

STRENGTHENING PRE-SERVICE BIOLOGY TEACHERS' COMPETENCIES IN DEVELOPING HOTS-ORIENTED COGNITIVE ASSESSMENTS THROUGH THE ASSESSMENT LINK APPLICATION AT UNIVERSITI SAINS MALAYSIA

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Abstract. The growing emphasis on Higher Order Thinking Skills (HOTS) in twenty-first-century education requires pre-service teachers to possess adequate competencies in designing cognitive assessments aligned with the revised Bloom's Taxonomy. However, many pre-service biology teachers continue to experience difficulties in constructing HOTS-oriented assessment items and integrating digital technology into assessment practices. This community engagement program aimed to enhance the competencies of pre-service biology teachers at Universiti Sains Malaysia (USM) in developing HOTS-oriented biology assessment items using the Assessment Link application. The program adopted a participatory, training-based approach integrated with structured mentoring and was implemented through a blended learning model consisting of face-to-face workshops and online mentoring. Program effectiveness was evaluated using pre-test and post-test instruments, participant assignments, observation sheets, and response questionnaires. The findings demonstrated that participants' mean score increased from 59.72 on the pre-test to 71.92 on the post-test, representing an average learning gain of 12.20 points. Participants also demonstrated improved competence in constructing HOTS-oriented biology assessment items and showed positive engagement throughout the training and mentoring activities. The integration of the Assessment Link application facilitated systematic assessment development while strengthening participants' digital assessment literacy. The program concludes that combining HOTS-oriented pedagogical training with digital assessment technology effectively improves pre-service teachers' assessment competencies and provides a sustainable model for teacher professional development in response to the educational demands of the twenty-first century and the Society 5.0 era.

Keywords: assessment link, digital assessment, higher order thinking skills

Abstrak. Penguatan Higher Order Thinking Skills (HOTS) dalam pendidikan abad ke-21 menuntut calon guru memiliki kompetensi yang memadai dalam menyusun asesmen kognitif sesuai dengan revisi Taksonomi Bloom. Kenyataannya, banyak calon guru biologi masih mengalami kesulitan dalam menyusun soal berbasis HOTS serta mengintegrasikan teknologi digital ke dalam proses asesmen. Kegiatan Pengabdian kepada Masyarakat (PkM) ini bertujuan untuk meningkatkan kompetensi calon guru biologi di Universiti Sains Malaysia (USM) dalam menyusun soal biologi berbasis HOTS menggunakan aplikasi Assessment Link. Program dilaksanakan menggunakan pendekatan partisipatif berbasis pelatihan yang dipadukan dengan pendampingan melalui model pembelajaran bauran (blended learning), yaitu pelatihan luring dan pendampingan daring. Evaluasi program dilakukan menggunakan instrumen pretest-posttest, penilaian tugas, lembar observasi, dan angket respons peserta. Hasil kegiatan menunjukkan adanya peningkatan rerata nilai peserta dari 59,72 pada pretest menjadi 71,92 pada posttest atau meningkat sebesar 12,20 poin. Peserta juga menunjukkan peningkatan keterampilan dalam menyusun soal biologi berbasis HOTS serta keterlibatan yang tinggi selama proses pelatihan dan pendampingan. Pemanfaatan aplikasi Assessment Link mendukung penyusunan asesmen secara lebih sistematis sekaligus meningkatkan literasi asesmen digital peserta. Program ini menunjukkan bahwa integrasi pelatihan HOTS dengan teknologi asesmen digital merupakan strategi yang efektif untuk meningkatkan kompetensi asesmen calon guru biologi serta berpotensi menjadi model pengembangan profesional guru yang berkelanjutan dalam menghadapi tuntutan pendidikan abad ke-21 dan era Society 5.0.

Kata Kunci: asesmen digital, keterampilan berpikir tingkat tinggi, tautan asesmen

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INTRODUCTION

The post-pandemic transformation of education has underscored the need to strengthen instructional quality beyond the mere transmission of knowledge, emphasizing the development of Higher Order Thinking Skills (HOTS). Educational reform initiatives implemented through learning recovery curricula prioritize not only mitigating learning loss but also fostering students' capacities for analysis, evaluation, and creation as essential competencies for addressing the challenges of the twenty-first (Astriawati et al., 2026; Khoza & Ndlovu, 2026). Within this context, teachers play a pivotal role as instructional designers and facilitators who are expected to develop assessment practices that are constructively aligned with HOTS-oriented learning objectives (Setiyowati et al., 2025). Despite these expectations, empirical evidence indicates that designing HOTS-based assessment items remains a significant challenge, particularly among pre-service teachers (Ahmat et al., 2022). This limitation is primarily attributed to insufficient conceptual understanding of the revised Bloom's Taxonomy and limited experience in integrating biological concepts with higher-order cognitive processes (Cammies et al., 2024). Consequently, many assessment instruments continue to emphasize lower-order cognitive skills, limiting opportunities for students to engage in meaningful reasoning and problem-solving (Yadav & Singh, 2026). Given that HOTS-oriented instruction has consistently been recognized as an effective pedagogical approach for enhancing learning quality, critical thinking, and graduate competitiveness, strengthening pre-service teachers' competencies in developing HOTS-based assessments has become an increasingly important priority in teacher education programs (Susanti & Gusfarenie, 2026; Tiok Wijanarko et al., 2025).

The partner institution involved in this community engagement program comprises pre-service biology teachers at the Universiti Sains Malaysia (USM), who face several critical challenges in developing assessment competencies. Limited understanding of the cognitive hierarchy presented in the revised Bloom's Taxonomy is evident, particularly in distinguishing the higher-order cognitive domains of analysis (C4), evaluation (C5), and creation (C6). The ability to construct HOTS-oriented assessment items that accurately reflect the conceptual characteristics of biology also remains inadequate. Utilization of digital technologies to support assessment development has yet to be fully integrated into instructional practice. The present community engagement program prioritizes strengthening pre-service teachers' competencies in designing HOTS-based biology assessment items through the integration of cognitive-domain principles and the digital Assessment Link application (Alanazi et al., 2024). This priority reflects the urgent need to improve assessment quality as an integral component of effective teaching and learning while preparing for future teachers to respond to the rapid advancement of educational technologies in the Society 5.0 era (Shahidi et al., 2024). The Assessment Link application is expected to bridge the gap between participants' conceptual understanding of HOTS and their practical competence in developing valid, reliable, and technology-enhanced assessment instruments (Susantini et al., 2021).

The program is grounded in a theoretical framework that integrates the concepts of Higher Order Thinking Skills (HOTS), the revised Bloom's Taxonomy, and the pedagogical application of digital technology in education. HOTS encompasses higher-order cognitive processes, including analysis, evaluation, and creation, as defined in the revised Bloom's Taxonomy proposed by Lorin W. Anderson and David R. Krathwohl. These cognitive processes are fundamental for enabling learners to analyze information critically, evaluate evidence, and generate innovative solutions to complex problems. The development of HOTS-oriented assessment items represents a key indicator of instructional quality because it promotes critical, reflective, and problem-centered thinking rather than rote memorization. Digital technologies have become an essential component of contemporary assessment practices, supporting the ongoing transformation of teaching and learning environments. The Assessment Link application functions as a scaffolding tool that guides pre-service teachers in systematically

designing assessment items aligned with the cognitive levels of the revised Bloom's Taxonomy. Integration of this digital platform is expected to facilitate assessment development, improve the efficiency of evaluation processes, and strengthen teachers' competence in designing valid, technology-enhanced assessments that support meaningful learning outcomes (Boumahdi et al., 2026; Sofyan, 2025; Susantini et al., 2022).

METHOD

Solution

The proposed solution for this community engagement program is a capacity-building workshop on the development of Higher Order Thinking Skills (HOTS)-oriented assessment items supported by the Assessment Link application for pre-service biology teachers at the Universiti Sains Malaysia (USM). The intervention is specifically designed to address the participants' primary challenges, including limited understanding of the cognitive hierarchy within the revised Bloom's Taxonomy and insufficient competence in constructing HOTS-based assessment items that are appropriately aligned with biological concepts and learning objectives. The Assessment Link application is incorporated as a digital pedagogical tool to facilitate the systematic design, organization, and evaluation of assessment items according to the appropriate cognitive levels. The integration of this technology enables participants to translate theoretical knowledge into practical assessment design while improving the accuracy and consistency of HOTS-oriented item development. The proposed intervention therefore combines conceptual reinforcement with authentic hands-on practice, fostering both pedagogical competence and digital assessment literacy among future biology teachers.

Implementation Approach

The program adopted a participatory, training-based approach integrated with a structured mentoring framework. This approach positioned participants as active contributors to the learning process through direct engagement in instructional sessions, collaborative discussions, and hands-on practice in developing Higher Order Thinking Skills (HOTS)-oriented assessment items. Active participation was expected to facilitate meaningful knowledge construction while strengthening participants' pedagogical competence in assessment design. Integration of digital technology constituted a central component of the intervention through the implementation of the Assessment Link application as a pedagogical support tool. The program was delivered using a blended learning model that combined face-to-face training with online mentoring, enabling flexible interaction, continuous guidance, and timely formative feedback throughout the learning process. This instructional design was intended to promote sustained competency development while supporting participants in transferring theoretical knowledge into authentic assessment practices.

Implementation Procedure

The community engagement program was implemented through a systematic and sequential framework consisting of four major phases. The workflow was designed to ensure the effective achievement of program objectives while facilitating the progressive development of participants' competencies in HOTS-oriented assessment design. A detailed overview of the implementation procedure is presented in Figure 1.

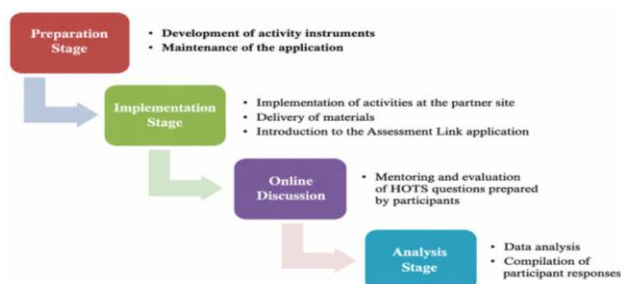


Figure 1. Workflow of the community engagement program

The first phase comprised program preparation, including developing training materials, designing evaluation instruments such as pre-tests and post-tests, coordinating with the partner institution, and preparing the technical aspects of implementing the Assessment Link application.

The second phase involved face-to-face implementation of the training program. Activities commenced with an opening session, participant orientation, and administration of the pre-test to assess participants' baseline understanding of HOTS-oriented assessment design. The instructional sessions subsequently covered the revised Bloom's Taxonomy, reinforcement of core biological concepts, principles for constructing HOTS-based assessment items, and hands-on training in using the Assessment Link application, as illustrated in Figure 2. Participants were then assigned to develop biology assessment items aligned with higher-order cognitive levels using the application, allowing them to apply theoretical knowledge in an authentic assessment design context.

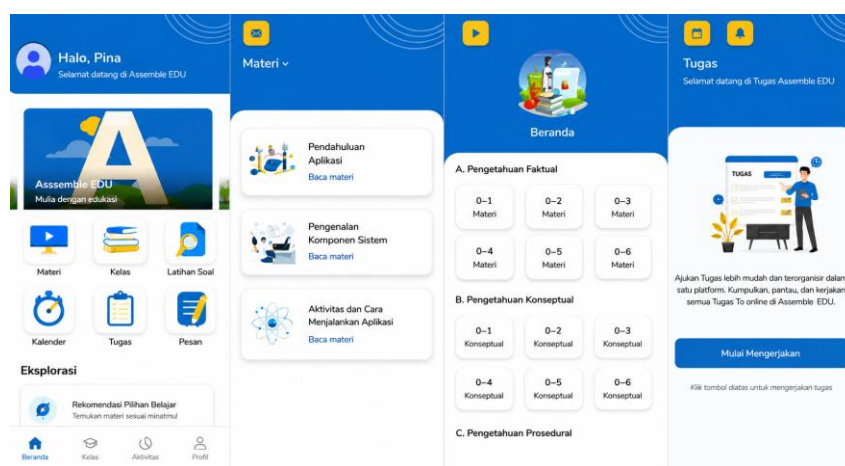


Figure 2. Features of the assessment link application

The third phase consisted of an online mentoring and discussion session conducted through a virtual learning platform. During this phase, participants presented the HOTS-oriented assessment items they had developed using the Assessment Link application. Constructive feedback and individualized recommendations were provided by the facilitators to refine the quality of the assessment items and strengthen participants' competencies in designing assessments aligned with higher-order cognitive processes. The final phase focused on program evaluation through the administration of a post-test to measure participants' learning gains following completion of the training program. The evaluation also included an analysis of program implementation, participants' perceptions of the training, and improvements in their competence to develop HOTS-oriented biology assessment items. These evaluation outcomes were used to determine the effectiveness of the intervention in enhancing both pedagogical knowledge and practical assessment design skills.

Table 1. Evaluation framework for the community engagement program

No	Training Aspect	Performance Indicator	Assessment Instrument
1	Training implementation	The training program is implemented successfully with an implementation rate of at least 75%.	Training implementation observation checklist
2	Participants' responses to the mentoring program	More than 75% of participants report positive perceptions of the training activities.	Participant response questionnaire
3	Knowledge of HOTS-oriented assessment design and the use of the Assessment Link	Participants demonstrate increased knowledge of HOTS-oriented assessment design and the use of the Assessment Link application. Learning mastery is achieved	Pre-test and post-test instruments

No	Training Aspect	Performance Indicator	Assessment Instrument
	application	when at least 75% of participants attain the predetermined post-test criterion, accompanied by an increase in the mean post-test score compared with the mean pre-test score.	
4	Participants' competence in developing HOTS-oriented cognitive assessment items	Participants are able to construct assessment items that accurately correspond to the higher-order cognitive levels of the revised Bloom's Taxonomy.	Assessment rubric for participants' assignments
5	Program sustainability	Pre-service teachers acquire practical examples and demonstrate sustained improvement in developing HOTS-oriented assessment items beyond the training program.	Training module and instructional materials

Time and Venue of Implementation

The community service program (PKM) was conducted from May to June 2025. The face-to-face (offline) activities were held on 30 May 2025 at Universiti Sains Malaysia (USM), Penang, Malaysia. Subsequently, follow-up mentoring sessions were conducted online throughout June 2025 via the Zoom platform to facilitate continuous discussion, guidance, and evaluation.

Table 2. *Schedule of Community Engagement Program Activities*

No	Program Component	Delivery Mode	Duration
1.	Opening Session and Program Orientation		2 hours
	a. Welcome address and opening remarks by the Program Coordinator	Face-to-face	
	b. Program orientation and learning agreement	Face-to-face	
	c. Pre-test administration	Face-to-face	
2.	Instructional Sessions		10 hours
	a. The revised Bloom's Taxonomy	Face-to-face	
	b. Reinforcement of fundamental biological concepts	Face-to-face	
	c. Principles of developing HOTS-oriented biology assessment items	Face-to-face	
	d. Training on the use of the Assessment Link application	Face-to-face	
	e. Assignment: Development of HOTS-oriented assessment instruments using the Assessment Link application	Face-to-face	
3.	Presentation and Discussion of Participants' Assignments	Online	14 hours
4.	Post-test Administration	Online	4 hours
5.	Program Evaluation	Online	2 hours
Total Duration of the Community Engagement Program			32 hour

RESULT AND DISCUSSION

Capacity Building through HOTS-Oriented Assessment Training

The workshop on developing cognitive assessment items using the Assessment Link application for pre-service biology teachers at the Universiti Sains Malaysia (USM) was conducted through a blended implementation model. The face-to-face training session was held on 30 May 2025, followed by a series of online mentoring sessions throughout June 2025. The community engagement program was led by Endang Susantini and implemented through active collaboration between the academic team from the Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya (UNESA), and the partner institution, the School of Educational Studies, Universiti Sains Malaysia. Training resources provided to participants included instructional presentation materials, practical workshop modules, and learning resources designed to support the development of HOTS-oriented biology assessment items using the Assessment Link application.

(<https://classroom.google.com/c/Nzc3NDI5MDQ2ODAy/m/NzY5MDk2MjYzNjc1/details>). Supporting materials for the community engagement program included a video documenting the implementation of the workshop, available at (<https://youtu.be/9gPA3tuGZjc>) and an assessment link user guide (https://drive.google.com/file/d/16POoBLCMYep1Q_kfMFv0NsnSruM45GYD/view?usp=sharing) (Figure 3).



Figure 3. Workshop materials for the assessment link training

The program commenced with participant registration involving undergraduate students enrolled in the Biology Education program at the Universiti Sains Malaysia (USM). The opening ceremony was officially initiated with welcoming remarks delivered by representatives of USM, followed by an address from the delegation of Universitas Negeri Surabaya (UNESA) as the collaborating institution. A pre-test was subsequently administered to assess participants' baseline knowledge of the training content. The pre-test also served as a diagnostic assessment to identify participants' initial level of understanding before the instructional sessions commenced.

The first instructional session was delivered by Sunu Kuntjoro, who presented the topic of Ecological Succession. The session explored the fundamental concepts, mechanisms, and ecological dynamics of succession, including both primary and secondary succession, as well as the biotic and abiotic factors influencing ecosystem development over time. Emphasis was placed on the relevance of ecological succession to biodiversity conservation, ecosystem restoration, and environmental sustainability, while highlighting its significance in biology education. To enhance participants' understanding, the presenter employed interactive instructional strategies, including contextual case studies, multimedia-supported explanations, collaborative group discussions, and question-and-answer sessions. These approaches encouraged participants to actively engage with the learning materials, critically analyze ecological phenomena, and relate theoretical concepts to authentic environmental issues encountered in educational and community contexts (Littlelyke, 2008).

The second instructional session was presented by Endang Susantini, who discussed Revised Bloom's Taxonomy and the application of the Android-based Assessment Link platform for developing Higher Order Thinking Skills (HOTS)-oriented assessment items. The session began with a comprehensive explanation of the conceptual framework of the revised taxonomy, emphasizing the cognitive processes of analyzing, evaluating, and creating as essential components of twenty-first-century learning. Participants were subsequently introduced to the features and functionalities of the Assessment Link application and received structured, hands-on training in designing valid and reliable HOTS-based biology assessment instruments using the digital platform. Throughout the session, practical competence was strengthened through guided simulations, authentic assessment design workshops, peer discussions, and direct mentoring from the facilitators. Participants were encouraged to develop assessment items aligned with curriculum objectives, integrate real-world biological contexts, and evaluate the quality of their instruments based on established assessment criteria. By the end of the session,

participants had gained both conceptual knowledge and practical skills, enabling them to effectively transform theoretical principles into meaningful, technology-supported classroom assessment practices that promote students' critical thinking, problem-solving, and scientific reasoning abilities (Kholid, 2026).



Figure 4. *Documentation of the training sessions*

Participants demonstrated a high level of engagement throughout the training program, particularly during the hands-on sessions involving the development of HOTS-oriented assessment items using digital technology. The discussions were highly interactive and reflected participants' active involvement, critical inquiry, and strong motivation to master the targeted pedagogical competencies. This active participation contributed to a collaborative learning environment that supported knowledge exchange and reflective practice (Yaacob et al., 2021). A post-test was administered at the conclusion of the instructional sessions to evaluate participants' learning gains and measure improvements in their understanding of HOTS-oriented assessment design. Participants were subsequently assigned a follow-up task aimed at reinforcing the application of the concepts and skills acquired during the training. The closing session featured a presentation by representatives of Universiti Sains Malaysia (USM), highlighting their initiatives in STEM-based instructional development and providing additional insights into innovative educational practices. The entire program concluded at 1:00 p.m. local time.



Figure 5. *Documentation of pre-service biology teachers' learning activities*

A follow-up phase of the training program on developing cognitive assessment items using the Assessment Link application for pre-service biology teachers at the Universiti Sains Malaysia (USM) was conducted through synchronous online mentoring via the Zoom platform. During this phase, participants presented the HOTS-oriented assessment items they had developed and submitted through

(<https://classroom.google.com/c/Nzc3NDI5MDQ2ODAy?cjc=vtlghz6p>) (Figure 5). Facilitators and resources provided constructive feedback and individualized recommendations to support participants in revising and refining their assessment items. The online discussion sessions were designed to foster reflective practice, strengthen critical thinking skills, and enhance participants' competence in developing HOTS-oriented assessments. Continuous mentoring also reinforced participants' understanding of integrating digital technologies into assessment design, thereby promoting the effective application of the Assessment Link platform within biology education.

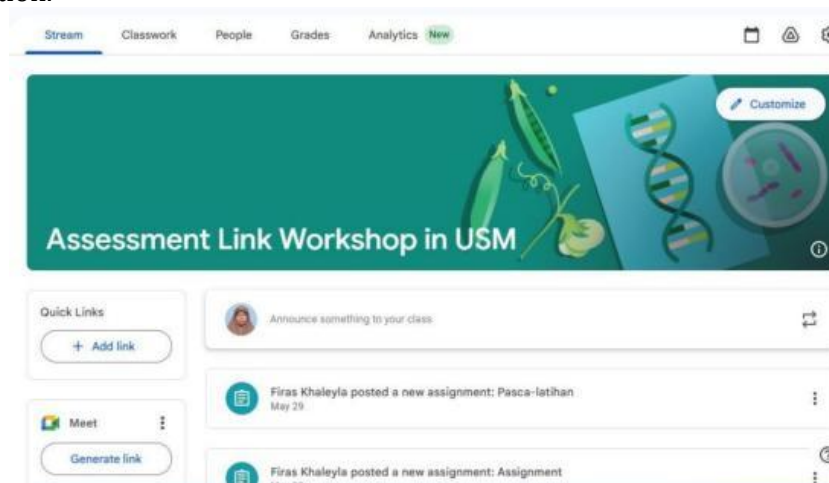


Figure 6. Google classroom

Implications for Biology Teacher Professional Development

Participants' baseline understanding was assessed through the administration of a pre-test delivered via Google Forms, with technical assistance provided by the facilitators to ensure that all participants completed the assessment successfully. The pre-test served as a diagnostic instrument to identify participants' initial knowledge of HOTS-oriented assessment design before the training intervention. A post-test was administered at the conclusion of the workshop to evaluate participants' learning gains and determine the extent to which their knowledge had improved following the training program. Comparison of the pre-test and post-test results provided evidence of the effectiveness of the intervention in enhancing participants' understanding of HOTS-oriented assessment development and the use of the Assessment Link application. The results of the pre-test and post-test assessments are presented in Figure 7.

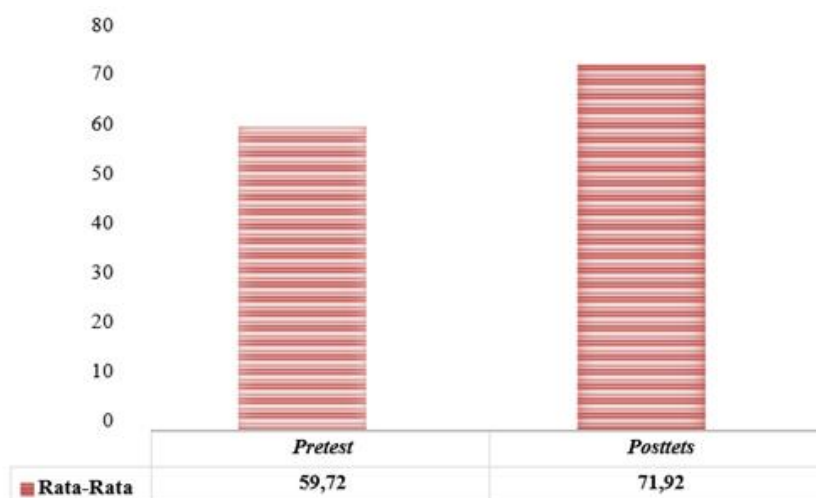


Figure 7. Comparison of mean pre-test and post-test scores

The results presented in Figure 7 indicate a measurable improvement in participants' knowledge following the training intervention. The mean pre-test score was 59.72, whereas the

mean post-test score increased to 71.92, representing an average gain of 12.20 points. This improvement demonstrates that participants' understanding of HOTS-oriented biology assessment design and the application of the Assessment Link platform increased after completing the workshop. The observed learning gains are consistent with previous findings demonstrating that professional development programs focused on HOTS-oriented assessment contribute substantially to strengthening teachers' pedagogical competencies. Training initiatives of this nature have been positively received by educators because they enhance teachers' ability to develop assessment instruments that conform to established HOTS principles and assessment guidelines (Susantini et al., 2025). Strengthening teachers' capacity to design Higher Order Thinking Skills (HOTS)-based assessments is essential for expanding pedagogical knowledge related to higher-order cognitive processes while improving practical competence in constructing valid and reliable assessment instruments (Supratman et al., 2025).

Digital assessment technologies also play an important role in supporting effective instructional practices. The integration of the Assessment Link application into the training enabled participants to translate theoretical concepts into authentic assessment design while facilitating the development and management of electronic assessments. Previous studies have reported that multiplatform assessment systems, including the Assessment Link application, improve the efficiency of e-assessment management and contribute to higher-quality teaching and learning in both online and face-to-face educational settings within the Merdeka Belajar framework (Susantini et al., 2025). Evidence from previous research further indicates that systematic training in HOTS-oriented assessment can strengthen critical thinking skills across multiple cognitive dimensions. Although learners often demonstrate relatively low performance in the domains of providing simple explanations, developing basic reasoning skills, drawing inferences, constructing advanced explanations, and formulating strategies and tactics, structured instruction in HOTS assessment has been shown to improve these competencies by encouraging deeper cognitive engagement and more reflective problem-solving processes (Supratman et al., 2025). These findings reinforce the effectiveness of the present intervention in enhancing participants' assessment literacy and their capacity to design cognitively demanding biology assessment tasks.

The quality of an education system is closely associated with the effectiveness of its teaching and learning processes, encompassing instructional planning, implementation, and assessment. Within this framework, teachers' competence in developing valid assessment instruments represents a fundamental component of instructional quality, particularly in the construction of Higher Order Thinking Skills (HOTS)-oriented assessment (Sayekti & Anggriani, 2025). Professional teaching practice requires educators not only to understand the theoretical foundations of HOTS but also to possess the practical expertise necessary to design assessment tasks that promote higher-order cognitive processes. These demands highlight the importance of systematic professional development programs that emphasize the significance and methodology of HOTS-based assessment design (Amrina et al., 2024). Despite the growing emphasis on higher-order thinking in contemporary education, many teachers continue to experience difficulties in developing HOTS-oriented assessment instruments. Limited mastery of HOTS assessment principles remains a significant challenge, even though such competencies are essential for preparing students to meet the demands of twenty-first-century learning (Husain, 2023). Students are unlikely to develop higher-order thinking skills without continuous exposure to cognitively challenging learning activities and assessment tasks that stimulate analytical reasoning, evaluation, and creative problem solving (Suciati, 2022).

The findings of the present community engagement program demonstrate that the intervention effectively supported pre-service biology teachers in developing HOTS-oriented assessment items. Consistent with previous studies, continuous and follow-up training is recommended to broaden participants' experience in designing diverse HOTS-based assessment tasks and to further strengthen their assessment competencies (Nafi'ah et al., 2025; Pujiastuti et al., 2024). Sustainable professional development initiatives that actively engage participants in authentic assessment design have also been shown to improve teachers' competence in constructing higher-order cognitive assessment instruments (Edwar et al., 2023; Rahmawati et

al., 2024). Such community engagement programs therefore represent an important strategy for enhancing teachers' professional competencies and equipping future educators with the knowledge and practical skills required to implement HOTS-oriented assessments that align with the educational demands of the twenty-first century (Toheri & Muchyidin, 2025).

CONCLUSION

The community engagement program successfully strengthened the competencies of pre-service biology teachers at Universiti Sains Malaysia (USM) in developing Higher Order Thinking Skills (HOTS)-oriented biology assessment items through the integration of the Assessment Link application. The combination of face-to-face training and online mentoring effectively enhanced participants' conceptual understanding of the revised Bloom's Taxonomy and their practical skills in designing technology-enhanced assessments. The increase in the mean score from 59.72 on the pre-test to 71.92 on the post-test, representing an average gain of 12.20 points, demonstrates the effectiveness of the intervention in improving participants' assessment literacy and pedagogical competence.

Sustained implementation of this training model has the potential to support the preparation of future biology teachers who can design valid, HOTS-oriented assessments aligned with the educational demands of the twenty-first century and the Society 5.0 era. Future community engagement initiatives should expand the program to a wider range of teacher education institutions and incorporate continuous mentoring to ensure the long-term application of HOTS-oriented assessment practices in authentic classroom settings.

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