



Research article

Evaluation of educational assessment module for flexible STEM education

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Abstract: Modules are instructional materials used in flexible STEM education. With this, the Plan-Do-Study-Act action research model was employed to design, implement, and evaluate a self-learning module on Assessment in Learning (ASL) 2 for preservice teachers. Three education experts validated the ASL 2 module during the design phase. The Math and Science preservice teachers (N = 95) used and rated the validated module utilizing a pretest/posttest exam, survey questionnaire, and open-ended questions. The findings revealed that ASL 2 adhered to the prescribed module structure, format, and relevant outcomes-based education (OBE), technological, pedagogical, and content knowledge (TPACK), universal design for learning (UDL), and inclusivity frameworks. The preservice teachers had significant learning gains in assessment in four ASL chapters and provided positive perceptions and feedback regarding the module. Hence, the ASL module is a valid, practical, and effective instructional tool, particularly in flexible STEM education. The second cycle of the PDSA model, considering other learning outcomes and specializations, is recommended to be implemented in other teacher education institutions.

Keywords: assessment in learning 2, module, flexible learning, STEM education

1. Introduction

The needs of a new generation of learners have led to considerable changes in education in the twenty-first century. Students now have unparalleled access to information due to the rapid growth of technology, particularly in information and communication technology (ICT), which calls for innovative approaches to teaching and learning. In this setting, flexible learning has gained significance. Shurville et al. [1] define flexible learning as "a set of educational philosophies and systems concerned with providing learners with increased choice, convenience, and personalization to suit the learner." It addresses the demand for more flexible and student-centered educational approaches by giving students autonomy over where, when, and how they learn.

Modular instruction has become a viable way to apply flexible learning in teacher education institutions, particularly in STEM education. This form of instruction involves using self-contained learning activity packages that enable independent student engagement with course material [2,3]. This approach works exceptionally well when teachers and students are geographically and temporally apart. Self-learning modules (SLMs) are essential components of modular training because they provide students with various tasks, control over learning pace, ways to demonstrate understanding in multiple contexts, and ways to demonstrate knowledge [4]. These features are intended to stimulate students' interest and curiosity. Additionally, learning results for a diverse student body can be improved by modules that include chances for both independent and collaborative learning.

Despite the demonstrated benefits of SLMs, the development of these resources has primarily entailed general education settings or broader subject areas, leaving significant gaps in STEM education, particularly for courses like Assessment in Learning 2 (ASL 2). As a component of professional STEM education, teacher education institutions in the Philippines offer ASL 2, which builds on Assessment in Learning 1 (ASL 1). While ASL 1 focuses on traditional assessment instruments and standard test development, ASL 2 emphasizes real learning experiences, process- and product-oriented evaluations, and the creation of performance-based rubrics. The Commission on Higher Education (CHED) Memorandum Order No. 75, series 2017, and the Philippine Professional Standards for Teachers (PPST) have reorganized ASL 2 to align with contemporary professional STEM education demands. However, resources for ASL 2, particularly self-learning modules tailored for flexible STEM education, remain scarce. This lack of accessible and context-specific SLMs limits the potential for independent and self-paced learning among pre-service teachers.

In this study, we address this critical gap by developing, implementing, and evaluating an SLM designed for ASL 2. The research innovatively integrates multiple educational frameworks to ensure the module's effectiveness, relevance, and inclusivity. Outcomes-Based Education (OBE) aligned the module's content and structure with desired learning outcomes, focusing on process- and product-oriented assessments critical in STEM education. Universal Design for Learning (UDL) principles informed the module's design to promote accessibility and inclusivity, offering diverse means of engagement, representation, and expression to cater to a wide range of learners. Technological, Pedagogical, and Content Knowledge (TPACK) ensured technology integration into pedagogical strategies and content delivery, fostering an engaging and contemporary learning experience. The synergy of these frameworks highlights our innovative approach to module development, filling a crucial gap in the field.

Furthermore, we provide empirical evidence of the module's effectiveness by evaluating its impact on pre-service teachers' entry and exit performance and gathering their perceptions and qualitative feedback. By critically analyzing the module's alignment with OBE, UDL, and TPACK, the study contributes to the literature on flexible STEM education. It offers practical insights for enhancing instructional practices in teacher education. The findings address the scarcity of specialized SLMs for ASL 2 and extend the discourse on innovative and flexible teaching strategies in STEM education.

2. Literature review

Modular instruction is an alternative instructional design that uses developed instructional materials based on the needs of students in STEM education. Students are encouraged to work on interesting and challenging activities to maintain focus and attention [5]. Evidence suggests that modular instruction is more effective than traditional instruction in meeting the needs of today's students in terms of both the quality of learning and content in various fields of education [3,6–9].

However, problems may arise when implementing modular instruction. For example, a teacher who mainly uses traditional methods of instruction often needs help switching to a modular one. The teacher must ensure that modules are engaging, informative, memorable, and built according to student's age and individual peculiarities. The material, examples, and tasks should be selected considering students' needs, life experiences, and current situations in the country and the world. [10]. These are presented from the perspective of the student, instructor, and administrator. Despite these problems, it has emerged as one of the most promising alternatives in higher education today, especially individualized learning and its adaptability to a larger group of students [11].

The development of self-learning materials is an integral process in modular instruction. One of the most notable self-learning materials in modular instruction is the module. A module is a form of individualized instruction that enables students to use a self-contained package of learning activities. These activities guide learners to know or to be able to do something. Further, a learning module contains activities to help students understand specific lessons [12]. Nardo [5] concluded that students can use modules without much teacher intervention but need instruction where the teacher is physically present.

Based on research, modules have advantages. Learning becomes more effective, and a system of assessment other than marks or grades is established. Users study the modules in their working environment without disturbing the typical duties and responsibilities. Additionally, modules can be administered in single-use, small-group, or large-group settings, and they are flexible so that implementation can be made using a variety of patterns. Moreover, modules are more appropriate for mature students, enabling them to control their learning and accept greater responsibility for learning. Modules already get wider accessibility in the present educational scenario and are economical. Furthermore, the disadvantages include appropriateness only for mature students, demands for smart classrooms considering that modules are more effective when aided with technologies for learning, and some activity sheets were answered by only parents/guardians [13].

The UDL approach is increasingly drawing attention from researchers and educators as a possible solution to promote content accessibility and fill the gap between learner abilities and individual differences [14]. It stands at the forefront of contemporary efforts to create universal access to educational curricula for all students, including those with disabilities. The UDL underscores the

need for flexible approaches to teaching and learning that meet the needs of different kinds of learners [15]. CAST, Inc. suggested guidelines for implementing UDL [16]. These guidelines offer concrete suggestions that can be applied to any discipline or domain to ensure all students can access and participate in meaningful, challenging learning opportunities. UDL proposes three essential principles. These are the provisions of multiple means of engagement, representation, and action & expression.

When designing instruction in UDL, teachers must ensure to spark excitement and curiosity for learning among students; students can tackle challenges with focus and determination; they can harness the power of emotions and motivation in learning; they can interact with flexible content that does not depend on a single sense like sight, hearing, movement, or touch; they can communicate through languages that create a shared understanding; they can construct meaning and generate new understandings; they can interact with accessible materials and tools; they can compose and share ideas using tools that help attain learning goals; and they can develop and act on plans to make the most out of learning [16].

A framework for teacher knowledge for technology integration called TPACK is another conducive framework for crafting self-learning modules. Koehler and Mishra [17], the framework's authors, extended Lee Shulman's construct of pedagogical content knowledge (PCK) by including technology knowledge. The TPACK framework for teacher knowledge is described in detail as a complex interaction among three bodies of knowledge: Content, pedagogy, and technology. The interaction of these bodies of knowledge, both theoretically and in practice, produces the flexible knowledge needed to integrate technology use into teaching successfully [17]. Using the TPACK framework is crucial to developing learning materials because teachers are guided on optimizing and effectively using technology in teaching and learning.

Last, OBE has become an essential approach to teaching. Decisions about the curriculum are driven by the exit learning outcomes that the students should display at the end of the course. In OBE, the product defines the process. Thus, it can be summed up as results-oriented thinking. It is the opposite of input-based education, where we emphasize the educational process and are happy to accept whatever result [18]. In developing self-learning modules, outcomes are carefully defined, and the activities and inputs are ensured to be constructively aligned and consistent with these outcomes.

The shift from conventional STEM education to a flexible one has posed a more significant challenge in sustaining quality education. In teacher education institutions, amalgamating self-learning material, UDL, TPACK, and OBE is an exciting topic worth researching. A module developed based on the abovementioned principles and guidelines could foster quality and meaningful STEM learning among students in teacher education institutions.

3. Methods

3.1. Research design

We evaluated the practice of using modules to teach and learn ASL 2. In particular, we followed the Plan-Do-Study-Act (PDSA) model, which has four phases: Planning for a solution, doing the solution while measuring progress, studying progress measures whether the solution is suitable or requires adjustment, and acting on the solution by adopting, adapting, or abandoning it [19].

Professional teachers can use the PDSA model in formulating and conducting action research [20] because it provides a cyclical approach to research and focuses on a specific research problem [21]. Through this model, the researchers have appropriately developed, validated, implemented, and evaluated the ASL 2 modules.

3.2. Research participants

The study participants included third-year Math and Science preservice teachers ($N = 95$) who used the modules in their ASL 2 course in the second semester at a state university in Central Visayas, Philippines. Most participants were 21 (79.29%) and females (71.72%). Most of them used smartphones (63.13%) as primary learning gadgets and had moderate internet access (80.81%).

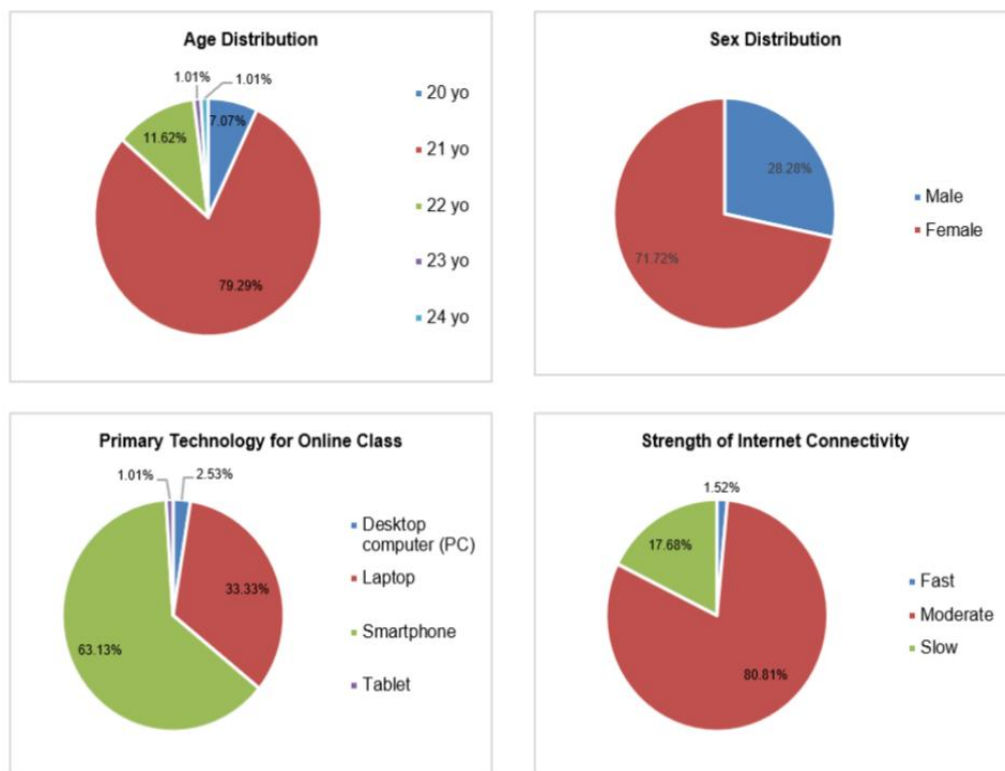


Figure 1. Demographic profile of the Math and Science preservice teachers.

3.3. Research instruments

We utilized four researcher-made instruments, which were administered online: (1) module, (2) pretest/posttest exam, (3) perceptions questionnaire, and (4) open-ended questionnaire.

ASL 2 Module. The module has five parts following the institutional format and is translated into a digital platform using the university's learning management system (<https://cnu.neolms.com>), as seen in Figure 2.

Figure 2. The flexible module in the University's LMS.

These parts include *Take Note*, which stimulates interest in the lesson; *Take On*, which presents the content; *Take Action*, which elicits student performance; *Take Off*, which assesses such performance; and *Take the Lead*, which extends student understanding to more realistic and practical situations. Three education experts validated the ASL 2 module to evaluate its structure and adherence to OBE, TPACK, UDL, and inclusivity.

Pretest/Posttest Exam. This exam comprised 55 items distributed across the five chapters of ASL 2. Eleven items comprised each chapter: performance-based assessment, authentic assessment, affective assessment, scoring performance-based assessment, and assessment of one's practice. These items were pilot-tested on 30 fourth-year students who had already taken the course. The results of the pilot testing showed that the tool had a Cronbach's alpha of 0.80, suggesting good internal consistency. This means the tool was reliable and could be used in the context of the study.

Perception Questionnaire. The preservice teachers also responded to a 25-item perception questionnaire on their perceptions of the ASL 2 module. There are 25 items in the questionnaire, which are categorized into six aspects. These aspects include OBE (6 items), TPACK (6 items), UDL (5 items), inclusivity (3 items), and satisfaction (5 items). This tool was also pilot-tested on the same 30 fourth-year students. The Cronbach's alpha for OBE items is 0.96, TPACK is 0.96, UDL is 0.91, inclusivity is 0.94, and satisfaction is 0.92. Overall, the internal consistency is 0.98, making the tool reliable for the study.

Open-ended Questionnaire. A researcher-made open-ended questionnaire was administered to gather preservice teachers' feedback on using the ASL 2 module. Three questions were raised: (1) How do you find the module? (2) How satisfied are you with the module? and (3) What have you experienced using the module?

3.4. Data gathering procedure

The researchers subjected the study to an ethics review by the university ethics committee. Once ethics certification was secured, they asked permission from the college dean and informed consent from the study participants for voluntary participation.

The first part of the study involved designing and developing the ASL 2 module in STEM education. The researchers crafted the module following the institutional format and considering the four frameworks of OBE, TPACK, UDL, and inclusivity. After crafting, the module was sent for validation to experts and teachers, who evaluated the module structure and frameworks. Their evaluation and improvement points were used to revise the ASL 2 module. The revised module was finalized for implementation in the ASL 2 class.

Once the module was implemented, the researchers sought pertinent permissions to conduct the study at the state university. The study manuscript was sent to the research ethics committee for ethics review. Once ethics certification was given, permission was asked from the college dean to conduct the study, and informed consent was requested from the study participants for their voluntary participation in the said research. When these permissions were secured, the revised module was used in the ASL 2 class.

A pretest was given to the preservice teachers during the orientation week to obtain their preliminary knowledge about assessment in learning. After pretesting, the module was employed in the ASL 2 class. The preservice teachers used the modules, from answering the activities in Take Note to understanding the content in Take On. They then demonstrated their understanding of assessment in Take Action and Take Off. Finally, they applied their knowledge to realistic and practical situations in Take the Lead. The use of the modules lasted for over a semester.

After a semester of implementation, the preservice teachers were given the posttest, survey, and qualitative questionnaires. The collected data were managed and organized in Microsoft Excel for data presentation. These data were stored in a file encrypted with a password and kept confidential. All names remained anonymous.

3.5. Data analysis

We used Statistical Package for Social Sciences (SPSS) version 22.0 to analyze the data in this study. To evaluate the extent of compliance with module standards and students' perceptions, percentages and weighted means were calculated, accompanied by appropriate qualitative descriptions to contextualize the findings. Descriptive and inferential statistical techniques were used to examine the pre-service teachers' pretest and posttest results. The results were summarized using descriptive statistics, such as means, standard deviations (SDs), and effect sizes. Inferential analysis was performed using a t-test for dependent samples to see whether there were any significant differences between the pretest and posttest scores.

The research locale's criterion-referenced grading system, which sets the minimum passing score at 60% of the best possible score, was the foundation for the success criterion. The passing score for the pretest and posttest combined was 33 out of 55 points, with the passing score for each chapter being 6.6 out of 11. Institutional standards guided the success criteria, guaranteeing conformity with established grading procedures that measure student performance against predetermined thresholds instead of normative comparisons.

The decision to utilize mean and SD for ordinal scales was made because the ordinal scales employed in this work resembled interval features, enabling parametric statistical techniques. The underlying premise of this method is that the distances between scale points are about equal. The data were examined for distributional traits, such as normality and homogeneity of variances, which are essential to applying mean correctly and SD to support this assumption. Furthermore, the utilization of mean and SD is consistent with social science and educational research norms, improving comparison with previous studies and streamlining the dissemination of results to interested parties. With efforts to reduce the impact of any outliers, the mean and SD are considered to fairly reflect the general trends in the data given the sample size.

The effect size was interpreted based on Cohen's guidelines, which state that values of 0.2, 0.5, and 0.8 generally denote small, medium, and large effects. The decision to interpret effect sizes was motivated by the need to go beyond statistical significance and measure the changes in pretest and posttest performance to provide a more nuanced understanding of the self-learning module's practical impact on students' learning outcomes.

Recurring themes were found in the qualitative data from student input, and these keywords were subsequently visualized using WordCloud Generator (<https://monkeylearn.com>), an online tool. This method made detecting recurring themes in the students' responses easier, enhancing the quantitative results and allowing for a more thorough assessment of the self-learning module's efficacy.

4. Results and discussion

External assessors evaluated the crafted module on ASL 2 according to module structure and format and relevant frameworks. The evaluation results of the module structure and format are presented below.

Table 1. Compliance of ASL2 module on its structure and format, N = 3 validators (V1, V2, V3).

Component	Compliance			Extent of Compliance
	V1	V2	V3	
Module Overview	✓	✓	✓	100%
Module/Course Contents	✓	✓	✓	100%
Course Learning Outcomes	✓	✓	✓	100%
Learning Experiences	✓	✓	✓	100%
Assessment	✓	✓	✓	100%
Enhancement	✓	✓	✓	100%
Assignment	✓	✓	✓	100%

Based on Table 1, all module components are present in the crafted instructional material. This means that the crafted module for ASL 2 has complied with the required elements, such as learning outcomes, learning activities, and assessment activities. Table 2 shows the evaluation results of the extent to which the content adheres to important educational frameworks.

Table 2. Compliance of ASL2 module on relevant frameworks, N = 3 validators.

Framework	Compliance			General Comments	Enhancements Made
	Low	Average	High		
OBE	0%	20%	80%	Ensure that the assessment strategies lead to the attainment of the desired learning outcomes	The assessment strategies were reviewed and revised to ensure that these tasks lead to the attainment of the outcomes.
TPACK	0%	80%	20%	Enhance the content and pedagogy by integrating the use technology in the lessons of the module.	Various online sources and tasks were embedded in the lessons of the module.
UDL	0%	80%	80%	Ensure that there are activities for engagement and continuity and consider the needs and wants of the current education students.	Provisions for flexibility are included to make sure that learning continuity occurs anytime anywhere.
Inclusivity	0%	50%	50%	Revise learning tasks that provide equal opportunity to all and respond to the diversity of students.	The learning tasks were reviewed to ensure that diversity, inclusivity, and gender sensitivity are integrated.

As shown in Table 2, there is high compliance with the outcomes-based education framework. This means that the module includes the features of a student-centered approach that ensures students demonstrate the outcomes of ASL 2. Moreover, the frameworks of TPACK and UDL moderately complied with the crafted module. This means there is partial integration of the principles of the said frameworks. To comply with these principles, the module should be enhanced by integrating technology into the different lessons and providing access to various online resources that could help in the learning of assessment. Furthermore, the inclusivity of the module has average-high compliance. This means that the crafter module adheres to most of the principles of diversity and inclusion, integrating various activities for all.

Table 3 presents the performance of Math and Science preservice teachers before and after using the self-learning module in ASL 2.

Table 3. Performances of the Math and Science preservice teachers, N = 95.

ASL 2 Outline	Pretest Mean Score (SD)	Posttest Mean Score (SD)	Paired Difference	Test Statistic (p-value)	Effect Size (Cohen's d)
Chapter 1	5.07* (1.47)	9.67* (1.31)	4.60 (1.80)	24.90* (.000)	2.55
Chapter 2	6.56 (1.53)	9.27* (1.90)	2.72 (2.18)	12.16* (.000)	1.25
Chapter 3	6.82 (1.36)	7.75* (1.84)	0.93 (2.08)	4.34* (.000)	0.45
Chapter 4	7.14 (1.40)	6.53 (1.22)	-0.61 (1.71)	-3.48* (.001)	0.36
Chapter 5	5.18* (1.98)	8.71* (1.11)	3.53 (2.32)	14.85* (.000)	1.52
<i>Overall Performance</i>	<i>30.77* (4.08)</i>	<i>41.93* (4.62)</i>	<i>11.16 (4.10)</i>	<i>26.52* (.000)</i>	<i>2.72</i>

Note: * the mean is significantly different from 6.60 and 33.00 (60% criterion success) for the chapters and overall performance, respectively; SD means Standard Deviation; * the test statistic is significant at 0.05

The findings presented in Table 3 reveal a marked improvement in the performance of preservice teachers after utilizing the newly designed ASL 2 module. Before the module's implementation, their performance did not meet the minimum standards in critical areas, particularly in discussing performance-based assessment concepts, following its steps, and planning assessments. However, after the intervention, preservice teachers demonstrated significant progress across most chapters, showing an enhanced ability to engage in activities such as authentic and reflective assessment, developing tools for affective learning, and applying professional reflection to improve teaching practices.

Interestingly, while substantial gains were observed in Chapters 1, 2, and 5, which covered foundational and application-oriented topics, Chapter 4 showed a slight decline in performance. This decrease may be attributed to the inherent challenges in scoring and analyzing affective assessment results, which require statistical proficiency and a robust understanding of rubric-based evaluation to minimize biases. As noted by Popham [27], "affective assessment is a measurement of a student's attitudes, interests, values, and other non-cognitive traits." The researchers observed that preservice teachers perceived affective assessment as less critical and practical than cognitive assessment. The large effect size underscores the module's practical significance in enhancing preservice teachers' capabilities, particularly in fostering cognitive and reflective skills crucial for their professional growth.

Table 4 describes the students' perceptions of using the ASL 2 module according to five aspects: OBE, TPACK, UDL, inclusivity, and learners' satisfaction.

Table 4. Preservice teachers' perceptions regarding OBE, TPACK, UDL, inclusivity, and satisfaction, N = 95.

Aspect	Mean (SD)	Description
OBE	4.63 (0.68)	Highly Observed
TPACK	4.52 (0.73)	Highly Observed
UDL	4.44 (0.77)	Highly Observed
Diversity and Inclusivity	4.53 (0.77)	Highly Observed
Satisfaction	4.41 (0.80)	Highly Observed

Legend: 1.00-1.80 (Not Observed), 1.81-2.60 (Fairly Observed), 2.61-3.40 (Moderately Observed), 3.41-4.20 (Observed), 4.21-5.00 (Highly Observed)

Based on Table 4, the students' features of OBE are highly observed when they use the ASL 2 module. They observed that the learning objectives, activities, and assessment strategies reflected the desired outcomes. This means constructive alignment between the activities and assessments vis-a-vis the outcomes. Such alignment enables the students to use the module effectively because the activities and assessment tools are directed toward attaining and demonstrating the learning outcomes. With clear outcomes, students can optimize their learning as they become responsible for their education. The students also perceived that the crafted module included activities that engaged them in more profound understanding and learning. They also highly observed that the said activities provided opportunities for further learning. These results signify that the module ensures mastery of the concepts and enrichment of their learning through practical and useful applications. Therefore, the outcomes are demonstrated even outside the classroom setting.

Aside from this, the students highly perceived that using technology in the module has improved learning. Appropriate technology tools enabled greater engagement and independent learning in this learning process. In other words, the crafted module-embedded activities can be accessed online, providing more information sources to help them learn the subject. Also, the preservice teachers' perceptions of the crafted module regarding UDL were highly notable. These teachers observed that the module's design promoted their learning continuity for both online and offline sessions, and the examples and learning activities were relevant to the learners' needs and interests. In short, the module includes learning tasks that can be done anytime and anywhere, providing flexibility in the learning process.

Furthermore, the preservice teachers highly observed all features of diversity and inclusivity embedded in the crafted module. These teachers perceived the lessons' topics, inputs, and learning materials as gender-sensitive. This means that the language used is gender-neutral, and the activities benefit all preservice teachers' learning. Last, the preservice teachers were delighted with the ASL module. They were happy with the lesson organization and the time allotment of activities. This finding means they perceive the module as organized well, which is evident in the logical arrangement of the topics and the coherence among activities from concept to transfer of learning.

The answers of the Math and Science preservice students to the three questions in the open-ended questionnaire contained important, significant words. The preservice teachers' feedback on using the self-learning module in ASL 2 summarizes these keywords in a word cloud.



Figure 3. Word cloud.

Eight feedbacks were derived from the word cloud in Figure 2. These feedbacks are presented below.

The module is challenging. In UDL, to sustain efforts and perseverance, the self-learning module is expected to challenge preservice teachers. The salience of learning targets (stated as *intended learning outcomes*) is heightened in each module chapter. Varied tasks and resources are provided to optimize challenges, foster collaboration and community, and increase mastery-oriented feedback.

“Due to my low internet connectivity, I cannot connect with the online sources suggested by

the module.” (Participant 8)

“While the tasks are good, some extension activities are quite exhaustive.” (Participant 15)

“The outcomes of the module help me as a teacher trainee. With this, I am challenged to accomplish the module in time.” (Participant 30)

The module is informative. For the preservice teachers, the module is informative because the contents are communicated through languages that create a shared understanding and are illustrated through multiple media such as pictures, websites, graphs, tables, texts, and research articles.

“What I love about the module is its informative nature. I learned more about assessment.” (Participant 2)

“There are more concepts about assessment I want to know. And I learned them here because of the informative content.” (Participant 21)

“The module includes online sources, making it very informative and engaging.” (Participant 50)

The module is relevant and appropriate. The preservice teachers said that the module is relevant and proper because the material is grounded in students' backgrounds and constructively aligned with the indicators of beginning teachers as defined in the Philippine Professional Standards for Teachers (PPST). Moreover, the activities are appropriate for their age and tap into various learning styles and preferences.

“The module includes activities where I know the situation of my community, especially the local school.” (Participant 10)

“The activities embedded in the module reflect the descriptions of the competencies of preservice teachers. The tasks are aligned with our standards.” (Participant 28)

“I am glad that I can choose which activity I can do and finish.” (Participant 43)

The module is stimulating. The preservice teachers are stimulated because a module anchored in UDL must recruit interest; excitement and curiosity for learning must be activated. In this module, students have been given individual choices and autonomy in learning. The threats and distractions are relatively minimal compared to the face-to-face learning setup.

“I feel excited every time I work on the activities in the module. I feel that I want to learn more about performance-based assessments.” (Participant 14)

“I cannot wait to use the module because it stimulates me to become independent in my learning.” (Participant 36)

“The module awakens me because it stimulates my critical thinking. I must think well how to make projects for my future students.” (Participant 80)

The module is concise and understandable. It is straightforward because only relevant information is included and displayed in the self-learning material. Although alternative sources and materials are provided, they are presented in bite-sized chunks that are relatively easier to comprehend.

“I am happy that the content is comprehensible because I can understand well the topics.” (Participant 6)

“Tables are presented that summarize the topics.” (Participant 12)

“The language is reader-friendly. Difficult concepts become easier to understand because of the familiar language.” (Participant 33)

The module is refreshing. The preservice teachers find the self-learning material refreshing

because the activities and inputs are logically sequenced. Before introducing the new topic, they are encouraged to accomplish tasks in the "Take On" part of the module. This part helps them stimulate their interest and enables them to recall and refresh their prior knowledge.

"At first I was scared of Educ 11. But when I took the preliminary activities, I am reminded of my prior lessons in Educ 8. It is so refreshing." (Participant 1)

"The activities are so engaging... so stimulating... so refreshing to use." (Participant 55)

"Being able to recall my previous knowledge on the assessment and connect it with assessment two is very refreshing. I feel that I should learn more." (Participant 78)

The module is precise, accurate, and intelligible. The module results from planning, developing, evaluating, and revising material. Careful planning was done before the development of the self-learning materials. An internal evaluation was regularly done among module writers. A pool of experts was invited to evaluate the materials towards the finality of the module. With this, errors, irrelevant inputs, unnecessary text, pictures, and the like are minimal, if not eliminated.

"The module is organized well. It underwent extensive planning, I think." (Participant 3)

"The content in the module and online sources are complementary. Accuracy is there." (Participant 26)

"I am glad that the module underwent checking. It is so easy to understand the concepts." (Participant 91)

Collectively, the modules are perceived as exemplary. When all the qualities mentioned above are considered, plus the proper packaging of the module, the preservice teachers eventually feel that the module is helpful and very good.

"In general, the module is beneficial during the pandemic." (Participant 4)

"The module is very informative. It is also very well-packaged. I like it because it makes my learning in assessment very meaningful." (Participant 46)

"The module helps me in my learning. I hope other teachers will make modules as good as ours, Sir." (Participant 64)

5. Discussion

Instructional materials, such as modules, should contain these major parts to provide holistic learning even during remote learning [22]. The module includes the features of a student-centered approach that ensures students demonstrate the outcomes of ASL 2. With this, assessment strategies should be formulated well so that students can demonstrate the attainment of their learning. Formulating the outcomes, planning the learning activities, and designing the assessment tasks ensure that learning is evident and transfer is effective [23]. Additionally, there is a partial integration of the principles of TPACK and UDL. To comply with these principles, the module should be enhanced by integrating technology into the different lessons and providing access to various online resources that could help in the learning of assessment. The module must also be enriched by providing activities that engage and provide continuity amidst challenges along the learning process, considering the needs and wants of current students. These observations are crucial in revising the present module, as TPACK and UDL are essential frameworks for 21st-century education. TPACK provides the necessary skills for collaboration, communication, and creativity using ICT in learning systems, including self-learning modules [24]. Equally important is the UDL framework, featuring flexible learning and barrier reduction when students learn, ensuring that everybody has access to

means of learning [25]. Aside from the frameworks above, the crafted module adheres to most of the principles of diversity and inclusion, integrating various activities for all. Although mostly complied, the evaluators commented that the learning tasks should be revised to provide all students equal opportunity and respond to diversity inside the classroom. Inclusivity must be integrated into modules to expose prospective teachers to functions that support diversity in the school [26].

Despite the physical absence of the teacher in the teaching and learning process, students can significantly learn and improve when using the ASL 2 module. The most essential characteristic of the module is that the learning material is developed based on the UDL. The UDL is a framework to improve and optimize teaching and learning for all students based on scientific insights into how humans learn [16]. Several researchers have concluded that using UDL in the classroom can significantly improve student learning. A meta-analysis conducted by Ok et al. [28] revealed that UDL-based instruction can increase engagement and access and improve students' academic and social outcomes. The UDL follows three fundamental principles: (1) Engagement, (2) representation, and (3) action & expression. The affective traits of the students are crucial elements of learning. With diverse students' affective characteristics, they differ markedly in how they can be engaged or motivated to learn. In these modules, an important feature is the provision of multiple and varied learning activities for engagement. These enable students with different learning styles and preferences to be highly engaged. They also have opportunities to work individually and in groups.

Moreover, salient learning targets are appropriately communicated, and opportunities for self-assessment and reflection are provided. Engagement is crucial to student learning and satisfaction in online courses [29,30]. Banna et al. [31] stressed that engagement is the critical solution to the issue of learner isolation, dropout, retention, and graduation rate in online learning. Moreover, students differ in how they perceive and comprehend information; thus, delivering a single means of representation cannot guarantee learning for all students. The self-learning modules provide options for representation. Pictures, tables, videos, graphs, and others are provided for students to grasp information quicker or more efficiently and make connections within and between concepts. The presentation of contents through multimedia can stimulate multiple students' senses at a time and enable more interaction between students and teachers. Thus, the variation of information representation is paramount in teaching [32]. Teachers can meet the needs of diverse learners via the recognition network through multiple means of representation [33].

Students differ in navigating a learning environment and expressing what they know. Hence, no means of action and expression will be optimal for all. Providing options for action and expression is essential in self-learning modules. Students can demonstrate and express learning through various activities, modalities, and tools. Teachers can meet the needs of learners by allowing students to demonstrate their knowledge through different methods, known as multiple means of action and expression [33,34]. Another factor that may improve students' performance while using the self-learning modules is incorporating technology into the teaching and learning process. When used appropriately, technology, mainly ICT, dramatically affects the quality of education. It increases the diversity of engagement, representation, and action and expression options. Using UDL in instruction coupled with technology significantly improves students' comprehension skills [35].

The perceptions of the students on the ASL 2 module are satisfactory. Modular learning enhances educational quality by providing preservice teachers with skills essential for 21st-century education [36,37]. By integrating the OBE process while implementing the module, learning is

improved, and knowledge transfer is evident [23]. The crafted module embedded activities that can be accessed online, providing more information sources to help them learn the subject. This process makes them engaged as they self-direct their learning. Technology use and integration in module development paved the way to more engaging and self-directed learning as learners learn remotely [38,39,59]. The preservice teachers have highly perceived the technology-embedded learning activities to promote their learning because technology has supported the content and understanding of the concepts. Therefore, the module has integrated not only the technological aspect but also the pedagogical and content aspects. This causes the module to be compliant with the TPACK. Learning materials, such as modules, appropriately integrated with TPACK features and principles can yield positive results among preservice teachers [40]. Modules based on TPACK sustain independent learning that facilitates various learning experiences, making these materials valid, practical, and effective during remote learning [41].

The module includes learning tasks that can be done anytime and anywhere, providing flexibility in the learning process. Flexible learning using the modules has equivalent efficacy to conventional face-to-face classes [42]. When activities become flexible, preservice teachers are given optimal opportunities to learn and address concerns of distance and time [43]. The students also highlighted that the learning activities in the module encouraged varied ways of action and expression, reflecting individual differences among the preservice teachers. In this way, the diverse capabilities of the preservice teachers were considered, and options were made available to suit their needs. The evident integration of UDL creates activities that are inclusive for all learners, giving them more learning opportunities that are engaging and relevant to them [44]. Materials with UDL support accessibility and inclusivity among learners and could lead to positive learning outcomes [45,46].

In addition, the language used is gender-neutral, and the activities benefit all preservice teachers' learning. To establish gender sensitivity and awareness in the classroom, instructional materials should also be gender equal, responsive, and fair, as found in the texts, pictures, and symbols [47]. The crafted module addresses gender sensitivity and awareness, which is appropriate for integrating gender equality in education [48]. Aside from gender sensitivity, the preservice teachers also highly observed diversity and inclusivity in the module. They perceived that the learning activities provided them with equal opportunities and diverse ways of learning. This means the preservice teachers were given learning experiences to adhere to diversity and inclusion. When diversity and inclusion are embedded in instructional materials, such as modules, students find accomplishing the activities accessible and confidently demonstrate their learning [49].

Considering their gadgets and internet connectivity at home, the time allotted for each activity is enough for them to accomplish. Self-learning modules should be organized well regarding lesson flow and time allotment. This characteristic of the modules improves the quality of the material's friendliness so that learners study and complete the tasks embedded [50]. This learner-friendly structure is deemed to promote holistic learning [51].

The preservice teachers also had high satisfaction with the ASL 2 module in terms of the capability of the module to lead them in independent, self-regulated, and engaging learning. This indicates that the activities embedded in the module provide mechanisms for them to study on their own and self-regulated what, where, and when to accomplish the tasks. While they self-direct themselves, they are also provided opportunities to engage in learning actively. True to its name, self-learning modules are made for self-paced and self-directed learning, where independent and engaging learning is evident. These modules can improve knowledge acquisition, skills development,

and attitude inculcation as the learners go through self-directed learning [52]. Self-learning modules are worth using, particularly for flexible learning [53,54].

Most importantly, the preservice teachers were satisfied with how the module enabled them to attain the maximum learning competencies of the course. This means that while they learn independently, they have derived optimal learning, as is evident in attaining curriculum standards beyond the minimum. Therefore, the ASL module is valid and effective based on the students' perceptions. Self-learning modules have improved learning, as shown in [50–54] studies, making the module applicable to flexible learning.

The feedback indicates that the preservice teachers have positive perceptions and experiences using the ASL 2 module. Their feedback shows the learning advantage of the module during the pandemic and the pedagogical edge on the teachers' side [58,60]. Self-learning modules should be of quality in terms of their format, structure, and content and how these instructional materials provide meaningful experiences to the learners. Informative, relevant, and accessible self-learning modules are essential for learning [55]. Moreover, modules that challenge learners could lead to better educational outcomes [50,51,56]. Furthermore, these materials improve the learning process, particularly during flexible learning [57].

6. Implications to modular instruction and self-learning

Considering students' various needs and preferences, effective and efficient modular education and self-learning resources should be created to promote autonomous and self-regulated learning. These modules accommodate a variety of learning styles, aptitudes, and speeds by providing a variety of means for students to interact with the material, demonstrate their comprehension, and communicate their knowledge. These materials are perfect for remote and flexible learning situations because of their flexibility, which guarantees that all students, regardless of their peculiarities, can access and interact with the information in ways that best suit their learning needs.

The modules should also clearly align the activities, evaluation techniques, and learning objectives. By directing students toward specified objectives, this alignment improves the coherence and concentration of the learning process and helps students achieve mastery of the material. Deeper engagement and comprehension are fostered by structured modules that clearly state learning objectives and offer pertinent, goal-oriented assignments that allow students to comprehend better the reason behind their learning activities and how to succeed.

To ensure the success of modular education, it is critical to regularly assess and improve these course materials in response to user input. The modules' quality and usefulness mainly depend on including varied and exciting activities, integrating suitable technology, and accessibility. These components increase the interaction and relevance of learning and allow students to take charge of their education, eventually improving the educational process's flexibility and responsiveness in various learning contexts.

7. Conclusion and recommendations

In conclusion, the Assessment in Learning 2 module adheres to the prescribed structure and format and follows OBE, TPACK, UDL, and inclusivity principles. It addresses the needs of preservice teachers, particularly during flexible learning modalities. The Math and Science preservice teachers shared challenging and positive feedback regarding their understanding of the

concepts of ASL 2. Therefore, the module is valid, practical, and effective for flexible STEM education.

Targeted interventions are suggested to improve these crucial evaluation skills for preservice teachers to address the minimal gains in Chapter 3 and the decline in Chapter 4. In Chapter 3, real-world exercises such as creating instruments for affective assessment and having thoughtful conversations about attitudes and values can improve the applicability and comprehension of affective assessment. Integrating practice with rubrics, feedback quality exercises, and statistical literacy seminars will assist equity and data-informed decision-making in Chapter 4, which deals with scoring, interpreting, and reporting assessment outcomes. With these focused enhancements, preservice teachers will gain the essential cognitive and analytical abilities required for successful classroom assessment.

While this study effectively demonstrates the ASL 2 module's potential in enhancing preservice teachers' learning, it is limited to the initial design, implementation, and evaluation phases within a single action research cycle. Rather than diminishing the module's efficacy, these limitations point to areas that require additional investigation and improvement. As we focused on specific performance outcomes, researchers should examine more profound cognitive, behavioral, and attitudinal effects over time to comprehend the module's long-term advantages. Furthermore, as the study was conducted in a single institution, the results may be more broadly applicable through translational research in different teacher education contexts, enabling the module to be tailored to different learner requirements and instructional contexts. Future research might evaluate the application of practical skills, behavioral engagement, and changes in teaching attitudes, which would improve our comprehension of how well the module prepares preservice teachers for the classroom.

Author contributions

V. T. M. Balo and J. M. P. Sanchez contributed equally to the conduct of this study.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in creating this article.

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Conflict of interest

The authors declare no conflict of interest in this paper.

Ethics declaration

The Research Ethics Committee of Cebu Normal University, Cebu City, Philippines, approved the data collection.

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