The Assessment Link application: improving HOTS-based assessment questions in portfolio tasks

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ABSTRACT: Developing teachers' skills in creating higher order thinking skills (HOTS)-based questions is crucial in 21st-century learning, including biology. However, prospective biology teachers face challenges in writing HOTS-based questions, hence the Assessment Link mobile application has been developed to help teachers in this task. This study aims to describe the effectiveness of this application in regard to the scores achieved by pre-service teachers in creating HOTS-based questions and their perceptions about the application. In this study, a pre-experimental design has been used with a qualitative approach and one-stage cluster sampling. Results showed that the scores for HOTS-based assessment questions were in a good category (M > 76.00) with no significant difference between classes (p = 0.391). Additionally, pre-service teachers showed a very positive response to the Assessment Link application across all items tested through a questionnaire (M > 4; M% > 90%). Hence, the application is effective in helping biology teachers develop HOTS-based assessment questions in portfolio tasks.

INTRODUCTION

Higher order thinking skills (HOTS) ought to be integrated in the concept of autonomous learning mode. They have a pivotal role in developing student's cognition to analyse and solve problems, including but not limited to, social and non-social issues. In connection to learning, developed HOTS can be helpful for students in understanding the most challenging issues across the globe and generating appropriate initiatives to address them [1]. Developing HOTS through suitable tasks and questions is another teaching challenge because the teachers have to know how to design HOTS-based learning activities and assess the effectiveness of them [2]. Therefore, the ability in developing HOTS-based assessment questions must be mastered by teachers when they want to measure the level of student's HOTS [3]. Hence, the ability to construct HOTS-based assessment questions is a critical component in HOTS-based teaching.

In developing HOTS-based assessment questions, pre-service teachers need to be actively involved and experienced in both self and peer assessment. This will ensure that the process of reflection and revision is carried out, so that genuinely good questions can be created and all of that recorded within an assessment portfolio. A learning portfolio is a continuous assessment tool based on a set of collected information, such as students' works and their reflections that demonstrates progress in students' learning performance over a certain period of time. Portfolios present the whole process of students' progress in accomplishing given tasks, which in turn provides all-round feedback, so that students can learn from each other to address their deficiencies [4].

As future teachers, pre-service teachers must be knowledgeable about HOTS, including HOTS-based assessment. The information needed for the assessment can be gathered in the mobile application [5]. Unfortunately, there have been limited studies focused on developing IT-based learning media that would enable pre-service teachers to create HOTS-based assessment questions, especially for junior high school students in biology subject materials. Some studies tend to outline development instruments for HOTS, including educational media or teaching techniques to improve student's or teacher's HOTS, for example, by Cai [6]. Therefore, it is essential to provide IT-based learning media to assist pre-service teachers in developing HOTS-based questions which is the focus of the present study

LITERATURE REVIEW

Portfolio in Learning

Portfolio assessment is a continuous process based on the information collected in a learning portfolio that enables to monitor students' learning performance over a certain period [7]. Portfolios can be used to monitor the growth of students' knowledge, skills and attitudes as outcomes of learning. Using portfolios can enhance students' engagement in learning and improve their satisfaction, as well as positively influence their efforts to achieve the educational goals.

Since portfolios present the whole process of students' progress in accomplishing a given task, the assessment can be done by self, peer and teacher assessment. This can provide all-round feedback, so that students can learn from each other to identify and address their deficiencies. Portfolios also enable students to constantly monitor their own performance during learning and gather experience regarding all aspects of learning through self-reflection, leading to improvement in their learning attitude, learning methods and higher quality of the accomplished task [8].

Existing Research on HOTS-based Assessment using Mobile Applications

Pre-service teachers must understand the importance of HOTS and their assessment, as well as of the method of collecting relevant information in a mobile application. Learning media, including mobile applications, can be helpful in developing HOTS, and many studies have focused on this topic. Unfortunately, some studies show that most teachers still could not complete the required components of HOTS-based questions [9]. Other studies concentrate on the analysis of assessment questions developed by teachers and still do not provide a solution to how teachers can develop good HOTS-based questions [10]. It appears that there is scarcity of studies that would help teachers in developing HOTS-based questions, and most studies present educational media or teaching techniques to improve student's or teacher's HOTS.

DEVELOPMENT OF THE ASSESSMENT LINK MOBILE APPLICATION

The Assessment Link mobile application has been developed by the authors of this article under the project of the Teacher Training campus at the State University of Surabaya (Universitas Negeri Surabaya), Surabaya, Indonesia. This application can be widely downloaded at Google Play Store for free. There are six features provided in Assessment Link; namely, tutorials, material, examples, quiz, task and author (Figure 1). In the tutorials feature, there is information on how to operate the application. In the material feature, there are three topics; namely, the introduction to Assessment Link, Bloom's taxonomy, and criteria and procedures in developing a HOTS-based assessment question. In the example feature, there are two sets of questions starting from C1 to C6 level of HOTS. In this section, users can explore the difference between factual, conceptual, procedural and metacognitive knowledge. In the quiz feature, there are many questions and users have to determine the cognitive level of the question. In the task feature, users have to write and submit sample questions on the C1 to C6 level. At last, in the author feature there is information about the author of the Assessment Link application.

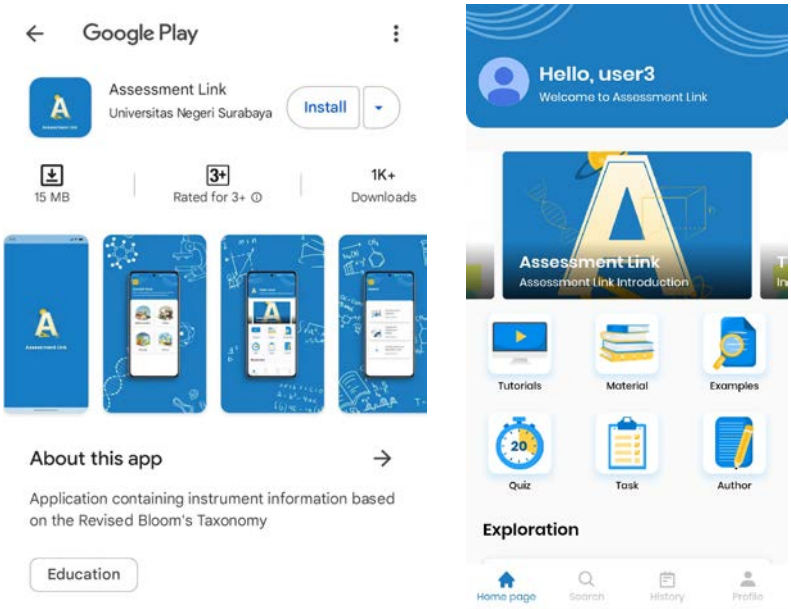

Figure 1: Interface of the Assessment Link mobile application.

The Assessment Link mobile application has not been used in experimental research yet. However, since there have been limited studies on developing mobile learning media to enable pre-service teachers to create HOTS-based assessment questions, this study aimed to describe how biology pre-service teachers can use Assessment Link to develop HOTS-based questions in a setting of portfolio assignments, in which students' progress in designing HOTS-based questions is demonstrated. The novelty of the present study lies in the use of the Assessment Link application in portfolio design and how it is used to help prospective biology teachers in developing HOTS-based questions.

RESEARCH METHODS

The study used pre-experimental research design with a qualitative research approach [11]. The teaching and learning process undertaken in this pre-experimental study used portfolio design. The process of documenting students' artefacts in portfolio design was monitored during the learning process using Assessment Link.

The learning process was conducted by the authors of this article, who also were the class lecturers for the Evaluation Development course in the Department of Biology Education at the State University of Surabaya. In the academic year of 2024, there were eight parallel classes enrolled in the Evaluation Development course. Each class consist of 32 students. Then, four classes were selected through simple random sampling as participants [12].

This study was conducted in September - October 2024 involving 126 pre-service biology teachers who were in the second-year, third semester. During the learning process, they were asked to install the Assessment Link application in Google Play Store using their Android mobile phone and instructed on how to operate it. They were also informed about each feature in the application along with the benefits, and provided with a one-by-one step procedure in developing HOTS-based assessment questions. At the end of the class, the pre-service teachers were asked to develop HOTS-based assessment questions for a portfolio task and complete a questionnaire of responses. The task was in the form of portfolio showcasing some HOTS-based questions developed by the pre-service teachers. By the end of four weeks of training, the pre-service teachers were expected to write good HOTS-based questions. Figure 2 illustrates how the Assessment Link application can be used.

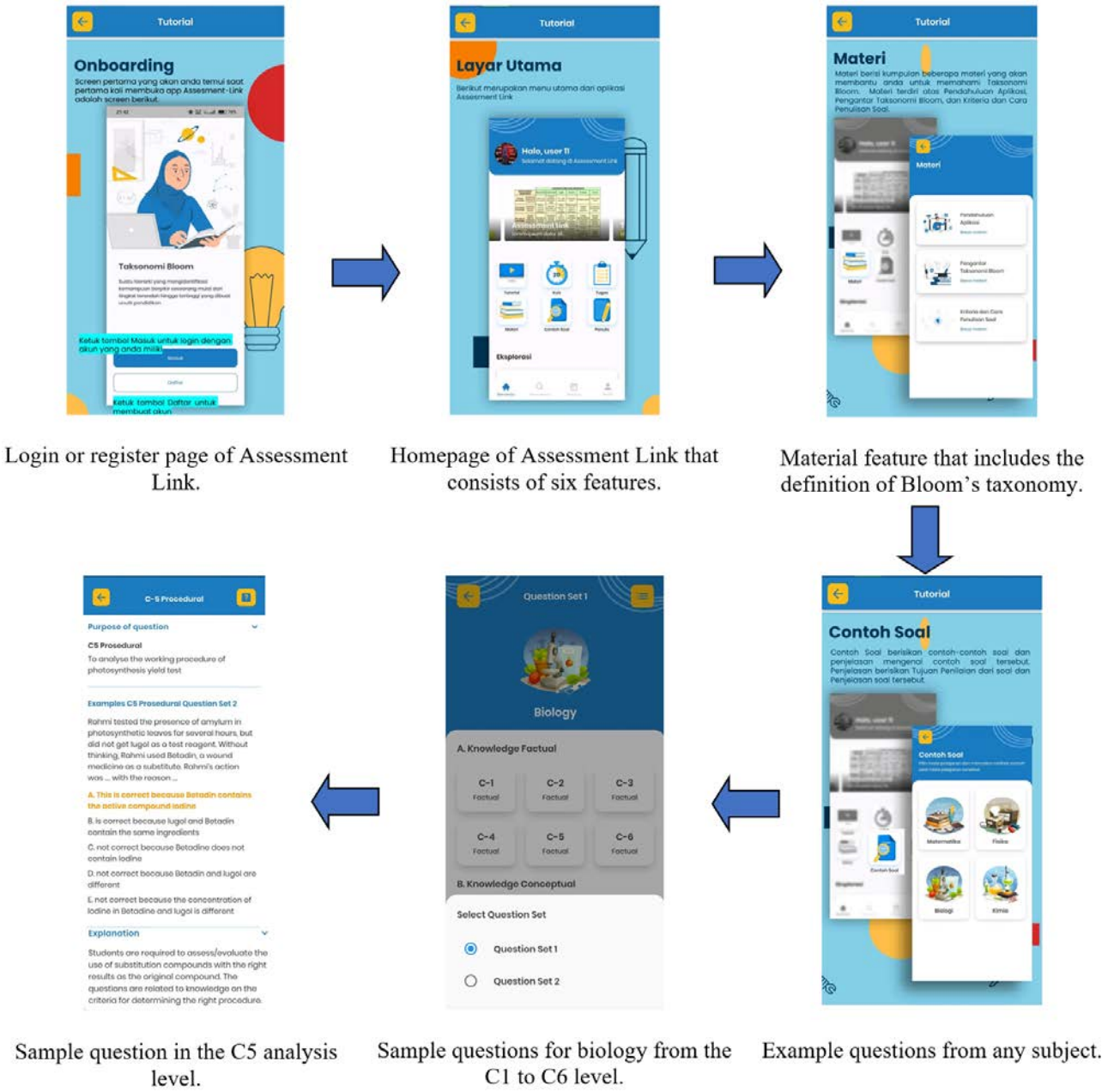

Figure 2: Assessment Link application - selected screens.

Data from each student's portfolio score was then collected using portfolio scoring sheets that consisted of five indicators for multiple-choice questions and four indicators for essay questions (Table 1). Students' responses to the questionnaire were collected to examine their perceptions about the application. The pre-service teachers were asked to provide an evaluation based on their experience during and after learning using Assessment Link by rating 15 aspects of the application included in the questionnaire. They also could write comments during the use of Assessment Link and add suggestions for improvement.

Table 1: Portfolio scoring sheets - indicators.

Type of question	Indicators
Multiple choice (for C4 and C5 questions)	1. Questions are developed in accordance with the indicators for levels C4-C5 of the cognitive domain. 2. Questions/statements are formulated in a clear way without any clues to the correct answer. 3. Prompts and additional information on questions are clear and practical. 4. Answer options are uniform, with the same length, and are systematically organised. 5. Answer choices have only one correct answer and the checkers on the answer choices are practical and helpful.
Essay (for C6 questions)	1. Questions are developed in accordance with the indicators for level C6 of the cognitive domain. 2. Prompts and additional information on questions are clear and practical. 3. The boundaries of the instructions or questions and answers are clear and not subject to multiple interpretations. 4. The answer signs on the questions are in accordance with the material concept, demand logical and argumentative answers, and have clear scoring guidelines.

The qualitative descriptive design was used, and the collected data were analysed accordingly. The data from the portfolio assessment of student's questions was calculated using the following formula:

Student's portfolio score = (total obtained score x 100) / maximum score.

The pre-service teachers' portfolio scores were then categorised based on Table 2. This was done to examine how well they developed HOTS-based assessment questions.

Table 2: Categorisation of portfolio scores [13].

Scores	Category
≤ 54	Very insufficient
55- 59	Insufficient
60 -75	Fair
76 - 85	Good
86 - 100	Very good

As mentioned above, a questionnaire was also used to reveal the pre-service teachers' perceptions after experiencing the teaching and learning process using Assessment Link. The questionnaire consisted of 15 items in the five-point Likert scale. The responses were then analysed using descriptive statistics to reveal the M score, which was then transformed into M% because of Swanson's categorisation.

RESULTS AND DISCUSSION

Portfolio of Developed HOTS-based Assessment Questions

The portfolio score of the developed HOTS-based assessment questions was obtained. Since there were four classes involved in the study, it was crucial to look at the difference between classes to ensure that the data were shared similarly by the four classes. As the data were not normally distributed, a Kruskal-Wallis test was undertaken to examine the difference between classes. Based on the Kruskal-Wallis test, it was found that there was no difference between the four classes ($p > 0.05$). It means that the four classes shared similar ability in developing HOTS-based assessment questions using the Assessment Link mobile application. In other words, no class performed better statistically than other class. Table 3 shows the portfolio scores obtained by each class in developing HOTS-based assessment questions.

Table 3: Portfolio scores based on C4-C6 levels of HOTS.

Class	HOTS level			$\bar{x}$	Category
	C4	C5	C6		
A	81.18	79.52	83.59	81.43	Good
B	80.62	82.00	81.25	81.29	Good
C	84.10	83.44	82.72	83.42	Good
D	77.87	82.01	81.77	80.55	Good

Table 3 shows that all classes were in a good category at each level of HOTS questions. This shows that the use of Assessment Link can help the pre-service teacher to write HOTS-based questions. The C4 and C5 questions were

constructed as multiple-choice questions, whereas the C6 question was an essay. The questions fulfilled the indicators for good questions (M = 81.67). This demonstrates that the use of Assessment Link can enhance learning attainment, in this case the pre-service teacher's ability to write HOTS-based assessment questions. This enhancement was possible as Assessment Link provides guidance regarding the HOTS domain and various examples of HOTS-based assessment questions ranging from the analysis (C4) to creation (C6) level. Apart from that, Assessment Link is easy to access by mobile phones and is interactive during learning. As reported by other studies, through mobile applications, students can easily learn using their smartphones without restrictions posed by time and place [14]. This approach can improve student motivation and the quality of learning [15]. Studies also demonstrated that the use of mobile applications could enhance students' understanding about HOTS leading to enhancement [16].

Developing HOTS-based questions is considered a difficult task. So there is a need to provide guidance to practice those skills. Some studies reported that student's and teacher's HOTS were developed at a sufficient level as they had practiced a lot through portfolios [17]. Generally, portfolios illustrate students' understanding of the concepts, topics, aspects, etc, learned in the form of visible works/products. Hence, this makes the learning portfolio more assessable [18]. Because of that, in this study portfolio tasks were used in learning with Assessment Link. By using a portfolio, pre-service teachers could identify the weaknesses of the questions they created and then reflect and revise them through discussion using Assessment Link. This shows that portfolios are a useful tool for encouraging learning through assessment. Table 4 shows some examples of HOTS-based questions for levels C4-C6 developed by the pre-service teachers involved in this study.

Table 4: Examples of the preservice teachers' HOTS-based questions for C4-C6.

HOTS level	C4	C5	C6
Indicator	Diagnosing symptoms in human body regarding metabolism that occurs in cells.	Assessing alcohol fermentation procedures.	Formulating a plan to perform a photosynthesis - experimenting with materials and tools you can find around your home.
Question type	Multiple choice	Multiple choice	Essay
Question	After several months of not exercising, Rani decided to begin running after she finished the final examinations. She could run for 2.5 kilometres in just 15 minutes. Then, she felt tired and experienced pain in her calf. It was caused by: a. Anaerobic respiration that produces pyruvate acid. b. Aerobic respiration that produces ethanol. c. Aerobic respiration that produces pyruvate acid. d. Anaerobic respiration that produces lactic acid. e. No respiration occurred because she has blood deficiency.	Kaneki wanted to make wine from the grapes harvested in his garden. After mixing the grape juice with yeast and water, Kaneki stored it in a tightly sealed bottle. Is Kaneki's procedure correct? a. Yes, because wine making is anaerobic fermentation so it does not require oxygen. b. No, because wine making is an anaerobic fermentation and does not require carbon dioxide. c. Yes, because wine making is an aerobic fermentation that requires oxygen. d. Yes, because wine making is aerobic fermentation so it does not require oxygen. e. No, because wine making is anaerobic fermentation so it does not require oxygen.	Look about your home and at your surroundings. Determine what plants are living around you. Devise a plan to do a photosynthesis experiment with tools you already own or can obtain with ease.

Considering the importance of HOTS development, the assessment is also an essential the HOTS-based learning process. Many studies emphasised the importance of HOTS-based assessment instruments and the researchers conducted the validity and reliability tests of the developed instruments [19]. Unfortunately, these studies still did not provide a learning media that could assist teachers in developing HOTS-based assessment questions by themselves. This indicates that the already developed instruments might not be reliable for diverse school settings and curricula. Therefore, the ability to construct HOTS-based assessment questions should be developed by teachers, so that they could create HOTS-based questions regarding the specific subject and material they teach at their respective schools. Thus, the present study offered Assessment Link to fill in the gaps for pre-service biology teachers.

In regard to the pre-service teachers' responses on the use of Assessment Link to develop HOTS-based assessment questions, it was found that the majority of the teachers rated the tested aspects of the application as *very positive*. The responses of the pre-service teachers after using Assessment Link were revealed through the 15 items of the administered questionnaire included in Table 5, which shows the summary of students' responses for each question.

Table 5: Pre-service teachers' responses.

Aspect	SD	M	M (%)	Category
Includes consistent information about the revised Bloom's taxonomy	0.49971	4.5476	90.95	Very positive
Provides guidance in differentiating between lower and higher order thinking skills	0.28340	4.9127	98.25	Very positive
Provides information about factual knowledge-based questions	0.22998	4.9444	98.88	Very positive
Provides information about conceptual knowledge-based questions	0.29472	4.9048	98.09	Very positive
Provides information about procedural knowledge-based questions	0.36688	4.8413	96.82	Very positive
Provides information about metacognitive knowledge-based questions	0.30540	4.8968	97.93	Very positive
Provides guidance in developing HOTS-based assessment questions	0.48337	4.6349	92.69	Very positive
Provides examples of analysis-based assessment questions (C4)	0.28340	4.9127	98.25	Very positive
Provides examples of evaluation-based assessment questions (C5)	0.28340	4.9127	98.25	Very positive
Provides examples of creation-based assessment questions (C6)	0.17602	4.9683	99.36	Very positive
Assists in exploring the framework of the cognitive taxonomy	0.24482	4.9365	98.73	Very positive
Assists in a better understanding of HOTS-based questions	0.22998	4.9444	98.88	Very positive
Provides feedback to improve learning experience	0.00000	5.0000	100	Very positive
Promotes autonomous learning	0.41196	4.7857	95.71	Very positive
Supports sustainable learning	0.33428	4.8730	97.46	Very positive

As shown in Table 5, pre-service teachers rated the Assessment Link mobile application as very positive in terms of assisting them to develop HOTS-based assessment questions. Considering this result, it can be stated that Assessment Link can assist pre-service teachers in developing HOTS-based assessment questions. The responses also revealed that the application could be used flexibly at any time and place to learn how to develop HOTS-based assessment questions. The use of effective media can make pre-service teachers' attitudes more positive, encourage self-motivation, show factors and ideas related to important topics and concepts, ensure relevance and credibility, and increase understanding of the concepts [20].

Positive user experiences across aspects, such as novelty, clarity, attractiveness, efficiency and dependability reinforced the finding that the use of media and technology could positively impact pre-service teachers' higher order thinking skills. In addition, it could have a positive impact on pre-service teachers' ability to create questions and satisfaction with the learning process. Positive user experience with mobile learning using applications can foster creativity in students and encourage lecturers to adopt more novel approaches to teaching. It also empowers students to incorporate new media and technology in the classroom while learning.

CONCLUSIONS

It can be concluded that developing HOTS-based assessment questions can be successfully accomplished using the Assessment Link application. The pre-service teachers involved in this study performed well as demonstrated by their portfolio scorings in regard to multiple-choice questions and the essay that they had to compose. They also rated various aspects of the Assessment Link application as *very positive/helpful* in developing HOTS-based assessment questions.

Thus, the Assessment Link application can successfully assist pre-service teachers in developing HOTS-based assessment questions through portfolios and can be used in digital learning to improve teachers' ability to write HOTS-based assessment questions.

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