ISSN 2087-8885
E-ISSN 2407-0610

Journal on Mathematics Education
Volume 10, No. 1, January 2019, pp. 37-46

DEVELOPING PISA-LIKE MATHEMATICS PROBLEMS ON UNCERTAINTY AND DATA USING ASIAN GAMES FOOTBALL CONTEXT

Dedi Yansen[1], Ratu Ilma Indra Putri[2], Zulkardi[2], Siti Fatimah[3]

[1]Sekolah Tinggi Ilmu Teknik Prabumulih, Jl. Patra No.50, Prabumulih, Indonesia
[2]Sriwijaya University, Jalan Srijaya Negara, Bukit Besar, Palembang, Indonesia
[3]SMA N 3 Prabumulih, Prabumulih, Indonesia
Email: dediyansen23@gmail.com

Abstract

This study aims to generate the valid and practical PISA-like mathematics problems on uncertainty and data using the football game context of Asian Games. It also aims to see the potential effects of the problems towards the high school students' mathematical ability. This study used a design research methodology with the type of development study which was divided into two stages, namely preliminary stage and formative evaluation stage. The preliminary stage covered the analysis of research subjects, curriculum analysis, PISA framework and creating a question instrument. The formative evaluation stage included the one to one consisting of three students together with expert review consisting of two validators, small group consisting of six students, and then the field test. This study produced valid and practical PISA-like mathematics problems on uncertainty and data content which have a potential effect on the senior high school students' mathematical literacy ability. The validity was determined based on the expert review, while the practicality was determined based on one-to-one and small group assessment. The students' mathematical literacy abilities appeared during the research were communication, reasoning and argument, and devising strategies for problem-solving.

Keywords: Asian Games, Design research, Mathematical literacy, PISA-like.

Abstrak

Penelitian ini bertujuan untuk menghasilkan soal matematika tipe PISA konten *uncertainty and data* dengan konteks cabang olahraga sepak bola pada Asian Games yang valid dan praktis, serta melihat efek potensial dari soal yang dibuat terhadap kemampuan literasi matematis siswa kelas X SMA. Metodologi penelitian yang digunakan adalah *design research* dengan tipe *development study*, yang terbagi menjadi dua tahap yaitu *preliminary* dan *formative evaluation.* Tahap *preliminary* meliputi analisis subjek penelitian, analisis kurikulum, *framework* PISA dan membuat instrumen soal. Tahap *formative evaluation* meliputi *one to one* yang terdiri dari tiga orang siswa bersamaan dengan *expert review* yang terdiri dari dua orang validator. Selanjutnya, tahap *small group* melibatkan enam orang siswa dan kemudian *field test.* Penelitian ini menghasilkan soal matematika tipe PISA konten *uncertainty and data* yang valid dan praktis, dan memiliki efek potensial terhadap kemampuan literasi matematis siswa SMA. Valid berdasarkan pada *expert review*, sedangkan praktis berdasarkan pada *one to one* dan *small group*. Kemampuan literasi matematis siswa yang muncul yaitu kemampuan komunikasi, penalaran dan argument serta kemampuan memilih strategi untuk memecahkan masalah.

Kata Kunci: *Asian Games*, *Design research*, Kemampuan literasi matematis, Soal tipe PISA.

How to Cite: Yansen, D., Putri, R. I. I., Zulkardi, & Fatimah, S. (2019). Developing PISA-like mathematics problems on uncertainty and data using Asian Games football context. *Journal on Mathematics Education, 10*(1), 37-46.

Programme for International Student Assessment (PISA) is an international study to measure the skills and abilities of 15-year-olds. PISA 2015 problems were developed based on four contents, including change and relationship, space and shape, quantity, and uncertainty and data (OECD, 2016). According to Jurnaidi & Zulkardi (2014), many of the weaknesses of Indonesian students' mathematical skills were revealed in the results of the PISA study. The low result of PISA Indonesian students can be caused by several factors such as the use of rote learning method, students are not accustomed to solving PISA-like problems, and students are accustomed to working on the same problems as provided by the teacher. It fits very well with PISA's three-year results. Based on data announced by the Organization for Economic Cooperation and Development (OECD), in PISA 2012, Indonesia ranks 64th out of 65 participating countries (OECD, 2013), while in PISA 2015, Indonesia ranks 62th out of 70 countries (OECD, 2016).

One of the PISA content related to the subject of statistics and probability is the uncertainty and data. Uncertainty and data are the phenomena at the heart of mathematical analysis of many problem situations including the theories of probability and statistics as a technique of data representation and description (OECD, 2016). According to Zuhra (2015), based on the results of the PISA study in 2012 on uncertainty and data content, students were only able to be in the level 2 of 6 PISA levels. The low PISA result of Indonesian students resulted from the lack of problem-solving abilities of non-routine or high order thinking problems. Moreover, the evaluation system in Indonesia still used low-level questions, and the students were accustomed to acquiring and using formal mathematics knowledge in the classroom (Stacey, 2010; OECD, 2014).

Mathematical literacy is defined as the ability of a person to formulate, employ and interpret mathematics in various contexts, including the ability to do mathematical reasoning and use concepts, procedures, and facts to describe, explain or estimate phenomena/events (OECD, 2016). Mathematical literacy involves the seven basic skills that students must possess and underlies the process of student mathematical literacy (OECD, 2016), namely (1) communication, (2) mathematization, (3) representation, (4) reasoning and argument, (5) devising strategies for problem-solving, (6) using symbolic, formal, and engineering, and operations, and (7) using mathematical tools.

According to Johar (2012) and Hendroanto *et al* (2018), the success of Indonesian students in solving the problems of PISA was determined by the evaluation system and the ability of teachers in developing students' mathematical literacy. Putri (2009) states that in the framework of improving the quality of education, efforts to increase competence in the education process was one aspect of substantive of education management that had to be realized through various operational programs. With the improvement of these competencies, teachers were expected to be competent in the process of teaching and learning activities.

One approach that can be used in mathematics learning is the PMRI approach, where the mathematics should be close to the student and relevant to the daily life situation of the students (Putri, 2014). According to Marpaung & Julie (2011), in PMRI, learning began by presenting a contextual/realistic problem. The context was a situation or phenomenon / natural occurrence associated with the concept of mathematics being studied. One context that could be used is the Asian Games sport. Some research used the context of the Asian Games 2018 sports in designing mathematics learning. Roni, Putri, & Zulkardi (2017) used sprint context for division of fractions material. Putri & Zulkardi (2017) developed fraction problem using shot-put context. Rahayu, Putri,

& Zulkardi (2017) developed multiplication of fraction using hurdles context. Gunawan, Putri, & Zulkardi (2017) used swimming context to develop fractions problem. And finally, Nasution, Putri, & Zulkardi (2017) used *dayung* context for fraction problem, too.

Based on the description above, the formulation of the problem in this study comprised (1) how were the PISA-like mathematics problems on uncertainty and data content which was valid and practical; and (2) how was the potential effect of PISA-like mathematics problems on uncertainty and data content developed towards the ability of mathematical literacy of grade X high school students. The objectives of the study were (1) to generate mathematics problem of PISA-like on uncertainty and data content that was valid and practical (2) to find out the potential effect of mathematics problem of PISA-like on uncertainty and data content developed to the ability of mathematical literacy of tenth-grade high school students.

METHOD

The method used in this study is design research with the type of development studies. This study aims to generate the valid and practical PISA-like mathematics problems for the tenth-grade enrichment program and to see the potential effect of the problems made on the mathematical literacy ability of tenth-grade students of high school. This development research consisted of two stages: the preliminary stage and formative evaluation stage. Preliminary stages include student analysis, curriculum analysis, and analysis of PISA questions. After that, researchers designed the developed device. The formative evaluation stage included self-evaluation, expert reviews and one-to-one, small group and field tests (Tessmer, 1993; Ahyan, Zulkardi, & Darmawijoyo, 2014).

In this study, the PISA-like developed was said to be good if it met the three criteria of validity, practicality, and having the potential effect on students' mathematical literacy ability. Validity was based on the expert review comments. Practicality was based on the student comments and results on the one-to-one and small group. Practicality means easy to use without much difficulty. Potential effects were based on the test results of the skills and interviews in the field test stage.

The subject of this study was the tenth-grade students of senior high school. This study was conducted from October 16 to November 29, 2017. The data were collected using (1) Documentation; the document used was the Curriculum 2013 for high school, PISA framework, and problems of PISA-like; (2) Walkthrough, conducted at the expert review stage. Experts provided feedback, comments or suggestions regarding the content, constructs, and languages; (3) Interview, conducted in the one-to-one, small group, and field test. The results of the interviews in the one-to-one and small group stages were used as revision material on the prototype. Later, the interview results in the field test stage were used to see the potential effects on students' mathematical problem-solving abilities; (4) Observation, conducted to find out students 'difficulties in doing one-to-one question, knowing practicality about when small group stage, and to see the potential effect on students' mathematical literacy ability in field test stage.

The data collected were analyzed using descriptive analysis method. First, walkthrough analysis derived from the expert comments at expert review stage to get validity from the question. Second, the results of interviews at the one-to-one and small group stages were used to see the practicality of the problem. Furthermore, the interviews in the field test stage were used to see the potential effect on students' mathematical problem-solving abilities. Third, the results of the observation analysis at one-to-one were used to find out the difficulties of students in problem-solving, the practicality in the small group stage, and the potential effect to the student's mathematical literacy on field test stage.

RESULT AND DISCUSSION

This study produced 12 units of PISA-like mathematics problems consisting of 21 questions with the context of aquatic sports, athletics, and games of the Asian Games 2018. The discussion referred to Unit 8 (Football) consisting of two questions. In Unit 8, some students answered using different strategies.

Preliminary Stage

At this stage, we performed student analysis, curriculum analysis, and analysis of PISA problems. The student analysis aimed to find out the 15-year-old student and the students who had the low, medium and high ability. The curriculum analysis aimed to find out the competence standard and basic competence of statistics and probability materials in the curriculum of 2013. The analysis of PISA problems aimed to develop PISA-like mathematics problems on uncertainty and data content based on the 2015 PISA framework. In the preliminary stage, we designed 12 units of mathematics problems of PISA-like on uncertainty and data comprising 21 questions.

Formative Evaluation Stage

Self-Evaluation

At this stage, the researcher evaluated and reviewed the design results about the PISA-like problems on uncertainty and data content created at the preliminary stage. The results obtained at this stage were called Prototype 1.

Expert Reviews

At this stage, the design results on prototype one were developed by self-evaluation given to experts to test the validity of the content, navigation, construct and language validity. Two validators were validating the prototype 1, namely (1) Kaye Stacey (The University of Melbourn, Australia); and (2) Shahibul Ahyan (Hamzanwadi university, Indonesia). In addition to the expert review stage, we also conducted a panel discussion. It was conducted at the Sriwijaya University and attended by three lecturers as well as nine students of math education mathematics of Sriwijaya University. Suggestions from validators and panel discussions were used to revise Prototype 1.

One-to-One

At this stage, the problems developed in prototype one were tested to three students of tenth-grade senior high school with high, medium and low ability level. The three students were EM, AN, and NA. The results of the interview and student's answer observation were used to revise the design of PISA-like problems made by the researcher. The expert review comments, panel discussions, and one to one on the unit 8 problem are presented in Table 1.

Table 1. Comments expert review, panel discussion and one-to-one on Unit 8 problem

Category	Feedback	Follow up
Validation by an expert: Kaye Stacey	I think Question 8.1 might be easier than level 4, but only data can decide. Yes, the Question 8.2 level is easier than the Question 8.1 level. I wonder if this question is too easy. It is important to have some easy items in an assessment here. There is a wide variety of student abilities. So its value will depend on your target audience.	- We have fixed the level of the question.
Validation by an expert: Shahibul Ahyan	In the Title diagram, the goal is not created but scored. The country's name and percentage make it brighter and clearer	- Changing the word "made" to "scored." - Clarify country name and percentage on the diagram
Panel Discussion	The level on Question 8.2 instead of level 3 remains lower than that level.	
One to one	Because it is deceptive, language and hints of the matter are clear. It takes precision in answering questions. Based on the answer, Student 1 and Student 2 can answer all questions correctly. While Student 3 can answer Question 8.2 correctly while for Question 8.1 error occurred in the calculation.	

Based on the expert review comments, panel discussions, and one-to-one exercises in parallel, the question on prototype one was then revised. The revised question was named Prototype 2.

Small Group

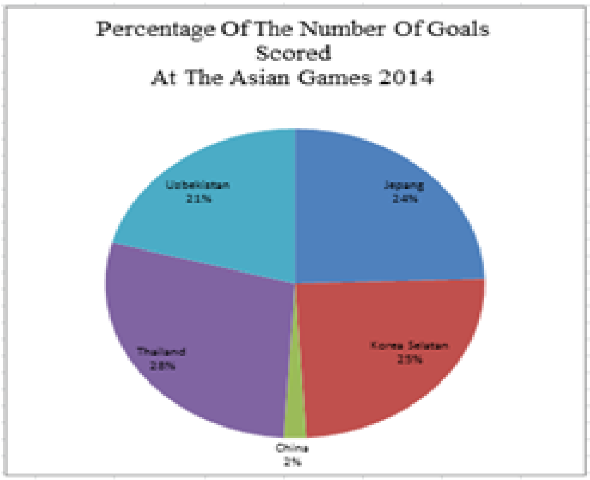
At the small group stage, a revised question based on panel discussions, expert reviews and one-to-one was called Prototype 2. It was tested on small group non-research subjects consisting of six students with different abilities, i.e., two students with high ability, two students with medium ability, and two students with low ability. We also interacted directly with the students to find out the location of the difficulties that might still occur on the PISA-like problems on Prototype 2. Small group stage looked at the practicality of the PISA-like problems. Students could work on the PISA-like problem according to the instructions. This phenomenon indicated that the PISA-like problem was practical or could be used by the students. Furthermore, the problem of PISA-like was rectified after receiving comments from the students at the small group stage.

Based on the results of the interviews and observation of student answers on Unit 8, the explanation or clue on the problem was clear, because it could be understood, most students were able to answer the problem correctly. So there was no revision on Unit 8. Based on the process at the small group stage, Prototype 3 was produced as shown in Figure 1.

UNIT 8.: Football

List of goals made by Japan, South Korea, China, Thailand, and Uzbekistan national team at the Asian Games 1998 to 2014

Year	Number of goals
1998	81
2002	51
2006	33
2010	52
2014	53



Question 8.1.: Number of goals

From the data showed above, how many goals created by South Korea national team?

Question 8.2.: Number of goals

Which country do you think made the most goals among the 5 countries stated above? Give your reasons.

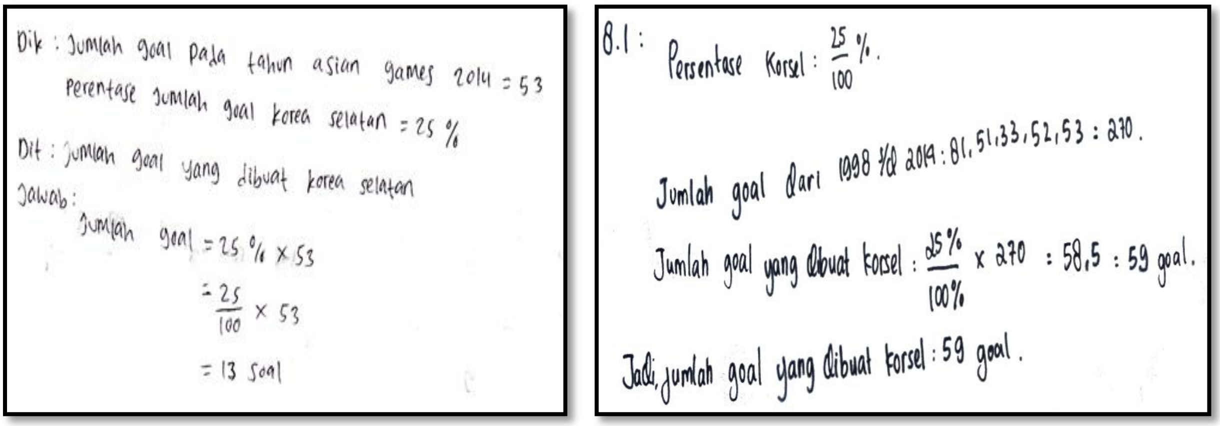
Figure 1. Prototype 3

Field Test

In the field test stage, the result of the revision of the small group stage was called Prototype 3. It was tested on tenth-grade of senior high school students involving 31 students. The situation is illustrated in Figure 2. The product to be tested in the field test stage had to meet the criteria quality. According to van den Akker (1999) a learning device developed in this case the problem was said to be good if it met three valid, practical, and effective criteria.

Figure 2. Students at the *Field Test*

Here is the student's answer to the question on Unit 8 problem in Figure 3.



(a) (b)

Figure 3. Student answers Question 8.1

Based on the answer, Figure 2(a) showed that students wrote the information first in reaching the solution completely and then determined the strategy to answer the questions given to the problems. The answer to Figure 2(a) included the category of full credit. As for the answer on Figure 2(b) students used the right steps and were able to use a good strategy, but the students were less careful in reading the instructions. Students used the number of goals in Asian Games 1998 to 2014. While on the instructions about, the number of goals that were used only in the Asian Games 2014 so that the answer included the category of partial credit. Judging from the analysis of the students' answers of a and b, the literacy ability that emerged was the ability in devising Strategies for Solving Problems. A total of 21 out of 31 students could define a strategy for reshaping mathematical contextual problems completely and correctly, as shown in Figure 4.

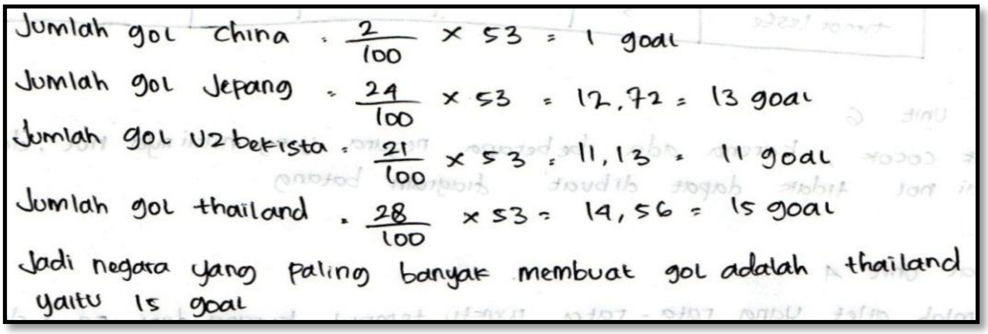

Jumlah gol China : 2/100 × 53 = 1 goal
Jumlah gol Jepang : 24/100 × 53 = 12,72 = 13 goal
Jumlah gol Uzbekista : 21/100 × 53 = 11,13 = 11 goal
Jumlah gol thailand : 28/100 × 53 = 14,56 = 15 goal
Jadi negara yang paling banyak membuat gol adalah thailand yaitu 15 goal

Figure 4. The answer of student 1 Question 8.2

Based on the students' answers one on Problem 8.2, students first calculated the number of goals for each country. After that, they concluded which country scored the most goals. The ability of the mathematical literacy that arose from the student's answer was the communication ability. A total of 25 out of 31 students could write the process in reaching the solution completely and correctly. One of the example is shown in Figure 5.

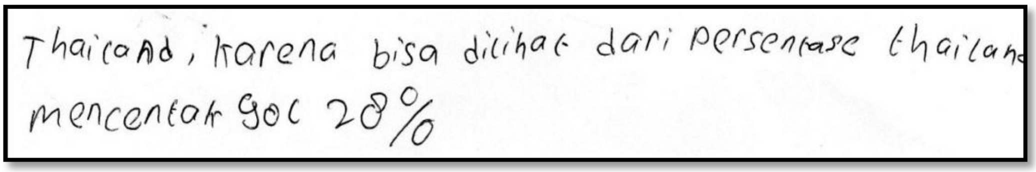

Thailand, karena bisa dilihat dari persentase thailand mencentak gol 28%

Figure 5. The answer of student 2 Question 8.2

Based on the student's answer in Figure 5, the student used different strategies by directly providing a reason for the answer in writing without having to perform the calculation process. By the PISA indicator, the emerged literacy abilities were reasoning and argument. A total of 4 out of 31 students could explain the full justification for the representation of the identified or designed real-world situation. From the students' answers of 1 and 2 to Question 8.2, students were able to apply communication skills and reasoning abilities and arguments to solve problems in Unit 8.2.

CONCLUSION

This study produced mathematics problems of PISA-like on uncertainty and data contents of 1 unit of questions consisting of 2 questions with the valid and practical context of football sport of the Asian Games 2018. Validity was based on one to one and expert reviews stages. Practicality was based on the interviews and student work on the small group stage. Also, the potential effects were obtained from the test results of students' skills and interviews in the field test stage. The results of the interviews showed that the developed mathematics problems of PISA-like were quite challenging, motivating, helping in using the ability of math in everyday life, training students to work on the mathematics problems of PISA-like, and students were happy to do the given questions. The emerged ability of students' mathematical literacy was communication, reasoning and argument ability, and ability in devising strategies for solving problems.

ACKNOWLEDGEMENT

The authors would like to express his gratitude to `the teacher (Siti Fatimah) and the tenth-grade students of Senior High School who have helped a lot in this research. Then, the authors would like to express gratitude to the Directorate General of Higher Education Indonesia -who has funded post-grant research in 2018.

REFERENCES

Ahyan, S., Zulkardi, & Darmawijoyo. (2014). Developing Mathematics Problems Based on PISA Level of Change and Relationships Content. *Journal on Mathematics Education*, *5*(1), 47-56.

Gunawan, M. S., Putri, R. I. I., & Zulkardi. (2017). Learning fractions through swimming context for elementary school students. *Proceedings of the 5th SEA-DR (South East Asia Development Research) International Conference 2017* (pp. 61-65). Paris: Atlantis Press.

Hendroanto, A., Istiandaru, A., Syakrina, N., Setyawan, F., Prahmana, R. C. I., & Hidayat, A. S. E. (2018). How Students Solves PISA Tasks: An Overview of Students' Mathematical Literacy. *International Journal on Emerging Mathematics Education*, *2*(2), 129-138.

Johar, R. (2012). Domain soal PISA untuk literasi matematika. *Jurnal Peluang*, *1*(1), 30-41.

Jurnaidi, J., & Zulkardi. (2014). Pengembangan soal model PISA konten change and relationship untuk mengetahui kemampuan penalaran matematis siswa Sekolah Menengah Pertama. *Jurnal Pendidikan Matematika*, *8*(1), 25-42.

Marpaung, Y., & Julie, H. (2011). PMRI dan PISA: Suatu usaha peningkatan mutu pendidikan matematika di Indonesia. *Widya Dharma: Jurnal Kependidikan*, *23*(1), 1-11.

Nasution, M. F., Putri, R. I. I., & Zulkardi. (2017). Dayung context in fraction. *Proceedings of the 5th SEA-DR (South East Asia Development Research) International Conference 2017* (pp. 1-6). Paris: Atlantis Press.

OECD. (2013). *PISA 2012 Results: What Students Know and Can Do, Student Performance in Mathematics, Reading and Science (Volume 1).* Paris: OECD Publishing.

OECD. (2014). *PISA 2012 Results in Focus: What 15-year-old know and what they can do with what they know*. Paris: OECD Publishing.

OECD. (2016). *PISA 2015 Results: Excellence and Equity in Education (Volume 1).* Paris: OECD Publishing.

Putri, R. I. I. (2009). Efek potensial pelatihan PMRI terhadap guru-guru di Palembang. *Jurnal Pendidikan Matematika, 3*(2), 65-71.

Putri, R. I. I. (2014). Evaluasi Program Pelatihan Pendidikan Matematika Realistik Indonesia (PMRI) Bagi Guru Matematika Sumatera Selatan. *Prosiding Seminar Nasional Evaluasi Pendidikan, 1*(1), 522-527.

Putri, R. I. I., & Zulkardi. (2017). Fraction in Shot-Put: A Learning Trajectory. *The 4th International Conference on Research, Implementation, and Education of Mathematics and Science (4th ICRIEMS) 2017* (pp. 1-8). Yogyakarta: Universitas Negeri Yogyakarta.

Rahayu, C., Putri, R. I. I., & Zulkardi. (2017). Multiplication of Fraction With Natural Number by Using Hurdles. *Proceedings of the 5th SEA-DR (South East Asia Development Research) International Conference 2017*, (pp. 43-47). Paris: Atlantis Press.

Roni, A., Zulkardi., & Putri, R. I. I. (2017). Sprint Context of Asian Games in the Division of Fractions. *Proceedings of the 5th SEA-DR (South East Asia Development Research) International Conference 2017*, (pp. *22-29*). Paris: Atlantis Press.

Stacey, K. (2010). Mathematical and Scientific Literacy around the World. *Journal of Science and Mathematics, 33*(1), 1-16.

Tessmer, M. (1993). *Planning and Conducting Formative Evaluations*. London: Kogan Page.

van den Akker, J. (1999). Principles and methods of development research. In J. van den Akker, R. Branch, K. Gustafson, N. Nieveen, & T. Plomp (Eds.), *Design approaches and tools in education and training* (pp. 1-14). Dordrecht: Kluwer Academic Publishers.

Zuhra, R. (2015). *Analisis Strategi Siswa dalam Menyelesaikan Soal PISA* (*Programme For International Student Assesment*) *Konten Uncertainty and Data pada Siswa Kelas VIII MTSN Model Banda Aceh*. Banda Aceh: Universitas Syiah Kuala.