Calculus Based On Contextual Learning Model To Cultivate Student's Activity, Interest And Mathematical Connection Ability

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Abstract: The preliminary study on Calculus classes in Department of Mathematics of Tarbiyah Faculty of IAIN Imam Bonjol Padang, reveals that the instructional process and materials that the lecturer used not yet facilitated the students to construct their own learning in calculus. The effectiveness of learning calculus is still low and the learning process is still conventional. So that, it needs for the development of calculus-based contextual learning model. The purposes of this research were to develop a model of calculus based contextual learning (CBCL) that is valid, practical, and effective. But, in this article, it just discussed about the effectiveness of this model. A Design research was conducted to develop a model of calculus instruction through contextual based adapted from the model suggested by Plomp [18]. The design research phases involved preliminary research, prototyping phase and assessment phase. The research data were qualitative and quantitative. Qualitative data were collected through observation and questionnaires and quantitative data were obtained through testing and observation activities of students. The result of prototype phase showed that the Syntax calculus-based contextual learning model consists of five phases, namely: (1) Phase 1. Delivering objective, Giving Motivation and Apperception, (2) Phase 2. Organize the students into groups and Delivering learning how to learn, (3) Phase 3. Guided group work, (4) Phase 4. Guiding and Class Discussion (5) Phase 5. Reflection and Evaluation. The improvement of the model of CBCL at the effectivity test show that the all four aspects of assessment obtain the effectivity percentage value with effective category, that is the result of students activity observation of the model of CBCL is 70,5% with effective category, students learning interest questionnaire of the model of CBCL is 76,5% with effective category, the IWS score is 74,39 with effective category. The students' mathematical connection ability taught by using the model of CBCL is higher than the student mathematical connection ability taught by using conventional learning.

Index Terms: model of learning, contextual teaching and learning, calculus

1 INTRODUCTION

The development of science and technology has bring basic change of goal and the nature of mathematics education starting from the elementary school level to university level. The changing paradigm of mathematics education emphasis on realistic and contextual learning situation; able to construct the solution, and interaction between the teacher and the students. The changing paradigm has many similarities with paradigm theory of RME (Realistic Mathematics Education) which is developed in the Netherland. According to RME, mathematic learning should be related with real life and CTL (Contextual Teaching and Learning) which has been developed in America. The core is that educator should bring the real world situation into the classroom and encourage the students to relate the knowledge they owned with the implication in their daily life. Hence, the students can get a real understanding on the lesson they are learning. Therefore, the four pillar of universal education suggested by UNESCO, namely learning to know, learning to do, and learning to be and learning to live together in peace and harmony could be realized [6]; [10]. CTL can change the regular program, a program which is not interesting to the university students, become dynamic programs, so that they can perform a high standard achievement. Learning on contextual based is a new constructivism approach on mathematics learning, which has been developed in America that is the forming of Washington State Consortium for Contextual by the department of Education, United Stated of America [1]; [2]; [10]. However, the real situation at schools and university indicate different. The teaching and learning process was held conventionally. The teacher and the lecturer dominate the classroom being active in talking meanwhile the students just be passive low involvement in classroom activity, so that learning outcomes which consist of cognitive aspect, affective aspect and psychomotor aspect cannot be reach well. The role of context problems used to be limited to the applications that would be addressed at the end of a learning sequence – as a kind of add on. Nowadays, context problems have a more central role. They are endorsed because of today's emphasis on the usefulness of what is learned, and because of their presumed motivational power. According to Tall, mathematicians tend to make a typical error when they design an instructional sequence for calculus. The general approach of a mathematician is to try to simplify a complex mathematical topic, by breaking it up in smaller parts that can be ordered in a sequence that is logical from a mathematical point of view. 'From the expert's view-point the components may be seen as part of a whole. But the student may see the pieces as they are presented, in isolation, like separate pieces of a jigsaw puzzle for which no total picture is available [22]. We will take a calculus course as an example, and show that in the reinvention approach, the role of context problems and of symbolizing and modeling are tightly interwoven. Actually, we build upon the work that has been done on symbolizing and modeling in primary-school mathematics. We try to show that the framework that has been developed for primary school can also be used for such an advanced topic as calculus [19]; [23]; [7]; [8]. A sensible alternative, according to Tall, would be to look for situations that can function as informal starting points, from which cognitive growth is possible. In this context, Tall (cited in Bishop et al., 1996) argues for more emphasis on visualizing mathematical concepts and more enactive experiences in mathematics education. The students should first experience a qualitative, global, introduction of a mathematical concept. This qualitative introduction then should create the need for a more formal description of the concepts involved. 'Graphic calculus' is such an alternative approach developed by Tall [3]; [20]; [21]. Tall (cited in Bishop et al., 1996, p. 314) observes that the problem for a calculus course is in the transition from meaningful discussions based on visual imagery to formal mathematical reasoning. Students interpret a definition that is based on visual imagery as a description, as a model of the picture, instead of a mathematical definition that can be used for formal reasoning. In contrast to Tall, Kaput (1994a), emphasizes the relationship between mathematical symbol systems like graphs and everyday reality. The problem, in his view, is the gap between the island of formal mathematics and the mainland of real human experience. He elucidates this gap with the difference between mathematical functions that are defined by algebraic formulas, and empirical functions that describe everyday-life phenomena. To underscore his point, he quotes Thomas Tucker's rhetorical question: 'Are all functions encountered in real life given by closed algebraic formulas? Are any?' [3];[12] [5] who describe an instruction period where the students invented graphing, for instance, report such an approach. Albeit, not as a result of ample instructional planning. As a matter of fact, the invention process was more or less incidental. The students had been programming simulations of real-life motions with a Logo-like turtle that left a trail of dots across the screen. Next, the students were asked to come up with a paper-and-pencil way to represent the motion story of one of the simulations they worked on. The solutions of the students that were to some extent inspired by the dot-track of the computer simulation, formed the starting point for a series of discussions and activities, in which a graph-type representation of this motion story emerged. Following [14] we can take this line of thinking one step further, by acknowledging a dialectical relation between notations-in-use and mathematical sense making. According to this dynamic point of view, it is in the process of symbolizing that symbolizations emerge and develop their meaning. In this process, notational systems shape the very activities from which they emerge, while at the same time, the activities shape the meanings that emerge. Calculus is one of the course learned by university students coming from mathematics, physics, biology, technique, agriculture, statistic, pharmacy [13] and also Mathematic Tadris at Tarbiyah Faculty, IAIN Imam Bonjol Padang. Calculus course which is part of mathematics tadris curriculum at IAIN Imam Bonjol Padang consist of Calculus I, Calculus II and Calculus with many changer variables, is an obliged course. Students can learn Calculus II after they finish learning Calculus I. Next, Calculus with many changer variables can be learned after learning Calculus II. In conclusion, in order to learn the next level of calculus, a student have to master the previous one. The effectivity of calculus learning at Tadris Mathematic is still low. The low of the effectivity in learning calculus, can be seen through the percentage of students getting score A to Calculus I, II and Calculus Multivariate in the last 4 years. The highest percentage of A is only 22%, and percentage of B is only 48%. The low of calculus learning effectivity also experienced by other universities. Some researchers observed this problem, such as [4]; [9]; [17]; [24], [25]. Research development of mathematics learning at university level is a relatively new phenomena, indeed research on calculus-based contextual learning model [11]. The problems occur on mathematics education at university cannot be solved only by having an experiment research to seek for learning strategy or method or by adopting new textbook. Therefore, it realized the importance practicing this research development.

a. Prototype Phase

This phase aimed to produce a valid prototype. There are three steps on this activity, (a) designing the prototype, (b) formative evaluation and (c) revision of prototype [18]..

b. Assessment Phase

This is aimed to hold a deeper assessment on revised prototype. Summative evaluation applied by using practicality testing and effectivity testing. The focus activity is field testing. The objective is to get to know whether the developed learning model is already practical and effective. The testing is limited field test [16];[18].

2. METHODS

This is a limited product testing applied to the students of mathematical Tadris Department, Tarbiyah Faculty IAIN Imam Bonjol Padang at 1st semester. There are two reasons in choosing the subject were as a realization of three university devotion and based on the analysis of needs and contexts. Types of data used in this research is qualitative and quantitative data. Qualitative data can be gathered from discussion result, observation, and interview. Meanwhile, quantitative data can be obtained from learning test result, questionnaire, and observation sheet. The obtained data in this research are qualitative and quantitative. These data are to answer the question of whether developed contextual teaching and learning model already valid, practical and effective.

3. RESULTS AND DISCUSSION

Syntax of the model of CBCL consist of five phases, namely: (1) phase 1. Delivering objective, Giving Motivation and Apperception, (2) Phase 2. Organize the students into groups and Delivering learning how to learn, (3) Phase 3. Guided group work, (4) Phase 4. Guiding and Class Discussion (5) Phase 5. Reflection and Evaluation. Every phase describes the sequence of lecturer and students activities during teaching and learning process. The analysis result of the model of CBCL development at the validity and the practicality test phase, it can be seen that the all of assessment aspects obtain validity percentage value with valid and very valid category and all of assessment aspects obtain practicality percentage value with practical and very practical category. So that, the try out can be continued to the effectivity phase. The effectivity lied on the aspects of (1) students learning activity at the model of CBCL; (2) students learning interest at the model of CBCL (3) the value of IWS; (4) the final test score of mathematical connnection ability [9] and (5) interview with the lecturer and students.

a. The Students Learning Activity in the Model of CBCL

The activity being observed is the student's activity in the learning process of the model of CBCL implemented at experiment class (class C) for seven times. There are two observers, both of them are mathematics lecturers of mathematics Tadris majors IAIN IB Padang, Ms. Roza Zaimil, S.Pd.I, M.Pd and Ms. Siska Resti, S.Pd.I, M.Sc. These two observers have been informed about the model of CBCL and the assessment aspects in the observation sheet of students learning activity in the model of CBCL. Together with the calculus lecturer, always have done reflection at the end of the meeting in order to find things that should be repaired in every learning phase, so that students learning activity in the model of CBCL can be improved. Table 1 and figure 1 shows the result of observation and students learning activity in the model of CBCL in the experimental class, there are 7 times meetings, as follow.

Table 1. *The Analysis Result of Students Learning Activity of The Model of CBCL in The Experimental Class*

TheTypes of of Activity	Meeting Activity							Mean	Category
	I	II	III	IV	V	VI	VII		
A1	29/85%	29/85%	30/88%	33/94%	33/97%	35/100%	34/100%	32/93%	Very Effective
A2	17/50%	20/59%	22/65%	29/85%	33/97%	32/91%	34/100%	27/78%	Very Effective
A3	13/38%	15/44%	12/35%	11/31%	18/53%	20/57%	22/65%	16/46%	Quite Effective
A4	11/32%	10/29%	11/32%	11/31%	16/47%	21/60%	18/53%	14/41%	Quite Effective
A5	34/97%	34/97%	34/97%	34/97%	34/97%	35/100%	34/97%	34/97%	Very Effective
A6	8/24%	15/44%	10/29%	11/31%	12/35%	12/35%	12/35%	11/31%	Quite Effective
	34	34	34	35	34	35	34	22/64%	Effective

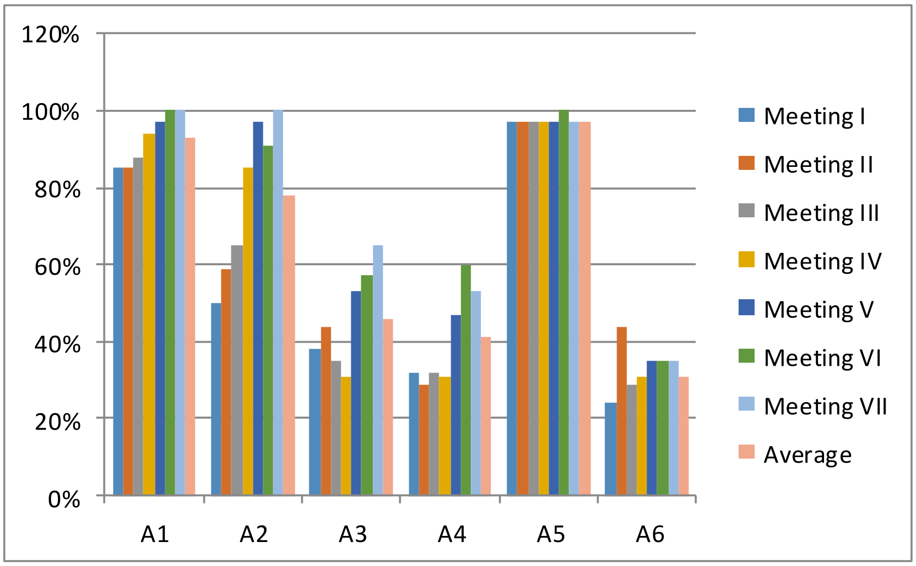

Figure 1. *Students learning Activity of the Model of CBCL in the Experimental Class*

b. The Questionnaire of Students Learning Interest in the Model of CBCL

The questionnaire of students learning interest in the model of CBCL was filled by 35 students of experimental class. The analysis result of students learning interest questionnaire of the model of CBCL in the experimental class can be seen on table 2, as follow:

Table 2. *The Result Analysis of Students Learning Interest of the Model of CBCL in The Experimental Classroom*

Variable	Indicator	The Statement Number		Mean		Category
		Positive	Negative			
The interest to the calculus material	a. The interest related with the nature of the material	2,18	1,3,13	3,90	78%	Effective
	b. The interest related with life	14,17,20	6,7,19	3,67	74%	Effective
The interest to the calculus material	**a.** The interest related with the learning model	4,9,22,24	5,12,21	3,84	77%	Effective
	b. The interest related with the students activity in learning	16,23	8,10,11,15	3,97	79%	Effective
				3,85	**77%**	**Effective**

Table 2 shows the average percentage effectivity of students learning interest of experimental class in the model of CBCL with the four indicators such as: the interest related with the nature of the material is 78% (effective), the interest related with life is 74% (effective), the interest related with the learning model is 77% (effective) and the interest related with the students activity in learning is 79% (effective) and the average of the four indicators are 77% with effective category. Figure 2 shows the percentage of student's effectivity on learning interest in the experimental class, as follow:

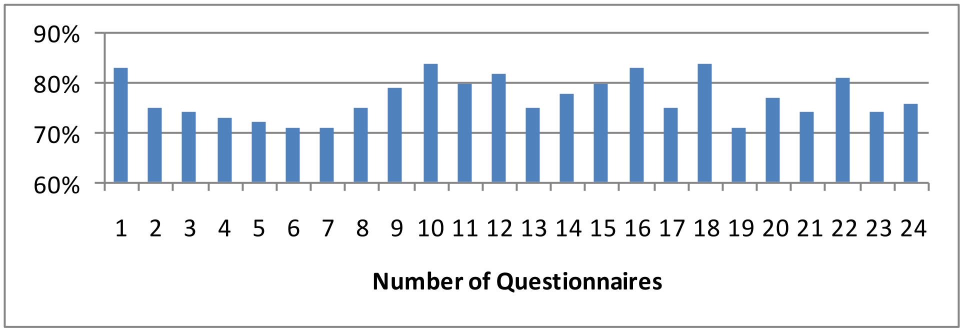

Figure 2. *The Effectivity on Students Learning Interest in The Experimental Class*

c. The Individual Working Sheet (IWS) Score

The IWS the model of CBCL handbook consists of IWS which is done individually, in order to see the students' mathematical connection ability of the model of CBCL in the experimental class which can be seen in the table 3, as follow:

Table 3. *The Analysis of Students' Score on IWS of the Model of CBCL in The Experimental Class*

The Meeting of IWS	Mean	Deviation Standard	Percentage	Category
I	76.7	13.51	77%	Effective
II	76.1	16.91	76%	Effective
III	64.9	13.16	65%	Quite Effective
IV	69.1	16.43	69%	Effective
V	74.2	12.64	74%	Effective
VI	71.3	11.11	71%	Effective
VII	87.1	13.44	87%	Very Effective
Mean	**74.2**	**13.89**	**74%**	**Effective**

Table 3 shows that the experimental students of the model of CBCL average percentage of IWS score in 7 times meetings is 74% (effective) within the range of values 65% (quite effective) up to 87% (very effective).

d. The Learning Result Test of Mathematical Connection Ability

The final test aimed to see the difference of student's mathematical connection ability among the students of control class that were taught by using conventional learning model. Table 4 shows the analysis result of students' score on mathematical connection ability of the model of CBCL in the experimental class compared with the students' score on mathematical connection ability of the model of CBCL in the control class, as follow.

Table 4. *The Mathematical Connection Test Result Distribution in The Experimental Class and Control Class*

Class	N	Mean	SD	Xmax	Xmin
Control	32	64.97	10.12	81	45
Experiment	35	73.37	7.00	88	58

Table 4 shows that the mean of students mathematical connection ability that were taught by using the model of CBCL model is higher than the mean of students mathematical connection ability that were taught by using conventional learning. Based on the standard deviation data, it can be seen that the score of students mathematical connection ability has a wider distribution compared with control class. The minimum score of mathematical connection ability of experimental class is higher than control class.

1) The Analysis Requirement Test

a) The Normality Test

The first analysis requirement test is the normality test with Kolmogorov-Smirnov and Shapiro-Wilk test by using SPSS software. The test result can be seen on Table 5.

Table 5. *The Result of Normality Test of Control Class vs Experiment class*

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	Df	Sig.
Ability Mathematical Connection	Control	,088	32	,200*	,960	32	,277
	Experiment	,079	35	,200*	,990	35	,980

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 5 shows that the significance value of all data > 0,05, where control class = 0,2 > 0,05 and experiment class = 0,2 > 0,05, so that it can be concluded that the students' score of experimental class as well as control class on mathematical connection ability are normally distributed.

b) The Homogeneity Test

The next analysis requirement test is homogenity test. The test result can be seen on Table 6.

Table 6. *The Homogenity Test Toward The Students' Score on Mathematical Connection Ability by Using Levene Test*

Levene Statistic	df1	df2	Sig.
3,399	1	65	,070

Table 6 shows that the value of significance is = 0,070 > 0,05, so it can be concluded that the data has a homogeneous variety to the test score of mathematical connection ability for both the experimental class and control class.

c) The Hypothesis Testing

Based on the analysis requirement test, every group of data distributed normally and homogeneous. The experimental research design used is t test. The management of hypothesis testing of this research is done by using SPSS software. The calculation result by using t test can be seen on table 7.

Table 7. *The Hypothesis Testing Toward The Mathematical Connection Ability Test Score by Using t Test*

Class	Mean	Df	t count	t table	Significance
Control	64.97	65	3.979	1.645	0.000
Experiment	73.37				

The criteria of hypothesis testing are if $t_{count} < t_{table}$, it means that H_0 is accepted and if $t_{count} > t_{table}$, it means that H_0 is rejected. Table 7 shows that the value of t_{count} for the distribution of mathematical connection ability is 3,979. The real level ($\alpha = 0{,}05$) and df = 65 shows t_{table} 1,645, because $t_{count} > t_{table}$, so H_0 is rejected, it means that the students mathematical connection ability taught by using CBCL is higher than the student mathematical connection ability taught by using conventional learning.

e. Interview with the Lecturer and Students.

Based on the interview result, it can be known that the practitioner understand about the guidance in the Lecturer Working Handbook Calculus Based Contextual, the practitioner never know the model of CBCL like what the research has designed. According to the practitioner, at the first and the second meeting, the time available for the students to finish Group Working Sheet (GWS) and IWS is not enough, since the students is still adapting the model of CBCL which is still new for both the practitioner and the students, the questions of GWS and IWS are in the moderate or difficult level for moderate level group and low level group of students, it can be seen from their IWS score, about the ease and the use of the Lecturer Working Handbook Calculus Based Contextual which is effective in use and the design which applied to the Lecturer Working Handbook Calculus Based Contextual is interesting for the practitioner. Based on the interview result with students, it can be known that according to the students, the guidance instruction of Students Working Handbook Calculus Based Contextual is clear and understandable. This book helps students to understand the learning material, especially in dealing with concept mapping. This is an interesting book, however, it should be enriched more, so that it can be much more interesting. The questions available in this book are in the moderate level, so that some of the questions in GWS and IWS can be answered, otherwise. The time given to fill the GWS and IWS in the Students Working Handbook calculus based contextual is enough.

5. CONCLUSION

Based on the result of the model of CBCL improvement at the effectivity test step shows that the four aspects of assessment obtain effectivity percentage value with effective category. They are, the observation result of students learning activity of the model of CBCL is 70,5% with effective category, the students learning interest questionnaire of the model of CBCL is 76,5% with effective category, the score of IWS is 74,39 with effective category. The students mathematical connection ability taught by using the model of CBCL is higher than the student mathematical connection ability taught by using conventional learning. Based on the interview result with the lecturer and the students, it can be concluded that the Lecturer Working Handbook and the Students Working Handbook are effective right in the time, the use and the benefit.

6. IMPLICATION

The Model of Calculus Based Contextual Learning shows effectivity to be implemented in the learning. Because it can facilitate students to improve their mathematical ability which has impact to the construction ability and knowledge inquiry, learning ability with multi context, effective thinking, analytical ability, cooperation ability in group and increase the interest and students learning motivation.

7. SUGGESTION

a. The calculus lecturer should implemented the learning model improvement activity which can facilitate students to improve their mathematical ability which can influence their ability to construct and knowledge inquiry, the ability to learn with multi context, think effectively, ability to analyze, ability to cooperate or work together in group and improve the students interest and learning motivation.

b. The test to the resulted product is still limited to the Tadris major of Mathematics IAIN Imam Bonjol Padang only. It is suggested to the researchers who are interested to implement to the other Mathematics major of other university.
c. The research product is still limited to the Lecturer Working Handbook and students Working Handbook. It is suggested that calculus lecturer and the researchers who are interested to make a teaching book based contextual.
d. The material being discussed at the Lecturer Working Handbook and The students Working Handbook is the derivative one and for the derivative use. It is suggested that calculus lecturer and the researchers who are interested to improve to other calculus I material.

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