Integration of Classwiz Calculator to Deliver Hots Concepts of Mathematics Learning in Indonesian Senior High School

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Abstract

The National Examination of senior high school in Indonesia began to apply some higher order thinking skills (HOTS) type problems. Among the four subjects that were tested in the National Examination, Mathematics is the lowest. Higher order thinking learning process directed at critical thinking, logical, metacognition, and creative is still a new thing. Not only students but teachers also face difficulties. Higher-order thinking involves demonstrating an understanding of information and reasoning rather than merely recalling information. Higher order thinking skill is one of the priorities in students' thinking skills in the Indonesian curriculum. Mathematics textbooks present HOTS type questions to be discussed together in the classroom. The use of affordable technology is a must in helping students understand the concept of Mathematics. Scientific calculator Casio Claswizz can be used as a learning tool to deliver HOTS concept.

1. Introduction

One of the demands of the 2013 Curriculum in Indonesia is the Higher Order Thinking Skills (HOTS) assertion in the learning and evaluation process including the National Examination which take place in all levels of Indonesian education [3]. National Examination with HOTS characteristics make evaluation more difficult but very meaningful. The average outcome of the result of Mathematics in last National Examinations is lower than the entire other subjects being tested, even lower than the average National Examinaton results of Mathematics last year. Mathematics is the most difficult field of study for students. For high school level mathematics, the average score earned this year is 34.40, which is much lower than last year's 37.72.

The passing grade of National Examination in Indonesia is 55 for all subjects tested, which applies for junior high school, high school and vocational high school. Based on the data of national exam passing year 2018 as follows [7]:

Tabel 1 Graduation Percentage of Students at the National Exam 2018

Level Major	Subjets	Completeness		Uncompleted	
		Number of Students	Percentage	Number of Students	Percentage
High School Science	Indonesian	757065	80,35	185144	19,65
	English	410201	43,60	532008	56,40
	Mathematics	132192	18,03	**810017**	**85,97**
	Physics	28632	18,07	129832	81,93
	Chemistry	51466	32,61	106357	67,39
	Biology	187544	29,90	439693	70,10
High	Indonesian	561503	58,84	392785	41,16

Level Major	Subjets	Completeness		Uncompleted	
		Number of Students	Percentage	Number of Students	Percentage
School	English	195493	20,51	758795	79,49
Social	**Mathematics**	63884	6,77	**890404**	**93,23**
	Economics	40689	25,15	121096	74,85
	Sociology	220096	38,98	344542	61,02
	Geography	76931	33,66	151623	66,34
Vocational	Indonesian	1087572	73,83	385504	26,17
	English	258801	17,58	1214275	82,42
	Mathematics	105044	7,14	**1368032**	**92,86**
	Major Competence	253606	18,10	1219470	81,90
SMP	Indonesian	3080846	72,55	1165668	27,45
	English	1394241	32,82	2852273	67,18
	Mathematics	937502	22,70	**3309012**	**77,93**
	Science	1100529	25,91	3145985	74,09

According to the Ministry of Education and Culture, the low score in Mathematics is caused by HOTS content among the test items. The short time provided to do the test makes it difficult for many students especially those who are not accustomed to it in previous learning. The scientific use of calculators to help answer the exam questions has been done in many countries in the world. Indonesia should be prepared to face this challenge and permit through regulation for the use of calculators in examinations, especially on HOTS.

2. HOTS-based Learning

Regulation of the Minister of Education and Culture of the Republic of Indonesia No. 59 year 2014 on Curriculum 2013 High School [3] in Annex I, states that one of the basic improvements of the curriculum is the existence of internal and external challenges. External challenges are related to the flow of globalization and various issues related to environmental issues, advances in technology and information, the rise of creative industries, culture, and the development of education at the international level. The 2013 curriculum is a refinement of various aspects including the Content Standards through the reduction of irrelevant material as well as the deepening and expansion of relevant material for learners and enriched with the needs of learners to think critically and analytically in accordance with international standards. Other improvements are also made to the assessment standard, gradually adapting international standard assessment models.

Higher order thinking includes critical, logical, reflective, metacognitive and creative thinking. The skills are prompted when students of any age encounter unfamiliar problems, uncertainties, questions or dilemmas. Successful applications of these skills result in explanations, decisions, performances and products that are valid within the context of available knowledge and experience and promoted continued growth in higher order thinking, as well as other intellectual skills [2].

Limbach and Waugh [5] describes five steps process for the development of higher level thinking skills, which are relevant to the context and can be implemented in any teaching learning situation to create a more active learning environment and to move learners towards higher level thinking. These five-steps are:

a) Determining the learning objectives

To make high level thinking happen, these learning objectives, as well as the activities and assessment, must require the students to perform and demonstrate high level thinking. Thus, a well written lesson plan should target a specific behavior, introduce and practice the desired behavior and end with the learner exhibition of the behavioral response. The development of well-written objectives will greatly accelerate learners' movement into higher level thinking. Bloom's revised taxonomy of cognitive objectives is usefully in planning curriculum that incorporates low to high level thinking activities.

b) Teaching through questioning

Questioning is a vital part of the teaching learning process. The art of questioning begin with establishing what is known and allows the teacher to extend beyond to develop new ideas and understandings. The level of student thinking is directly proportional to the level of questions asked. When the teachers plan, they must consider the purpose of each question and then develop the appropriate level and type of question to accomplish the purpose. All students need experience with higher level questioning once they become familiar with a concept. Questioning techniques can be used to foster the thinking ability of students. Questions can be categorized in a number of different ways. One simple method is to use the general categories of convergent questions and divergent questions. Convergent questions seek one or more very specific correct answer, while divergent questions seek a wide variety of correct answers. Convergent questions apply to Bloom's lower level and divergent question apply to Bloom's higher level objectives.

c) Practice before assessment

To make learning more active, teachers need to add experiential learning and opportunity for reflective dialog. Practice is necessary to master any skill, the students must have the opportunity to practice the knowledge, skills, attitudes and behaviors that will be evaluated. Therefore, choosing learning activities that allow them to practice is important. For students to participate in higher level thinking, they must pose arguments, state opinions, look for evidence, critique the evidence and think with fair mindedness.

d) Review, refine and improve

Teachers should strive to continually refine their course to ensure that their instructional techniques are in fact moving students toward critical thinking. Students become responsible for their own learning when teachers monitor class activities, create a supportive environment and carefully track student participation. Collecting feedback from student about what they have, or have not learned, may present the need to offer opportunities for relearning and expose areas in need of improvement. Creating a condusive classroom environment in which all students feel good about participating is a very important step in higher level thinking. Student feedback is also an important tool to be used in improving the course.

e) Provide feedback and assessment of learning

Feedback like assessment compares criteria and standards to students' performance is an effort to evaluate the quality of work. Prior to providing opportunities to practice what is to be assessed, it is imperative that students first understand the standards by which they will be assessed. Next, students should be provided with constructive and relevant feedback by the teacher and peers as well as assessing their own performance. Students' feedback and assessment provides an immediate and significant source of information for the outcome-based assessment process in evaluating instructional techniques students, achievement, specific learning activities, the course, departmental program etc. Comparing criteria and

standards to student performance as a feedback to the students, assessment of the course and departmental programs provide a significant source of information when determining effectiveness. Teacher feedback like assessment can be used to evaluate the quality of students' work. Teacher should provide good feedback to their students through frequent opportunities to practice whatever they are expected to do at assessment time. Teachers should spend ample time helping student to understand what the criteria and standards are and what they mean. Students' peers also provide feedback and evaluation. Each of these techniques help students learn to distinguish between satisfactory and unsatisfactory performance.

3. HOTS-based Evaluation

HOTS problems are the measurement instruments used to measure high-level thinking skills, namely the ability to think not just recall, restate, or refer without recasting [1]. The HOTS questions in the assessment context measure the ability to: 1) transfer one concept to another concept, 2) process and apply information, 3) look for links from different information, 4) use information to solve problems, and 5) examine ideas and information critically.

Judging from the dimensions of knowledge, it is generally a matter of HOTS measuring the metacognitive dimension, rather than simply measuring factual, conceptual, or procedural dimensions. The metacognitive dimension describes the ability to connect several different concepts, interpret, solve problems, choose problem-solving strategies, discover new methods, reasoning, and make informed decisions.

The compilation of HOTS questions generally use the stimulus which is the basis for making the question. In the context of HOTS, the stimuli presented should be contextual and appealing. The goals can be sourced from global issues such as information technology, science, economics, health, education and infrastructure

4. Use of Calculators in Some Countries in the National Exam

Paul Drijvers [6] stated that calculators have been used in schools in various countries such as Vietnam, Singapore, Australia, USA, and Western Europe. In Vietnam, the calculator used as a medium of learning began in 64 pilot schools in 1999. It was integrated into the national curriculum and examination since 2003. National teacher training held by the Ministry of Education extensively in 2001-2007. The use of an efficient Vietnamese typical calculator through the competition.

In Singapore, the Ministry of Education expects students to learn mathematics using a scientific calculator from the 5th grade. Detail of the curriculum has referred to the use of calculators and one of the curriculum objectives contain technological developments. Calculators in Australia have been used in math lessons since the late 1970s and are available to all children. Technology will be successfully integrated only when it can be used in the test. It means it should be coherently used in learning, teaching and assessment. The curriculum contains 3 forms of computing namely mental, writing and calculator. Competence is expected to be with or without the use of digital technology. National Examination (NAPLAN) are available in with or without calculator version. For University entrance tests, a calculator is provided. Higher level subjects use more sophisticated calculators.

In America, the use of calculators has been widespread since the 1970s and over the last 30 years of graphic calculators and also of outstanding scientific calculators. Both graphic calculators and scientific calculators are now used routinely by students in all significant external tests, such as: SAT, ACT, Advanced Placement examinations. There is coherence between teaching, learning and assessment. The written textbook assumes the use of the calculator. Calculators in Europe are widely and routinely used in almost all European countries, including in official exams.

From the type of calculator, there is a scientific calculator, graphics, and CAS Calculator. The Scientific Calculator has limited functionality compared to the other two types of calculators. From some of the descriptions of the use of calculators in mathematics learning, teachers can quickly master and then design mathematical learning by utilizing calculators for exploration, investigation, and problem solving. Thus, many teachers are ready to learn by using the calculator.

5. The Use of Calculator in Learning and Evaluation for HOTS Activities

Difficulty in answering HOTS questions in the National Examination is not only because of the HOTS-question, but also the unfamiliarity of Indonesian teachers on teaching Mathematics with higher order thinking learning process. As a result, the students have no ability in connecting the problem, not able to analyze and evaluate. Calculator could be a tool to assist the student in learning process [4]

> While the revised curriculum continued to emphasize the mastery of mathematical concepts and acquisition of mathematical skills, greater emphasis, as compared to the curriculum before 2006, was given to the development of students' abilities to conjecture, discover, reason and communicate mathematics with the aid of technological tools. To achieve this objective, teachers were required to make suitable adjustment to their classroom practices and pedagogical strategies. For instance, teachers were encouraged to plan lessons such that the calculator would play a key role when students engage in stimulating discussions and activities in which they can explore possibilities and make connections. (p 141)

The use of calculators in national exams as they take place in other countries can be implemented in Indonesia. Calculators could help students solve HOTS questions that are not just counting, but students are expected to analyze and evaluate questions, form mathematical models, and then solve them with a calculator. On the other hand, calculators are not only used in examinations, but also in learning so that students do not understand the problem and then assist with a calculator.

Example 1. One of the problems with the HOTS National Exam is the following:

> Every year the selling price of land in a residential complex increased 20% from the previous year, while the selling price of the building decreased 5% from the previous year. The selling price of a house (land and building) is currently in the complex if 5 years ago purchased for 210 million IDR and the comparison of land selling price to the building at the first time buy 4: 3 is ...

Solution. Calculator may not be used directly for the HOTS model. In the learning process, teachers need to do the learning steps so that students' ability is in high proficiency that is as follows:

1) Students are directed to learn and collaborate through groups

2) Ask and guide students to think logically and understand the content of the problem and reasoning the language of the story on the matter
3) Students start analyzing the Mathematical model for solving the problem, separating various issues from initial purchase, land price increase, decay of house price and projected selling price per year, ie :
   a) The selling price of land and building is the first time when buying

      Land Price $= \frac{4}{7} \times 210 = 120$ (in million IDR)

      House Price $= \frac{3}{7} \times 210 = 90$ (in million IDR)

   b) The selling price of land occurs in price increases per year $Ln = Lo \times (1+i)^n$

      While house prices are declining in price per year $Hn = Ho \times (1-i)^n$

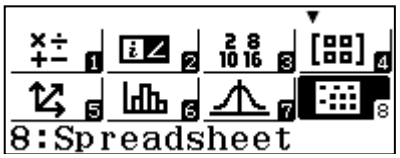
      The price of land and house each year becomes $Ln + Hn$
4) Students evaluate the results of the discussion in their group related to the mathematical concepts that have been analyzed. So that

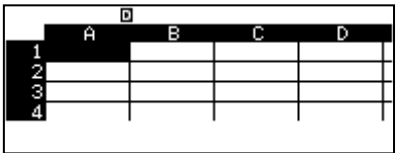
   The price of land per year becomes

   $Ln = 120 \times (1+20\%)^n$

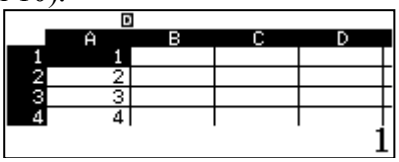
   The price of house per year becomes

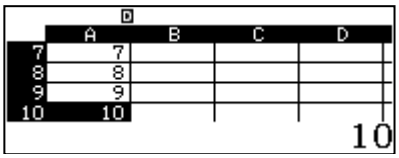
   $Hn = 90 \times (1-5\%)^n$
5) Creating the Mathematical Concept of the problem solving, including completing it in Classwiz scientific calculator assisted using spreadsheet mode, as follows :
   a) Press Menu 8 on calculator





   b) Suppose Cell A is the number of years, then simulate up to 10 years (type 1 through 10).





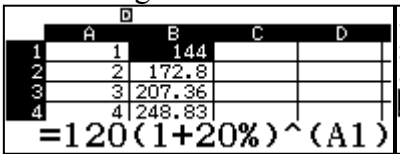
   c) Cell B is an increase in land prices. Place the cursor on Cell B1 and then input the formula through the calculator button as follows:

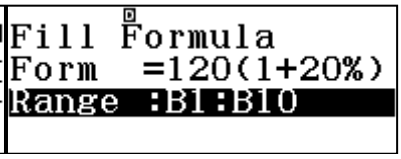
      =120(1+20%)^(A1)

      for the formula of land price per year $= 120(1+20\%)^n$

      :B1:B10

      for the result cell range





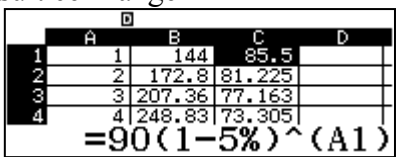
   d) Cell C is the decay of house prices. Place the cursor on Cell C1, input through the calculator button as follows :

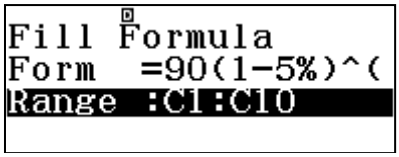
=90(1-5%)^(A1)

for the the formula of house prices per year $=90(1-5\%)^n$

:C1:C10

for the result cell range

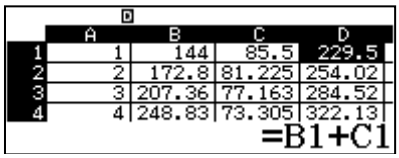




e) Cell D is the selling price of land and house per year, is the sum of Cell B and Cell C. Place the cursor on Cell D, press the following button in the Calculator :

Form: =B1+C1

RangeL :D1:D10



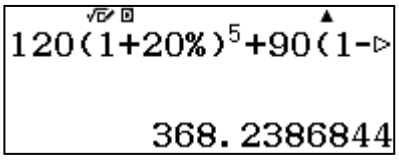
f) From the table in Cell D, the projected sales of land and house price are recorded every year. For example for the next 5 years the price of home sales is IDR 368.23 million.

g) Each group of students is asked to communicate the results and express their learning experiences as part of the student learning feedback.

In the examination, the calculator can function as computation, so it does not require the step of achieving the concept as above. If the question is about the sale price of land and house in the fifth year, then simply input a mathematical expression as follows:

Press Menu 1 to enter Computation Mode, then type the equation $120(1+20\%)^5+(90-5\%)^5$

120(1+20%)^5+90(1-5%)^5



Proceeds from the sale of land and houses in the fifth year

Example 2. HOTS problem on National Examination for composition function

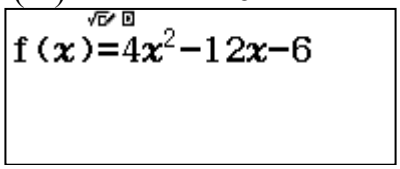
A paper mill with wood base material (x) produces paper through two stages. The first stage using machine I produces semi-finished paper material (m) by following the function $m = f(x) = x^2 - 3x - 2$. Second stage of the produce is using machine II with following the function $g(m) = 4m + 2$, x and m in ton unit. If the basic wood material is available for a production of 4 tons, many of the paper produced is …

Solution. In the learning process, teacher can perform activities using scientific calculators by increasing the range of available wood base materials, for example, what if 1 to 20 tons of wood are available, with the function of the composition on how much paper is produced. The learning steps can be done as follows:

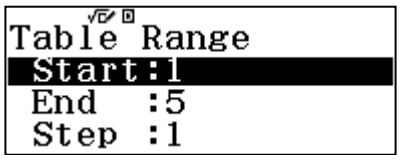
1) Students work in their groups think logically and reasonably to understand the content of the matter.
2) Students analyze the function f composed in function g as $(g \quad f)(x)$
3) Students evaluate the composition of the resulting function

$$\begin{aligned}(g \quad f)(x) &= g(f(x)) \\ &= 4(x^2-3x-2)+2 \\ &= 4x^2-12x-6\end{aligned}$$

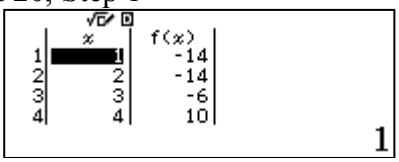
4) Students create Mathematics concepts through the completion of the solution using the classwiz scientific calculator in the table mode as follows:
   a) Press menu 9 on the calculator
   b) Input the function of the composition above
      (fx)=4x^2-12x-6

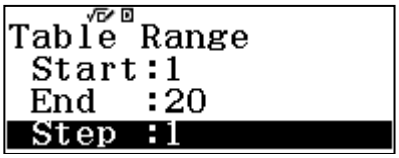


   c) Skip $g(x)$ by press =, then specify the following range:



   d) Start 1, End 20, Step 1



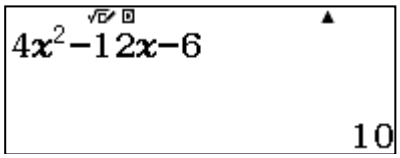


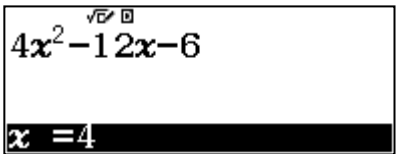
5) The student group communicates the results and provides feedback on the learning process

Students will not only use 4 tons of wood to produce 10 tons of paper, or 20 tonnes of wood to produce 1354 tonnes of paper, but students may be surprised to learn that 1 to 3 tonnes of wood cannot produce paper. Ask students to discuss it. Teachers can develop an exploration to the extent to which the wood in the above function produces new paper, for example what if the inner range is again between 3 and 4.

The above learning experience is certainly very enjoyable and meaningful, generating students' creativity thinking as well as improving high-order thinking skills. But on the test, the calculator functions can calculate directly faster through computing functions through the following steps:

Menu 1 Computation menu
4x^2-12x-6 for function $4x^2-12x-6$
x=4 for input $x = 4$





So, for x = 4 tonnes of wood then the paper produced as much as 10 tonnes.

Higher order thinking skill is a strategy that uses a high-thinking process that encourages students to search for and explore information themselves to find the underlying structure and relationships, using facts that are available effectively and precisely to solve problems. This strategy can stimulate students to interpret, analyze information so that learning becomes meaningful. In conventional learning teachers usually give students with a lot of information that must be memorized and remembered by students, but in learning focused on HOTS the teacher teaches students to look for information sources, evaluate information obtained and use that information for themselves and for other people. Analyzing and evaluating support critical thinking and creating helps to develop the students' creative thinking. HOTS in learning is realized through integrating high-level thinking in the learning process and evaluation, while calculators can help students through exploration activities and activities in that direction, through fact and data.

6. Conclusion

The examples chosen for this paper are HOTS national examination questions which turned out to be delivered by calculator integration, in this case the classwiz scientific calculator. Not only in solving HOTS questions, but calculators can also be used for learning based on HOTS, helping students explore concepts, analyze problems, evaluate problems to be solved and obtain various creations to complete them. Technology integration in learning mathematics is a must, an introductory calculator that can help students present problems in real life, real facts, generate creativities and then they can solve problems. Therefore it is necessary to change the teaching style of teacher so that learning is aligned with HOTS-based evaluations. HOTS however has to be started from learning process and does not suddenly appear during the exam. Therefore, if the HOTS question are included in the national exam, we hope the government allows the use of calculator in Mathematics learning, especially during exam setting.

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