Developing mathematics teaching tool using ELPSA

E Gradini and F Bahri
STAIN Gajah Putih, Jl. Aman Dimot No.10, Aceh Tengah, Aceh. Indonesia, 24519
E-mail: egagradini@staingp.ac.id

Abstract
This study aimed at measuring the validity, practicality, and effectiveness of teaching tools designed to address students’ mathematical understanding in the classroom. This paper discusses validity and effectiveness only. Five components of ELPSA (Experience, Language, Picture, Symbol, and Application) are proposed to give teachers and students a more tangible way to construct the understanding and learning experience. Four-D model (Define, Design, Develop, and Disseminate) by Thiagarajan, Semmel, and Semmel was used as the developmental approach in this study. The finding showed that teaching tools designed are valid and effective to be used in the mathematics classroom.

1. Introduction
The paradigm of mathematics learning has changed from a transfer of knowledge to the construction of knowledge that assigned students as the centre of learning activities. Despite the change of curriculum in Indonesia, from KTSP to Kurikulum 2013, most Indonesian teachers still use teacher-centred instructions as opposed to student-centred classroom learning. The teacher-centered class has been embedded into Indonesian school culture for a very long time [1]. Such method leaves a little room for students’ creativity and expressiveness, a subject of criticism by academic society in Indonesia [2]. In contrary of the significant role of teachers in the classroom, many Indonesian teachers have lack of teaching competence [1]. Researchers believe this is because of the long tradition of teacher-centred teaching and rote learning in the Indonesian classroom [3].

Construction of knowledge was difficult to pursue if the classroom is dominated by a teacher. Teacher-centred instruction is regarded to be undemocratic because it fails to consider students’ learning dynamics and ignores students’ contributions in the classroom [3]. It also prevents students to construct the mathematical understanding by the learning experience. According to an interview with one of junior high school mathematics teacher in Aceh Tengah, students learn mathematics from the teacher’s explanation only. The teacher had difficulties in providing learning activities, media, and material that promote students to construct mathematical understanding [4]. Therefore, it is necessary to develop teaching tools to promote students’ understanding.

ELPSA as a learning framework offers opportunities for teachers to better understand the way in which pedagogical practices and learning experiences can be effectively presented to students in ways that reflect students’ concept development [5]. The learning framework provides opportunities for teachers to enhance the content pedagogical knowledge as well as provides learning experiences for children that could be classified as culturally appropriate and personalized. In ELPSA framework, learning is an active process where students construct their understanding through individual thinking and social interaction.
ELPSA consists of five components; Experience, Language, Picture, Symbol, and Application. Experience means the association students previous knowledge with new knowledge that will be studied [5]. The first component is Experience (E). ELPSA assumes that experiences are the foundations for the introduction of new learning opportunities. Learning on this phase occurs through participation and encourage high levels of engagement and interaction. By experiencing the learning, mathematical ideas/content can be introduced in meaningful ways. The foundation is embedded with the language used in promoting learning.

The second component is Language (L). It is important to connect students experience with mathematical terminology to promote students’ understanding. Culture and daily language are believed to influence both students’ perception and understanding. ELPSA believes that language is important for teacher and students. Explaining mathematical concept with students’ language could help students to clarify and strengthen their understanding.

The third component of ELPSA is Pictures (P). This component helps student to construct their understanding of abstract. This component is built using a visual representation to represent mathematical ideas. The images used to promote students’ understanding and stimulus to solve mathematical tasks before they used symbols to represent the abstract concept. The fourth component is Symbol (S). This component involves students’ capacity to represent, construct, and manipulate analytic information. Symbols are best utilized when students understand a particular concept and it is necessary for students to practice using symbolic operation [5]. Kinach suggested that symbol introduced problem-solving level [6]. In common mathematics instruction, a symbol is often used at first level before students able to perform concept understanding. Students placed on the problem-solving level before they have concept and content understanding. The research concludes that if a symbol is introduced at the early phase, students are likely to use them inappropriately [7]. The last component is Application (A). At this phase, students apply mathematics idea to a situation that is considered to enhance students’ mathematical understanding. This is the biggest problem of mathematics instruction in Indonesia, where students believed that mathematics is irrelevant to their daily life. Although problem-solving activities are challenging to be solved by students, they are not connected to real-life experiences [8]. The application component also provides opportunities for students to see how mathematics can be used in and out of school contexts [5]. ELPSA views this component as activities that encourage students to apply mathematics knowledge to new and related situations, both help to reinforce concepts and provide opportunities to scaffold mathematical understanding.

There were many previous studies on ELPSA framework in a mathematics classroom. Johar and Hajar implement ELPSA using technology in learning integral [9]. Syahdan applied ELPSA framework in Bruner Theory based-mathematics classroom [10]. Whereas this study discussed designing teaching tools using ELPSA framework by focusing on E and A component of ELPSA to build the connection between mathematical concept and students’ daily life. The objectives of this study are to develop learning tools using ELPSA framework.

2. Research method
This study employed Thiagarajan, Semmel, and Semmel’s model of developmental approach [11]. This model has four phases; (1) Define, (2) Design, (3) Develop, and (4) Disseminate [11]. This study measures the validity, practicality, and effectiveness of teaching tools. The validity of teaching tool is measured by the relevance and consistency. The expert agreement index for content validity is a comparison of the number of items from two experts with strong relevance category of overall items [12]. While the results of the relevancy tabulation (contingency tables) are presented in Table 1, the validity coefficient is presented in Formula 1.
Table 1. The relevance category scoring with two validators [12]

| Validator 2 | Weak | Strong |
|-------------|------|--------|
| A           | B    |        |
| C           | D    |        |

Content validity coefficient = \( \frac{D}{A+B+C+D} \) (1)

Teaching tools is effective if it fulfills 3 of 4 criteria; (1) more than 50% student response to material and worksheet positively, (2) more than 70% students’ activities at good-level, (3) all teacher’s activities at good-level, and (4) more than 75% students passed the Minimum Criteria of Masterly Learning (KKM) [13].

3. Result and finding

3.1 The validity of teaching tools
Content validity is determined using expert agreement index suggested by Gregory [12]. The index ranges from 0 to 1. It is conducted by making contingency tables on two experts, with the first category that is not relevant and less relevant become the weak relevancy category, and the second category which is for quite relevant and very relevant that is created in a new strong relevant category. The expert agreement index for content validity is a comparison of the number of items of the two experts with strong relevance category of overall items. The expert agreement index for content validity is a comparison of the numbers of items from two experts as validators with strong relevance to the overall items category.

3.1.1 Content validity coefficient of the lesson plan
Aspects assessed in validating Lesson Plan are curriculum, material, learning, language, and time allocation. Table 2 shows the relevance category scoring of two validators.

Table 2. Relevance category scoring of the lesson plan

| Validator 2 | Weak | Strong |
|-------------|------|--------|
| 0           | 2    |        |
| 2           | 17   |        |

Content validity coefficient of lesson plan is 0.809. It means that the lesson plan has high relevancy with their indicators.

3.1.2 Content validity coefficient of teaching material
Teaching material designed are teachers’ book and students’ book. Aspects assessed in validating students’ book and teachers’ books are curriculum, material, illustration and example, problem, layout, and language. While Table 3 shows the relevance category scoring of students’ book, the relevance category scoring of teacher’s book presented in Table 4.
Table 3. Relevance category scoring of student’s book

|               | Validator 1 |   | Validator 2 |   |
|---------------|-------------|---|-------------|---|
|               | Weak        | Strong | Weak | Strong |
| Weak          | 0           | 0     | 0    | 0     |
| Strong        | 5           | 17    |      |       |

Table 4. Relevance category scoring of teacher’s book

|               | Validator 1 |   | Validator 2 |   |
|---------------|-------------|---|-------------|---|
|               | Weak        | Strong | Weak | Strong |
| Weak          | 0           | 0     | 0    | 0     |
| Strong        | 4           | 18    |      |       |

Content validity coefficient of student’s book is 0.773 and teacher’s book is 0.818. It means the validator agreement index about both teacher’s book and students’ book relevance with their indicators is high. Although the content validity coefficient is high, validators gave some suggestions as presented follow:

- Make activities more interesting to students by inserting the activity on student worksheets.
- Give answer key for every problem and task at the end of chapter
- Add reflection part in order to make students able to do self-assessment. This part also helps the teacher to find out what students feel and know after learning.

3.1.3 Content validity coefficient of students’ worksheet

Table 5 presents aspects assessed in validating students’ worksheet are curriculum, material, illustration and example, problem, layout, time allocation and language.

Table 5. Relevance category scoring of students’ worksheet

|               | Validator 1 |   | Validator 2 |   |
|---------------|-------------|---|-------------|---|
|               | Weak        | Strong | Weak | Strong |
| Weak          | 0           | 0     | 0    | 0     |
| Strong        | 1           | 13    |      |       |

Content validity coefficient of students’ worksheet is 0.928. It means the validator agreement index about students’ worksheet relevance with their indicators is high. Although the content validity coefficient is high, validators gave some suggestions as presented follow:

- Illustration need to be placed for every problem to encourage students to construct their understanding through the picture
- Replace Avocado in problem 3 (Presented in Figure 1) with another thing because each avocado has a different weight.
3.2. The effectiveness of teaching tools

3.2.1. Students’ response to students’ book and worksheet

Students asked to assess teaching material (students’ book) and worksheet. All items responded positively by 72% of students, hence teaching tools are effective to implement in a mathematics classroom.

3.2.2. Students’ activities in the classroom

Six students are observed during teaching and learning process. The observation of students’ activities is presented in Table 6.

| No | Observation items                                                | Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Score | Category     |
|----|------------------------------------------------------------------|----------|----------|----------|----------|----------|-------|--------------|
| 1  | Students’ interest during instruction                           | 3.00     | 3.17     | 3.17     | 3.08     | 3.17     | 3.12  | Good         |
| 2  | Students active in the utilization of teaching media            | 2.50     | 3.17     | 3.17     | 3.33     | 3.33     | 3.10  | Good         |
| 3  | Students active in a group discussion                          | 3.17     | 3.28     | 3.17     | 3.33     | 3.33     | 3.26  | Good         |
| 4  | Students active in sharing idea during group discussion        | 2.83     | 3.00     | 3.00     | 3.08     | 3.00     | 2.98  | fair         |
| 5  | Students active in responding to teacher questions             | 3.00     | 3.32     | 3.32     | 3.17     | 3.17     | 3.20  | Good         |
| 6  | Students have a responsibility in their groups                 | 3.17     | 3.33     | 3.33     | 3.33     | 3.33     | 3.30  | Good         |
| 7  | Students participation in problem-solving                      | 3.17     | 3.33     | 3.33     | 3.42     | 3.42     | 3.33  | Good         |
| 8  | Students active in helping their friends to understand the material | 2.67     | 2.83     | 2.83     | 3.08     | 3.00     | 2.88  | Fair         |
| 9  | Student responsible to his/her own task in the group           | 3.17     | 3.00     | 3.00     | 3.17     | 3.17     | 3.10  | Good         |
| 10 | Students give correct and relevance answer                     | 3.50     | 3.53     | 3.53     | 3.58     | 3.53     | 3.53  | Very Good    |

**Figure 1.** Problem 3 “ avocado” on students’ worksheet
3.2.3. **Teacher’s competency in instruction**

**Table 7. Teacher’s competency in instruction**

| No | Observed activities                                           | Lesson 1 | Lesson 2 | Lesson 3 | Lesson 4 | Lesson 5 | Average | Category   |
|----|-------------------------------------------------------------|----------|----------|----------|----------|----------|---------|------------|
|    |                                                            | 1        | 2        | 3        | 4        | 5        |         |            |
| 1  | Phase 1. Clarify goals and establish set                    |          |          |          |          |          |         |            |
| 1  | Teachers motivate students to learn                         | 3        | 4        | 3.5      | 4        | 4        | 3.70    | Very good |
| 2  | Teachers explain goals of learning                          | 3        | 3.5      | 4.5      | 4        | 5        | 4.00    | Very good |
| 3  | Teachers establish a set of learning                        | 3.5      | 4        | 4        | 4        | 4        | 3.90    | Very good |
| 4  | Teachers provide daily life problem                         | 4        | 4        | 3.5      | 3        | 3        | 3.70    | Very good |
|    | Average score                                               |          |          |          |          |          | 3.83    | Very good |
| 2  | Phase 2. Providing information                              |          |          |          |          |          |         |            |
| 1  | Teachers provide information to students                    | 5        | 4.5      | 4        | 4        | 4        | 4.30    | Very good |
| 2  | Teachers demonstrate an example, problems, or skill         | 4        | 4        | 4        | 3.5      | 3        | 3.70    | Very good |
| 3  | Teachers give an opportunity for students to ask difficult material | 4        | 4        | 4        | 4        | 3        | 3.80    | Very good |
|    | Average score                                               |          |          |          |          |          | 3.93    | Very good |
| 3  | Phase 3. Organize students in group                         |          |          |          |          |          |         |            |
| 1  | Teachers organize students into groups according to their achievement | 4        | 4        | 4        | 3.5      | 3        | 3.70    | Very good |
| 2  | Teachers distribute worksheet to students                   | 4        | 4        | 4        | 4        | 4        | 4.00    | Very good |
|    | Average score                                               |          |          |          |          |          | 3.85    | Very good |
| 4  | Phase 4. Assist teamwork and study                         |          |          |          |          |          |         |            |
| 1  | Teachers make sure that every student understand their task and responsibility in group | 4.5      | 4        | 4        | 3        | 3        | 3.70    | Very good |
| 2  | Teachers ask students to discuss and solve problems in the worksheet. | 4        | 4        | 4        | 4        | 3.5      | 3.90    | Very good |
| 3  | Teachers assist students who have difficulties in group discussion | 4.5      | 4        | 4        | 3        | 3        | 3.70    | Very good |
| 4  | Teachers rephrase the explanation if the student does not understand the problem/question | 4        | 4        | 3.5      | 3        | 3        | 3.50    | Very good |
|    | Average score                                               |          |          |          |          |          | 3.70    | Very good |
| 5  | Phase 5. Evaluation                                         |          |          |          |          |          |         |            |
| 1  | Teachers evaluate students individually                     | 4        | 4        | 4        | 3.5      | 3.5      | 3.80    | Very good |
| 2  | Teachers ask every group to present their work             | 4        | 4        | 4        | 3.5      | 3        | 3.70    | Very good |
| 3  | Teacher give feedback to students’ work                    | 4        | 4        | 3.5      | 4        | 4        | 3.90    | Very good |
|    | Average score                                               |          |          |          |          |          | 3.80    | Very good |
| 6  | Phase 6. Providing recognition                              |          |          |          |          |          |         |            |
| 1  | Teachers recognize students’ achievement                    | 4        | 3.5      | 3        | 3        | 3        | 3.30    | Very good |
| 2  | Teachers ask student to resume the lesson/material          | 4        | 4        | 3.5      | 3        | 3        | 3.50    | Very good |
|    | Average score                                               |          |          |          |          |          | 3.40    | Very good |
|    | Total score                                                 |          |          |          |          |          | 3.75    | Very good |
During the teaching and learning process, the teacher uses the scientific approach and cooperative learning as the teaching method. The teacher observed for five meetings in order to see the teacher’s ability in implementing teaching tools. Teacher’s competency in instruction is presented in Table 7.

4. Conclusion

This study showed that students able to understand effectively when they experience the learning by themselves. In this study, content-level understanding conducted on experience (E) phase and problem-solving level on application (A) phase. By experiencing the learning process, students allowed to interact with other students and develop their understanding. This finding supports theory stated that in Experience component, students learn through participation and develop their mathematical ideas. Students able to solve the given problem accurately when the problem is routine and familiar with their experience, when they face non-routine problems, most students were not able to. Unlike other studies carried out on ELPSA, this study found that applying the concept to a new daily life situation still challenging for some students. Teaching tools were valid and effective to be implemented in the mathematics classroom. The effectiveness of teaching tools based on (1) the ability of teachers in managing to learn is well, (2) students’ activity during the learning process was active, and (3) student responses to learning were positive. Thus, it recommended using the developed teaching tools in the mathematics classroom.

References

[1] Azra A 2002 Paradigma Baru Pendidikan Nasional: Rekonstruksi dan Demokrasi (Jakarta: Kompas)
[2] Zulfikar T 2010 The Making of Indonesian Education: an Overview on Empowering Indonesian Teachers J. Ind. Soc. Sci. Hum. 2 13
[3] Wolk S 1998 A Democratic Classroom (Portsmouth: Heinemann)
[4] Bahri F 2017 Efektivitas ELPSA Framework dalam mengkonstruksi Pemahaman Siswa pada Pembelajaran Matematika (Aceh: STAIN Gajah Putih Press)
[5] Lowrie T and Patahuddin S M 2015 ELPSA as a Lesson Design Framework J. Math. Edu 6 2
[6] Kinach B M 2002 Understanding and Learning-To-Explain by Representing Mathematics: Epistemological Dilemmas Facing Teacher Educators in the Secondary Mathematics “Methods” Course J. Research on Mathematics Teacher Education 51 53
[7] Ball D L 1992 The Mathematical Understandings that Prospective Teachers Bring to Teacher Education J. Advances in Research on Teaching 2 1
[8] Lowrie T and Patahuddin SMELPSA-Kerangka Kerja Merancang Pembelajaran Matematika J. Didaktik Matematika 2 94
[9] Johar R and Hajar S 2017 Implementation of ELPSA Framework in Teaching Integral Using Technology Int J. Sci. Technol 1 1
[10] Syahdan S 2016 Efektivitas Penerapan Experience, Language, Pictorial, Symbol and Application (ELPSA) Pada Pembelajaran Matematika Berbasis Teori Bruner Pada Siswa Kelas VII SMP NEGERI 29 Makassar (Makassar: Universitas Negeri Makassar Press)
[11] Perkins DN and Simmons R 1988 Patterns of Misunderstanding: an Integrative Model for Science, Math, and Programming J. Rev. Edu Research 58 303
[12] Gregory R J 2007 Psychological Testing: History, Principle, and Applications (Boston, MA: Pearson)
[13] Nurhuda, Lukito A, and Masriyah 2018 Effectiveness of Cooperative Learning Instructional Tool With Predit –Observe –Explain Strategy on The Topic of Cuboid and Cube Volume J. Physics. Conf Series. 947 1