Competency indicator of integral calculus in scientific debate strategies based on student education background

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Abstract. Middle schools in Indonesia are one of the educational levels pursued by Indonesian children informal learning. This stage is a strategic and critical stage for the development and future of Indonesian children. This study aims to analyze the influence of students' education backgrounds that are: SMA, MA, and SMK towards increasing the integral concept competence with Scientific Debate. The research was an experiment involving 200 college students. Enhancement of competence data is calculated using normalized gain. Value categories use Standard Reference Benchmark. The influence of educational background on the competence enhancement was analyzed using One Way ANOVA and Kruskal Wallis. The results showed that average of competence enhancement was the medium category. Competence indicator average with education background of SMA includes the concept understanding good; procedure fluency good; strategic competence enough; adaptive reasoning enough and productive disposition excellent. MA includes an understanding of concepts enough; procedure fluency enough; strategic competence enough; Adaptive reasoning enough and productive disposition good. SMK includes an understanding of concepts enough; fluency of procedure enough; strategic competence enough; Adaptive reasoning less and Productive Disposition good. The educational background of the college students does not have a significant influence on the increase in Integral Calculus competence.

1. Introduction

Learners are placed in a central position in the learning to develop their competencies. This is in accordance with the purpose of curriculum development in order to become a human being who has faith and devoted to God Almighty, having the noble character, healthy, knowledgeable, capable, creative, and independent and become a democratic and responsible citizen. Achieving these goals is done through the development of competence of learners in learning tailored to the potential, development, needs, and interests of learners and environmental demands. Learning activities organized by institutions that are formal, non-formal and informal with various levels ranging from early childhood education, high school to higher education.

Middle schools in Indonesia are one of the education levels pursued by Indonesian children informal learning activities. This stage is a strategic and critical stage for the development and future of
Indonesian children. At this level, Indonesian children are at the gate to enter the world of higher education which is a vehicle to form the integrity of the profession that coveted. At this stage also, Indonesian children are preparing to enter a challenging world of work and the competition.

The public high school consists of three types: Senior High School (SMA), Islamic High School (MA) and Vocational High School (SMK). Different types of schools above bring up various problems. These issues are related to learning systems such as curriculum, media, learning resources, teachers, or the environment in which they learn such as school culture and climate as well as the macro environment in which the learners are located. This condition is in accordance with the results of the researchers by identifying several variables that have an impact on student learning including family background and socioeconomic status [1], gender differences [2] and [3], personal characteristics [4], and peer influence [5]. With regard to mathematical achievement, several research findings have identified factors affecting student achievement. These factors are: (1) Student factors are student self-efficacy in math, family background characteristics at home [5]; (2) Teacher factors are instructional approach, knowledge, and teacher self-efficacy [6]; and (3) School factors such as location and learning facilities [7]. Some research results highlight that student factors as a major factor for predicting mathematical achievement [5] and [8]). Kupari [5] analysed the relationship between students, teachers, school background and mathematical achievement based on 1999 TIMSS data. The results showed that students' self-concept in mathematics has a very strong (reciprocal) relationship with achievement. Student factors, especially the characteristics of family backgrounds, such as socioeconomic status of students and educational background of family members have a significant influence on student performance [1].

Student education background is the main factor to predict learning achievement. This characteristic is attached to the student and can lead to differences in performance. The difference of educational background of college students on conventional learning in integral concepts have a significant effect on enhancement ability of communication, reasoning, and mathematical connections [9]. Based on the above conditions, it is necessary a learning strategy that is able to develop integral calculus competence equally. Integral is an important concept in mathematics. Mastery of college students in integral concepts contributes to the development of engineering, science, and industry. Hine et al. underscored that an understanding of mathematics is crucial in laying a solid foundation for post-secondary studies in a range of disciplines, including engineering, business, and finance (In [10]). Additionally, mathematical skills and knowledge have been considered essential for university courses in health sciences [11] and [12]. Economic and industry expert predict that all new economic will be built on the foundations of mathematics and science [13].

The selection of instructional strategies depends heavily on teacher competence. Competence is as a work commitment of teachers and job satisfaction [4] and [14]. The effective teachers are teachers who have a combination of three competencies namely knowledge, pedagogical skills, and dispositions that generate a strong sense of self-efficacy [15] and [4]). The gifted teachers can provide dynamic, innovative, and creative math lessons. The teachers should encourage students to undergo a cognitive process as scientists do, including present a question, form a hypothesis, design an exploration, acquire data, draw conclusions, redesign explorations, and lastly, form and revise theories [16]. The construction of knowledge in the application of the Scientific Debate strategy is based on several habits that can be created in learning such as creating uncertainty of settlement [17]. In mathematical knowledge, uncertainty is expressed in conjecture form. Different results are developed and validated. Such conditions can develop indicators of competence of integral calculus equally.

The application of scientific debate strategy in Integral Calculus learning can enhance communication ability and mathematical connections and the ability of college students' mathematical creative thinking better than conventional [18] and [19]. The influence of the application of scientific debate in learning is the majority of college students reach the mastery level in understanding the concept of integral, in addition, college students can find out how to explore their knowledge where the completion use algorithm not applied [20]. The application of scientific debate strategy in Integral Calculus learning, differences in college student education background has no effect on improving
communication, reasoning, and mathematical connections [9]. The college student learning outcomes that follow Integral Calculus learning with scientific debate strategy are better than conventional [17].

Improved capabilities in the application of scientific debate strategies are competency indicators in integral concepts including conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. The importance of mathematical competence in accordance with Howell’s [21] research results were large resource investments (e.g., labour, time, and costs) involved in the planning and execution of such competitions, it appears that many mathematics educators, school leaders, parents, and public sponsors believe that math competitions are useful.

2. Experimental method
The population in this study is students of Department of Mathematics and Statistics in Indonesia, the same level with the Department of Mathematics and Statistics Bandung Islamic University (Unisba). The subjects of the study were three-semester students (N = 200). Increased category of mathematical competence among students group of Scientific Debate strategy and group of conventional is used test of normalized gain with the formula:

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\text{Normalized gains (g)} = \frac{\text{Postes Score} - \text{Pretest Score}}{\text{Ideal Score} - \text{Pretest Score}}.
\]

With the category (g) of normalized gain is: g < 0.3 is low; 0.3 ≤ g < 0.7 is middle and 0.7 ≤ g is high. The category level of value is 80 ≤ N < 100 is A (Very Good), 70 ≤ N < 79 is B (Good), 60 ≤ N < 69 is C (Enough), 50 ≤ N < 59 is D (Pretty Good), and N < 50 is E (Less). The difference of enhancement of mathematical competence indicator between Scientific Debate and conventional learning is used t-test and Mann-Whitney U with p-value = 0.05.

3. Result and discussion
Mathematical competence indicator data include: X1 is concept understanding including concept comprehension, operation, and relation. X2 is fluency of procedure including the ability to apply procedures in a flexible, accurate, efficient, and appropriate. X3 is a strategic competence including the ability to formulate, present, and solve mathematical problems. X4 is an adaptive reasoning including the capacity to think logically, do reflection, explain, and propose justification. X5 is a productive disposition that includes: the ability to always see mathematics in a positive, useful, and meaningful way.

The comparison of mean scores for each indicator of the competence of integral concepts on Scientific Debate strategies based on college student education background is presented in table 1 below:

| Educational Background | Average Value of Indicator | Category |
|------------------------|---------------------------|----------|
|                        | X1  | X2  | X3  | X4  | X5  | X1  | X2  | X3  | X4  | X5  |
| SMA                    | 72.48 | 72.59 | 66.87 | 68.62 | 87.52 | B  | B  | C  | C  | A  |
| MA                     | 68.92 | 68.59 | 63.15 | 63.23 | 79.85 | C  | C  | C  | C  | B  |
| SMK                    | 66.40 | 64.66 | 64.40 | 58.70 | 77.00 | C  | C  | C  | D  | B  |
| Total                  | 71.47 | 71.35 | 66.18 | 67.02 | 85.59 | B  | B  | C  | C  | A  |

From table 1 it appears that college students with SMK education background have average scores for each indicator lower than SMA and MA. The learning of SMK mathematics differs from mathematics learning in SMA and MA. Mathematics learning in SMK has unique content. The SMK curriculum consists of three subject groups: normative, adaptive and productive subjects. Normative subject groups are groups of subjects that function to form learners into a whole person, who have the norms of life as individual beings and social beings (members of society) both as citizens of Indonesia and as citizens of the world. Group of productive subjects is a group of subjects that serve to equip learners to have work competence according to Indonesian National Work Competence Standards. Group of adaptive subjects is a group of subjects that function to form learners as individuals in order to have a broad knowledge base and strong to adapt theirs with changes that occur in the social environment, work environment,
and able to develop themselves in accordance with the development of science, technology, and art. Mathematics lessons include a group of adaptive. Referring to the elucidation of Article 15 of Law Number 20 the Year 2003 regarding National Education System, the main purpose of vocational secondary education is to prepare learners to be able to work in certain fields.

The existence of a group of productive subjects requires students to practice their science in school with the real business world in life. A vocational character of curriculum that is applicable in the business world requires students in SMK to participate in the internship program. Other than that, the students must also follow the learning of group normative and adaptive. The vocational education involves courses that teach valuable skills with very high standards [22]. The need for high school vocational courses for the US is high school students were stressed at their working lives better with more stable jobs, higher wages, and higher incomes [23]. The low mathematical competence of college students with SMK education background is caused by curriculum direction which emphasizes more on a productive subject group. This condition resulted in different initial capabilities compared to SMA and MA. It is mean that, students' ability to learn new ideas depends on their previous prior knowledge and existing cognitive structures. The success of each student in learning is almost completely influenced by student intelligence, student readiness, and student talent [24].

Furthermore, do the analysis of the influence of learning factors on the improvement of competency indicator for the integral concept. From the prerequisite test results, it is known that the competence indicator data is normally distributed and has the same variance. The calculation results are shown in table 2 below:

|                  | Sum of Squares | df  | Mean Square | F     | Sig. |
|------------------|----------------|-----|-------------|-------|------|
| Between Groups   | 675.715        | 2   | 337.858     | 2.165 | 0.120|
| Within Groups    | 16074.428      | 103 | 156.062     |       |      |
| Total            | 16750.143      | 105 |             |       |      |

From table 2 it is known that the educational background factor in the Scientific Debate strategy does not have a significant effect on the improvement of competence in the integral concept.

Data of competency indicators in integral concepts based on the educational background of college students presented in table 1 then analysed the influence of learning factors and college students' educational background on the improvement of competency indicators of integral concept. From the prerequisite test results, it is known that the competence indicator data is normally distributed and has the same variance. The calculation results are shown in table 3 below:

|                  | X1     | X2     | X3     | X4     | X5     |
|------------------|--------|--------|--------|--------|--------|
| Chi-square       | 1.341  | 7.346  | 0.807  | 3.789  | 4.313  |
| Df               | 2      | 2      | 2      | 2      | 2      |
| Asymp. Sig.      | 0.512  | 0.025  | 0.668  | 0.150  | 0.116  |

From table 3 it is known that the educational background factors of college students do not have a significant influence on the improvement of concept understanding, the strategic competence, adaptive reasoning and productive disposition. The educational background factors of the college students have a significant influence on the enhancement of procedure fluency.

In general, the educational background factors of college students do not have a significant influence on the improvement of competency indicators for integral concepts. This condition is caused by the great adaptability of each college student. The adaptability of college students is influenced by the implementation of scientific debate strategy. Scientific Debate Strategy is a college student-centered learning model, the lecturer acts as a facilitator, as well as new information or concepts are obtained.
through self-directed learning activities. The learning process begins with the problem of integral application that must be solved by the college students. This application problem is the focus, stimulus, and vehicle for the development of problem-solving skills. The mathematical problems of the real world can shape positive attitudes, shape creativity, enhance deep understanding, and develop problem-solving skills or investigative skills that can be applied in various areas of life [25].

Implementation of Scientific Debate strategy is more emphasis on college student learning activities. College students work collaboratively to identify the data they need to develop solutions and find relevant sources, share and synthesize findings, and ask questions that lead to further learning. In this case, lecturers act as mentors who facilitate the learning process. As a facilitator, lecturers can ask college students questions to sharpen or deepen their understanding of the interconnectedness of the concepts they build. Lecturers try to balance between direct guidance activities and encourage self-directed learning. This condition will trigger the increase of mathematical competency of the college students evenly because in applying of scientific debate strategy of the college student is challenged to have bigger adaptability. Overall scientific debate strategy can improve competence and competence indicator for integral concept evenly. In the scientific debate strategy of college student are challenged to learn actively. Active learning college students will have a positive correlation to their learning achievement. In everyday life requires activeness that learning and or working actively is more fun, that active learning will broaden the horizons and so on, and then active learning is very important. Minimum to help manifest the least human active beings in the future [24].

4. Conclusion
Based on the results of the study showed that the average value of enhancement of competence of integral calculus is the moderate category. The average score of competency indicators of integral calculus of college students with education background of SMA is: Conceptual understanding is Good (B); The fluency of procedure is Good (B); Strategic competence is Enough (C); adaptive reasoning is Enough (C) and the productive disposition is very good (A). The average score of competency indicators of integral calculus of college students with educational background of MA is: understanding of concept is Enough (C); the fluency of procedure is Enough (C); Strategic competence is Enough (C); adaptive reasoning is Enough (C) and productive Disposition is Good (B). The average value of the indicator of college students integral calculus competence with SMK education background is: The conceptual understanding is Enough (C); the fluency of procedure is Enough (C); Strategic competence is Enough (C); adaptive reasoning is Less (D) and productive Disposition is Good (B). The educational background factor in the Scientific Debate strategy does not have a significant effect on the improvement of competence in the integral concept. The educational background factors of the college students do not have a significant influence on the improvement of concept understanding, the strategic competence, adaptive reasoning and productive disposition. The educational background factors of the college students have a significant influence on the enhancement of procedure fluency.

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