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Development of Mathematics Interactive E-Worksheet

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Abstract: Technology integration has become essential in the rapidly evolving landscape of education of the 21st century. Moreover, the aftermath of the Covid-19 pandemic has accelerated the adoption of digital tools in learning. This article explores the development of interactive e-worksheets in mathematics education using the Wizer.me platform. In Indonesia, the Merdeka Belajar curriculum emphasises digital technology as a fundamental aspect of addressing accessibility, quality, and equality in education. The developed e-worksheets are designed to enhance the traditional worksheet experience by transforming it into an interactive, engaging, and contemporary format. The advantages include cost savings, environmental friendliness, and combining multimedia elements such as videos and animations to boost student motivation. The study investigates the necessity of digitally accessible learning activities, aligning with the demands of future educational needs. Focusing on fractions as a challenging topic for students, this study uses the 4D model (Define, Design, Develop, Disseminate) as the Research and Development (R&D) model. The Wizer.me platform is employed for its user-friendly interface, varied question types, and integrated Google Classroom. The validation process involves expert judgment from mathematics educators and practical testing among junior high school students. The findings indicate that the developed interactive e-worksheets are valid and practical, receiving positive student responses during the limited trial. The article reveals the importance of innovative learning materials and suggests that teachers leverage technology to create engaging and accessible content, fostering a more dynamic learning environment. The study recommends the widespread adoption of interactive e-worksheets to enhance students' motivation and comprehension, particularly in challenging mathematical concepts like fractions.

Keywords: E-Worksheet, Fraction, Mathematics, Technology

Introduction

Technology as a learning tool has become an essential aspect of education in today’s digital age, which is known as the 21st century's demands. The lesson learned from the Covid-19 pandemic is the accelerating use of technology and digital frameworks in education. The use of digital technology in learning is one of the basic infrastructure requirements of the Merdeka Belajar curriculum in Indonesia. It is positioned to significantly

enhance access, quality, and social justice within the education sector. Jupri (2018) mentions that technology in the learning process, especially mathematics, is an important topic that requires discussion and implementation since it ensures easy access to education and offers flexibility to engage learners of all types (Gadelha, 2018). It has made education more accessible, efficient, and effective (Ilyas et al., 2023). Incorporating technology into the learning process also improves students' motivation, significantly enhancing their willingness to participate in learning activities (Cóndor-Herrera et al., 2021).

In technological and digital development, printed worksheets are increasingly being phased out. This shift is driven by the higher costs associated with printing and the increased time required for teachers to assess students' work manually. It is in line with Balla (2023) claims of which modern technologies have made education less expensive for students. With technology, printed worksheets can be transformed into interactive e-worksheets that are more engaging and interesting to enhance students' innovation and creativity. In addition, teachers can insert various videos, animations, audio, and other interesting images to raise student's motivation and comprehension. Interactive e-worksheets can be accessed by students using a computer or smartphone. It agrees with the opinion of Haryanto et al. (2020) on the current need for learning activities that are digitally or internet-based accessible.

E-worksheets serve as valuable tools in teaching and learning, fostering effective interactions between students and teachers and boosting student engagement to enhance learning outcomes (Haryanto et al., 2020) These digital resources support and facilitate learning activities, aligning with contemporary educational goals that encourage students to take a proactive approach in addressing material-related challenges. Interactive e-worksheets offer a solution to deepen students' understanding of specific subjects (Choo et al., 2011). Typically, an e-worksheet comprises sections like a title, study guides, learning competencies, basic competencies, supporting information, assignments, and assessments. Consistent with this structure, Mohammad et al. (2019) note that e-worksheets provide detailed descriptions of materials, assignments, and related exercises. The adoption of e-worksheets offers several advantages, including space and time efficiency, environmental sustainability due to reduced paper and ink usage, adjustable font sizes in digital formats, and cost-effectiveness. Numerous studies have highlighted the benefits of electronic worksheets in learning contexts, particularly in mathematics. Such tools have been shown to enhance student's critical thinking skills (Erna et al., 2021; Sujatmika et al., 2018), problem-solving abilities (Eriana et al., 2024; Mawaddah & Siswanto, 2022), and conceptual understanding of mathematical concepts, as well as promoting self-regulated learning practices among students (A'la et al., 2021; Indriani et al., 2021).

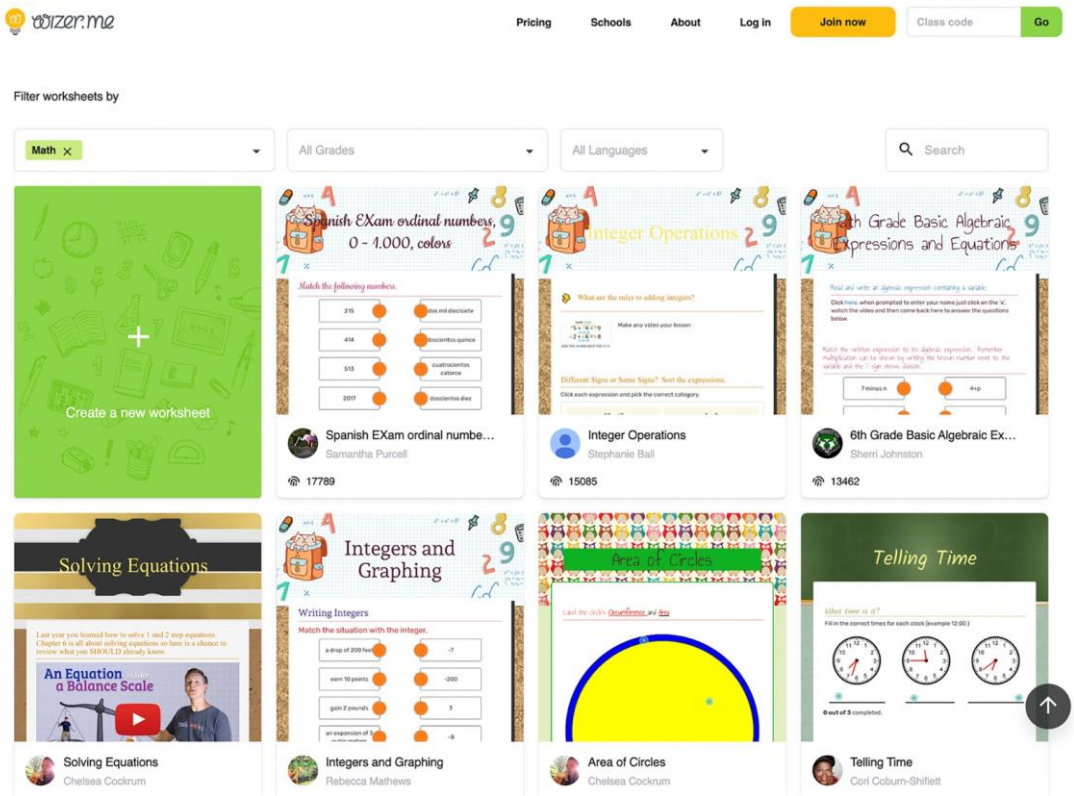

Figure 1. The overview of dashboard wizer.me

The integration of interactive e-worksheets in learning aims to shift students' perceptions of challenging materials, such as fractions in mathematics. A study conducted by A'la et al. (2021) in a school in Central Java revealed that only 45.36% of students were able to solve fraction-related problems, indicating a significant challenge in understanding this topic. This observation is further supported by research from Yeni et al. (2020), which identified common difficulties students face when solving fraction problems. These challenges include a lack of understanding of the questions, an inadequate grasp of mathematical concepts, and a reluctance to re-evaluate answers. Additionally, students encountered epistemological barriers, such as limited knowledge of basic fraction concepts and arithmetic operations, which impede their ability to solve fraction problems effectively (Hariyani et al., 2022). Given these challenges, this research aims to develop an interactive e-worksheet focused on fraction materials. The chosen platform for creating this electronic worksheet is wizer.me. Known for its user-friendly interface, wizer.me offers both free and premium services and is designed to facilitate online assignments. Accessible via smartphones, tablets, and computers, this platform allows teachers and students to engage with the content anytime, anywhere, without constraints of time or location. Below is an overview of the wizer.me interface from a teacher's login.

Kopniak (2018) mentions several advantages of the Wizer.me platform. Specifically, it offers many selections of question types, an attractive appearance, anytime & anywhere access, automatic provision of corrections and grading, and the ability to connect to the Google Classroom account. The following are the types of questions offered.

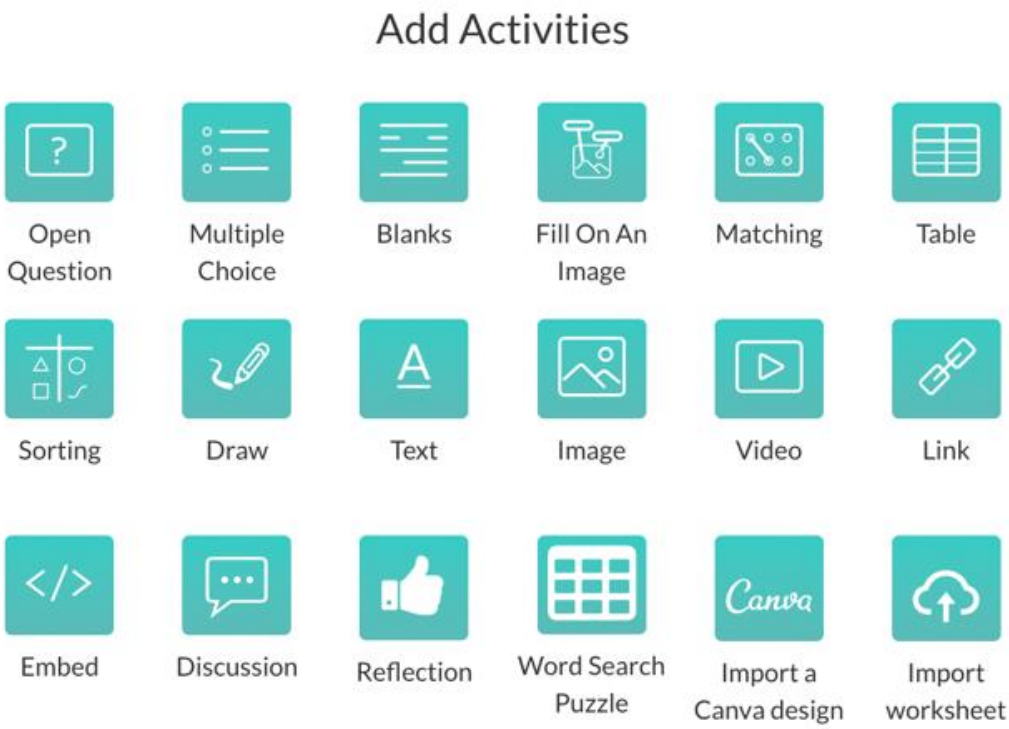

Figure 2. Some activities at wizer.me platform

The screenshot provided showcases the "Import Worksheet" feature on Wizer.me, enabling teachers to effortlessly upload existing question files or student worksheets, eliminating the need for manual retyping. Moreover, wizer.me offers integration with Canva, empowering teachers to design visually engaging electronic worksheets. This feature underscores the importance of teacher creativity, as highlighted by Kaliappen et al. (2021), who emphasised that the platform's comprehensive features allow educators to craft diverse and visually appealing questions for students. Furthermore, wizer.me facilitates interactive discussions between teachers and students. All participants can view and engage with questions and answers posted in the discussion section. This interactive feature fosters collaborative learning and enhances student engagement. Another significant advantage of wizer.me lies in its assessment capabilities. Teachers can provide real-time feedback, and students can respond and reflect on the feedback they receive. Feedback plays a crucial role in the learning process, influencing learning outcomes, motivating learners, and enhancing the overall educational experience (Bosc-Miné, 2014; Kalimullina, 2023). With the wizer.me platform, students are not required to download questions separately. Instead, they can directly access and work on the questions within the platform. The system automatically saves students' responses, alleviating concerns about losing work due to forgotten saves or internet connectivity issues.

Method

The study belongs to Research and Development (R&D). The development model referred to Thiagarajan's development theory, called the 4D model - Define, Design, Develop, Disseminate (Thiagarajan et al., 1974). The four stages are described as follows:

a. Define Stage: The activity of outlining the product and determining its specifications. The define stage is done through 1) Analysis of student characteristics and 2) material analysis.
b. Design Stage: This part contains the process of designing a given product. In the context of teaching material development, e-worksheet content is created based on curriculum and results from the analysis of teaching material.
c. Development Stage: The research phase comprises two distinct activities: expert judgment and practical testing. Expert judgment serves as a method to validate and assess the feasibility of the product design. Following the expert judgment, the subsequent step involves conducting a limited trial with junior high school students
d. Dissemination Stage: The dissemination phase involves sharing and distributing the tested products to benefit a wider audience. This phase ensures that the developed materials and findings from the research are made accessible and available to educators, students, and other stakeholders in the educational community, fostering broader impact and utilisation of the innovative teaching resources.

This article presents findings up to the development stage, focusing solely on the developmental outcomes. The research employed validation and practical questionnaires as its primary instruments. The validation questionnaire encompassed both media and content aspects. Product validation was conducted by four validators, comprising a mathematics teacher and three mathematics education lecturers. The validation data of the e-Worksheet were analysed using a percentage calculation, as shown in the following equation:

$$p = \frac{Average\ Score}{\sum Total}$$

The score (p) result is converted into a category that adapts from Ratumanan & Laurens (2011) as presented in Table 1.

Table 1. Validation score conversion

Interval Score Result of Assessment	Criteria
3,25<p<4.00	Very Valid
2,50<p<3.25	Valid
1,75<p<2.50	Less Valid
1,00<p<1,75	Invalid

Following the validation stage, a limited trial was conducted with junior high school students. After studying the material and completing the questions on the e-worksheet, students were asked to fill out a response questionnaire related to the developed e-worksheet. The response questionnaire was distributed as a Google Form, comprising nine statements with answer choices ranging from "Strongly Agree" to "Strongly Disagree." Subsequently, the questionnaire data was processed using the following formula:

$$NP = \frac{R}{SM}\ x\ 100\%$$

Information:
NP : The percent value expected R : Raw scores obtained by students SM : Maximum score

Table 2. Interactive E-worksheet practicality categories

Interval Score Result of Assessment	Criteria
86% - 100%	Very Good
75% - 85%	Good
60% - 74%	Enough
< 60%	Not Good

Furthermore, the categories of student responses to the interactive e-worksheet are based on the calculation of the final scores in the following Table 2:

Results and Discussion

The outcomes from each stage of the development of the interactive e-worksheet conducted are as follows:

Define Stage

The development stage comprised two phases: student analysis and material analysis. In the first phase, the student analysis revealed that most 7th-grade students had already grasped some foundational concepts, such as simple fractions and integers, before delving into the study of fractions. This prior knowledge proved crucial for their understanding of fractions. Drawing upon Piaget's theory (Hamilton & Ghatala, 1994) , students at this age typically attain a formal operational thinking stage. This means they can use logical reasoning about abstract concepts, showcasing more systematic, hypothetical, and scientific problem-solving abilities than concrete thinking. Regarding the learning environment, insights gathered from interviews with mathematics teachers indicated a predominant reliance on traditional teaching methods. E-worksheets were rarely incorporated into the teaching process, and the instructional approach was generally teacher-centric. The second phase focused on material analysis. The curriculum introduces whole numbers and fractions as the initial topics for 7th-grade students. Conversations with two math teachers from State Junior High School Rambah Samo highlighted the predominant use of textbooks for teaching fractions. Additionally, the limited availability of these textbooks within the school emphasised the need for alternative learning resources. Therefore, the development of interactive electronic worksheets emerges as a promising solution to supplement traditional teaching methods, aiming to enhance learning engagement and motivation among students.

Design Stage

In this stage, the researchers prepared the material on the student worksheet by adapting the materials available in books, including from the mathematics book of the Merdeka Curriculum. The prototype of interactive e-worksheets can be seen in the Figure 3:

Figure 3. The prototype of Interactive E-worksheet

Development Stage

The development stage aimed to produce student worksheets that experts had validated and revised. The experts consisted of two mathematics lecturers as media experts and two mathematics teachers as instructional material experts. The validation result of the interactive e-worksheet by the media expert can be seen in Table 3.

Table 3. The validation result of media expert

No	Aspect	Validator		Average of Each Aspect
		1	2	
1	Display	3,50	2,84	3,17
2	Ease of Use Aspects	4,00	3,33	3,67
3	Language Aspects	2,75	3,25	3,00
	Average			3,28
	Category			Very Valid

Based on Table 3, the assessment calculation for the three aspects yielded the following results: the Display aspect averaged 3.17, falling into the "valid" category; the Ease-of-Use aspect averaged 3.67, classifying it as "very valid"; and the Language aspect had an average of 3, also falling into the "valid" category. The overall average assessment stands at 3.28, categorising the interactive e-worksheet teaching materials as "very valid". It can be concluded that the interactive e-worksheet teaching materials, based on the validity tests conducted, are valid. These findings affirm that the developed interactive e-worksheet teaching materials are well-suited for instructional use, as presented in Table 4.

Table 4. The validation result of material expert

No	Aspect	Validator		Average of each aspect
		1	2	
1	Content Eligibility	3,50	3,25	3,37
2	Presentation	3,67	3,00	3,33
3	Language content	4,00	3,00	3,50
	Average			3,40
	Category			Very Valid

Table 4 shows the calculation of 3 aspects of the assessment: the Content Eligibility aspect averaged 3.37, falling into the "very valid" category; the Presentation Feasibility aspect averaged 3.33, also categorised as "very valid"; and the Language aspect had an average of 3.5, further confirming its classification as "very valid". Based on these results, it can be concluded that the interactive e-worksheet teaching materials, as determined by the validity tests, are valid. Following the expert judgment stage, the subsequent phase involved a limited trial. The interactive e-worksheet was administered to 12 junior high school students. The results of their responses to the developed e-worksheet are as follows:

Table 5. The result of limited trial

No	Aspects	Percentage
1	The display of e-worksheet is interesting	85
2	E-worksheets are easy to access and run	73
3	The types of questions in the e-worksheets are varied and exciting so it challenges me to solve it	81
4	The video explanation in the e-worksheet material is interesting and helps me to comprehend fraction material	77
5	The sentences and paragraphs used in the e-worksheets are clear and understandable	75
6	The language used in the e-worksheets is simple and understandable	77
7	The questions presented in the e-worksheets are related to daily life	71
8	The image illustrations used in the e-worksheets are appropriate and interesting	75
9	Using interactive e-worksheets on fraction problems is not boring	79
	Average	77
	Category	Good

Based on Table 5, the students' opinions regarding the developed e-worksheet predominantly fall into the "good" category. Before commencing teaching, it is essential for educators to prepare the necessary teaching materials. Teachers should aim to design learning experiences that align with the stated educational objectives (Sapta et al., 2018). Teaching materials serve as the instruments educators utilize to effectively manage the

teaching and learning process, contributing to improved student outcomes (Olayinka, 2016). During the initial stages of this research, it was observed that the teaching and learning processes predominantly relied on textbooks, with limited incorporation of technology in mathematics education. Additionally, traditional teaching methods were commonly employed. Such an approach may lead to monotonous learning experiences and suboptimal student outcomes. Hence, educators need to innovate their teaching methodologies beyond textbook-centric approaches (Sari et al., 2019; Siagian et al., 2019). Teachers can introduce innovative teaching models tailored to the subject matter and students' needs, such as STEM, PBL, and PjBL, among others. Leveraging technology to develop teaching materials, like modules, books, and worksheets, can enhance student accessibility. This technological integration ensures that educational resources are easily accessible across various platforms, including computers, tablets, and smartphones.

Mastering fractions is undeniably a fundamental skill for future success in mathematics. Teachers play a pivotal role in guiding students through the intricacies of learning fractions. Incorporating Information and Communication Technology (ICT) in the educational process can significantly enhance this learning experience. Utilising ICT in mathematics education enables students to engage with technology-driven tools to explore concepts related to numbers, geometry, problem-solving, and data analysis (Sivakova et al., 2017). As highlighted by Tomljenović and Zovko (2016), the integration of ICT in classrooms can lead to improved learning outcomes and knowledge acquisition. How teachers contextualize and convey fraction concepts to their students significantly influences the depth and quality of their understanding.

Worksheets serve as valuable tools to assist students in identifying and comprehending essential mathematical concepts (Amalia et al., 2018). In this context, an interactive e-worksheet was meticulously crafted by aligning it with competency standards, essential competencies, and learning objectives about fractions. The e-worksheet is structured to include an introduction, online source materials, a set of questions, a discussion section, and a reflection component. To enrich the learning experience, the source materials are supplemented with educational videos sourced from YouTube and an e-book based on Curriculum 2013 and the Merdeka Curriculum. During the development stage, valuable feedback was obtained from both media and material experts. These insights and recommendations are instrumental in refining and enhancing the quality of the developed e-worksheet, ensuring its effectiveness and relevance in facilitating comprehensive learning experiences for students.

Conclusion

Based on the results and discussion presented, it can be concluded that the interactive e-worksheet teaching materials have been validated and proven to be both valid and practical through the calculation of the validity and limited trial tests. This indicates that the interactive e-worksheet teaching materials are innovative and serve as practical, effective, and efficient learning tools for mathematics. As such, they are well-positioned to be embraced by students and integrated into mathematics education. Implementing interactive e-worksheets is expected to bolster students' learning motivation, particularly in the challenging area of fractions. It is therefore recommended that educators leverage these technological resources to enhance their students' learning experience and outcomes. By doing so, students will become more adept at utilising computers, laptops, and smartphones, broadening their perspectives and understanding of the subject matter. One limitation of this study is the reliance on instructional videos sourced from YouTube. For future research endeavours, it is advisable to create custom videos tailored to align with the specific content and learning objectives of the e-worksheets to ensure greater coherence and relevance in the instructional materials.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

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