THE ABILITY OF STUDENTS AS TEACHER CANDIDATES IN DEVELOPING HIGHER ORDER THINKING SKILLS MATHEMATICS TEST

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ABSTRACT

The research objective is to describe the ability of students as mathematics teacher candidates in developing High Order Thinking Skills (HOTS) Mathematics. This research is descriptive qualitative. The instruments used in this research are documentation and interview. Data analysis was carried out through stages of data reduction, categorization, synthesizing, and arranging work hypothesis. The result of data analysis shows that students as mathematics teacher candidates have been able to arrange the framework of HOTS mathematics test items considering the aspects of C4 (analysing) dan C5 (evaluating). They found it difficult to develop test items for mathematics using HOTS, in which they were only able to make the HOTS test of 33.33%.
Keywords: Mathematics test instrument, higher order thinking skills.

Introduction

Mathematics plays an important role to solve problems in daily life. However, frequently students are not able to use the knowledge of mathematics they have into their daily life. Even, they are not able to use the skill to solve a problem if they are given a slightly different problem from what they had learnt. (Budiman, A. and Jailani, J., 2014:140).

The result of Research on Improvement of System Education (RISE) in 2018 in Rarasati, N. in Bona, M.F. (2018) showed that the students' ability to solve simple mathematics problem was not significantly different between new elementary students (SD) and students who already graduated from the high school (SMA). Besides, the result of Programme for International Student Assessment (PISA) in 2018 explained that the mathematics ability of Indonesian students was decreasing from 386 to 379. (Dewabrata, M: 2019).

It has been evaluated by the Indonesian government and they have applied Higher Order Thinking Skills (HOTS) to boost the mathematics ability of Indonesian students. HOTS is the ability to connect, manipulate, and change the knowledge as well as the experience that had already been possessed critically and creatively in determining a decision to solve problems in new situation (Dinni, H.N., 2018: 170).

It can be concluded that higher order thinking skills (HOTS) is a means that can be used in learning to improve mathematics skill of the students to think critically and creatively in solving contextual problems.

Ariandari (2015:491) added that HOTS provides learning effect for both students and teachers, i.e.: (1) learning will be more effective with higher order thinking; (2) improving teachers' intellectual skills in developing higher order thinking; (3) in evaluating learning using this new concept, the teachers should always prepare questions which later will not be answered in a simple manner. Therefore, each teacher should be able to arrange HOTS test as one of the pedagogic competences that must be mastered, i.e. developing instrument of assessment and process evaluation and learning result. Such competence must also be mastered by the students as the mathematics teacher candidates.

However, students as Mathematics teacher candidates usually only take questions from the handbook or from the internet disregarding the learning taxonomy (Bloom taxonomy). Although, Bloom Taxonomy should be well-considered in arranging questions. New version of Bloom Taxonomy consists of 6 cognitive levels i.e. C1 (remembering), C2 (understanding), C3 (applying), C4 (analysing), C5 (evaluating), and C6 (Creating). The following is the figure of bloom taxonomy hierarchy.

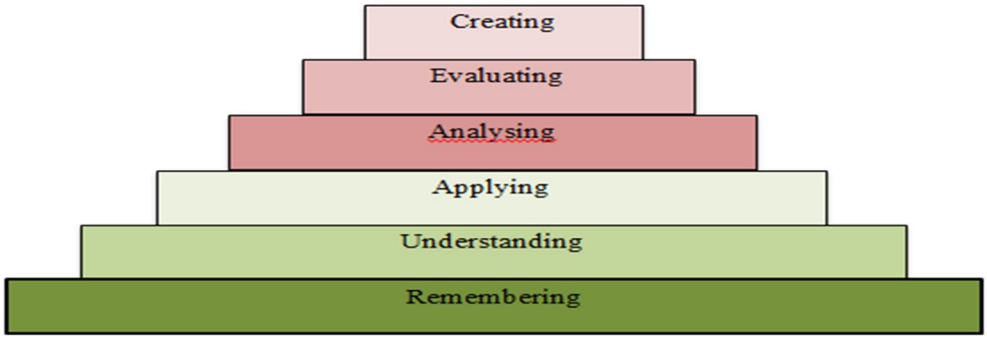


Figure 1. New Version of Bloom Taxonomy (Adoption from Amstrong: 2020)

HOTS question category is in C4, C5, and C6. Based on that, Saidah, N. et al (2019) suggested that the characteristics in hots question are measuring high level of ability, questions based on contextual problems, questions not familiar or known to students as well as various forms

Based on the above explanation, this research aims to describe the students' skill as the mathematics teacher candidates in Institut Keguruan dan Ilmu Pendidikan (IKIP) Budi Utomo Malang in developing the instruments of Higher Order Thinking Skills (HOTS) mathematics test.

Method

This research was qualitative research. Moloeng, L.J. (2016) revealed that qualitative research is the research aiming to understand a phenomenon experienced by the research subject, for example, behaviour, perception, motivation, attitude, etc., holistically, in descriptive manner in the form of words and language, in a natural specific context and by using various natural method.

The data collected in this research were in the form of figures or words. The instrument used in this research was the documentation of the students' project results in developing HOTS mathematics questions. Besides, interview was used for data triangulation to clarify the students' ideas put into the project of HOTS mathematics test questions. The interview was carried out in Focus Group Discussion activity (FGD) guided by a moderator (TC). This was required to obtain valid data. Data analysis was carried out through stages of data reduction, categorization, synthesizing, and arranging working hypothesis.

The research was carried out in Study Program of Mathematics at IKIP Budi Utomo Malang. The subject of the research is 9 students of the study program of Mathematics at IKIP Budi

Utomo Malang who have taken Evaluation of Education subject. They were divided into 3 groups to discuss to arrange mathematics questions for HOTS. Group I consisted of MF, HS, and PH. Group II consisted of VN, AW, and MA. While Group III consisted of IA, DN, and RM.

Result and Discussion

Each group worked on the project in developing HOTS Mathematics questions based on the revised edition of the 2013 curriculum focusing on the Geometry discussion for Junior High School (SMP) students. The project's analysis result of each group in developing HOTS Mathematics questions and the interview was described as follows.

1. First Group

Research subject of the first group consisted of MF, HF, and PH. In developing HOTS questions, this group has made the framework of the questions based on the curriculum and determined the cognitive level of each question. The following are the indicators and cognitive levels used by the first group.

Table 1. Indicator and Cognitive Level of Group I

Indicators	Cognitive Level	Question No.
A contextual problem about the width of a park in the form of Trapezium was presented and the students could determine the circumference of the park	C5	1
A contextual problem about the length of one side of a kite and Trapezium was presented and the students are able to determine the circumference of the object	C4	2
A contextual problem about a field in the form of Trapezium and rectangle are presented and the students are able to determine the width of the field planted with grass	C4	3

Table 1 shows that the indicator of each question has met the criteria of HOTS questions, i.e. contextual. Bloom Taxonomy can be also seen in C4 and C5 as other characteristic of questions type of HOTS. However, framework of test questions has not mentioned C6.

Based on the formula of the questions, group I made the following question.

Kompetensi Dasar : 3.1 Mengaitkan rumus keliling dan luas untuk berbagai jenis segiempat (persegi, persegi panjang, belah ketupat, jajargenjang, Trapezium, dan layang-layang) dan segitiga

4.1 Menyelesaikan masalah kontekstual yang berkaitan dengan luas dan keliling segiempat (persegi, persegi panjang, belah ketupat, jajargenjang, Trapezium, dan layang-layang) dan segitiga

Kontekstual Materi : Menyelesaikan masalah kontekstual yang berkaitan dengan luas dan keliling segiempat (persegi, persegi panjang, belah ketupat, jajargenjang, Trapezium, dan layang-layang) dan segitiga (penerapan luas persegi panjang dan persegi)

Indikator Soal : Disajikan sebuah masalah kontekstual mengenai luas taman berbentuk Trapezium serta peserta didik dapat menentukan keliling taman tersebut

Level Kognitif : Penalaran (L3/C5)

Soal :

1. Taman berbentuk Trapezium sama kaki dengan panjang sisi-sisi sejajarnya $(x + 4)$ m dan $(3x + 2)$ m. Jika jarak kedua garis sejejar $2x$ m dan luas taman 180 m^2 , kekelilng taman adalah

Figure 2. Question Card and Question Number 1 of Group I

Kompetensi Dasar : 3.1 Mengaitkan rumus keliling dan luas untuk berbagai jenis segiempat (persegi, persegi panjang, belah ketupat, jajargenjang, Trapezium, dan layang-layang) dan segitiga

4.1 Menyelesaikan masalah kontekstual yang berkaitan dengan luas dan keliling segiempat (persegi, persegi panjang, belah ketupat, jajargenjang, Trapezium, dan layang-layang) dan segitiga

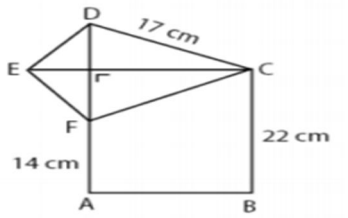
Kontekstual Materi : Menyelesaikan masalah kontekstual yang berkaitan dengan luas dan keliling segiempat (persegi, persegi panjang, belah ketupat, jajargenjang, Trapezium, dan layang-layang) dan segitiga (penerapan luas persegi panjang dan persegi)

Indikator Soal : Disajikan sebuah masalah kontekstual mengenai panjang sisi layang-layang dan Trapezium serta peserta didik dapat menentukan keliling dari bangun tersebut

Level Kognitif : Penalaran (L3/C4)

Soal :

2. Perhatikan bangun trepesium ABCF dan laying-layang EFCD.



Jika panjang DE = 2 cm, keliling bangun di atas adalah?

Figure 3. Question Card and Question Number 2 of Group I

Kompetensi Dasar : 3.1 Mengaitkan rumus keliling dan luas untuk berbagai jenis segiempat (persegi, persegi panjang, belah ketupat, jajargenjang, Trapezium, dan layang-layang) dan segitiga

4.1 Menyelesaikan masalah kontekstual yang berkaitan dengan luas dan keliling segiempat (persegi, persegi panjang, belah ketupat, jajargenjang, Trapezium, dan layang-layang) dan segitiga

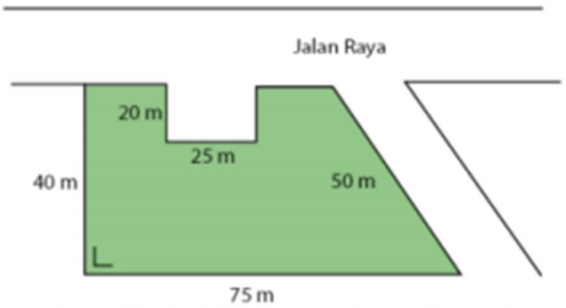
Kontekstual Materi : Menyelesaikan masalah kontekstual yang berkaitan dengan luas dan keliling segiempat (persegi, persegi panjang, belah ketupat, jajargenjang, Trapezium, dan layang-layang) dan segitiga (penerapan luas persegi panjang dan persegi)

Indikator Soal : Disajikan sebuah masalah kontekstual mengenai sisi tanah berbentuk Trapezium dan pesegi panjang peserta didik dapat menentukan luas dari tanah yang ditanami rumput

Level Kognitif : Penalaran (L3/C4)

Soal :

3. Perhatikan gambar berikut :



Daerah yang diarsir adalah sketsa tanah yang ditanami rumput. Luas hamparan rumput tersebut adalah...

Figure 4. Question Card and Question Number 3 of Group I

From figure 2, 3, and 4, it can be seen that question number 1 and 3 have shown contextual questions. However, question 2 did not show a contextual question since there was no explanation in the question correlated with the daily life problem. In C4, question number one cannot be considered as HOTS question since in its problem solving, trapezium formula can directly be applied.

Question number two does not meet the requirement to be categorized as HOTS question since it was not contextual. In the question, a clue has been provided i.e. trapezium and kite shape. While number three, it can be considered as HOTS mathematics question since in order to find the solution, it requires critical and creative way of thinking from the students. In question number 3, there has not been any key word such as trapezium shown.

The interview with the first group can be seen in the following transcript:

TC : How long did it take for you to make HOTS questions?
HS : Monday to Friday (5 days)
TC : Did you look for a source/browse from the internet in developing HOTS questions?
PH : Yes, I browsed from the internet. And then I adopted some. Discussed them via WhatsApp group.
TC : Please, elaborate your reasons in choosing such questions!

MF : I once provided HOTS question and it turned out the students could solve them easily so that I modified the questions I browsed.
TC : Did you find any difficulties in developing HOTS questions?
MF : Yes, it is difficult to determine HOTS questions.
HS : I could not just make questions the way I like.
PH : I could differentiate HOTS questions from LOTS questions.
MF : I could identify HOTS questions.

From the interview, it can be concluded that group one took longer time to develop the instrument of HOTS Mathematics test. They found difficulties in determining HOTS Mathematics questions even though they discussed them in WhatsApp group and browsed from the internet to modify the questions. It was identical with Budiman, A and Jailani (2014) who revealed that the instrument used by the teachers to assess the learning result of the students in terms of cognitive aspect usually was taken from various handbooks or questions bank.

Despite having difficulties in developing the instruments, group I could identify the criteria of HOTS questions and differentiate HOTS questions from LOTS questions.

2. Second Group

Group two consisted of VN, AW, and MA. In developing HOTS questions, this group developed the framework of the questions based on the curriculum and determine the cognitive level of each question. The following is the indicator and the cognitive level used by the first group.

Table 2. Indicator and the Cognitive Level of Group II

Indicator	Cognitive Level	Question No.
A contextual problem about the volume of a book and a block of box is presented along with a figure as a stimulus so that the students are able to determine the number of books that could be put into the box.	C4	1
A contextual problem about different volume of pyramids is presented, students are able to determine the small blocks needed to cover the empty space of big block.	C4	2
A contextual problem is presented, different volume of pyramids, students are able to determine the volume of each pyramid and the volume of the entire pyramids.	C4	3

Based on Table 2, it could be identified that group II has understood the criteria of HOTS questions which was taken from real daily life problem and took C4 as one of the HOTS' cognitive level. Yet, this group has not listed C5 and C6. The followings are the questions made by group II.

Mata Pelajaran	: Matematika	**Bentuk Soal**	: Uraian
Jenjang Sekolah	: SMP / MTs	**Nama Penyusun**	:
Kelas/Semester	: VIII / Genap		

KOMPETENSI DASAR

3.9 Membedakan dan menentukan luas permukaan dan volume bangun ruang sisi datar (kubus, balok, prisma, dan limas)

MATERI

Bangun Ruang Balok

INDIKATOR SOAL

Disajikan sebuah masalah kontekstual mengenai volume buku dan kotak berbentuk balok disertai dengan gambar sebagai stimulus agar peserta didik dapat menentukan jumlah buku yang bisa diamsukkan kedalam kotak.

LEVEL KOGNITIF

C4

NOMOR SOAL

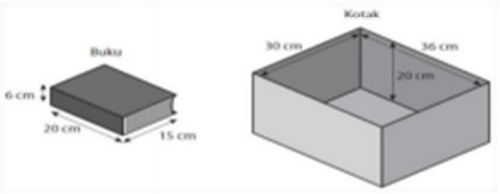
1

JAWABAN

12 Buku

SOAL :

Aulia akan memasukkan buku-buku yang berukuran sama dalam sebuah kotak berebntuk balok seperti pada gambar dibawah ini'



Berapakah jumlah buku maksimum yang dapat dimasukkan aulia ke dalam kotak ?

Figure 5. Question Card and Question Number 1 of Group II

KARTU SOAL

Mata Pelajaran	: Matematika	**Bentuk Soal**	: Uraian
Jenjang Sekolah	: SMP / MTs	**Nama Penyusun**	:
Kelas/Semester	: VIII / Genap		

KOMPETENSI DASAR 3.9 Membedakan dan menentukan luas permukaan dan volume bangun ruang sisi datar (kubus, balok, prisma, dan limas)	**LEVEL KOGNITIF** C4	**SOAL :** Seorang pedagang emas memiliki lemari penyimpanan emas batangan yang memiliki ukuran panjang 1,2 m, lebar 0,8 m, dan tinggi 2 m. Bagian dalam lemari tersebut akan diisi seluruhnya dengan emas batangan yang memiliki ukuran 20 cm x 10 cm x 5 cm, banyaknya emas batangan yang dibutuhkan untuk memenuhi lemari tersebut dan tidak terdapat ruang kosong adalah.....buah.
MATERI Bangun Ruang Balok	**NOMOR SOAL** 2	
INDIKATOR SOAL Disajikan sebuah masalah kontekstual volume limas yang berbeda-beda, peserta didik dapat menentukan balok kecil yang dibutuhkan untuk menutupi ruang kosong balok berukuran besar.	**JAWABAN** 1.920 buah	

Figure 6. Question Card and Question Number 2 of Group II

KARTU SOAL

Mata Pelajaran	: Matematika	**Bentuk Soal**	: Uraian
Jenjang Sekolah	: SMP / MTs	**Nama Penyusun**	:
Kelas/Semester	: VIII / Genap		

KOMPETENSI DASAR 3.9 Membedakan dan menentukan luas permukaan dan volume bangun ruang sisi datar (kubus, balok, prisma, dan limas)	**LEVEL KOGNITIF** C4	**SOAL :** Sebuah gedung bertingkat milik perusahaan keluarga pak andi memiliki 6 kubah berbentuk limas segitiga dengan setiap kubah memiliki ukuran yang berbeda. 3 Kubah utama memiliki ukuran 8 m, 10 m, dan 12 m. 2 kubah berukuran 4 m, 6 m, dan 10 m. Dan 1 kubah memiliki ukuran 3 m, 4 m, 8 m. Volume dari keseluruhan kubah tersebut adalah…
MATERI Bangun Ruang Limas	**NOMOR SOAL** 3	
INDIKATOR SOAL Disajikan sebuah masalah kontekstual, volume limas yang berbeda-beda peserta didik dapat menentukan volume setiap limas dan volume limas keseluruhan	**JAWABAN** 576 m^3	

Figure 7. Question Number 3 of Group II

Figure 5, 6, 7 show that the questions made by group II have already shown as contextual questions. Figure 5 has not been considered as HOTS question since the question could still be done directly using a formula for having a clue in the questions in the word “box”.

Figure 6 has already shown HOTS questions but it needs to consider the size of the furniture and the gold bars. The size of the furniture is commonly in centimetre (cm), while the gold bar is in millimetre (mm). For the third question or figure 7, the question cannot be categorized into HOTS question since it can be directly done by using the formula of pyramid.

The interview result of Group II can be seen in the following transcript:

TC : How long did it take for you to make HOTS questions?
VN : Three days
TC : Did you look for a source/browse from the internet in developing HOTS questions?
AW : Yes, I browsed from the internet. Besides buying some books, I also borrowed some books about HOTS. And then I discussed it via WhatsApp group and at home.
TC : Please, elaborate your reasons in choosing such questions?
VN : The questions are contextual.
TC : Did you find any difficulties in arranging HOTS questions?
MA : Yes, it is difficult to determine HOTS questions.
VN : I could understand HOTS. I could not just arrange questions the way I like.
AW : I learned a lot how to arrange HOTS based test. Based on the characteristics of the HOTS questions. Though, I got confused about C4, C5, and C6.
MA : I know how to develop HOTS questions.

The interview result shows that group two took two days faster than group I. They have already understood the concept of HOTS contextual questions but were not fully able to determine the cognitive level of Mathematics HOTS questions. To overcome the difficulties, they discussed it in WhatsApp group and at home. The sources used to arrange HOTS questions were internet and books. They used different learning sources since there has not been any assessment instrument specifically designed to train HOTS (Budiman, A and Jailani: 2014). Even so, they understood that in making questions, they could not just make the test items and they had to pay attention to the cognitive level.

3. Third Group

The third group consisted of IA, DN, and RM. The framework of the questions made by this group have been in line with the curriculum and met HOTS criteria i.e. contextual. The Indicator of each question is shown in the following table.

Table 3. Indicator and Cognitive Level of Group III

Indicator	Cognitive level	Question no.
A contextual problem about a *tumpeng* in cone shape is presented and then the top is cut, students are able to determine the volume and the circumference of the cone surface.	C4	1
A contextual problem about a water tube and a ball is presented, the students are able to determine the water level in the tube once a ball was put inside.	C4	2
A contextual problem about a ball is presented that the students are able to determine the volume of a ball.	C4	3

The questions arranged by group III could be seen in the following figure.

- **KARTU SOAL**

Mata Pelajaran : Matematika
Kelas / Semester : IX/2
Kurikulum : 2013

Kompetensi Dasar:

3.7 Membuat generalisasi luas permukaan dan volume berbagai bangun ruang sisi lengkung (tabung, kerucut, dan bola).

4.7 Menyelesaikan masalah konstektual yang berkaitan dengan luas permukaan dan volume bangun ruang sisi lengkung (tabung, kerucut, dan bola) serta gabungan beberapa bangun ruang sisi lengkung.

Kontekstual Materi: Menyelesaikan masalah konstektual yang berkaitan dengan luas permukaan dan volume bangun ruang sisi lengkung (tabung, kerucut, dan bola) serta gabungan beberapa bangun ruang sisi lengkung (penerapan luas permukaan dan volume kerucut).

Indikator soal : Disajikan sebuah masalah konstektual mengenai tumpeng yang berbentuk kerucut kemudian bagian atasnya di potong, siswa dapat menentukan volume dan luas permukaan kerucut

Level kognitif : Penalaran C4

- **SOAL**

1. Pak Budi memesan tumpeng untuk melakukan syukuran rumah baru.Tumpeng tersebut memiliki diameter 36 cm dan tinggi 24 cm Namun diawal acara Pak Budi memotong bagian atas tumpeng tersebut secara mendatar setinggi 8 cm.
Berapa luas permukaan dan volume dari tumpeng yang tersisa?

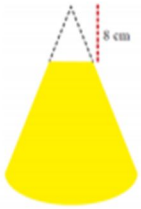


Figure 8. Question Card and Question Number 1 Group III

- **KARTU SOAL**

Mata Pelajaran :Matematika
Kelas/Semester : IX/2
Kurikulum : 2013

Kompetensi Dasar:

3.7 Membuat generalisasi luas permukaan dan volume berbagai bangun ruang sisi lengkung (tabung, kerucut, dan bola).

4.7 Menyelesaikan masalah konstektual yang berkaitan dengan luas permukaan dan volume bangun ruang sisi lengkung (tabung, kerucut, dan bola) serta gabungan beberapa bangun ruang sisi lengkung.

Kontekstual Materi : Menyelesaikan masalah konstektual yang berkaitan dengan luas permukaan dan volume bangun ruang sisi lengkung (tabung, kerucut, dan bola) serta gabungan beberapa bangun ruang sisi lengkung (penerapan volume tabung dan bola).

Indikator soal : Disajikan sebuah masalah konstektual mengenai tabung air dan bola peserta didik dapat menentukan tinggi air dalam tabung setelah dimasukkan bola

Level kognitif : Penalaran C4

- **SOAL**

2. Dalam tabung berisi air setinggi 30 cm dimasukkan 6 bola besi yang masing-masing berjari jari 7 cm. Jika diameter tabung 28 cm, tinggi air dalam tabung setelah dimasukkan enam bola besi adalah.....

Figure 9. Question Card and Question Number 2 Group III

- **KARTU SOAL**

Mata Pelajaran : Matematika
Kelas/Semester : IX/2
Kurikulum : 2013

Kompetensi Dasar:

3.7 Membuat generalisasi luas permukaan dan volume berbagai bangun ruang sisi lengkung (tabung, kerucut, dan bola).

4.7 Menyelesaikan masalah konstektual yang berkaitan dengan luas permukaan dan volume bangun ruang sisi lengkung (tabung, kerucut, dan bola) serta gabungan beberapa bangun ruang sisi lengkung.

Kontekstual Materi: Menyelesaikan masalah konstektual yang berkaitan dengan luas permukaan dan volume bangun ruang sisi lengkung (tabung, kerucut, dan bola) serta gabungan beberapa bangun ruang sisi lengkung (penerapan volume bola).

Indikator soal : Disajikan sebuah masalah konstektual mengenai sebuah bola peserta didik dapat menentukan volume bola

Level kognitif :Penalaran C4

- **SOAL**

3. Pak Haru ingin membeli bola untuk sepak bola di sekolahnya. Bola yang ingin dibeli Pak Haru harus memiliki panjang 68 cm – 70 cm. Tentukan volume bola minimal dan maksimal yang harus dibeli Pak Haru!

Figure 10. Question Number 3 Group II

Figure 8, 9, and 10 have shown contextual Mathematics questions. But the question in Figure 8 cannot be considered as HOTS question since it can directly be worked out using cone concept in its problem solving. For question number 2 in Figure 9 also has not shown HOTS question since the solution to the problems can easily be read. Meanwhile, question number three in figure ten can be categorized as HOTS question since the diameter or the radius of the ball are not shown directly in the question.

The following is the transcript of the interview with group III:

TC : How long did it take for you to make HOTS questions?
DN : Monday to Friday. 5 days.
TC : Did you look for a source/browse from the internet in developing HOTS questions?
IA : We browsed, looked for some books, watched YouTube, and WhatsApp group discussion.
TC : Please, elaborate your reasons in choosing such questions?
IA : Those questions need some analyses.
TC : Did you find any difficulties in developing HOTS questions?
RM : Yes, it is difficult to determine HOTS questions. I have not found my confidence in determining HOTS question.
RM : Common question could be HOTS. HOTS require C1, C2, and C3
IA : Not all difficult questions are considered as HOTS. HOTS require figures. Contextual questions in HOTS.

The interview transcript shows that group III took the same days as group I to develop HOTS Mathematics test. They learned from internet, book, YouTube and WhatsApp discussion to determine analytical questions or C4. the difficulties faced by Group III was that they were not confident in determining HOTS questions. But they finally understood that in developing HOTS question, they need not only contextual but also need to consider C1, C2, and C3. HOTS requires the students to be able to change or to create the knowledge they already have and produce something new (Dinni, H.N.: 2018).

CONCLUSION

Based on the research result and discussion on Group I, II, and III, it can be concluded that students as the Mathematics teacher candidates have understood the characteristics of HOTS mathematics questions which are contextual and involving C4 (analysing) and C5 (evaluating) in framework of the questions. However, the students as the teacher candidates had difficulties in determining whether the questions they made were called HOTS questions or not. They could only make the HOTS mathematics test items of 33.33%. This requires further research so that students as Mathematics teacher candidates will be able to develop the HOTS Mathematics HOTS test better.

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