Mathematics teacher supporting higher order thinking skill of students through assessment as learning in instructional model

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Abstract. The Curriculum 2013 revised in 2017 emphasizes the implementation of higher order thinking skills (HOTS) questions in learning and it is required for teacher to employ kind of evaluation such as assessment in students’ learning. The teachers as a supporter of both mentioned aspects needs to be given attention due to the difficulty of applying assessment as learning (AaL) and hots in mathematics learning. This is due to the unfamiliarity with the type of HOTS questions. AaL is a reflective learning based on obtaining feedback for both teachers and students. The current study is an experimental research aiming at assessing AaL in facilitating students solve HOTS problems. This mentioned aspect is the potential point helping teachers to assist their students learning and being successful learners. The subjects of this research are students of 7th grade in Sleman, Yogyakarta. The findings of this study are 1) an improvement has been found to happen after the integration of AaL in instructional model, and 2) The teachers succeeded employing portfolio for learners to facilitate HOTS in mathematics learning. Teachers used the portfolio with conceptualization and characteristic of AaL bases portfolio with problems of HOTS type.

1. Introduction
Many initiatives has been taken by researchers to develop the students’ HOTS [1-3]. Emphasizing the importance of HOTS, the Indonesian government has made several efforts. The efforts focused on changes made to the curriculum, teacher training and supporting research in the education field. The curriculum aims to improve the quality of human resources and enhance the nation's competitiveness, and with the development of science, technology, and art. The curriculum is expected to produce productive, creative, innovative and effective human resource competencies through strengthening attitudes, knowledge, and skills [4]. However, in reality, the government declared that the curriculum did not fully meet the expectations. Teachers face difficulties in applying the curriculum in 2013 to students in the classroom. Applying HOTS questions are one of the initiatives that should be made by teachers.

Taken from the revised version of Bloom's taxonomy, HOTS have defined by three levels of upper-level cognitive skills in the learning hierarchy: analysis, synthesis, and evaluation. The analysis refers to the ability of learners to deconstruct their knowledge structures and categories into their respective groups and identify relationships between components of knowledge structures [5]. High-level thinking skills are the ability of students to complete tasks without algorithms, which require justification or explanation for more than one possible solution [6]. In Bloom's Taxonomy, students' abilities involve
analysis, evaluation, and manufacture that are considered to be high-thinking skills [7]. With this ability, students are expected to connect to various instructions (instructions) and facts with their knowledge to make predictions of the end result. Bloom’s Taxonomic Revision states that indicators can measure high-level thinking skills analyzing (formulating problems, hypotheses, and collecting data), evaluating (analyzing data and conclusions), and shaping (shaping products) [8].

Besides HOTS, teaching and learning in the 21st century should focus more on student-centered and independent learning, project-based learning and collaborative learning, as well as authentic assessment [9]. This approach promotes the use of high-level thinking skills as well as cognitive development. For example, student-centered learning (SCL) has become an effective approach to improving learning experiences for students by applying various methods, tasks or assessments to understand one problem [10]. Assessment that teachers should be able to use and hold a dominant role at the moment is Assessment as Learning (AaL). The AaL principles attract some theoretical perspectives, including motivation theory, autonomy, metacognition, and self-regulation. Another crucial feature of AaL is the significant role played by learners in the assessment process leading to the proliferation of self-combination and relevant assessment concepts including, self-assessment, self-evaluation, and self-reflection [11]. Much of the AaL research has raised concerns over the reliability of student appraisal compared with teacher judgments [12], so there is a need for done by students as well as self-assessment. One of the main things in AaL is feedback [13,14] that teachers and students need every use of AaL. One of the things that should have used in the 2013 revision curriculum of 2017 is the use of learning models. Learning models are used to help AaL use in improving student HOTS.

The current research aims at 1) discovering the improvement of students’ HOTS through assessment as learning in learning model, 2) know the successful use of AaL-based fortified sheet on learning model.

2. Research method
The participants of this research are 61 students of class VII SMP 1 Depok and SMP 2 Cangkringan, Daerah Istimewa Yogyakarta, Indonesia. Data collection is done through fortoffolio using AaL in learning circuit learning model, instructional design, and test. The effectiveness of the instructional design is analyzed by quantitative descriptive, by looking at the improvement of students’ pretest-posttest scores as well as the results of each portfolio with AaL used by teachers. Testing is also done with the T-test to find out an increase when using AaL in the learning model.

\[
t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}
\]

3. Findings and discussion
3.1. Findings
The teacher knows that one of the assessments they need to use is AaL. In the 21st century, the curriculum in Indonesia wants them to apply it when they teach in the classroom. The portfolio is one of the effective and systematic collections of student work that demonstrates student effort, progress, or overtime achievement [15]. An effective portfolio can realize many charisms of assessment as learning. They document progress, improvement, learning, and achievement of student goals; provide individualized learning and assessment; and they encourage self-responsibility, active learning, self-evaluation and reflection [16]. Told about portfolio conceptualization as a learning tool. There are eight things we need to do in the portfolio as a learning tool as outlined in table 1 [17].

The concept of this AaL-based portfolio applied by teachers to students in quadrilateral learning. AaL-based portfolios used through learning models must have characteristics that need attention. In table 2, it is explained that the characteristics of this AaL-based portfolio are 11 things to note:

The conceptualization and characteristics of this portfolio assessment form the basis for creating a portfolio by teachers. The AaL-based portfolio used by teachers is simple, this is because the teacher
uses the portfolio at the end of each lesson to know the increased ability of completion in the HOTS type and the feedback between the students and teachers on the matter as shown in figure 1. Students coherent in writing the answer because they are accustomed to doing HOTS questions. Previously students always have difficulty to write answers in harmony. Students also give conclusions on the answers, this means students understand the questions given. Teachers also write down the importance of parents' comments to find out the student portfolio results as in figure 1.

Answer:

(jawaban):

- Satu karton berbentuk persegi 
  \[ x = 28 \, \text{cm} \]
  \[ \text{Luas karton yang tidak dipakai} = x^2 - 2 \times 25 \]
  \[ = 28 \times 28 - 2 \times 25 \]
  \[ = 784 - 50 \]
  \[ = 734 \, \text{cm}^2 \]

Score:

6.67

Parents comment and action about student’s learning mathematics:

Komentar dan tindakan dari guru:

- Gangguan suasana buku
- Meminta guru untuk membantu

- Ingin lebih memahami

- Selalu gampang menyelesaikan permasalahan yang diberikan

Score:

Parents comment and action about student’s learning mathematics:

Komentar dan tindakan orang tua tentang pembelajaran matematika siswa:

- Minta guru untuk membantu

Other Notes:

Catatan:

Figure 1. Example of portfolio as learning tools design by teacher with hots problems.

Use of this portfolio when the steps in the learning model ask students to solve the problem type analysis, evaluation, or form (HOTS). In figure 1, it shows students' answers when they have used their last portfolio. There are 5 times face-to-face on math subjects when using AaL-based portfolios. Every 1 face to face, the teacher will provide a portfolio at the end of learning to know students' understanding of the material delivered. The portfolio is returned directly during the meeting, and the discussion of the answer is also given directly. The scoring on the portfolio is done directly, as well as the students are asked to look for deficiencies in the answers to be fixed. After that, the portfolio was brought up by a teacher commentary and brought by the student to be shown to parents to comment on.
3.2. The effectiveness of the use of AaL-based portfolios in the learning model

Before a learning model using AaL-based portfolios is applied in the classroom, students are given a pre-test that aims to identify early HOTS students. Furthermore, after applying the learning design that has been developed, students are given post-test to know the impact of the implementation of learning. The average pre-test and post-test grade of students is shown in figure 2.

![Figure 2. The mean of students’ pre-test and post-test.](image)

Based on figure 2, the average pretest and posttest of students after using HOTS-based circuit learning model increased. It seems from the average pretest of students who score 40, and after using HOTS-based circuit learning model increased to the average value to 80. The result of each student's improvement in figure 3.

![Figure 3. The mean of each students’ pre-test and post-test.](image)

Figure 3 shows the average pretest and posttest results of each student after using the learning circuit learning model. Based on figure 3, the results of each student increased after using the model of circuit learning based HOTS so that the model used effectively for students. Student learning outcomes during the meeting. It showed that every meeting, students can improve problem-solving ability with HOTS problem. Implementation of meetings held during five meetings at each meeting there is an increase. The results of each meeting showed in figure 4.
Based on figure 4 shows that each HOTS student score during pre-test increases after the implementation of the instructional design developed. Although not all students achieve a minimum completeness Criteria score of 70, this achievement clearly shows that the AaL used in the learning model can improve the HOTS of each student. Thus, the application of AaL-based portfolios in effective learning models to improve student HOTS. The T-test that has done that supports it is 42.992, = 82.41, after calculating the t-test, we got t-observation is 13.276. Based on t-table we got the critical area is 2.0003. That means rejected. Thus, we can conclude that there is a change in the use of judgment as a lesson to learn math.

3.3. Discussion
The findings of data analysis show that AaL in the learning model used effectively to improve HOTS of students. It is because asking open-ended questions (creative issues) through portfolio makes students more challenged to explore possible ideas that can be used to solve problems. Loewen [18] suggests that with the filing of creative issues can raise awareness for students that not all problems have only one correct solution. It is what can trigger and train students’ creativity in learning math, and creativity is part of HOTS.

Another factor leading to student HOTS improvement is the existence of meaningful learning activities, where students are actively involved in the discussion process to build knowledge and utilize relevant sources to explore desired knowledge. It is by the opinions expressed by Bohan & Bohan [19] that the learning process involving the active participation of students to solve various problems can present meaningful learning activities for students. Also, students become enthusiastic because they feel challenged for a given problem. It, of course, can increase students' motivation to learn. It is in line with Loewen's opinion [18] which states that challenging presentation of creative issues can increase students' interest and motivation to learn. Thus, the increased interest and motivation for student learning becomes the decisive factor for the HOTS improvement of the students.

4. Conclusion
There is change when using assessment as learning to mathematics learning. It because of teacher tried to use portfolio to students to facilitate their higher order thinking skill. Teacher made the portfolio use the conceptualization and characteristic assessment as learning.
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References

[1] Limbach, Barbara and Wendy W 2010 Developing higher level thinking Journal of Instructional Pedagogies 3 p 1
[2] Nagappan R 2001 The teaching of higher-order thinking skills in Malaysia Journal of Southeast Asian Education 2 pp 1-22
[3] Polly, Drew, and Leigh A 2009 Developing higher-order thinking skills through webquests Journal of Computing in Teacher Education 26(1) pp. 29-34
[4] Puskrubuk 2012 Pergeseran Paradigma belajar abad 21
[5] Marzano R J and Kendall J S 2006 The New Taxonomy of Educational Objectives Corwin Press
[6] Lewy Zulkardi and N Aisyah 2009 higher order thinking skill Jurnal Pendidikan Matematika 3(2) pp 14-28
[7] Pohl M 1999 Learning to Think, Thinking to Learn: Models and Strategies to Develop a Classroom Culture of Thinking (New York: Hawker Brownlow Education) p 98
[8] Krathwohl D R 2002 A Revision of Bloom’s Taxonomy: An Overview Theory Into Practice 41(4) College of Education: The Ohio State University
[9] Sener N, Turk C and Tas E 2015 Improving science attitude and creative thinking through science education project: A design, implementation and assessment Journal of Education and Training Studies 3(4) pp. 57–67
[10] Bishop C F, Caston M L and King C A 2014 Learner-centered environments: Creating effective strategies based on student attitudes and faculty reflection Journal of the scholarship of teaching and learning 14(3) pp 46-63
[11] Lee I 2016 Putting students at the centre of classroom L2 writing assessment The Canadian Modern Language Review 72(2) pp 258–280.
[12] Matsuno S 2009 Self-, peer- and teacher-assessments in Japanese university EFL writing classrooms Language Testing 26(1) pp. 75–100
[13] Nicol D J and Macfarlane Dick D 2006 Formative assessment and self-regulated learning: A model and seven principles of good feedback practice Studies in higher education 31(2) pp. 199-218.
[14] Sadler D R 1998 Formative Assessment: Revisiting the Territory Assessment in Education: Principles, Policy & Practice 5(1) pp. 77–84.
[15] British Columbia Ministry of Education 1994 Portfolio assessment Victoria (Bc: Author)
[16] Lund J and Kirk M 2002 Performance-based assessment for middle and highschool physical education (Champaign,IL: Human Kinetics)
[17] Lam R 2015 Assessment as learning: examining a cycle of teaching, learning, and assessment of writing in the portfolio-based classroom Studies in Higher Education pp 1-18
[18] Gibbons S L and Kankkonen B 2012 Assesment as learning in physical education: making assessment meaningful for secondary school students Physical and health education journal 76(4) pp 6-13’