed		Vocational School	.091	Data is normally distributed
	Conventional Class Vocational school	.200*	Data is normally distributed				

RESULTS AND DISCUSSION

The differences in achievement of decision-making abilities of students with a vocational education background (Problem Formulation 1)

The data on students' decision-making ability among the three classes based on the type of vocational school are similar. Therefore, the test used to test the achievement of the data difference is called the One-Way ANOVA test. The rejection criterion H0 in this test is if the probability value (Sig.) < 0.05. The results of the One-Way ANOVA statistical test for vocational school category learning class data can be seen in Table 5.

Table 5. Statistical Test Results of Differences in Achievement of Decision Making Abilities from Three Classes of Undergraduate Students in the Vocational Learning Category

ANOVA					
Reach_Making_Decision					
Sum of Squares		**df**	**Mean Square**	**F**	**Sig.**
Between Groups	529.936	2	264.968	3.442	.048
Within Groups	15602.064	26	600.079		
Total	16132.000	28			

A probability value (Sig.) = 0.048 < 0.05, then H0 is rejected, which means there is a difference in the average achievement of decision-making ability of vocational students who receive video-assisted cognitive apprenticeship learning, cognitive apprenticeship learning, and conventional learning.

The Post Hoc test is carried out to determine the difference in the average achievement of students' decision-making abilities based on vocational schools in different learning classes. The hypothesis of the data test in question is H0: There is no difference in the average achievement of student decision-making abilities between each learning class of the vocational category, and H1: There is a difference in the average achievement of student decision-making abilities between each learning class of the vocational category.

Acceptance criterion H0 if the probability value (Sig.) > 0.05, based on the Post Hoc test results, the probability value (Sig.) < 0.05 was obtained in the comparison between class with video-assisted cognitive apprenticeship learning and class with conventional learning.

Table 6. Post Hoc Test Results of Achievement of Decision Making Ability from Three Classes of Undergraduate Students in the Vocational Learning Category

Multiple Comparisons							
Dependent Variable: Reach_Decision-Making_							
	(I) Class_ Learning_Vocational School	**(J) Class_ Learning_ Vocational School**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
						Lower Bound	**Upper Bound**
Tukey HSD	Video-assisted Cognitive Apprenticeship	Cognitive Apprenticeship	1.950	10.488	.981	-28.01	24.11
		Conventional	-8.728	12.072	.025	-38.72	21.26
	Cognitive Apprenticeship	Video-assisted Cognitive Apprenticeship	-1.950	10.488	.981	24.11	28.01
		Conventional	10.678	11.650	.635	-39.62	18.27
	Conventional	Video-assisted Cognitive Apprenticeship	8.728	12.072	.025	21.26	38.72
		Cognitive Apprenticeship	-10.678	11.650	.635	-18.27	39.62
* The mean difference is significant at the 0.05 level							

From the complete calculation of the Post Hoc test shown in Table 6, the provision of different learning in video-assisted cognitive apprenticeship classes and conventional classes significantly affects students' decision-making abilities. The average difference between these two classes is 8.278, which means that the average achievement of student decision-making ability in the class with Video-assisted cognitive apprenticeship learning is higher than that of undergraduate student decision-making ability in a conventional class. Therefore, video-assisted cognitive apprenticeship learning is more effective in optimizing students' decision-making abilities than conventional learning.

The Differences in improving the decision-making ability of students with a vocational education background (Problem Formulation 2)

Applying the equivalent expression, the One-Way ANOVA test was performed to test the difference in the average increase in students' decision-making ability among the three research classes. The results of the One-Way Anava statistical test are provided in Table 7.

Table 7. Statistical Test Results of Difference Improvement (N-Gain) in Decision Making Ability from Three Classes of Undergraduate Students in the Vocational Learning Category

ANOVA					
N_Gain_Making_Decision					
Sum of Squares		**df**	**Mean Square**	**F**	**Sig.**
Between Groups	45.225	2	31.201	3.973	.007
Within Groups	1412.031	26	62.012		
Total	1505.344	28			

Table 7 shows that the probability value (Sig.) = 0.007 < 0.05, which causes the rejection of H0. It means there is an average difference in the increase in decision-making ability of undergraduate students who receive video-assisted cognitive apprenticeship learning, cognitive apprenticeship learning-only, and conventional learning in the vocational category.

Then the Post Hoc test was carried out with a hypothesis test: H0: There is no difference in the average increase in student decision-making ability between each of the learning classes in the vocational category, and H1: There is an average difference in student decision-making ability between each learning class of the vocational category. If the probability value (Sig.) >0.05, the criterion H0 is accepted. Post Hoc test results are presented in Table 8.

Table 8. Post Hoc Test Results (N-Gain) Decision Making Ability from Three Classes of Undergraduate Students in the Vocational Learning Category

Multiple Comparisons							
Dependent Variable: N_Gain_Making_Decision							
	(I) Class_ Learning_Vocational School	**(J) Class_ Learning_ Vocational School**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval Lower Bound**	**95% Confidence Interval Upper Bound**
Tukey HSD	Video-assisted Cognitive Apprenticeship	Cognitive Apprenticeship	.06900	.03628	.453	-.0714	.2874
		Conventional	-.00754	.05826	.042	-.2480	.2361
	Cognitive Apprenticeship	Video-assisted Cognitive Apprenticeship	-.06900	.03628	.453	-.2874	.0714
		Conventional	-.07554*	.04730	.047	-.3117	.0829
	Conventional	Vide-assisted Cognitive Apprenticeship	.00754	.05826	.042	-.2361	.2480
		Cognitive Apprenticeship	.07554*	.04730	.047	-.0829	.3117

* The mean difference is significant at the 0.05 level

Table 8 shows the probability value (Sig.) < 0.05, which causes the rejection of H0. This indicates a difference in the average achievement of students' decision-making abilities, namely in comparing video-assisted cognitive apprenticeship learning classes with conventional learning classes and cognitive apprenticeship learning classes with conventional instruction classes.

Based on the result of the One-Way ANOVA statistical test, which answers the first problem formulation regarding the differences in achievement and the second problem formulation regarding the differences in improvement in decision-making ability reviewed from vocational school, it shows a rejection of the null hypothesis. The decision to reject H0 is the difference in achievement and improvement in the decision-making ability of undergraduate students among classes of the type category of vocational school.

Following the results of the Post Hoc test in Table 6, the difference in achievement obtained a probability value (Sig.) < 0.05 in comparing undergraduate students' decision-making abilities between CAV and conventional learning classes. These calculations mean that the treatment of learning in CAV learning classes has a significantly different effect on the decision-making ability of vocational school graduates. The average difference in achievement between CAV learning classes and conventional learning classes is 8.728, which means that students' decision-making ability in CAV learning classes is higher than in conventional learning classes. These results show that the decision-making ability of undergraduate students from vocational schools can be more effectively supported through CAV learning.

Meanwhile, the Post Hoc test results for differences in students' decision-making abilities showed a rejection of H0 in testing between CAV and conventional instruction classes and between CA learning and conventional instruction classes. The statistical calculation in Table 8 supports the explanation of the rejection of the null hypothesis between CAV learning class and conventional instruction class that the difference in the increase in decision-making ability between undergraduate students in the two classes.

The results suggest that students with a vocational education background have opportunities to improve decision-making abilities through CAV learning. Furthermore, statistical calculations to support the exposure to H0 rejection between the CA learning class and the conventional instruction class are presented in Table 8. The results presented in Table 8 indicate that the decision-making ability of undergraduate students from high schools and vocational schools is developed and improved by implementing CA learning. Thus, CA learning and CAV learning effectively increase the decision-making ability of undergraduate students from vocational school significantly compared to conventional learning.

In general, from this category of vocational school types, this learning approach has an important contribution to improving decision-making skills, especially having a major impact on undergraduate students from the vocational school. There is a considerable difference between the implementation of CA learning and CAV learning with conventional learning at the type of vocational high school. The low improvement in decision-making ability of undergraduate students from vocational school among three classes indicates that students in this category need intensive assistance and serious attention compared to other category students in CA learning activities and CAV learning.

The observer of students' activity evaluates the implementation of learning in two main namely (1) students' activities in response to the instructions/questions from the lecturer and (2) students' activities in the group discussion/class. Similar to the observations on the lecturer's activities, the observation of students' activity was also done in eight times activity with indicators observing whether exists or no response to the activity in question through information scale evaluation, namely 1 for 'no active; a response which is less than 20% of students who responded active, 2 for response 'less active' which is 20 – 40% of students who respond active, 3 for response 'active enough' which is 40 – 60% of students who respond active, 4 for response 'active' 60 – 80% of students who respond active, and 5 for response very active that is more than 80% of students who responded active. As for percentage average yield evaluation from two observers on the activity student for eight meetings stare advance served in Table 9.

In general, the students that successfully observed and witnessed by observers both in the cognitive apprenticeship help self-paced video classroom and in the learning cognitive apprenticeship classroom obtained results of 70 – 80% from each observer. This indicates that around 22-32 students respond to active interaction And discussion groups/classes on each class learning.

Table 9. Recapitulation Results of Students' Activity Observation

No.	Aspect Observation		Percentage CAV Class		Percentage CA class	
			Observer 1	Observers 2	Observers 1	Observers 2
1	Activity student in respond instructions/questions lecturer	Modeling	66.67	78.33	77.50	79.17
		Coaching	75.83	77.50	79,17	86.67
		Scaffolding	85	90	78.75	86.25
		Articulation	69,17	72.50	65	70.83
		Reflection	77.92	86.67	78.75	87.08
		Exploring	81.25	88.75	78.75	85
Sub Percentage Point 1						
2	Activity student in activity discussion group/class		69.09	69.77	67.73	68.64
Sub Percentage Point 2						
Total Percentage			74.99	70.54	75.09	80.52

The CA learning approach, which is applied to the teaching and learning activities in the classroom, can trigger the excavation of the ability to find and develop alternative student problem-solving, called hidden creativity thinking skills (de Bruin, 2018). According to Kuo et al. (2012), creativity in finding problem solutions is facilitated through modeling activities as the main step where students' understanding is determined by the successful delivery or visibility of the problem and modeling how the experts solve the problem. Understanding the problem, followed by applying problem-solving to obtain meaning from the solutions offered in the CA learning approach, focuses on students' direct practice activities with their experts. Khaled et al. (2014) respond to hands-on activities as a typical form of vocational education for their learners to achieve curriculum objectives.

In addition, Wedelin and Adawi (2015) state that modeling in cognitive apprenticeship provides a directed and systematic work stimulation for students with a vocational education background. The characteristics of coaching in CA are considered as situations that correspond to the environment and habits of vocational education, namely mentoring (M. Brown et al., 2019), so that through this learning, students are more easily directed and fostered to develop creative thinking potential and produce problem-solving (Yusof et al., 2015). Individuals from vocational schools tend to be able to follow an internship learning pattern where expertise is obtained by learning directly from their experts in theory, practice, and experience, both cognitive and non-cognitive expertise (Poortman et al., 2011).

Students from vocational education are prepared to meet the demands and needs of the business and industrial world (Ulicna et al., 2016), which is loaded with high qualifications both in the mastery of knowledge, skills, attitudes, and values of the world of work (Eichhorst et al., 2015). Some qualifications that students from vocational schools must master include critical thinking, logical view patterns, and analytical, systematic workflows to support the quality of performance dominated by decision-making procedures when facing problems, especially analyzing and choosing alternative problem-solving (Aaltonen et al., 2013).

The necessary qualifications must be cultivated, developed, built, and directed at individuals as early as possible through the educational process. Ghefaili (2003) states that implementing the cognitive apprenticeship learning strategy has the same mission as the vocational education curriculum in shaping a critical, logical, and analytical mindset to characterize students' skills through learning directly with experts. CA learning technique is carried out through scaffolding which focuses on gradually assigning tasks with increasing problem complexity and reducing the level of assistance.

Verenikina (2008) and Radford et al. (2015) explain that scaffolding has a positive impact and high acceleration power to characterize thinking skills and work skills so that it is appropriately applied to students who are specifically prepared to dive into the world of work directly. In addition, articulating CA learning provides opportunities for vocational students to build knowledge, translate understanding, and clarify their way of thinking, especially on problem-solving and, in general, on other aspects that have a foundation to synergize in the world of work (Greenleaf, 1977; Moss & Brookhart, 2012).

Furthermore, McGrath (2012) explains more deeply about the responsive and anticipative attitude that must be reflected in the upbringing of the vocational curriculum, not only on the problems that arise but also on the solutions offered. Such attitudes tend to be effectively instilled through familiarizing reflection activities with brainstorming and exchanging views and experiences with experts. In CA learning, reflection activities carried out by students stimulate the connectivity scheme of understanding and experience carried out by oneself with others. Therefore, there is an exchange, the dissemination of knowledge and experience with each other.

This thought aligns with Burgon et al. (2012), who stated that knowledge assimilation occurs due to scientific alterations from two parties interacting, such as students with teachers or other students. With the formation of a mix of knowledge, it is possible to diversify understanding in solving problems, especially in selecting, implementing, and evaluating alternative solutions. In addition, Anastasiou and Kyriakou (2017) assessed the factors of readiness and willingness to explore self-efficacy through learning by doing to focus on the mental formation of students in vocational schools, which according to Middleton (2011) can be facilitated by learning cognitive apprenticeship through stages of exploring. Fernandez et al. (2014) said exploring activities encourage students to explore the knowledge acquired, deepen the skills learned and promote their actual understanding. These attitudes are expressed by Bayle and Mettas (2010) as supporting the building of decision-making abilities, especially activities evaluating the implementation of solutions that require.

The use of integrated learning media in CA learning, according to Valentine (2011), can help the performance of students in vocational schools who are known to have mathematical abilities below students in general secondary schools, especially in mathematical concepts with a high level of abstraction. Specifically, on the inclusion of audiovisual media such as video, although there are no findings that specifically support the application of video-assisted mathematics learning in students in vocational schools, the use of video for introductory material and guidance for working has been widely implemented in vocational education curricula (Holsted, 2016). Colasante and Leedham (2013) concluded that students with vocational education curricula showed great enthusiasm and positive achievements after attending video-assisted learning. Moreover, in their research report, Cakiroglu and Yilmaz (2017) reveal the picture of student responses in vocational schools that video helps visualize techniques about a material clearly and in detail to provide a complete understanding.

Cognitive apprenticeship learning assisted by self-paced video implicitly contributes to improving adaptive reasoning skills, decision-making, and self-directed learning of students with vocational high school backgrounds and those from high schools in rural areas. However, what needs to be considered in more detail is the selection of learning videos that suit the needs and abilities of the students being measured so that their contribution can be more comprehensive for all students with any background and origin from any school. Cognitive apprenticeship learning assisted by self-paced video has not optimally improved all indicators of cognitive and affective ability in this study, so it is necessary to conduct a deeper study of the causes of this non-optimality or conduct further research by collaborating ideas from other learning models.

Adaptive reasoning abilities, decision-making, and self-directed learning cannot be improved simultaneously. Therefore, an intense focus is required to create learning tools such as student worksheets that include all indicators. There are numerous and diverse studies on calculus. However, there are which specialize in the definition of formal limits, particularly on how to understand the concept to students in their first year at university.

CONCLUSION

There are differences in achievement and improvement of student decision-making skills with a review of the type of vocational school between undergraduate students who experienced cognitive apprenticeship learning assisted by video with undergraduate students who instructed cognitive apprenticeship learning only and the undergraduate students who received the conventional learning. Partially, (1) the decision-making ability of undergraduate students from vocational school between those who experienced cognitive apprenticeship learning assisted video is not different from those who instructed cognitive apprenticeship learning only; (2) The decision-making ability of undergraduate students from vocational school between for those who received cognitive apprenticeship learning assisted video is better than for those who taught conventional learning; and (3) The decision-making ability of undergraduate students from vocational school between for those who received cognitive apprenticeship learning only is better than for those who received through the conventional learning.

Cognitive apprenticeship learning assisted by self-paced video can be applied to the limit of functions calculus course to improve adaptive reasoning abilities, decision making, and self-directed learning of students from secondary schools in urban and rural areas. Self-paced video-assisted cognitive apprenticeship learning can be taught in the function limits chapter calculus course for increasing adaptive reasoning ability, retrieval decision, and self-directed learning students by paying attention to learning devices, learning environment, and students intrinsic motivation. The choice of research subjects plays a significant role in the success of a learning experiment. Students used as participants in cognitive apprenticeship classes using self-paced videos are ideal students with an audiovisual learning style. In classroom practice that includes learning videos and worksheets, creating an LKM incorporating video sections as instructions for understanding a concept or creating interactive guided worksheets based on videos is best.

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