Designing computer-based fraction worksheets for junior high school

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Abstract. In mathematics learning, the use of student activity worksheets is still limited. In addition, the use of computers as one of the media for learning mathematics is still very minimal. The concept of fractions, as one of mathematics subjects, is quite complex but fundamental to be mastered by students. The purpose of this study was to develop valid, practical, and effective computer-based worksheets on the topic of fractions for grade 7 junior high school. This study used modified 4-D research development model. The result showed that the students responded positively towards the implementation of the computer-based student activity worksheets. Therefore, the computer-based worksheets can be useful in mathematics learning, especially on the topic of fractions.

1. Introduction
Mathematics plays an important role in various disciplines and human life in general. Learning mathematics aims to connect knowledge learned at schools to everyday life, provide skills acquisition, prepare students for their future, and cultivate mathematical thinking [1]. Mathematics is often considered to be the most difficult subject, boring and unrelated to everyday life. The concept of fractions is one of mathematics subjects that many students find to be difficult. Fractions have been taught since elementary to junior high school level, but many junior high school students and college students cannot solve fractional problem seven though fractions are very closely related to everyday life. Empson and Levi argued that "the study of fractions of algebra on the fundamental mathematical relationships that constitute the core of algebra ... [that] govern how addition, subtraction, multiplication, and division work in algebra as well as arithmetic" [2]. More broadly, fractions applications is useful in various professions, such as in the field of medicine for example in determining the level of drug delivery; pilots need fractions in reading the direction of a flight radar; traders use fractions in calculating the percentage of profit or loss; and farmers use fractions in determining the appropriate fertilizer for maximum plant growth.

The Delors' Report marked the beginning of UNESCO's 21st-century learning competencies which include learning to live together, forming the four pillars of learning [3]. Teachers need to be aware of the four pillars of education in the current era of globalization. Teachers as learning agents need to master and apply information and communication technology (ICT) in the learning of mathematics at school. The National Council of Teachers of Mathematics argues that technology is an important tool for teaching and learning mathematics. Viewed as an integrated part of learning tools, technology can broaden the scope of course material that students can learn and can expand their knowledge [4].
The implementation of technology in teaching fractions can help teachers to assess online materials, interactive media, software, games and so on. Previous studies suggest that exploratory games that implicitly support mathematics knowledge can improve students' understanding of mathematics and their classroom engagement [5]. Researchers have developed some effective learning strategies to improve students' understanding of fractions. Recent research on interventions to support students at-risk and/or those with learning disabilities, report that they have been successful in promoting students' understanding of fractions using: a) mnemonic devices for teaching addition and subtraction of fractions [6-7]; b) manipulatives with pictures to solve problems involving fractions [8]; and c) direct instruction model [9-10]. Other researchers have reported success with similar strategies with a broader range of student abilities. These techniques include direct instruction using guided practice and focused feedback [9], and cue cards [11].

Teacher-designed learning in each mathematics topic will have an effect on students' mastery of mathematical concepts. Therefore, teachers must prepare appropriate learning tools. One means to increase student activity during learning is by using student activity worksheets (SAW). Teacher-made SAW should be integrated with ICT. Teachers must be able to design mathematical tasks using an attractive, varied display of images, stimulating curiosity and understanding of the material. Teachers can also use other media such as calculators, games, interactive whiteboards and other audiovisual aids, together with various software packages. The Internet can also be used to design effective learning tasks such as problem-solving simulations. Therefore, computer-based student activity worksheets should be developed. Based on the above description, this study aimed to produce computer-based student activity worksheets on fractions that is valid, practical, and effective for students of junior high school grade 7.

2. Method
The development model used in this research was the Four-D Model. The product was a computer-based student activity worksheet. Thigarahjan’s 4-D model consisted of 4 development stages: Define, Design, Develop and Disseminate [12]. In the Define stage, there were 5 activities to be done: curriculum analysis, student analysis, task analysis, concept analysis and objective learning analysis. While in the Design stage the steps to be done were: format selection (i.e. selection of existing resource formats and setting the format of teaching materials), and making the initial design according to the selected format. The Develop stage included evaluation by experts. Experts’ suggestions were then used to revise the material and the design of the learning instruments. Developmental testing was also conducted to test the product on real targets. At the time of this trial, perceptions, reactions or comments from the target users were collected. Test results were used to revise the product. After the product was revised, it was re-tested to obtain effective results. The last phase, Disseminate, was done by way of disseminating teaching materials through distribution for a limited number of teachers and learners [13]. But in this development research, disseminate stage was not done because of time constraints.

The procedure of development in this research consisted of (1) preparation of research, (2) implementation of research, and (3) data analysis. The steps taken by researchers in the preparation of research were as follows:

- Developing research instruments. Instruments in this research were validation sheet, computer-based student activity worksheets, competency test, and student response questionnaire.
- Submitting prototype computer-based student activity worksheets to the validator.
- Revising the prototype of computer-based student activity worksheets that have been validated to produce student worksheets that were ready to be tested (draft-1).
- Asking for permission of the school to be used as the place of study, as well as consulting with mathematics teachers to determine the timetable of the study.

At the time of conducting the research, the researchers conducted the test using mathematics student worksheets on fractions for students in grade 7 in one of the junior high schools in Kota
Langsa, Indonesia. The study took place in the academic year 2017/2018. After the implementation of the research, researchers analyzed the data using appropriate analytical techniques. After that, researchers compiled a report of the study. The subjects of this trial were all students in one of the classes at a junior high school in Kota Langsa, which consisted of 20 male and 10 female students.

3. Result and discussion
The results of each stage of the development that has been done were as follows.

3.1. Defining stage
This stage consisted of 5 phases. The first phase was curriculum analysis. At this phase, the thing to note was that the curriculum was applicable in the school where the research took place. The school used Curriculum 2013 for grades 7 and 8. The approach of the research in developing computer-based student activity worksheets which contained a scientific approach, grouping, and utilization of ICT, was very compatible with Curriculum 2013. In the development of computer-based student activity worksheets we focused only on one basic competency, namely knowing about fractional numbers and performing fractional operations in problem-solving.

The second phase was student analysis. When viewed from the background of students’ knowledge, in general, the students of grade 7 have mastered some prerequisite materials that have been taught before studying fractions, such as simple fractions and integers. These existing knowledge were important in studying fractions. As for the learning conditions of the students, after interviewing with teachers of mathematics at that school, it was revealed that the teachers rarely used ICT or computer-based student activity worksheets, and the learning activity was usually concentrated on the teacher.

The third phase was task analysis. Computer-based student activity worksheets on fractions was designed as a teaching material that would be used for learning fractions by utilizing ICT so that learning would be more interesting and fun. Assessment of students’ achievement was done by examining students’ activities while they do the tasks. The tasks were assigned both individually and in groups according to sub-materials. Individual tasks consisted of guiding questions in embedding fractional concepts through guided discovery. While the group tasks were aimed to examine students’ performance in solving more difficult problems or questions that required exchanges of opinion through group discussions.

The fourth phase was concept analysis. The concept analysis was done by analyzing the concepts of fractions, focusing on determining the meaning of fraction, determining the value of a fraction, determining the way to simplify fractions, determining and comparing two fractions, and determining fractions between two fractions. The computer-based student activity worksheets encompassed definitions, worked examples, problems and practice questions, online learning resources, softwares, and varied educational games.

The fifth phase was analysis of learning objectives. The analysis of learning objectives was done by elaborating basic competencies into the indicators of achievement in accordance with sub-material of fractions. In elaborating the basic competencies into indicators of achievement, we also took into account the results of concept and task analysis.

3.2. Design stage
The design stage consisted of 2 phases. Phase 1 was the selection of worksheets’ format. The selection of student worksheet formats was intended to design the content of learning, strategies, approaches, learning methods, and learning resources, and ICT. The material on the student worksheet was prepared by the researchers by adapting the materials available in books, including from the mathematics book of Curriculum 2013.

Phase 2 was initial design of student worksheets. After choosing the format of student worksheet, the next step was to develop the initial design of computer-based student activity worksheets which was called the prototype of student worksheet. This prototype was then validated by experts. The validated product was referred to as draft 1.
3.3. Development Stage

The development stage aimed to produce student worksheets that had been validated and revised by experts. The experts were Mr. Muhammad Zaki, S.Pd.I., M.Pd. and Ms. Fadillah, SP, S.Pd., M.Pd., lecturers of Mathematics Education at Samudra University, and Mrs. Masrah Nasution, S.Pd., a mathematics teacher at the school where the research took place.

There were three aspects to be validated using a five-point rating scale: 1 = very poor, 2 = poor, 3 = fair, 4 = good, and 5 = very good. The validation result of the computer-based student activity worksheets can be seen in table 1.

| Number | Aspects rated                  | Validator | Average | Average of Each Aspect | Average Amount |
|--------|--------------------------------|-----------|---------|------------------------|---------------|
| I      | Format:                       | 1         | 2       | 3                      | 4.67          |
|        | 1. Instructions.              | 4         | 5       | 5                      | 4.67          |
| II     | Language:                     | 1         | 2       | 3                      | 4.56          |
|        | 1. Goodness of language.      | 4         | 4       | 4                      | 4             |
|        | 2. Ease students in understanding the language. | 4 | 5 | 5 | 4.67 |
|        | 3. Clarity of sentence structure. | 4  | 5 | 4 | 4.33 |
|        | 4. Sentences do not contain double meanings. | 4 | 5 | 5 | 4.67 |
| III    | Content:                      | 1         | 2       | 3                      | 5             |
|        | 1. Material correctness       | 5         | 5       | 5                      | 5             |

There were some suggestions of improvement from the validators for the worksheets. The validators suggested that not all the material should be strictly guided. Rather, they suggested to provide some sub-materials that the students could find the concepts by themselves. Following this advice, for the sub-content of determining the fractions between two fractions, the students were asked to learn independently by themselves. Various online learning resources were made accessible for the students.

The next step was the limited trial. After the limited trial, we obtained data about the validity, reliability, sensitivity of the item and students’ perceptions on their learning completeness. The calculation of the validity of the problems in the worksheet was done by correlating the existing score of each item with the total score by using the formula of product moment correlation. Then we obtained the validity coefficient of less than 0.80 and more than 0.60, meaning the worksheets had high validity. The calculation of the reliability of the description was done using the Alpha formula. The result was 0.62.

As for students’ achievement, the students were assumed to have achieved mastery of a concept if they earned the minimum score of standard accomplishment which was established by the school. The minimum score was 75. Table 2 shows the students’ learning outcomes.

| Category of Achievement | Number of students | Percentage (%) | Average |
|-------------------------|--------------------|----------------|---------|
| Pass (Score ≥ 75)       | 24                 | 80             |         |
| Fail (Score < 75)       | 6                  | 20             | 86.03   |
| Amount                  | 30                 | 100            |         |
Based on table 2, it could be concluded that majority of the students had achieved mastery learning with an average score of 86.03.

Students’ questionnaire was aimed to investigate students’ perceptions on the implementation of the computer-based student activity worksheets. The results of the student response questionnaire are as follows: the percentage on the worksheet display statement is interesting that is 87.5%, has clear instructions 83.3%, worksheet instructions are easy to understand 85%, the language used on the worksheet is easy to understand 85%. Worksheet allows students to understand the topic of fractions 80% and worksheet can make students more motivated 80%. Thus, the average percentage of students' response questionnaires from 30 respondents to computer-based student activity worksheets was 83.472%. The respondents’ questionnaire value is very strong.

Based on the assessment of the expert validators, the test of learning outcomes and mastery of learning, and the result of a questionnaire of student response, computer-based student activity worksheets on fractions was valid, practical, and effective for students of junior high school grade 7 semester 1.

Fractions are essential foundational skills for future mathematics success [14]. Students' mastery of fractions can be achieved through the management of learning by the teacher. One of them is by utilizing ICT in learning. The implementation of ICT in mathematics enables students to learn integers, geometry, problem-solving and working with data using technology [15]. This is in line with research conducted by Tomljenovic and Zovko (2016) who found that using ICT in teaching leads to better learning and knowledge acquisition in primary schools [16].

Developing meaningful learning of fractions in the classroom depends on how teachers connect these fraction concepts to their students’ own learning [17]. The teacher can make a guided discovery of the material through a worksheet designed by the teacher. This is because the teacher know their students better, the teacher knows how to explore the knowledge and curiosity of their students. A worksheet can be designed to help students identify and analyze important mathematical concepts. A worksheet should include definition, the web of attributes, examples and non-examples [18].

The computer-based student activity worksheet was made by adjusting the competency standards, basic competencies and learning objectives on fractions. The learning included blended learning, which combined face-to-face learning and the deepening of online material directed in the worksheet. The worksheet consisted of an introduction, sample questions, questions, competency tests and online source materials.

The source materials also came with online games that could be downloaded and played by students. Fraction games provided opportunities for teachers and students to think about mathematical contexts and to engage in ongoing reflection about the teaching and learning of mathematics [19]. Games provided a situation that naturally combined issues of practice and theory, and reflection on those relationships and provided opportunities for discussion, reflection, and collaboration within a meaningful context [19].

So, the computer-based student activity worksheet offered an interesting and fun learning alternative through worksheets that combined offline and online learning. The guided discovery of offline material on the worksheet consisted of an introduction, sample questions, questions, competency tests and some topics. The fractional materials could be accessed through various online learning resources, virtual manipulatives, online games, software, and more.

4. Conclusion

The validity test for the computer-based student activity worksheets was based on three aspects, namely content feasibility, language, and presentation. The validation score was 4.74. This score fell into very valid category. The practicality of the worksheets was viewed from general assessment of all validators. Based on the general assessment of all validators, the computer-based student activity worksheets could be used with little revision. Thus, it could be concluded that the student worksheets were practical. The effectiveness of the student worksheets was judged by the students’ learning
outcomes. 80% of the students passed the test with an average score of 86.03. So it could be concluded that computer-based student activity worksheet was effective.

The questionnaire used to investigate the students' perceptions on the implementation of the computer-based student activity worksheet showed that the students responded positively towards the worksheets. The average score of the questionnaire was 83.47% which fell into very strong category.

Acknowledgment
We gratefully thank the lecturers of Mathematics Education of Samudra University, mathematics teachers and all students of a junior high school in Kota Langsa who participated in our study.

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