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THE DEVELOPMENT AND PILOT IMPLEMENTATION OF ELPSA FRAMEWORK FOR LEARNING STATISTICS

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ABSTRACT

Previous studies suggested that real-world problems and students' characteristics should be emphasized when designing statistics teaching materials. ELPSA Framework could address those considerations and was used as a learning framework for teaching statistics to junior high school students. Prior to classroom implementation, the teaching materials was tested and deemed valid and practical. Pilot implementation results showed that the teaching materials was effective for learning statistics because the ELPSA framework components facilitate students' understanding of statistical concepts. Students also perceived learning based on the ELPSA framework positively because it enables them to enjoy the learning process.

Keywords: mathematics learning materials; ELPSA framework; statistics; mathematics education

ABSTRAK

Penelitian-penelitian sebelumnya mengemukakan bahwa permasalahan dunia nyata serta karakteristik siswa harus lebih ditekankan saat merancang perangkat pembelajaran statistika. Kerangka ELPSA dapat menjawab pertimbangan tersebut dan kemudian digunakan sebagai kerangka pembelajaran untuk mengajarkan statistik kepada siswa sekolah menengah pertama. Sebelum diimplementasikan dalam pembelajaran di kelas, perangkat pembelajaran diuji dan dinyatakan valid serta praktis. Hasil uji coba implementasi menunjukkan bahwa perangkat pembelajaran yang dikembangkan efektif untuk pembelajaran statistika karena komponen kerangka ELPSA memudahkan pemahaman konsep statistika. Siswa juga berpandangan positif terhadap pembelajaran berbasis kerangka ELPSA karena pendekatan ini membuat mereka menikmati proses pembelajaran.

Kata kunci: perangkat pembelajaran matematika; kerangka ELPSA; statistika; pendidikan matematika

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INTRODUCTION

From calculating monthly household needs to investing money in the stock market, mathematical competence is undoubtedly vital for conducting daily activity. Mathematical competence has been proven to be an essential determinant for career aspirations (Shapka, Domene, and Keating, 2006), actual success in job employment (Rivera-Batiz, 1992), educational advancement (Benbow, Lubinski, Shea, and Eftekhari-Sanjani, 2000), or the success in students' respective career (Schoon, 2001). In achieving mathematical competence, previous studies found that mathematical competence attainment problems still occurs: from fragmented mathematics conception (Crawford, Gordon, Nicholas, and Prosser, 1998), low mathematics performance (Jansen, Louwerse, Straatemeier, Van der Ven, Klinkenberg, and Van der Maas, 2013), to high degree of errors in a mathematical test (Kusmaryono, 2018).

Students' competence in statistics can also be considered as an area of concern because students' ability such as in data and chance has the lowest international average compared to mathematics contents tested in Trend in International Mathematics and Science Study or TIMSS (Mullis, Martin, Foy, and Arora, 2012). Moreover, Prinz, Golke, and Wittwer (2018) study found that incorrect conceptions of statistics concepts influenced not only conceptual comprehension but also students' procedural comprehension. Previous studies also revealed that even if students may be able to manipulate and calculate statistical data, students still facing difficulty in making interpretations of statistical data (Sotos, Vanhoof, Van den Noortgate, and Onghena, 2007). Studies (Evans, 2007; Garfield and Ben-Zvi, 2009; Blackburn, 2015) observed that the use of real-world exam-

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ples and applications enable the students to understand statistical concepts better. However, Boaler (1993) stated that real-world context should also consider the individual nature of students' mathematical procedures and performance because they interact with the context of a task in a rather personal way. Students construct their meaning in different mathematical situations, and the use of a variety of contexts and a clear direction of mathematical activity will help students construct understanding (Boaler, 1993). Consequently, designing statistics learning should: (1) use real-world problems and applications, (2) consider students' nature such as students' learning routes and experiences, and (3) arranged systematically.

ELPSA is a cyclic mathematics learning framework rooted in the importance of Experience, Language, Pictorial, Symbolic, and Application (ELPSA) in learning mathematics: (1) experience considers how students have used mathematics, what particular concepts they know, how they can acquire that information, and how individuals have experienced mathematics, both in and outside of classrooms, (2) generic and specific language as well as visual representation or pictures (3) and symbols (4) are required to represent mathematical ideas, and (5) application component of the learning design highlight how symbolic understanding can be applied to new mathematical situations (Lowrie and Patahuddin, 2015). The systematic nature of ELPSA framework and the use of real-world problems with consideration of students' individual characteristics denote the framework potential to be use as a basis for designing effective statistics learning materials. ELPSA framework was implemented previously in learning Integers (Arifin, 2015), Integral (Johar and Hajar, 2016), or Algebra (Patahuddin, Lowrie, & Lowrie, 2018) but not yet for learning statistics. Therefore, considering the prospect and successful implementation of the ELPSA, this paper reported the development and implementation of the statistics teaching materials based on ELPSA framework.

METHOD

Following Plomp and Nieveen (2013), teaching materials development was conducted in three-phase: preliminary, prototyping, and assessment. In the preliminary phase, a questionnaire concerning curriculum, learning resources availability was given to teachers and the school administrator (vice-principal for curriculum) to determine and assess learning needs. The preliminary phase suggested that statistical data presented in a diagram, mean, materials, and modus should be the targeted statistical concepts covered in the teaching materials. The teaching materials was developed based on the ELPSA framework after considering the framework characteristics and the benefits it offers. The "ELPSA-based Framework Statistics Teaching Materials" consisted of a lesson plan, students' worksheet, and learning evaluation test. Six experts were then given questionnaires (score 0-5) to evaluate the developed learning materials' validity. The average validity score for each teaching material was 4.1 for the lesson plan, 4.2 for students' worksheets, and 4.5 for the learning evaluation test, with average overall validity of 4.27. Thus, the teaching materials was deemed valid to use in learning statistics. In small-scale testing, seven students from one of the junior high schools in Takengon District-Central Aceh were randomly selected as a sample and were given a questionnaire concerning their perception of the teaching materials. With a 94% average score for readability, 97.2% score for practicality, and 96% score for average students' active participation when learning, the materials was deemed ready to be implemented.

Finally, in the assessment phase, 23 students from the same schools were randomly selected as a sample, and the teaching materials was implemented in learning statistics concepts for a total of four meetings. The students were divided into five groups when working on the worksheets. In addition to a written test to evaluate students' statistical competence after learning with ELPSA-based teaching materials, students were also given a questionnaire concerning their perception of the teaching materials. Their response to contents of the lessons, learning environment when using the materials, and how their teacher uses the materials to teach statistics concepts was evaluated. Students' activity was recorded in observation sheets. Maximum score for written test and worksheets was 100 whereas students' activity score was in a form of percentage. The learning activity of ELPSA framework for learning statistics concepts is presented in Table 1.

RESULTS AND DISCUSSION

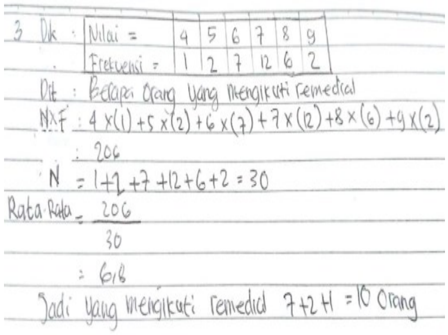
Students' activity observation and students' worksheets uncovered that 96% of students actively participated in every learning activity (Table 2).

Table 1. Activity in the Implementation of ELPSA Framework for Learning Statistics

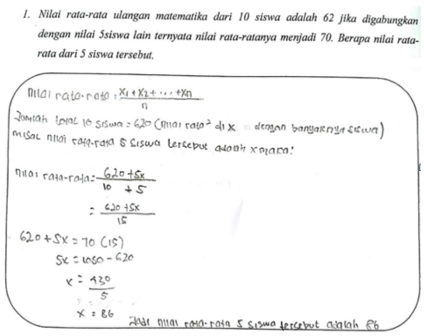
LESSON	LEARNING GOALS	LEARNING ACTIVITY
Lesson I *Data collection and presentation*	By actively working together, students can: 1. Discovering the concept of data and its types 2. Collecting data by enumerating, measuring, and recording data accurately and honestly 3. Differentiate data collection techniques from observation, interviews, and questionnaires.	a) Watching videos related to data collection (Experience) b) State data collection techniques (Language) c) Choosing the right data collection technique to obtain information/data (Pictorial) d) Summarizing terms in data collection (Symbols) e) Collect data and present it in tabular form.(Symbols)
Lesson II *Presenting Data in line and bar chart*	Through discussion, group work, and quizzes students can: 1. Present data in the form of tables, line charts and bar charts 2. Use Microsoft Excel to present data in the form of line diagrams and bar charts.	a) Recollection of previous lessons (Experience) b) Observing existing data in newspapers (Experience) c) Specify ways of presenting data (Language) d) Present data in the form of line charts and bar charts (Pictorial) e) Present data in the form of line charts and bar charts using Microsoft Excel (Symbols)
Lesson III *Presenting Data in a bar chart*	By actively working together students can: 1. Present data in the form of a pie chart 2. Use Microsoft Excel to present data in the form of a pie chart.	a) Observing newspapers related to the presentation of data in the form of a circle diagram (Experience) b) Stating that a pie chart is another way of presenting data besides line and bar charts (Language) c) Define ways to present data in a pie chart: (i) Determine the percentage of each frequency amd (ii) Determine the size of the area center angle of each frequency (Pictorial) d) Present data in the form of a pie chart (Symbols) e) Solve problems in the form of non-routine questions regarding the presentation of data in a circle (Application) f) Use Microsoft Excel to present data in the form of a pie chart (Application)
Lesson IV *Data Processing*	By actively working together students can: 1. Determine the average, median, and mode of a data 2. Analyze data based on mean, median and mode values to draw conclusions, make decisions and make predictions 3. Use Microsoft Excel to calculate data average	a) Paying attention to students' learning outcomes, such as report cards, or grades in elementary school (Experience) b) Express the average, median and mode values of a simple data set (Language) c) Knowing steps to express mean, mode and median values (Pictorial) d) Find the formula for average, median and mode (Symbols) e) Solve non-routine problems / questions related to the mean, median and mode (Application) f) Using Microsoft Excel to find the average value (Application)

Table 2. Learning Results after the Implementation of ELPSA Framework for Learning Statistics

Evaluation	N	Range	Average	Remark
Students' Activity Score	5	94-98%	96%	Group Score
Students' Worksheets Score	5	88.8-98.8	94.02	Group Score
Written Test Score	23	60-100	82.4	Three students unable to reach Learning Achievement Threshold (LAT) of 75. Four reached maximum score (100) while 16 reached LAT and above LAT.



(1a)



(1b)

Figure 1a-b. Students Answers for Remedial (1a) and Unknown Average (1b) Question

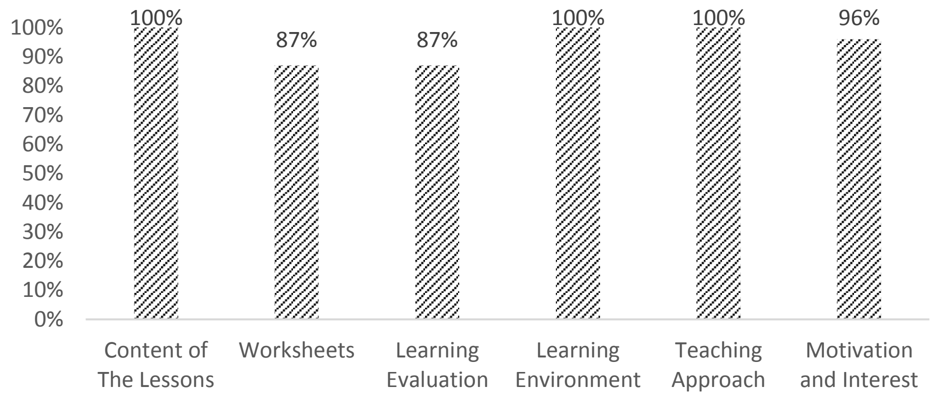


Figure 2. Students Perception of the ELPSA Framework for Learning Statistics

Students' worksheets score indicated high ability in solving statistical problems in which the average score for five groups was 94.02. This high ability was also reflected in the individual written test score. After four weeks of implementation, students were subjected to a written test in which their mathematical competence was determined by their ability to (1) paraphrase the concepts that have been learned, (2) apply concepts algorithmically and (3) present concepts in various forms of mathematical representations. Test results showed that 69.56% (16 out of 23 students) reached the Learning Achievement Threshold (LAT) score of 75 or above, and only three students failed to achieve the LAT score. The average score for 23 students was 82.4 (Table 2), which suggested that the ELPSA frameworks aided the students in learning statistics concepts effectively. Students' questionnaire results also showed that students have a positive perception the ELPSA-based teaching materials and 96% of students (Figure 2) showed their interest in using it for learning other subjects.

Students' ability to understand statistical concepts was reflected in their answers (Figure 1a-b). Firstly, students were asked to calculate how many students have to take a remedial test if one student got 4, 2 students got 5, seven students got 6, twelve students got 7, six students got 8, and two students got 9. Most students can correctly answered the question because they know that they have to determine the class average and then calculate how many students got a score below the average score (Figure 1a). In another question, students were given information that the average test score for ten students was 62, and if this average score was combined with the average score of five other students, the average for 15 students become 70. Students were asked to determine the average score of the additional five students, and as shown in Figure 1b, they apply their understanding of the frequency and mean to calculate a mean from an unknown score (Figure 1b).

ELPSA framework views learning as an active process where students develop understanding through individual thinking and social interactions (Lowrie and Patahuddin, 2015). In the framework, the development of personal thinking process was aided through the use of real-world context (Application), consideration on how students have used and experienced mathematics, what particular concepts or terminologies they already know, and how they can acquire further information to achieve deeper understanding (Experience). The effectiveness of real-world context in learning statistics concepts was in correspondence with previous results (Evans, 2007; Garfield and Ben-Zvi, 2009; Blackburn, 2015) and the importance of considering students' mathematics experience when designing learning activity has been emphasized in the literature (Hailikari, Nevgi, and Lindblom-Ylänne, 2007; Hourigan and O'Donoghue, 2007; Fyfe, Rittle-Johnson, and DeCaro, 2012; Yuksel, 2014; Geary, Nicholas, Li, and Sun, 2017).

In addition to using real-world context and the consideration of students' previous mathematics experiences, working in a group could be one reason the learning materials could foster students' understanding. Social interactions with fellow group member could promote students' conceptual understanding because working in a group facilitate the transfer of understanding and experience. Previous study corroborate this notion in which working in a group could increase achievement scores in statistics (Delucchi, 2006). Further, Krause, Stark, and Mandl's (2009) study found that elaborative and reflective processes in a cooperation could promote learning sustainability.

CONCLUSION

Students' learning achievement and positive perception of the ELPSA framework-based teaching materials showed that the developed materials was useful for learning statistics because the components in ELPSA framework facilitate students' understanding of statistical concepts. However, this study characteristics as a pilot project should be considered when making generalizations from the results. A further experimental study, for example grouping based on students' initial knowledge and different learning situations as well as with a larger sample, is still necessary.

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