

IMPROVEMENT OF PHYSICS CONCEPT MASTERY AND PEDAGOGY SKILLS THROUGH ANDROID-BASED ASSESSMENT LINK PRACTICES

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ABSTRAK

Dalam era pendidikan digital dan modern, pembelajaran berbasis teknologi semakin penting. Sebagai bagian dari proses belajar mengajar di sekolah dan universitas, penggunaan gawai berbasis Android untuk penguatan konsep dan keterampilan pedagogi adalah menantang. Dalam hal ini, studi ini mengeksplorasi *Assessment Link in Physics*, aplikasi berbasis Android yang dirancang untuk meningkatkan penguasaan konsep fisika dan keterampilan pedagogi melalui analisis soal fisika SMA dalam bentuk dua kali latihan dan satu kali tes berdasarkan Taksonomi Bloom revisi. Responden yang terlibat adalah 15 orang guru fisika SMA dari berbagai sekolah menengah atas di Tuban, Jawa Timur. Penelitian ini bertujuan untuk menguji persepsi responden terhadap keunggulan, kemudahan, dan konten aplikasi saat digunakan untuk meningkatkan keterampilan kognitif dan pedagogi. Dari serangkaian tes, dimana tren positif hasil tes diperoleh (ada peningkatan skor rerata dari 71 dan 80 pada Problem Set 1 dan 2 menjadi 88 pada Quiz merupakan respons sangat baik terhadap pembelajaran berbantuan gawai) dengan skor Quiz bervariasi antara 79-96, jauh lebih baik dibandingkan dengan skor tes pendahuluan, kami menyimpulkan bahwa *Assessment Link in Physics* berhasil meningkatkan penguasaan konsep fisika dan keterampilan pedagogi. Hal ini sesuai dengan informasi yang dikumpulkan dari kuesioner, dimana semua responden setuju dengan manfaat, kemudahan penggunaan, dan konten aplikasi. Hasil-hasil penelitian memberikan wawasan pengembangan lebih lanjut pembelajaran berbantuan gawai untuk implementasi proyek STEM dengan pendekatan TPACK yang diperkenalkan kepada seluruh siswa pada semua jenjang pendidikan.

Kata Kunci: *Pendidikan Digital, Pembelajaran Berbasis Teknologi, Assessment Link*

ABSTRACT

In the digital era of education, technology-enhanced learning has been increasingly important. As part of a teaching-learning process in schools and universities, the use of Android-based smartphones to strengthen concept mastery and pedagogy skills is challenging. In this context, this study explores *Assessment Link in Physics*, an Android-supported running application. This application was used to analyse high-school physics problems in two sets of exercises and a Quiz using the revised Bloom's Taxonomy. Participants involved were 15 physics teachers from various senior high-schools in Tuban, East Java. Regarding the mobile apps, this study aims to examine the respondents' perceptions on benefit, ease of use, and content of the apps. From a completed series of tests, where a positive trend was obtained (increasing mean scores of 71 and 80 in Problem Sets 1 and 2 to be 88 in Quiz) with the scores of the Quiz ranged between 79-96, much better than those of the preliminary tests, we conclude that the apps is successful to improve physics concept mastery and pedagogy skills, consistent with information from a filled three-in-one questionnaire, where all the respondents agree well with the benefit, ease of use, and content of the application. The results provide insight into the development of the existing mobile apps-supported learning for further work on STEM and TPACK projects introduced to students at all levels of education.

Keywords: *Digital Education, Technology-Enhanced Learning, Assessment Link*

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INTRODUCTION

The widely known 4 skills required for promoting the 21st century education model are creativity, collaboration, communication, and critical thinking (4Cs) skills with two examples of recent publications have followed (Thornhill-Miller et al., 2023; Herlinawati et al., 2024). These skills could be trained to students in classroom settings by implementing technology-enhanced learning using mobile applications for improvement of student engagement and hence learning outcomes in views of Android-based PHET simulations (e.g., Hasyim et al., 2020), supportive digital learning environments (e.g., Nkomo et al., 2021), scientific e-physics books (e.g., Ndoa et al., 2022), and well-structured HOTS-based lesson plans (e.g., Susantini et al., 2022). Such instructional applications were introduced to students for some reasons, including for convenience of practice and learning independence (e.g., Arista & Kuswanto, 2018).

With such numerous advantages, digital learning is in replacement of an old-fashioned teaching-learning process, which relies on a face-to-face meeting. It introduces Technological, Pedagogical, and Content Knowledge (TPACK) to support Science, Technology, Engineering, and Mathematics (STEM) education (Kapici & Akcay, 2020; Setyowati & Rachmajanti, 2023; Kong et al., 2024). These studies, along with prior publications (Rosenberg & Koehler, 2015; van Laar et al., 2017), addressed issues upon digital skills for the 21st century education and the introduction of digital literacy (Tinmaz et al., 2022), where the 4Cs skills were completed with subject mastery via digital competence-enriched capacity, leading to expected technology-empowered students and problem-solving capability at individual levels to support the notion of technology-assisted learning media.

In the context of digital learning media, current smartphones can be effectively used to improve the quality of learning and teaching processes, for which they are classified into part of mobile-supported learning of multi modes (Yuan et al., 2025). They provide a better look at state of the art of adopted digital technology in terms of devices used for educational purposes (Naveed et al., 2023). This mode of learning is of importance to strengthen student engagement through interactive learning media, allowing for optional flexibility and accessibility (Arista & Kuswanto, 2018) and a broad aspect of students' active participations and attitudes towards mobile learning (Ahmad, 2020). However, the application of this mode of learning is limited with caution in the sense that it can face challenges, such as improper training for educators and students on how to use mobile applications effectively.

Hence, in the present case we develop an interactive Android-based Assessment Link, containing two problem sets of senior high-school physics for exercises and a physics quiz for a test. The questions were written using a revised version of Bloom's Taxonomy, promoting revised Bloom Taxonomy-oriented learning activities (Pujawan et al., 2022; Sudirtha et al., 2022) with two measures, namely cognitive process and knowledge contexts. All these question sets were completed with elements for easy tutorials needed to start running Assessment Link in Physics embedded in Android-supported smartphones.

The revised Bloom's Taxonomy of Krathwohl (2002) argued for some changes from the original version, including the introduction of metacognitive knowledge into the 4 types of knowledge, namely factual, conceptual, procedural, and metacognitive and the newly ordered 6 hierarchical levels of a cognitive learning domain using action verbs, namely C1 (remember), C2 (understand), C3 (apply), C4 (analyse), C5 (evaluate), and C6 (create). Along with specific purposes on mastering physics concept, the problem sets and associated quiz were designed for users to understand well these pedagogical dimensions. Therefore, this study aims to determine whether the Link in Physics is useful to improve physics concept mastery and pedagogy skills, along with the analysis of respondents' perceptions upon issues associated with the benefit, ease of use, and content of the application.

METHODS

The methodology used to run this study is here detailed. To better suit the problem of digital technology-enhanced learning in schools and universities, we set up breakthrough for autonomous learning activities settled in a community service program for 15 physics teachers as participants from senior high-schools in Tuban, East Java. SMAN 1 Plumpang, Tuban served as a host for a meeting held on 18 March 2023. During training time, the participants were practicing an interactive Android-supported Assessment Link in Physics and doing individual performance within an amount of time given, followed by going on trials for physics problems available in the form of written tests embedded in the Link in Physics.

Here we describe what Android-supported mobile learning is, from the beginning till the end, where the result of one's performance after taking a quiz is presented. Initial steps on how to use Assessment Link in Physics were introduced to the participants until all instructions embedded in the application were well understood. Figure 1 shows interface features of the Link in Physics (accessible all participants once they are registered). Those who are not familiar with a revised Bloom's Taxonomy may refresh themselves by clicking appropriate buttons available in the Link. At the end of the training sessions, each participant was then allowed to go on individual trials doing a physics test available in the application.

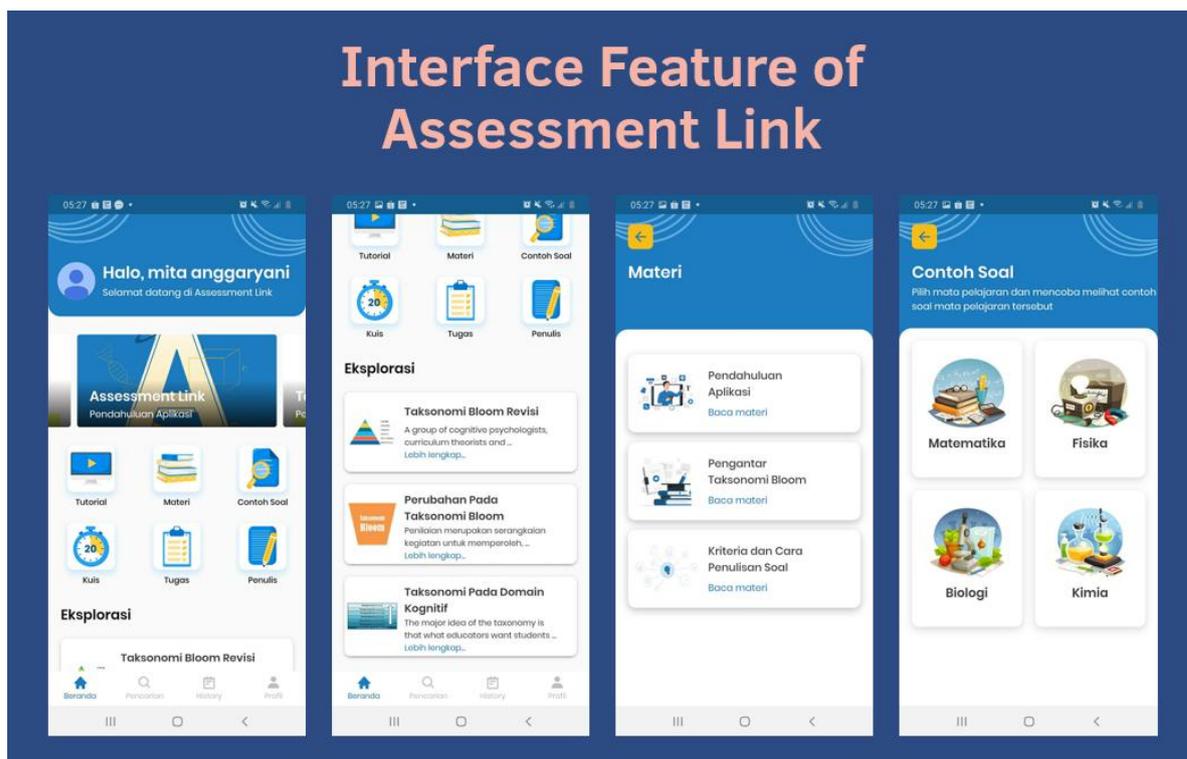


Figure 1. Interface features in the Assessment Link showing main ingredients necessary for running the application.

In addition to Physics Problem Sets and Quiz, the participants were asked to complete questionnaires for which the participants are also called the respondents by writing on their own what they were thinking of Assessment Link in Physics for improvement of physics concept in senior high-schools and associated pedagogy skills using Android-supported smartphones. Assuming that information given in Table 1 is adequately accurate, the quality of the response from each respondent is helpful to develop the application with more learning activities for further advancement.

Table 1. A three-in-one questionnaire, distributing over the respondents to extract information on different aspects of perception: benefit, ease of use, and content.

No	Uraian	1	2	3	4	5
Persepsi Manfaat:						
1	Assessment Link in Physics memberikan wawasan mobile learning kepada Guru Fisika SMA					
2	Assessment Link in Physics memperkenalkan digital learning media using Android-supported smartphones kepada Guru Fisika SMA					
3	Assessment Link in Physics meningkatkan penguasaan konsep fisika melalui pendekatan belajar TPACK bagi Guru Fisika SMA					
4	Assessment Link in Physics memberikan aksesibilitas dan fleksibilitas kepada Guru Fisika SMA (dapat diakses dimanapun dan kapanpun)					
5	Assessment Link in Physics memberikan peluang kepada Guru Fisika SMA untuk menguasai 4Cs skills					
Persepsi Kemudahan Penggunaan:						
6	Assessment Link in Physics mudah diakses dan dipelajari					
7	Assessment Link in Physics mendukung sistem belajar mandiri dan bertanggung jawab					
8	Tutorial dan petunjuk teknis penggunaan Assessment Link in Physics mudah dimengerti					
9	Assessment Link in Physics menyediakan fitur-fitur untuk mendorong keterlibatan aktif dalam proses belajar mandiri					
Persepsi Konten:						
10	Materi belajar pada Assessment Link in Physics sangat menarik					
11	Contoh soal pada Assessment Link in Physics sangat mudah dipahami					
12	Kuis pada Assessment Link in Physics relevan untuk mengukur hasil belajar					

Note that numbered scales 1-5 in Table 1 have the following meanings: 1 = strong disagreement, 2 = disagreement, 3 = fairly agreement, 4 = agreement, 5 = strong agreement.

RESULTS AND DISCUSSIONS

The results and associated discussions are separately reported. In each, the increased levels of physics concept mastery and pedagogy skills, and those describing all respondents' responses to the different aspects of perception: benefit, ease of use, and content are provided.

Results

As previously stated, all participants were asked to solve Problem Sets 1 and 2 before taking a Physics Quiz, each containing 24 validated questions of senior high-school physics written on the basis of the revised Bloom’s Taxonomy (Krathwohl, 2002) with the 4 dimensions of knowledge and the 6 dimensions of a cognitive learning process. Note that all questions in Problem Sets 1 and 2 were made in a comparable level of difficulty while those in Physics Quiz were created with a slightly difficult arrangement. The correct answers for questions in the Quiz are presented in Table 2.

Table 2. List of the correct answers for a Physics Quiz embedded in Assessment Link in Physics using the revised Bloom’s Taxonomy.

Cognitive Process Dimension \ Knowledge Dimension	Factual	Conceptual	Procedural	Metacognitive
	Remember (C1)	C1 + Factual 5	C1 + Conceptual 1	C1 + Procedural 7
Understand (C2)	C2 + Factual 6	C2 + Conceptual 2	C2 + Procedural 4	C2+ Metacognitive 19
Apply (C3)	C3 + Factual 9	C3 + Conceptual 3	C3 + Procedural 8	C3 + Metacognitive 21
Analyse (C4)	C4 + Factual 12	C4 + Conceptual 10	C4 + Procedural 20	C4 + Metacognitive 18
Evaluate (C5)	C5 + Factual 15	C5 + Conceptual 14	C5 + Procedural 13	C5 + Metacognitive 23
Create (C6)	C6 + Factual 11	C6 + Conceptual 17	C6 + Procedural 22	C6 + Metacognitive 24

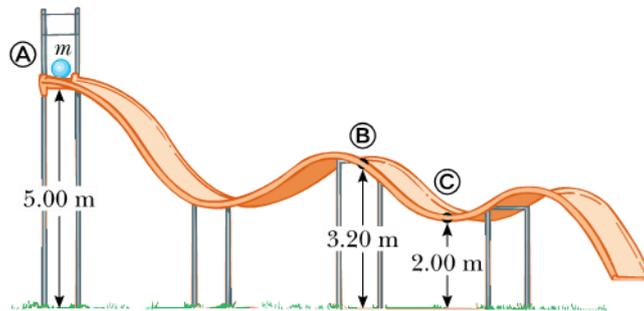
Every single individual performance completed by each participant is evaluated and assessed by comparing one’s answer for each question given in Problem Set 1, Problem Set 2, and Quiz with the relevant reference. For example, listed in Table 2 are the correct answers for the Quiz while references for the correct answers for Problems Sets are not provided to make this report as short as possible.

To understand how Table 2 is fully filled with numbers representing physics problems, we here provide reasoning why Problem 3 on the Quiz (it is just an example) is classified into a “C3 + conceptual” physics problem.

Problem 3. Perhatikan gambar berikut ini.

Sebuah benda bermassa 5 kg dilepaskan tanpa kecepatan awal dari posisi A dan meluncur tanpa gesekan sampai pada posisi C setelah melalui posisi B. Apabila diketahui percepatan gravitasi Bumi

adalah $9,8 \text{ m/s}^2$ maka usaha yang dilakukan oleh gaya gravitasi untuk memindahkan benda tersebut dari posisi A menuju posisi C adalah ...



(A) 245,0 joule

(B) 156,8 joule

(C) 147,0 joule

(D) 98,0 joule

(E) 88,2 joule

Jawab: C (C3 + konseptual)

Alasan: Soal meminta siswa untuk menerapkan relasi antara usaha dan perubahan energi potensial, dimana perbedaan tinggi posisi awal dan akhir adalah penentu besarnya usaha mekanik.

It is clear that the correct solution to Problem 3 is obtained by applying energy conservation between kinetic and potential energies during the motion of mass m . Mechanical work required to displace mass m from A to C is supplied by a decrease in potential energy during the motion between these points. For this reason, any solution or answer other than “C3 + conceptual” is considered wrong. Each problem has its own characteristic so that there are reasons available for other problems in Table 2 but are not provided to keep this paper as short as possible.

Rather than providing the systematic, complete reasoning behind correct solutions to all questions embedded in the Link in Physics (as given in the previous paragraph), we here provide directly the results of preliminary tests (Problem Set 1 and Problem Set 2) and a real test (Quiz). These preliminary tests, along with the introduction upon how to do, were completed during training sessions while the real test was finished during an independent session at which time participants were not allowed to interact with anyone. The results for all these tests are shown in Table 3 with x are representing the scores obtained, where $70 < x \leq 75$ considered adequate, $75 < x \leq 80$: fairly good, $80 < x \leq 85$: good, $85 < x \leq 90$: very good, and $90 < x$: excellent.

Table 3. Scores of Problem Set 1, Problem Set 2, and Physics Quiz tests individually obtained by the participants after running the Assessment Link in Physics.

Participant	Problem Set 1	Problem Set 2	Quiz
1	54	71	83
2	71	79	88
3	71	75	88
4	83	88	92
5	75	83	88
6	54	63	79
7	83	92	96
8	71	79	83
9	71	75	83
10	58	67	83

Participant	Problem Set 1	Problem Set 2	Quiz
11	83	88	92
12	63	79	88
13	83	92	96
14	75	83	88
15	63	79	88

At the end of the meeting, all the respondents were asked to fill a three-in-one questionnaire, distributing over the respondents to extract information on the different aspects of perception: benefit, ease of use, and content (see Table 4).

Table 4. Questionnaire average scores to extract information on the respondents' responses to the benefit, ease of use, and content of the Assessment Link in Physics.

No	Uraian	Skor Rerata
1	Assessment Link in Physics memberikan wawasan mobile learning kepada Guru Fisika SMA	5,0
2	Assessment Link in Physics memperkenalkan digital learning media using Android-supported smartphones kepada Guru Fisika SMA	5,0
3	Assessment Link in Physics meningkatkan penguasaan konsep fisika melalui pendekatan belajar TPACK bagi Guru Fisika SMA	4,7
4	Assessment Link in Physics memberikan aksesibilitas dan fleksibilitas kepada Guru Fisika SMA (dapat diakses dimanapun dan kapanpun)	5,0
5	Assessment Link in Physics memberi Guru Fisika SMA peluang untuk menguasai 4Cs skills	4,1
6	Assessment Link in Physics mudah diakses dan dipelajari	5,0
7	Assessment Link in Physics mendukung sistem belajar mandiri dan bertanggung jawab	4,7
8	Tutorial dan petunjuk teknis penggunaan Assessment Link in Physics mudah dimengerti	5,0
9	Assessment Link in Physics menyediakan fitur-fitur untuk mendorong keterlibatan aktif dalam proses belajar mandiri	5,0
10	Materi belajar pada Assessment Link in Physics sangat menarik	4,7
11	Contoh soal pada Assessment Link in Physics sangat mudah dipahami	3,7
12	Kuis pada Assessment Link in Physics relevan untuk mengukur hasil belajar pengguna	4,3

Note that (with respect to Table 1) items 1-5 in Table 4 having an average of 4.8 are asked to obtain the respondents' perception on the benefit of the application, items 6-9 having an average of 4.9 are written to extract information on the ease of use of the application, and items 10-12 having an average of 4.2 are explored to examine the content of the application.

Discussions

The detailed analysis of Table 3 and corresponding discussions, containing the results derived from the initial tests (Problem Sets 1 and 2) and the final test (Quiz) are of importance. When carefully examining the scores of Problems Sets and Quiz listed in Table 3, we can see

at glance that in consecutive rows all participants have positive trends in their scores, as also clearly indicated by increased peaks of the bars from blues to greens for each participant seen in Fig. 2. Indeed, we have tried to produce some other graphs drawn from the results listed in Table 3 using the grouped scores as previously defined. Unfortunately, there is no clear relation between variables used one to another in the graphs with respect to the aim of the study. Thus, we here provide only one graph shown in Fig. 2, thought to be the best of all clearly representing the learning process each participant or respondent takes part in.

Using the grouped scores available, Fig. 2 demonstrates that individual performance has increased by increasing coloured bar peaks, as expected for this study, where Participants 4, 7, 11, and 13 get remarkable scores of greater than 90, considered “excellent” with the best score achieved is 96 by Participants 7 and 13. However, there remains a score of 79 obtained by Participant 6, falling within a “fairly good” category. It is then the majority (6 of 15 participants, comprising 40%) scoring 88 that is a “very good” response to mobile apps-supported learning, in favour of other previous studies with similar results (Hasyim et al., 2020; Nkomo et al., 2021; Susantini et al., 2022).

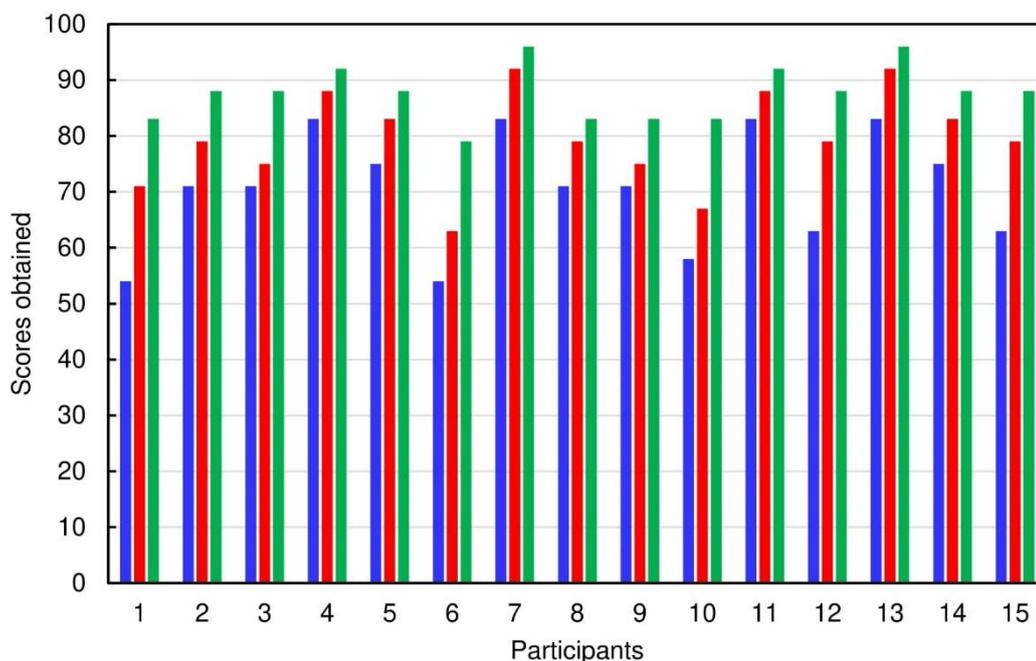


Figure 2. Simple bar histogram showing the scores obtained by individuals of 15 participants in Problem Set 1 (blues), Problem Set 2 (reds), and Quiz (greens) after running the Link.

Furthermore, when the scores obtained in Problem Set 1, Problem Set 2, and Quiz are separately averaged for all 15 participants in each learning activity, we obtain 71, 80, and 88, respectively. It follows that participants’ competence in physics concepts and pedagogy skills is, on average, classified into “adequate” observed during Problem Set 1, where 5 participants score below 70, the lower bound upon the adequate competence (see Table 3). With respect to the result for Problem 1, increased mean scores of 80 and 88 are found for Problem Set 2 and Quiz, considered “fairly good” and “very good” responses to the smartphones-assisted learning. Thus, there is a significant increase in participants’ overall performance from an adequate level of physics concept mastery and pedagogy skills to a very good one during intense practices of the Assessment Link in Physics, prompting better improvement of learning results through independent digital learning supported by interactive media using Android-based smartphones (Hasyim et al., 2020; Susantini et al., 2022; Yuan et al., 2025).

It is clear from Table 4 that respondents' perceptions on the benefit (items 1-5), ease of use (items 6-9), and content (items 10-12) of the mobile apps vary between 4.0 (agreement) and 5.0 (strong agreement). On average, the perceptions on the benefit and ease of use take amounts of 4.8 and 4.9, respectively, indicating that almost all respondents are in strong agreement with the use of the application in favour of mobile learning using Android-based smartphones, which is also reported by recent studies (Arista & Kuswanto, 2018; Ahmad, 2020; Nkomo et al., 2021; Setyowati & Rachmajanti, 2023). However, the respondents are in doubt about the applicability of the Link in Physics to fostering students' 4Cs skills (see an average score of 4.1 achieved on item 5 in Table 4). Other learning activities with either a more comprehensive instruction of mobile apps or other learning modes called multi-modalities in technology-enhanced learning (Yuan et al., 2025) that explore creativity, collaboration, communication, and critical thinking (Thornhill-Miller et al., 2023; Herlinawati et al., 2024) may also be combined with the existing mobile apps to obtain better results.

Interestingly, the perception upon the content of the Link in Physics is on average 4.2, substantially lower than the other two perceptions. This finding reflects that all respondents remain struggling with levels of difficulty when solving physics problems provided in the Link, as opposed to the ones found in previous work (Arista & Kuswanto, 2018; Ndoa et al., 2022). That is why they are not in favour of total agreement with this issue, leading to a mean score of only 3.7 for item 11 in Table 4. Hence, it is understood that the respondents do not strongly agree with relevance of the application to measure students' learning achievement, resulting in a score of 4.3 for the last item in Table 4. However, with all the mean scores greater than 4.0 for the perceptions on the advantage, ease of use, and content of the mobile apps, along with the increasing trends in the test scores, we here state that the use of Assessment Link in Physics running on Android-based smartphones is effective to improve physics concept mastery and pedagogy skills during intense practices of the apps, in good agreement with similar results from earlier studies (Sudirtha et al., 2022; Naveed et al., 2023; Yuan et al., 2025).

Among other things, the integration of technology into digital learning in schools and universities provides better insight into the role of the Android-based mobile apps, such as smartphones in driving student engagement in learning activities, whether in classroom settings or outdoor environment. With respect to the results presented here, this leads to the improvement of academic performance observed as the increased levels of physics concept mastery and pedagogy skills during Android-supported Assessment Link in Physics practices.

CONCLUSIONS

We have examined technology-enhanced learning, where Android-based smartphones are used to strengthen concept mastery and pedagogy skills. In this study, Assessment Link in Physics is used to analyse high-school physics problems using the revised Bloom's Taxonomy, with participants are 15 physics teachers from various senior high-schools in Tuban, East Java. Therefore, this study aims to examine the respondents' perceptions on the benefit, ease of use, and content of the mobile apps. From a series of tests, where a positive trend is obtained (mean scores increase from 71 and 80 in Problem Sets 1 and 2 to 88 in Quiz) with the Quiz scores are in the range 79-96, much better than those of the preliminary tests, we conclude that the apps is successful to improve physics concept mastery and pedagogy skills, in line with information from a filled three-in-one questionnaire, where all the respondents agree well with the benefit, ease of use, and content of the apps. The current results provide insight into the development of the existing mobile apps-supported learning for further work on STEM and TPACK projects introduced to students at all levels of education.

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