Developing a numeracy diagnostic assessment module for early primary students in the post COVID-19 pandemic

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Article Info	Abstract
	School closures due to the COVID-19 pandemic have resulted in learning loss in primary school students, so a diagnosis of the students' numeracy skills is urgently needed at the beginning of learning to adapt learning to students' average ability levels (teaching at the right levels). This study aimed to develop a module that can assist and become a reference for teachers in schools in diagnosing and mapping students' numeracy abilities at the beginning of learning. Therefore, this research was carried out following the procedures of research and development (R&D). Prior to implementation, the developed module was validated by two experts (media and material experts) with validation results in "very good" categories for each aspect of the material, layout, and graphics. The results of the study based on the teacher's response questionnaire indicate that the module developed is very helpful for the teachers in mapping students' numeracy abilities at the beginning of learning after the COVID-19 pandemic and provides an alternative follow-up to the results of students' numeracy assessments. Thus, the developed module is suitable for use as a reference in conducting assessments regarding early primary school students' numeracy. **Keywords:** diagnostic assessment module, early primary students, numeracy, post COVID-19 pandemic

INTRODUCTION

The Coronavirus Disease (COVID-19) pandemic that occurred from the end of 2019 until 2021 has had a significant impact on various sectors and the life of the global community. Education is one of the sectors affected by the spread of the virus, where most countries around the globe, including Indonesia, closed schools and other educational institutions. Through Circular Letter Number 4 of 2020 issued by the Ministry of Education and Culture of Indonesia regarding the implementation of education policies during the emergency period, the government closed schools and required the learning process from home (study from home) through online/ distance learning. This policy was an effort to continue providing a learning

experience for students, even though it is out of the school environment. Hence, the government did not burden teachers and students to fully complete all the competencies targeted within the national curriculum.

Such a policy taken during an emergency, in practice, certainly faced its challenges. First and foremost, both educators and students in general were not prepared for a learning system that switched from face-to-face to online (Donnelly & Patrinos, 2022; Middleton, 2020). This was because teachers as educators were used to teaching systems that involved direct interaction with students without going through digital intermediaries, while students had difficulties in concentrating or understanding lessons from home. Another notable challenge faced during distance learning is the fact that there is a significant gap in educational facilities or access to technology expected to help the learning process that becomes a barrier to create meaningful learning experiences for students (Andrew et al., 2020; Handayani, 2020). In other words, limited educational support facilities owned by teachers and students at home complicate the learning process because distance learning, in essence, is hugely dependent on the internet network and other supporting modern technologies. Lastly, although the contribution of parents in assisting their children in studying from home is crucial, not all parents are able to do so due to various reasons, such as parents' other responsibilities or work or a lack of motivation and skills in teaching children at home (Panaoura, 2020; Suswandari, 2022).

The complexity of the challenges faced during online/ distance learning is compounded by the fact that conditions like these have been going on for more than one academic year and are continuing today. The World Bank released that the potential impact of continuing school closures would result in learning loss among students (World Bank, 2020). The term learning loss refers to a condition in which general or specific loss of knowledge or skills is generally caused by discontinuities or long gaps in student education, so this term can also be interpreted as the opposite of academic progress (The Great Schools Partnership, 2013). Furthermore, learning loss can be defined as a condition where children's knowledge deteriorates or becomes progressively worse over time because the learning that students would have acquired during the normal school year had not occurred due to school closures (Angrist et al., 2021; Donnelly & Patrinos, 2022). Even though this term has become an issue that is being widely discussed in the world of education as the impact of the pandemic, in fact, it is not a term that has just emerged during the pandemic. For example, most public schools in Western countries such as the United States and the United Kingdom provide students with summer vacations of up to two and a half months. As a result, there is a learning loss among students during the summer holidays. This condition is commonly known as "summer learning loss" (Kerry & Davies, 1998; Shinwell & Defeyter, 2017). This term is also commonly used in cases of disrupted formal education as experienced by immigrant children, natural disasters, or global pandemics such as what previously happened (Andrabi et al., 2021; The Great Schools Partnership, 2013).
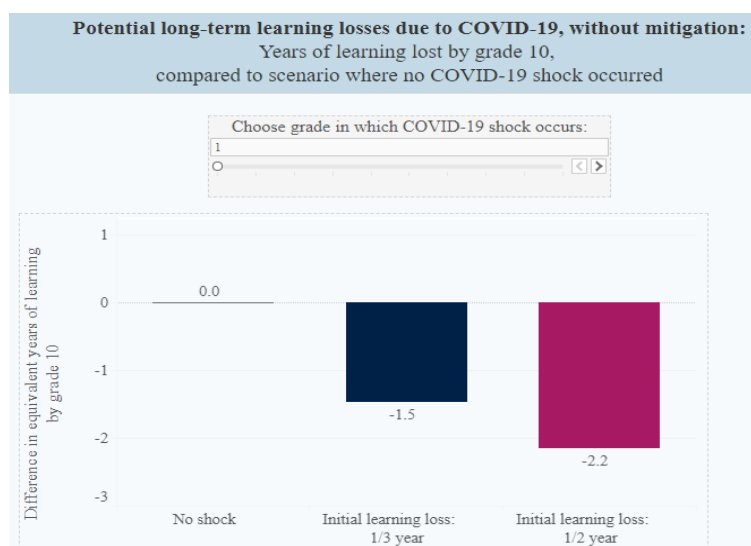
Figure 1. Potential Long-Term Learning Losses due to COVID-19

Figure 1 presents the potential for long-term learning loss to be more severe at lower grade levels in the context of school closures due to the COVID-19 pandemic as proposed by Belafi and Kaffenberger (2020). The purple bar in Figure 1 above shows that grade 1 elementary school students spending just 6 months of study potentially could be left behind by 2.2 years of study. Therefore, mitigation of potential learning loss is needed to prevent further impacts. Assessment of student learning levels is one of the first steps in reducing the risk of learning loss phenomena (Andrabi et al., 2021; Belafi & Kaffenberger, 2020). This aims to ensure the level of student's knowledge and skills as a prerequisite for use at a higher grade level. The Minister of Education and Culture of the Republic of Indonesia, Nadiem Makarim, stated that the permanent impact of this learning loss occurred especially for generations at a younger education level.

Numeracy is basic knowledge and skills that are taught to students starting from the early childhood education level as the foundation for advanced learning. Mathematics and numeracy are linked but not the same. Numeracy is also referred to as mathematical literacy in numerous sources (Haara et al., 2017; Jain & Rogers, 2019; Pratiwi et al., 2021). While mathematical progress is characterized by increasing abstraction, numeracy practice is firmly rooted in making sense of real-world settings (Gal et al., 2020; Ghazali, 2020; Goos & O'Sullivan, 2022). In other words, numeracy refers to the ability to understand and work with numbers and mathematical concepts, yet it goes beyond basic arithmetic skills and involves a broader set of competencies related to quantitative reasoning and problem-solving. Numeracy encompasses a range of mathematical skills and understanding that are essential for functioning effectively in everyday life, as well as for success in various academic and professional pursuits. Goos et al. (2020) stated that global education systems recognize the importance of numeracy as an essential goal of schooling because inadequate numeracy skills are known to limit an individual's life opportunities as well as national economic and social progress.

However, some recent research has shown that the COVID-19 pandemic has caused learning loss, particularly greater in numerical skills of various elementary school students (UNESCO, 2021; Contini et al., 2022; Barumbun & Salim, 2023). In other words, students at the same level of education do not necessarily have the same level of learning achievement.

Therefore, a diagnostic assessment is crucially needed at the beginning of learning to determine the level of learning achievement, especially students' numeracy skills, including students' obstacles and weaknesses during learning from home that is less effective. The results of the assessment become a source of information for teachers in determining the appropriate treatment or strategy according to each student's level of numeracy ability. In addition, the results of the assessment can also be a reference for teachers in providing remedial or enrichment as a follow-up effort to ensure that no students are left behind. In reality, the Indonesian government has released a number of diagnostic assessment modules, one of which is specifically designed to evaluate the mathematical competencies of only third-grade children. However, relatively little research has been done on developing and evaluating diagnostic evaluation tools for early elementary school students' mathematical proficiency. For this reason, teachers must be independently able to create diagnostic tests on their own in practice. The gap in this research, therefore, lies in the absence of tailored assessment tools that specifically address the unique challenges and changes in learning environments brought about by the pandemic. While existing studies on numeracy assessments may offer insights, they often overlook the distinctive post-pandemic context and the impact of prolonged disruptions on early primary students' numeracy development. The novelty of this research is in its dedication to crafting a diagnostic module that not only considers the aftermath of COVID-19 on education but also addresses potential learning loss and adapts to the evolving needs of students and educators in the post-pandemic era. This novel approach ensures a comprehensive and contextually relevant tool for assessing and enhancing early numeracy skills.

This study aimed to develop a module that could assist and become a reference for teachers in schools in diagnosing and mapping students' numeracy abilities. It is expected that the developed module will be able to be used by elementary school teachers in North Kalimantan, as well as in Indonesia in general, in mapping students' numeracy abilities, so that teachers know the level of ability of each student and provide learning according to that level which is commonly known as teaching at the right level.

RESEARCH METHOD

The method used in carrying out this research follows the flow of research and development method. This type of research is a process or method used in developing and validating a product design. The product researched and developed through this research is the diagnostic assessment module for the numeracy skills of early elementary school students. The research and development steps were carried out using the research and development model from Borg & Gall (1983) which consists of 10 main stages which are summarized in Figure 2 below.
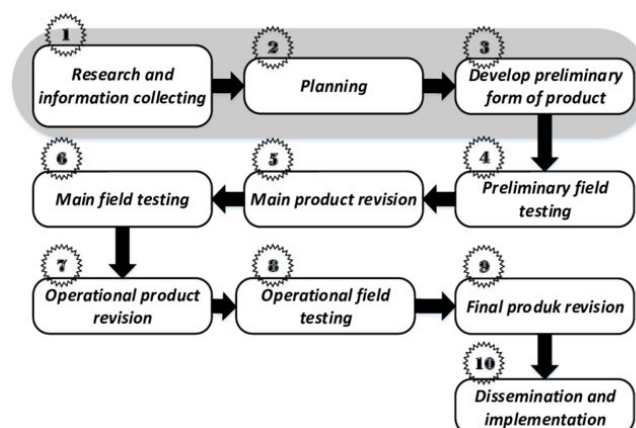
Figure 2. Research and Development Procedures Borg & Gall (1983)

Figure 2 outlines the steps of research and development. They consist of research and information collecting, planning, developing a preliminary form of product, preliminary field testing, main product revision, main field testing, operational product revision, operational field testing, final product revision, and dissemination and implementation. Research and data collection is the first stage. It was carried out by collecting data through interviews to analyze teacher's needs related to diagnostic assessments at the beginning of learning, in addition to conducting literature and curriculum reviews at the early elementary school grade level. The results of the need analysis and review of the literature and curriculum became the initial source of information in designing the student numeration ability assessment module would be designed. In planning, the initial data that had been collected were used as a reference in preparing the product plan, namely the diagnostic assessment module. This planning activity concerned with the parts that would be contained in the module including the form of student numeration assessment that would be designed.

The third step is developing a preliminary form of the product. In this step, the draft of the assessment module product included administrative parts such as the main cover of the module, preface, and table of contents, as well as main parts consisting of the numerical assessment grid at each level, assessment questions, answer keys, and guidelines for coding as well as interpretation and follow-up for each possible student answer. Subsequently, this module draft was given to two different experts to be validated. They assessed whether the module design met the feasibility criteria on aspects, such as content, layout, and graphic design. After the validation, the draft of the product was revised based on the feedback in the form of suggestions and criticisms obtained from the experts. Then the product that had been validated and revised was tested on a limited and direct basis in schools that were willing to be involved. The assessment module was given to teachers to use as a guide in providing diagnostic assessments of students' numeracy abilities. Questionnaires related to teacher responses regarding the module were collected as evaluation material for the module that had been developed.

Based on the results of product trials in the field, if the teacher's responses say that this product is interesting and very useful, it can be said that this product has been developed to produce the final product. However, if the product is not perfect, the results of this trial are used as material for improvement and refinement of the product made, so that the final product can be produced in the form of a diagnostic assessment module for students' numeracy abilities that

is feasible to use. In this case, the operational product revision, operational field testing, and final product revision were done. Finally, in the dissemination and implementation step, the product in the form of a diagnostic assessment module for the numeracy skills of early primary school students which had gone through the series of stages above was ready for mass production and disseminated as a reference material for primary school teachers in mapping students' numeracy abilities, especially after the COVID-19 pandemic. This module can also be used at the beginning of a new school year to determine the level of attainment of the mathematics competence of early grades of primary school students.

This development research collects data related to the teacher's needs, the feasibility of the module being developed as well as data related to teacher responses to the diagnostic assessment module being developed. The data regarding teacher's needs were collected through interviews. Additionally, the substance or content, layout, and visual design components of the media being developed can be used to determine its feasibility (Oktaviah et al., 2023). Data related to the feasibility of the module was collected through validation by two experts who filled out the validation sheet. This validation sheet used the Likert Scale (ranging from 1 to 5) to measure each aspect. Similarly, data related to teacher responses to the modules developed was collected using a 20-statement questionnaire containing aspects regarding the level of practicality and effectiveness in using the modules in the classroom that also used a Likert scale (from 1 to 5). This questionnaire was used during the preliminary field testing as well as main field testing.

The data collected through validation by experts and questionnaires were then analyzed following the descriptive quantitative approach using Ms. Excel. Analysis of the validation sheet from the respective experts as well as responses from the teacher on the module being developed was calculated using the following formula adapted from Haka et al. (2020) and categorized into the feasibility criteria.

FINDINGS AND DISCUSSION

This development research produced the final product in the form of a diagnostic assessment module for the numeracy skills of early elementary school students. Through an initial study related to the analysis of teacher needs at the beginning of learning after the COVID-19 pandemic, it was found that teachers faced obstacles in teaching materials according to the curriculum due to the varying levels of students' numeracy skills. Therefore, a diagnostic assessment related to students' numeracy abilities at the beginning of learning is crucially needed. However, the teachers' difficulty in understanding and carrying out appropriate assessments is an evident obstacle. This fact became the reason for designing a numeracy assessment module for early-grade students in elementary schools. The assessment module contains information related to the meaning of assessment and the importance of conducting an assessment at the beginning of learning after the COVID-19 pandemic; the stages in preparing and implementing the assessment; as well as the interpretation and follow-up of the assessment results.

The modules designed were then given to two experts to be validated regarding the aspects of material or content, layout, and graphic design. The validation results from experts are presented in Table 1.

Table 1. Expert Validation Results

Aspects	Expert 1	Expert 2	Average	Category
Content	87.5%	90%	88.75%	Very decent
Layout	88.3%	91.7%	90%	Very decent
Graphics design	88%	90%	89%	Very decent
Average	87.9%	90.6%	89.25%	Very decent

Table 1 shows the validation results from the two experts. The assessment module developed in general shows very good criteria for each aspect assessed including the material, presentation, and graphic aspects. Even though the results of the expert validation of the assessment module that was developed showed very good results, there were some suggestions for improvement from the experts for module revisions, such as adjustments to typography and font size used and some minor errors in writing words or sentences.

The revised module based on suggestions from the experts was then tested on a limited basis at an elementary school in North Kalimantan involving 1 classroom teacher who was the teacher of a grade 2 class. The developed module was given to the teacher. Then the teacher gave the assessment provided in the module to 25 students and interpreted the results of students' ability diagnosis using the guidelines provided in the module. This preliminary field trial produced data on teacher responses to the developed module in terms of practicality and effectiveness through a questionnaire. Table 2 is the summary of the results of the teacher's response to the developed module which was collected through the questionnaire.

Table 2. Results of the Teacher's Response to the Developed Module in the Preliminary Trial

Aspects	Average	Category
Practicality	87.5%	Very good
Effectiveness	80%	Very good
Average	83.75%	Very good

Table 2 above indicates that the developed module for diagnosing students' numeracy skills is in a very good category in terms of the level of practicality and effectiveness. In addition, the teacher responded very positively to the design of the assessment module that was developed and admitted by the teacher that she has had difficulties in preparing assessments because most teachers at the school had never conducted a written diagnostic assessment at the beginning of learning. The notes from the teacher regarding the modules developed at the preliminary field testing included the need to adjust the assessment sheets on the modules into worksheets that were ready to be filled out by students, so the teacher only needed to copy the sheets and distribute them to the students at the beginning of learning. Product revisions were made again after this preliminary trial. The revised module is then piloted for full use in the school. Figure 3 below shows sheets of the assessment modules that had been developed and implemented.

Figure 3. The Diagnostic Assessment Module

Figure 3 above contains the sheets of the diagnostic assessment module developed. The implementation of the developed product in the form of an assessment module for diagnosing students' numeracy skills was carried out at a public primary school in North Kalimantan involving two teachers who were Grade 1 and Grade 2 classroom teachers respectively. The teachers and classes that participated in this implementation stage were different from the ones participating in the previous preliminary trial stage. This was done with the aim that the research results were not biased. In the implementation stage, teachers were given modules that had been developed and they used them to design, modify, and fully use the diagnostic assessment tool for early-grade students' numeracy abilities. The instrument for diagnosing numeracy skills in this module was designed, so that the main objective of implementing an assessment at the beginning of the learning could be achieved which was to identify or specifically highlight the weaknesses and strengths of students both individually and in groups so that interventions can be designed to enable teachers to prepare lessons in the best way possible by taking into account the abilities of students (Hattie et al., 2015) After carrying out the assessment, the teachers interpret or maps students' numeracy skills according to their level. Assessment of student learning levels is one of the first steps in reducing the risk of learning loss phenomena (Kaffenberger, 2021). The COVID-19 pandemic lasting for approximately 2 academic years had an impact on the varying levels of numeracy skills of each student.

The results of the assessment become a reference for teachers in carrying out teaching according to the average level of student's numeracy abilities. This learning approach is closely related to the differentiated learning approach which provides opportunities for students to learn based on their level of ability (teaching at the right level). These two things are the approach applied in the current curriculum implemented in Indonesia, *Kurikulum Merdeka* (Cahyono, 2022; Mariati et al., 2021).
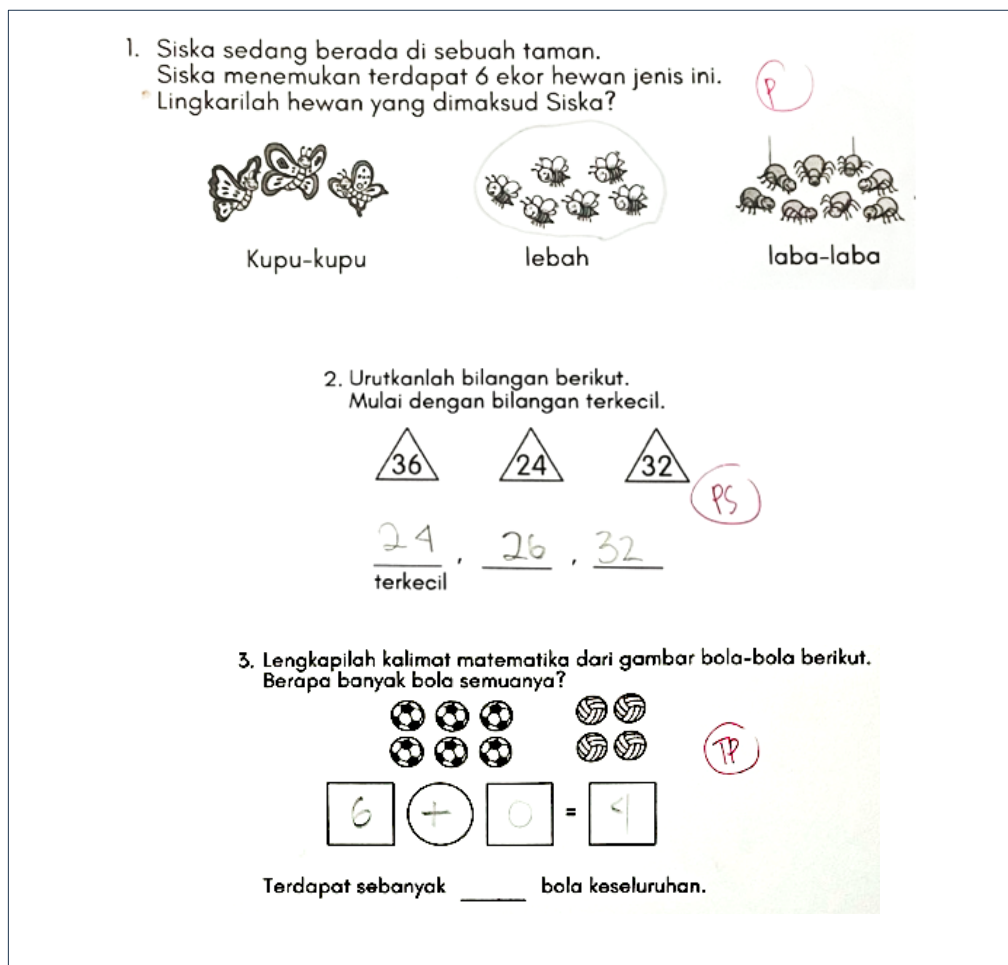
Figure 4. Snippets from Students' Answers Sheets along with Teachers' Coding (Red Marks) on Each Response

After implementing the product developed as illustrated in Figure 4 above, the teachers were asked to respond to the developed module in terms of practicality and effectiveness by filling out a questionnaire. The summary of the results of the teacher's response questionnaire to the assessment module at the implementation stage is presented in Table 3.

Table 3. Results of the Teacher's Response to the Developed Module in the Main Field Testing

Aspects	Teacher 1	Teacher 2	Average	Category
Practicality	90%	87.5%	88.75%	Very good
Effectiveness	95%	92.5%	93.75%	Very good
Average	92.5%	90%	83.75%	Very good

The results of the teacher's response questionnaire show that the diagnostic assessment module developed is feasible to use because of its very good practicality and effectiveness. Furthermore, the teachers gave very positive responses to the module for assessing the numeracy abilities of early-grade students because the teachers did not understand the importance of conducting an assessment at the beginning of learning. The diagnostic assessment has a very crucial role as a means of gathering authentic evidence regarding students' knowledge, skills, and understanding (Forster, 2009) because just like when students

first enter formal education, students returning to school after the COVID-19 pandemic started school with experience, understanding, and prior knowledge that were very different and there was significant variation regarding the development of literacy and numeracy (Hattie et al., 2015).

Interruptions to children's education in the form of closing schools for quite a long time as during the COVID-19 pandemic, not only cause stagnation but also degradation in children's academic development (Engzell et al., 2021; Gore et al., 2021; Pier et al., 2021). The impact of learning loss due to COVID-19 does not only occur as long as children are absent from school but even continues to occur when children return to school on a larger and even permanent scale, if not handled swiftly and seriously (Kaffenberger, 2021). Therefore, teachers are expected to be able to mitigate this problem by identifying students' abilities as soon as possible, especially the numeracy abilities of elementary school students at the beginning of learning (Lake & Olson, 2020). It is hoped that the presence of the assessment module designed will be able to provide elementary school teachers with an understanding of the diagnostic assessment of numeracy skills and the procedures for assessing no further what teachers need to do based on the results of the assessment.

Developing a numeracy diagnostic assessment module for early primary students in the post-COVID-19 pandemic is a valuable and timely research initiative that brings several key novelties to the field of education and assessment. First, this research is timely as it addresses the unique educational challenges posed by the COVID-19 pandemic. The pandemic disrupted traditional learning environments and highlighted the need for innovative assessment tools to gauge and address learning gaps that may have arisen during remote or hybrid learning. Besides, this research narrows its focus to numeracy which is foundational for a child's future academic success, recognizing its importance in early childhood education and setting a strong foundation for future mathematical and problem-solving abilities. Furthermore, the diagnostic approach that was highlighted in this study implies that the module developed goes beyond traditional assessment by pinpointing specific areas of strength and weakness in a student's numeracy skills. This personalized approach can inform targeted interventions and instructional strategies, making it a valuable tool for educators.

Given the uncertainties surrounding educational environments in the post-pandemic, an adaptable assessment module could be particularly valuable. If this module can be administered in various settings (e.g., in-person, remote, or hybrid), it would add an extra layer of flexibility for educators and researchers. Beyond its practical applications, this research can contribute to the broader body of knowledge in education and assessment. Novel assessment tools and methodologies can pave the way for further research in the field, potentially influencing education policy and practices. Lastly, this research has pedagogical implications by highlighting effective teaching strategies or interventions for addressing numeracy challenges in early primary school students. This information can be valuable for educators and curriculum developers. In short, the novelty of this research lies in its specific focus on early primary students, the emphasis on numeracy skills, the diagnostic nature of the assessment module, and its potential adaptability and integration of technology in the post-COVID-19 educational

landscape. These aspects make this research a significant contribution to the field of education and assessment.

CONCLUSION

This current study developed an educational product in the form of an assessment module for diagnosing the numeracy skills of early elementary school students which was conducted by following the research and development (R&D) procedures by Borg and Gall. A series of stages in developing this product was carried out to produce an assessment module that is suitable and feasible for use in terms of its practicality and effectiveness. The results of this study indicate that the developed assessment module meets the feasible criteria of practicality and effectiveness. Therefore, the presence of this assessment module is expected to be an answer and solution to teachers' difficulties in understanding and carrying out a diagnostic assessment of students' numeracy abilities at the beginning of learning. Teachers are also expected to be able to use the module as a reference in designing their assessments and other important tools in learning. The research faced limitations in terms of the generalizability of the developed module, as the post-COVID-19 educational landscape varies significantly across regions and contexts, making it challenging to create a universally applicable tool. This research also encountered challenges in accurately assessing non-numeracy factors, such as social and emotional development, which are integral to early primary education but might not be adequately addressed within a numeracy-focused assessment module.

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