

# How To Increase Lower Order Thinking Skills To Higher Order Thinking Skills Through Modifying Problems Using The fx-991 ID Plus Scientific Calculator

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*Abstract: The demands of high-level thinking are not only the goal of learning in school but so for students to solve the problem in their life in the 21<sup>st</sup> century which is full of challenges. In fact the possession of high level thinking skills based on Bloom's taxonomy revision requires the fulfillment of three lower order thinking skills i.e knowing (C1), understanding (C2) and applies (C3). Without the mastery of the three, higher level thinking skills comprising analyzing (C4), evaluating (C5) and being creative (C6) cannot be reached. This paper will exemplify how to modify low-level math questions into high-level questions assisted by the fx 991 ID Plus scientific calculator. This paper can be considered by teachers who want their students to think critically in mathematics.*

## **1. Background**

Based on the 2005, 2009 and 2015 PISA results summary assessment conducted by the Education Assessment Center for the Indonesian Ministry of Education and Culture's Research and Development Agency, Indonesia's achievements were significant [11]. Associated with the results of the 2015 National Examination, there was a correlation between the PISA results and the result of the national exam (UN). Schools with high PISA result also has high mean score in national exam [11]. Although these results indicate an increase in the provision of education in Indonesia, the achievement of Indonesian students in general is still below the OECD (The Organization for Economic co-operation and Development) average. A number of recommendations generated based on the assessment of PISA and UN results are (1) the students must be familiarized with questions of high order thinking skills (HOTS) and (2) the teachers should encourage 21<sup>st</sup> century competencies such as problem solving, critical thinking (critical thinking) within their students. The effort of the Indonesian government takes form in the publication publishing of the percentage of HOTS types in the national exam questions starting in 2015 as shown in the Table. 1[11].

Table 1. Changes Indonesia's Exam Nation from 2011 to 2016

Aspect	Exam Nation 2011-2015	Exam Nation 2016
<b>Component</b>	consist 2 component: competency and problems indicator (what will be asked)	two dimensions measured are material coverage and cognitive level
<b>Form</b>	Specific indicators refer to the questions being tested	there is no problems indicator
<b>Leveling</b>	Not explicitly reflect leveling cognitive, existing levels difficulty: 40% easy, 40% medium, 20% difficult. There are 10% of HOTS questions	With more levels explicit: 40% understand 40% apply 20% reasoning

In achieving 21<sup>st</sup> century skills that require reasoning (critical thinking, creativity, communication, and collaboration), the type of problems used in mathematics classroom become important. Problems need to be designed according to the environmental conditions, leading to discovery in a problem/project based learning, collaborative learning and using technology. Specifically on the use of technology, although based on the review of text books required for students and teachers which is issued by the government, lower order thinking skills questions (LOTS) question and higher order thinking skills (HOTS) questions appears in the books but there is no single example of problem that need to be solved using technology, including a calculator.

On the other hand , the results of the high school mathematics teachers supervision in 2015 reveals that the majority of teachers use LOTS questions in their test, which means that most teachers are not skilled at compiling HOTS questions. Examples in modifying LOTS questions into HOTS questions that can be solved using technology (calculator) can thus be considered in designing problem-based mathematics learning activities. This paper will discuss about the modification of LOTS questions in mathematics textbook to encourage the students to think in higher level and the role of the calculator in the process. The modified questions were selected from the Class XI Series and Series topics based on learning objectives , Bloom's taxonomy revision and calculator utilization [2,8, 12]

## 2. Higher Order Thinking Skills

Broadly speaking, the three groups of competencies needed in the 21<sup>st</sup> century are: (a) having good character (belief and obedience, curiosity, persistence, social and cultural sensitivity, the ability to adapt, and competitive), (b) has a number of competencies (critical and creative thinking, problem solving, collaboration, and communication), and (c) mastering literacy including thinking skills in using knowledge resources in print, visual, digital, and audio forms. The presentation of HOTS problems in the assessment process can support learners to build their skills according to the

demand of 21<sup>st</sup> century. Through an assessment based on HOTS questions, creative thinking and doing, creativity and self-reliance, will be built through training activities to solve real problems in daily life (problem solving) [1,6, 10,11,12,13].

To develop students' high-order thinking skills there are five stages [10], namely: (1) determining learning objectives, (2) teaching through questioning, (3) practicing before assessment, (4) review, refine, improve, as well as (5) providing feedback and assessment learning. This indicates that giving HOTS question is not the only way to develop high-level thinking skills in an integrated way. HOTS questions are measuring instruments used to measure higher order thinking skills, i.e. unexpected capabilities (recall), restatement (repetition), or attempt without using processing (reading). HOTS questions in the assessment context measure abilities such as: 1) transferring one concept to another, 2) processing and applying knowledge in real life, 3) looking for links from different information, 4) using information to solve problems, and 5) examining ideas and information critically. However, HOTS-based problems do not mean more difficult than recalling problems [6].

The dimensions of the thinking process in Bloom's Taxonomy as perfected by Anderson & Krathwohl consist of abilities such as knowing (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6) [2]. At level one: C1 and C2 are classified as Lower order thinking skill (LOTS). Level two: C3 is classified as Medium Order Thinking Skill (MOTS). And the last, level three: C4, C5 and C6 are classified as Higher Order Thinking Skill. In general, the questions are structured to measure those abilities. In selecting operational verbs to formulate indicators about HOTS, teachers should not be trapped on the grouping of operational verbs. For example the "determine" verb in Bloom's Taxonomy lies in domain of C2 and C3. In the context of writing HOTS questions, the verbs can be in domain C5 (evaluate) if the purpose is to determine a decision preceded by a thought process. Then, analyzing the information presented in the stimulus and then the learners are asked to determine the best decision. Even "determine" verbs can be classified as C6 (creating) when a question demands the ability to devise a new problem-solving strategy. Thus, the domain of the operational verb is strongly influenced by the process of thinking on what is needed to answer the given question. Description of verbs according to the dimensions of revised Bloom's taxonomy [1,5] is described in Table 1 below.

Table 2. Dimension Process of Thinking

Level			
3	HOTS	Creating	<ul style="list-style-type: none"> <li>• Creating your own ideas / ideas</li> <li>• Verbs: constructs, designs, creates, develops, writes, formulates</li> </ul>
		Evaluate	<ul style="list-style-type: none"> <li>• Make your own decisions</li> <li>• Verbs: evaluate, rate, refute, decide, vote, support</li> </ul>
		Analyze	<ul style="list-style-type: none"> <li>• Specifies aspects / elements</li> <li>• Verbs: compare, examine, criticize, test</li> </ul>
2	MOTS	Apply	<ul style="list-style-type: none"> <li>• Use information on different domains</li> <li>• Verbs: using, demonstrating, illustrating, operating.</li> </ul>

Continue of Table 2. Dimension Process of Thinking

Level			
1	LOTS	Understand	<ul style="list-style-type: none"> <li>• Explain ideas / concepts</li> <li>• Verbs: explain, classify, accept, report</li> </ul>
		Knowing	<ul style="list-style-type: none"> <li>• Recalling</li> <li>• Verbs: remember, register, repeat, imitate</li> </ul>

Judging from the dimensions of revised Bloom's thinking process, textbook presentations on both samples and exercises tend to be separate. The students who are not familiar with HOTS problems will have difficulty in the process of acquiring higher order thinking skills. A diagnostic test conducted by the authors on eighteen 9th grade students in topic of the series and sequence [5] reveals that 90% of students could solve the LOTS problems. But, only 60% could solve the MOTS problems and 20% for HOTS problem. Through interviews it was discovered that the inability of the students to answer MOTS and HOTS questions is because they did not understand or has never been exemplified before. The LOTS question can be solved because they remember the formula the teacher asked to memorize. This gives the idea that MOTS and HOTS can be built or developed through the modification of LOTS problems that have been mastered previously by the students.

### 3. The Use of Calculators fx-991 ID Plus to Help The Acquirement of HOTS

The integration of technology in important in mathematical learning [7,10,12]. One technology that is affordable and easy to use in classroom learning is the calculator. According to Kissane [8] there are four roles of calculators in mathematics learning, namely (1) representation, (2) computation, (3) exploration, and (4) affirmation. Calculator offers an opportunity to develop a precise understanding of representational differences. With computing, the students can devote their time to more worthwhile tasks rather than focusing on rote calculation. The students can also explore ideas for themselves. Mathematics becomes an experimental form. Calculators are also used when students need an affirmation of the results obtained from their thinking.

Taking into consideration the advantages of using the calculator [7,8], although Ministry of Education in Indonesia does not allow the use of calculators in exam settings, using calculators in the classroom are not prohibited. The following is the recommendation of the use of calculator application in developing the students' higher order thinking skills on the topic of Series and Sequences through the modification of LOTS problems taken from the student textbooks [5].

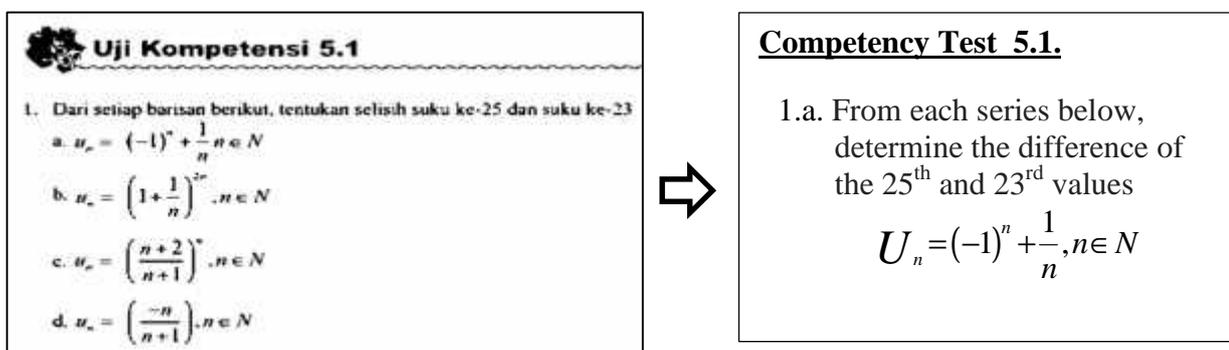


Figure 1. LOTS Problem

Alternative solution from problem 1.a. is as follows.

$$U_n = (-1)^n + \frac{1}{n}, n \in N$$

For n=25, the 25th value =  $U_{25} = (-1)^{25} + \frac{1}{25} = (-1) + \frac{1}{25} = \frac{-25+1}{25} = \frac{-24}{25}$

For n=23, the 23rd value =  $U_{23} = (-1)^{23} + \frac{1}{23} = (-1) + \frac{1}{23} = \frac{-23+1}{23} = \frac{-22}{23}$

The difference of the 25<sup>th</sup> and 23<sup>rd</sup> value is

$$U_{25} - U_{23} = \frac{-24}{25} - \frac{-22}{23} = \frac{(-24)(23) - (-22)(25)}{(25)(23)} = \frac{-552 + 550}{575} = \frac{-2}{575}$$

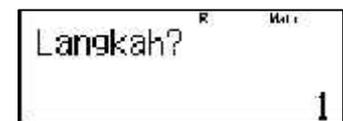
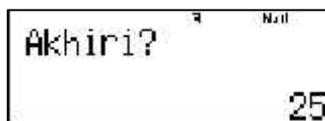
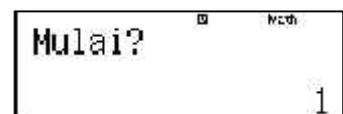
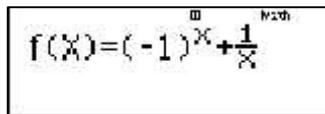
In this problem, the student simply replaces the value of n to the formula and used some counting operations. This problem is LOTS or are in the level one because to solve it requires only the conceptual and procedural skills related to substitution, the definition of the difference, and the operation on fractions. If students are proficient at LOTS then it can be modified into a HOTS question. Exemplified as follows:

Modify LOTS problem to HOTS problem

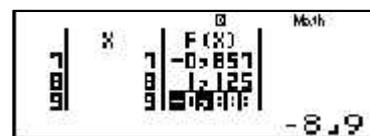
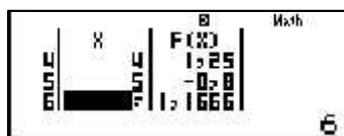
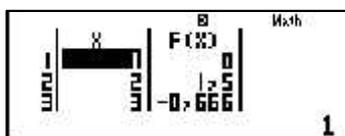
<p>From series <math>U_n = (-1)^n + \frac{1}{n}, n \in N</math></p> <p>Determine the difference of <math>U_{25}</math> and <math>U_{23}</math></p>		<p>If series <math>U_n = (-1)^n + \frac{1}{n}, n \in N</math> is a function from n. Is <math>U(n)</math> limited? Use calculator fx 991 ID Plus to find your answer.</p>
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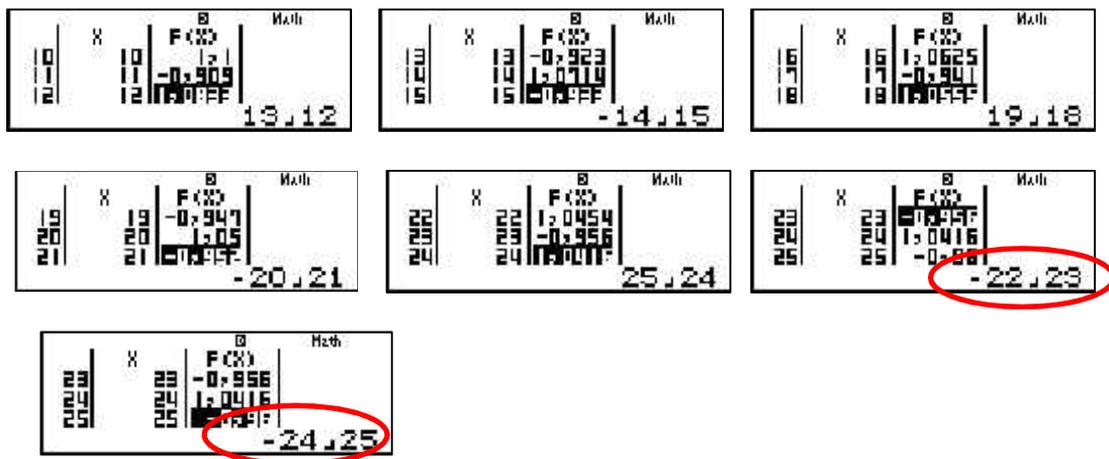
Alternative solution:

Press the button below and it will be appear on the calculator screen fx 991 ID Plus as follows

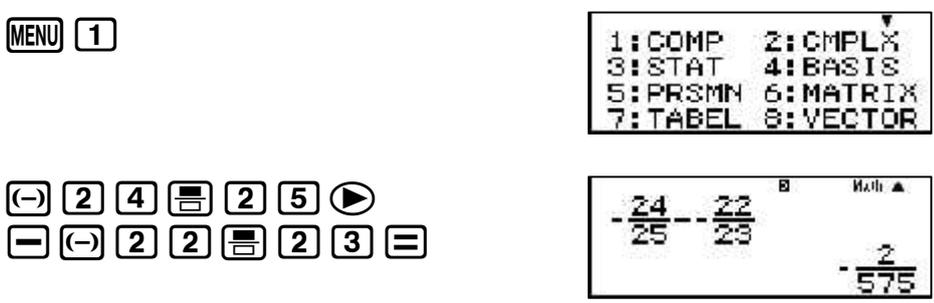


Use the buttons R for investigate the value of U (n) in this case  $f(x)$ . Note the value of  $f(x)$  for x=23 and x=25. Use mode 1 to check the truth of difference  $U_{25}$  and  $U_{23}$ .





Thus, with calculator fx 991 ID Plus, the difference of the 25<sup>th</sup> and 23<sup>rd</sup> value is  $-\frac{2}{575}$



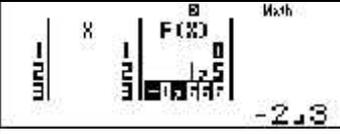
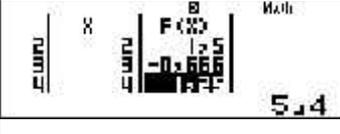
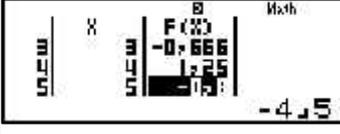
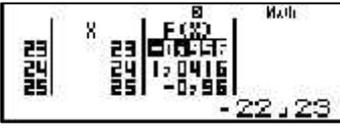
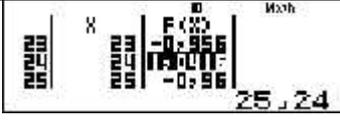
From the table that appears on the screen, what is obtained if the arrow keys R is repeatedly pressed on column  $f(x)$ ? It appears that although the screen is displayed decimal numbers but at the bottom of the screen turns into fractions. At this stage the calculator has a representational function that can reinforce the previous material on the similarity in decimal and fractional numbers.

Suppose the value of  $x = n$ ,  $U_n$  sequence will be obtained as follow

Table 3 . Exploration Stage

n	Un	Calculator Screen	Alternative Questions
1	0		
2	$\frac{3}{2}$		For $x = 2$ , what is the value of $f(x)$ in the table? What's with the value at the bottom of the screen?

Continue of Table 3 . Exploration Stage

n	Un	Calculator Screen	Alternative Questions
3	$\frac{-2}{3}$		For x = 3 , what is the value of f (x) in the table?What's with the value at the bottom of the screen?
4	$\frac{5}{4}$		For x = 4 , what is the value of f (x) in the table?What's with the value at the bottom of the screen?
5	$\frac{-4}{5}$		For x = 5 , what is the value of f (x) in the table?What's with the value at the bottom of the screen?
	↓	↓	Hold to press the  sign next. Can you guess the answer? For n = 6 to n = 25? Give your colleague a calculator to match your answers Looking at the previous pattern? Notice for n odd and n even, is there a difference in results? Is there a pattern for n even and n odd?
23	$\frac{-22}{23}$		Match your answer?
24	$\frac{25}{24}$		
25	$\frac{-24}{25}$		

To indicate whether  $U(n)$  is limited or not students should remember the definition of limited sequence. The set  $\{U_n : n \in N\}$  is called the series value set  $(U_n)$ . The  $(U_n)$  is said to be limited if the set value is limited. So  $(U_n)$  is limited if and only if there is  $K > 0$  such that for each  $|U_n| \leq K$  for each  $n \in N$ . Through the observation of  $f(x)$  on the calculator the student can conclude that the sequence is not limited.

## Conclusion

HOTS can be fostered through problem-solving exercises. LOTS questions can be modified into HOTS questions related to Bloom's revised stages of thinking. There are three benefits of using calculator on learning mathematics, namely: (1) to solve the HOTS problem, in which calculator is used after the students have a LOT of skills, (2) the students have more opportunity to experiment with mathematics, and (3) there will be more time to explore HOTS problems that will speed up the acquirement of higher-order thinking skills.

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