American Research Journal of Humanities & Social Science (ARJHSS)

E-ISSN: 2378-702X
Volume-03, Issue-04, pp 01-08
April-2020
www.arjhss.com

Research Paper **Open Access**

Instructional Design for Mathematics Oriented High Older Thinking Skills

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ABSTRACT:- This study aimed to provide teachers with an understanding of the basic concepts of designing high older thinking skills (HOTS)-oriented mathematics learning, improve teachers skill in designing high older thinking skill learning and provide guidelines for policy makers to conduct coaching and socialization about high older thinking skill oriented learning design. This study is a research development concept of instructional design with qualitative descriptive of data analysis techniques. In the results of the study, there are three stages of the procedure for designing HOTS-oriented mathematics learning, namely learning planning, learning implementation, and learning assessment. At the planning stage of learning activities carried out by the teacher namely a) analyze the competency standards of graduates, core competencies, basic competencies and indicators of achievement of competencies; b) determine the thinking process skills and knowledge dimensions; c) determine the learning objectives; d) integrate the strengthening of character education and literacy; e) determine the learning model. At the learning stage, the activities conducted were designing activities (initial learning, core learning and closing learning). At the assessment stage, activities conducted were developing an evaluation grid, developing assessments and evaluating learning.

Keywords: –Instructional design, Mathematics Learning, High Older Thinking Skills (HOTS)

I. INTRODUCTION

Learning design is the science and art creating detailed spesifications for the development process, how to evaluate, and maintain from various situations that facilitate learning and implementation, Richey, Klein & Tracey (2011). The six components of learning design are a) learner and learning process, preliminary abilities & prerequisite abilities, b) learning contect and performance, c) content and sequence structure, d) learning and non learning strategies, e) media and delivery systems, f) designers and design process. Learning design models by Gustafson and Branch (2020) are grouped into three categories, namely class-oriented design models, product-oriented models, system oriented models. This grouping aims to make it easier for users to choose learning designs to implement. In additions, Simsek (2013) categorizes learning design models into six major themes namely core models, linear models, flexible models, communicative models, heuristic models and hybrid models. This category provides a guide for learning designers to choose learning design models by considering the objectives, scope and structure.

Although there are various learning design models that have been produced since the 1970s, Gustafson & Branch (2002); R.M.Branch & Kopcha (2014) practically said the core elements of learning design model contain elements from ADDIE (Analysis, Design, Development, Implementation, and evaluation. At present there is a lot of design development research reports that develop designs as needed using the results theory as in table 1 below:

Table 1: Result of Analysis of Development of Learning Design Models Using Theories

Design Model The Proposed	The Model is Taken The as Basis	Author (Year
Curriculum Referencen	ADDIE	C.S Lee & Kolodner (2011)
Hybrid design	Dick & Carey; Morisson, Ross dan Kemp: McManus Model	Passerini & Granger (2000)
Living system design	ADDIE	Plass & Salisbury (2002)
Developmeny Courseware	ADDIE, Morisson, Ross and Kemp; Rapid Prototipe	Durdu, Yalabik & Cagiltay (2009)
ELESS		Freitas & Routledge (2013)
Eternal, Synergic Desain	ADDIE	Crawford (2004)
Integratif	ARCS	Burke & Moore (2003)
Mutiple Intelligences Design	ARCSm Sell and Galsgow, Morisson, Ross and Kemp; Smith and Ragan	Tracey & Richey (2007)
RETAIN	ARCS, Gagne and Briggs	Gunter, Kenny, and Vick (2008)
Six-Step ID	4C-ID	Nadorlski, Kirschner, van Merrienboer, & Hummel
WisCom		Gunawardena et all (2006)
New Model Proposed	Gagne nad Briggs, Smith and Ragan	Croje (2006)
Existing Model Revised	Appreciative Instructional Design	Norum (2000)
Existing Model Revised	Virtual Realty Model	Chen & The (2013)

Source: Gokzu, Ozan, Cakir, & Goktas (2017)

As a science that is always developing, learning design is developed eclectically based on the perspective adopted by learning design designers from various systems of throught accprding to needs. Lee and Jang (2014) reviewed many papers relating to the development of learning designs to create a procedural framework for learning design development.

Based on a review of the model, information was obtained that the existing learning design model did not provide enough guidance to users of the learning design model to improve higher order thinking skills (HOTS). Therefore this article can be used as a reference for mathematics teachers in designing learning more effectively and giving student the broadest opportunity to develop higher order thinking skills.

The development of learning design oriented to higher level thinking skills or Higher Olders Thinking Skills (HOTS) is a program developed as an effort of the Ministry of Education and Culture thourgh the Directorate General of Teacher and Education Personnel in an effort to improve the quality of learning and improve the quality of graduates. Education in the industrial revolution 4.0 is directed at developing 21st century competencies, which consist of three main components namely competence of thinking, acting and living in the world. Thinking abilities include thinking (critical, creative, and problem solving abilities). Moving components include communication, kaloboration, data literacy. The component of live includes initiative, self-direction, global understanding, and social responsibility. The 2013 curriculum is designed with various improvements greared towards equipping students towards the 21st century. Learning and assessment of learning outcome are expected to help students to improve higher order thinking skills.

However, the result of the examination of items carried our by the Directorate of High School Development is assisting USBN over the past 3 years indicated that of the 1,779 items analyzed were mostly at level-1 and level-2. Out of the 136 Referral High School, only 27 schools compiled HOTS questions under 20% of all USBN questions made, 84 schools compiled HTS wuestions below 20% and 25 schools said they did not know whether the questions compiled HOTS or not. This is not in accordance with the demands of curriculum 2013 which further enhance the implementation of HOTS assessment models.

In addition, the results of the international study program for Intenational Student Assessment (PISA) show that literacy achievement, mathematics literacy, and scientific literacy achieved by Indonesian students is very low in integrating information, generalizing case by case into a common solution, formulating real-world problems into in the concept of the subjects, and carry out investigations. Based on the facts above, it is necessary to change the system in learning and assessment. Teachers are expected to be skilled in designing learning and assessment in order be able to encourage the improvement of higher-order thinking skills, increase creativity, and build students independence in solving problems. Therefore, this article can provide guidance and guidance in carrying out HOTS.

II. THEORICAL THEORI

2.1 Instructional Design

Instructional design is a systematic procedure in teaching to achieve the desired learning goals. Instructional design can provide assurance that learning is being planned can realize the desired goals. Learning design is the science and art creating detailed spesifications for the development process, how to evaluate, and maintain from various situations that facilitate learning and implementation, Richey, Klein & Tracey (2011). The six components of learning design are a) learner and learning process, preliminary abilities & prerequisite abilities, b) learning contect and performance, c) content and sequence structure, d) learning and non learning strategies, e) media and delivery systems, f) designers and design process. Learning design models by Gustafson and Branch (2020) are grouped into three categories, namely class-oriented design models, product-oriented models, system oriented models. This grouping aims to make it easier for users to choose learning designs to implement. In additions.

Instructional design was initially equipped to organize learning in the general point of view, suvh as the Dicks, Carey and Carey models (Dick, Carey, & Carey, 2015), Morisson and Kemp Model (Morisson, Ross, Kalman, & Kemp, 2003), Banathy model (banathy. 1987), ASSURE model (Smaldino, Lowthe, Mims, & Russel, 2015), Gerlach and Ely model (Gerlach , & Ely, 1980), ARCS model (keller, 1987), and Smith and Ragan Models (Smith & Ragan, 2005).

2.2 High Older Thinking Skills (HOTS)

High Olders Thinking Skills (HOTS) according to Resnick (1987) is a complex through process in breaking down material, making conclusions, building representations, analyzing and building relationships by involving the most basic mental activities. Brookhart (2010) identifies high- level thinking skills inti three categories, namely knowledge transfer, critical and creative thinking, problem solving. High-older thinking skills as knowledge transfer are abilities that indicated meaningfull learning in which students are required to not only remember but also be able to bring that knowledge into different and meaningful situations. High-order thinking skills as critical & creative and argumentative thinking that focus on making decisions to believe or do, Collins (2014). Higher-order thinking skills as problem solving is students are involved in a problem when students want to get specific results or goals but are not automatically able to recognize the way or how to get it. High-level Thunking in Bloom-Anderson's taxonomy Bloom categories cognitive processes into six levels, namely remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6). Bloom's taxonomy in the cognitive realm is the basis for high-level thinking skills or known as High Older Thinking Skills (HOTS).

III. METHODS

The development of HOTS-oriented instructional design model was developed conceptually supported by the theory and experience of practitioner, Lee and Jang (2014). The steps for developing HOTS-oriented instructional design models are as follows:

a. Analyzing relevant research from conceptualized instructional design models, Goksu, I., Ozkan, V., K.,, Cakir, R., & Goktas, Y. (2017)
b. Analyzing learning theories, Moallem, M. (2003); analyze theories that support learning design, Richey, & Klein. (2007.
c. Reviewing relevant literature on metacognition and mathematical problem solving abilities in learning design models, Clifford, M. A. (2009); You, Y. (2002)
d. Ontology to compare a subjective instructional design model (a instructional design model that is influenced through the learning designer's beliefs or epistemology) with an objective instructional design model (a model that is independent of the instructional designer's beliefs or epistemology).
e. After a literature review, compile important variables from the model and predict logical relationships of the variables, then selecting components of the conceptual model, Clifford, M. A, (2009).

IV. RESEARCH AND DISCUSSION

Instructional design that is development research that needs to be considered systematic steps that invite teachers to trace the instructional design flow oriented towards higher order thinking skills. The design step for learning oriented to higher order thinking skills are as follows:

4.1 Learning Planning

Before implementing the learner process, the important thing that is done by the teacher is analyzing graduates competency standards, core competencies and basic compentencies. Analysis was done at the beginning of the school year. The purposes of analyzing the graduate competence standard (GCS) is to find out direction of the achievements of each student in completing the learning carried out. While analyzing core competence aims to find out whether the core competence that has been formulated supports the achievement of graduate competence standard (GCS) and core competence as follows:

1. Read and understand Minister of National Education Regulation number 20 concerning GCS and Minister of National Education Regulation number 21 concerning core competence.
2. Looking at the demands in the GCS and core competence descriptions.
3. Paying attention to the dimensions of knowledge in GCS and core competence; knowledge/skills components in GCS and core competence; place of application described in GCS and core competence; See the relationship between GCS and core competence.

4.2 Learning Implementation

There are three steps carried out at the learning implementation step, namely designing the initial learning activities, core activities and closing activities, as follows:

4.2.1 Designing Initial Activities

Strategic step that need to be considered in designing the initial learning activities, as follows:

1. At this step the teacher determines and analyzes basic competencies that are in accordance with the demands of Minister of National Education Regulation number 24 concerning basic competence which are the minimum targets to be achieved according to basic competence, using the format as seen in table 2 below:

Table 2. Basic Competence Pair Format Knowledge And Skills

Basic Competence of Knowledge	**Basic Competence of Skills**
<Number Basic Competence>< Basic Competence of Knowledge>	<Number Basic Competence>< Basic Competence of Skills>

2. Determine the targets to be achieved in accordance with basic competence by using a format such as Table 3 by separating in basic competence both knowledge and skills.

Table 3. Format Of Targeting Basic Competence Of Knowledge And Skills

Number	**Basic Competence**	**Basic Competence Target**
<Basic Competence of Knowledge>		
	<Basic Competence of Knowledge>	<knowledge targets are mandated by basic competencies>
Basic Competence of Skills		
	<Basic Competence of Skills>	<The target of expertise is mandated by basic competencies>

3. Project as in picture 1 below for combination of dimensions of knowledge and through processes.

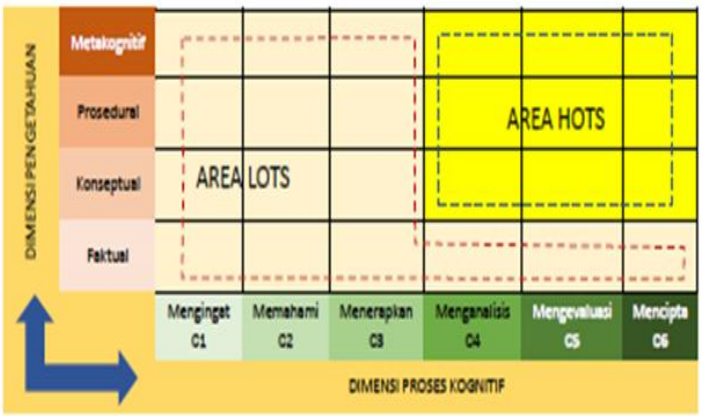


Figure 1. Combinations of Dimensions of Knowledge and Thinking Processes

4. Formulation of competency achievement indicators (CAI) by following these stages, a) pay attention to the dimensions of cognitive processes and the dimensions of knowledge that are targets that students must achieve; b) determine the basic competence target to be lowered to CAI; c) use operational verbs that are appropriate for the formulation of social studies so that the material concepts can be conveyed effectively. Gradation of CAI was identified from LOTS to HOTS; d) formulate supporting CAI and key CAI, ehile enrichment CAI was formulated if the minimum competency of basic competence has been fulfilled by students. The formulation of the CAI can be done by filling out the format shown in the following table 4.

Table 4. Formulation Of Competency Achievement Indicator (CAI)

BC	Level Competence	Thinking Process (C1-C6)	Matter and Sub Matter	Competency achievement indicators
Basic Competence of Knowledge				
	Dimension Knowledge	The throught process and knowledge dimension (Gradation of the tharough process dimension)		Indicators of achievement of supporting competencies
				Indicators of achieving key competencies
				Indicators of achieving competency enrichment
Basic Competence of Skills				
	Level of process skills	Skill process steps (Gradation of the skill dimension)		Indicators of achievement of supporting competencies
				Indicators of achieving key competencies

5. Formulate learning objectives, whether cognitive, psychomotor or effective improvement. The formulation of learning objectives must be clear in showing the skills students must have.

4.2.2 Designing Core Activities

The steps to design learning activities based on the selected learning model, as follows:

a. Understand basic competence that has been analyzed
b. Understand the CAI and learning material has been develop
c. Understand the syntax in the chosen learning model
d. Formulate CAI, student characteristics, scientific approach, 4C (creativity, critical thinking, communication, and collaboration).
e. Literacy

4.2.3 Designing Closing Activities

In this activity includes both individual and group reflection activities. The design steps are as follows:

a. Provide feedback on the process and learning outcomes
b. Carry out follows-up activities
c. Inform the plan of learning activities for the next meeting
d. Closing activities can be given a final assessment according to the relevant basic competence
e. Determine learning resources based on learning activities
f. Formulate an assessment for learning that refers to the CAI

4.3 Learning Assessment and Evaluation

To write a HOTS problem, first a question writer determines the behavior to be measured and formulated material that will be the basis of the question (stimulus) in a particular context in accordance with the expected behavior. Choosing material requires high reasoning, teacher creativity in choosing stimulus questions that are interesting and contextual. The steps for compiling the HOTS question can be presented like the following picture 2:

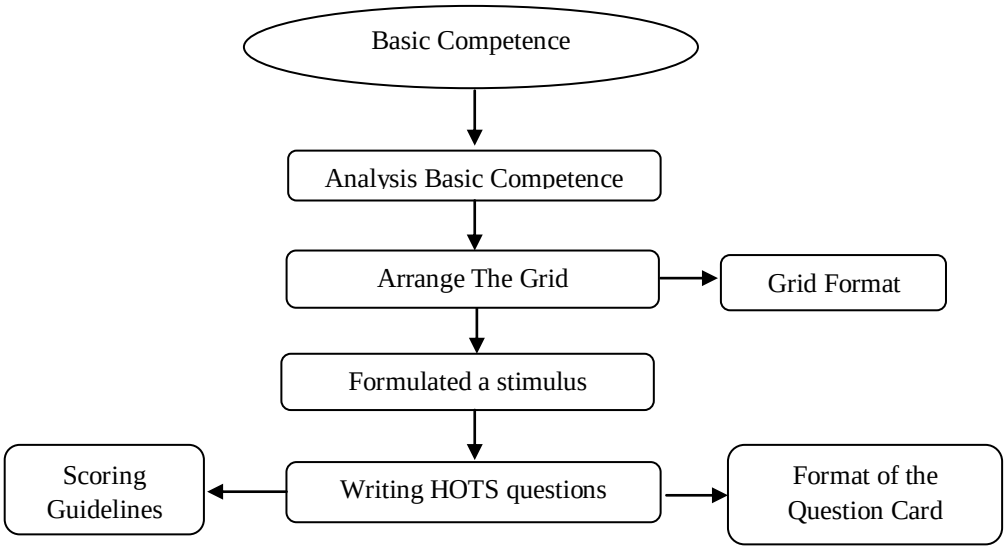


Figure. 2. The Steps For Compiling the HOTS Question

4.3.1 For Example Of Design Evaluation Hots Math
Steps to design an assessment, students are given problems like the following:
a. Compiling Problem Grid for High School

Basic Competention:

- Explain and determine the functions (especially linear functions, quadratic functions, and rational functions formally which include natation, area of origin, area of result and symbolic expression and sketch of the level graph (C4).
- Analyzing the characteristics of eac graph (intersection point with axis, peak point, asymptotes) and changes in graph of functions due to transformation

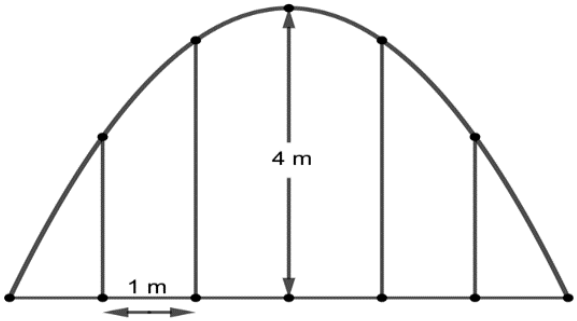
Theory : Function Kuadrat
Problem Indicator :
Given an ilustration of a parabolic bridge (quaratic functions) supported by a supporting iron, students can determine the length of the supporting iron needed by the bridge.
Format Questions: Description
Level Cognitive : L3 (C4)

b. Example of a stimulus
Stimulus: Presented the problem of a parabolic bridge (quadratic function), which is supported by irons that are perpendicular to the base the longest known length of iron and the distance between the supporting iron.
Test ability : Calculate the minimum length of a bridge supporting iron.
Stages of thinking :

- Construct the quadratic equation that satisfies the case.
- Calculate the length of each support iron based on the symmetrical nature of the quadratic function or associate images of bridges and support iron into cartesian coordinates

c. Example of HOTS Questions
Batanghari bridge is connection between Jambi City and Kuala Tungkal is parabolic and supported by iron vertically as shown in the following figure. 3

Figure.3. Example question HOTS



If the distance between the supporting iron is 1 m and the largest length of the iron is 4 m, determine:

a. The parabolic equation of the brigde?
b. How many meters of supporting iron are needed for the bridge?

V. CONCLUSION

HOTS- oriented mathematics instructional design procedures have three main steps namely learning planning, learning implementation, and learning assessment. The first stage of learning planning activities carried out by the teacher are a) analyzing graduate competency standards, core competencies, basic competencies and competency achievement indicators; b) determine thinking process skills and knowledge dimentions; c) determine learning objectives; d) integrated the strengthening of character education and literacy; e) determine the learning model. The two stages of learning implementation, the activities carried out include designing a) initial learning activities, b) core learning activities and c) closing learning activities, evaluating learning.

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