Developing PISA-like Numerical Problem Using Vaccine Context During Pandemic

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Abstract

This is a type of development research with the main stages of preliminary and formative evaluation consisting of self-evaluation, expert review, one-on-one, small group, and field tests, with the goal of producing valid and practical PISA-like numerical problems and having an effect potential in the context of vaccines during the COVID-19 pandemic. This research was motivated by Indonesian students' poor level of mathematical literacy result to their lack of experience. The participants in this study were eighth-grade students younger than 15 years old. The qualitative analysis of this study's findings was conducted on the basis of student responses to the field test. This study's data collection methods included walkthroughs, observations, interviews, and tests. This study produced the development of a PISA-like numerical problem with the characteristics of the Change and Relationship content, the vaccine context, and the social analysis context, all of which were valid and applicable. According to the results of the validator's evaluation, the questions are sound in terms of content, structure, and language. Practically illustrated from the results of small group trials where the majority of students can easily comprehend and interpret the material. Based on the results of field trials, it can be concluded that the PISA-like numerical problems in the context of a pandemic vaccine has the potential to improve students' mathematical literacy skills.
Keywords: Development Research, PISA-like Numerical Problem, Vaccine Context

Abstrak

Penelitian adalah jenis penelitian pengembangan dengan tahapan utama *preliminary* dan *formative evaluation* yang terdiri dari *sefl-evaluation, expert review, one to one, small group, dan field test* dengan tujuan menghasilkan soal numerasi tipe PISA yang valid dan praktis serta memiliki potensi efek dengan konteks vaksin selama pandemi COVID-19. Penelitian ini dilatarbelakangi oleh rendahnya hasil literasi matematika siswa Indonesia karena kurangnya pengalaman. Subjek dalam penelitian ini adalah siswa kelas VIII yang berusia di bawah 15 tahun. Analisis hasil penelitian ini dilakukan secara kualitatif berdasarkan hasil jawaban siswa saat uji lapangan. Teknik pengumpulan data dalam penelitian ini adalah walkthrough, observasi, wawancara, dan tes. Hasil yang diperoleh dalam penelitian ini adalah pengembangan soal numerasi tipe PISA dengan karakteristik yang digunakan konten *Change and Relationship,* konteks vaksin yang meliputi konteks analisis sosial yang valid dan praktis. Valid tergambar dari hasil penilaian validator yang menyatakan bahwa soal baik secara isi, konstruk, dan bahasa. Secara praktis tergambar dari hasil uji coba pada tahap kelompok kecil dimana sebagian besar siswa dapat dengan mudah dipahami dan diinterpretasikan dengan baik oleh siswa. Berdasarkan hasil uji coba lapangan terlihat bahwa respon siswa berbeda-beda dengan tingkat kesulitan yang sesuai untuk siswa kelas VIII, sehingga dapat disimpulkan bahwa soal penomoran tipe PISA dengan konteks vaksin saat pandemi memiliki dampak positif. efek potensial pada keterampilan literasi matematika siswa.
Kata kunci: Penelitian Pengembangan, Soal Numerasi Tipe PISA, Konteks Vaksin

INTRODUCTION

The development of science and technology in the 21st century demands that every individual be able to think critically, systematically, logically, creatively, and have good social interactions (Abidin, 2020). Learning in schools in the 21st century requires the ability to communicate, collaborate, think critically, and have problem-solving skills (van Laar et al., 2020). Mathematical literacy skills are one

of the abilities that should be taken into account in the twenty-first century (Masfufah & Afriansyah, 2021). Mathematical literacy is the ability of students to formulate, apply, and interpret mathematics in a variety of contexts, and to reason mathematically (Farida et al., 2021). (OECD, 2017) explains that the development of mathematical literacy can be used to define an individual's capacity for mathematical reasoning and the application of mathematical concepts, facts, and methods to describe, justify, and predict behavior. Mathematical literacy ability is essential because there are many daily activities related to mathematics. It can help someone to understand the role or usefulness of mathematics in everyday life (Priyonggo et al., 2021) and can assist a person in making judgments based on constructive and reflective decisions (OECD, 2017, 2019a).

The level of education in Indonesia does not adequately balance the value of mathematical literacy. This can be seen from one of the types of international level assessments that Indonesia has participated in, the Program for International Student Assessment (PISA) (Baroroh et al., 2019). Indonesian students' poor level of mathematical literacy results from their lack of experience with issues similar to those found in PISA exams (Mutia et al., 2021; Nizar, H. Putri, R I I., Zulkardi, 2018). In addition, students are not allowed to seek and find their knowledge and relate it to real-life situations, so students' mathematical connection abilities have not been maximally facilitated. Therefore, PISA-like questions are needed in classroom learning activities so that students are familiar with the procedures for solving problems on PISA questions (Nasriadi & Sari, 2018).

Many studies have developed PISA-like questions, including (Charmila et al., 2016)developing PISA-like questions using the Jambi context, (Dasaprawira et al., 2019) developing PISA-like questions using the Bangka archipelago context. (Jannah et al., 2019) developed PISA-like questions using the context of the Asian Games, and several studies also used the context of COVID-19 (Jayanti et al., 2021; Nusantara et al., 2021a, 2021b; Zulkardi et al., 2021). However, no one has used the context of a vaccine, which is currently a hot topic, to reduce the virus's spread during this pandemic. In addition, students can only solve math problems using contexts familiar to them (Zulkardi et al., 2020). It shows that PISA-like questions using contexts that are familiar to students are fundamental to development.

As learning develops in the 21st century, teachers' learning models also experience development. Teachers must employ learning methods that can encourage students to think critically, creatively, and innovatively in order to bridge the abilities that students must master. Since educators need to pique students' curiosity in order to promote successful learning, inquiry-based learning is a useful learning strategy to apply. Inquiry motivates students to find answers to the problems given (Kencana Sari et al., 2019). Learning by applying the inquiry model gives students the freedom to develop the concepts they learn and allows them to solve the problems they face in groups (Purwiningsih & Sari, 2022). So it can be concluded that the inquiry model is a learning model that aims to actively involve students

in teaching and learning activities (KBM). In practice, the teacher provides fairly broad guidance for students (Asni et al., 2020)

The research results by (Juniati & Widiana, 2017) show that inquiry learning can increase students' interest in learning. Likewise, the results of(Damayanti & Jirana, 2018) research show that inquiry learning can improve learning activities and student cognitive learning outcomes (Sanjaya, 2016).

However, until now, no one has used PISA problems using the Inquiry-Based Learning (IBL) model with the context of the vaccine during the pandemic to see mathematical literacy skills. Therefore, this study intends to develop valid and practical PISA-like numerical problems using the vaccine context during a pandemic and potentially have an impact on mathematical literacy abilities.

METHOD

This study uses the stages of development research (Bakker, 2018), namely the preliminary and formative evaluation. This research aimed at obtaining valid and practical questions and learning tools. The questions will be validated using the 2022 PISA Frameworks. The stages of the development research flow can be seen in Figure 1:
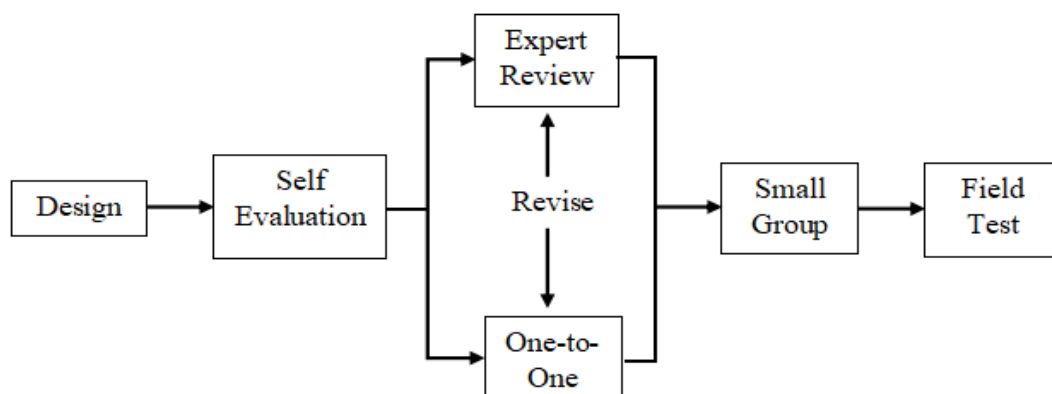

Figure 1. Development research flow (Zulkardi, 2006)

At the preliminary stage, the researcher conducts a review of the literature regarding the research to be carried out, analyzes the 2013 curriculum and connects it with the framework, determines the research subject, discusses with mathematics teachers at the school where the research is conducted, and so on. At this stage, the formative preliminary researchers designed grids, question cards, and scoring guidelines by the framework, especially on change and relationships, then collaborated to discuss PISA-like numerical problems developed with colleagues. In this case, the design of a question has criteria based on aspects of content, construct, and language. In addition, the researcher also arranges learning activities to apply the questions developed by using the inquiry-based learning (IBL) learning model, which will later be used in the small group and field test stages. The results at this stage are used as an initial prototype draft.

In the self-evaluation stage, the researcher modifies the questions created in accordance with conversations with colleagues. Then reviews the questions that have been designed, including the question grid, scoring guidelines, and so on, which already contain indicators of mathematical literacy ability, then corrects and completes the things that need to be added to form the prototype.

The self-evaluation results, in the form of prototype I, were then given to the expert in the expert review stage. Three students with different skill levels also complete a one-on-one step in addition to the expert review stage (high, medium, low). The students will be asked to observe and solve the developed questions individually, then provide comments or responses to the developed PISA-like numerical problems. The one-to-one stage was held face-to-face in schools following the health protocol. During the phase of expert reviews, the prototype was approved by a number of specialists in mathematical literacy. The validator performs validation based on three aspects: content, construct, and language. This process was carried out using e-mail and focus group discussions through the Zoom application with two Sriwijaya University lecturers, doctoral students, and several Sriwijaya University master students then having mail review to an expert who have conducted research related to the development of PISA questions. In response to the comments and suggestions made by experts during the expert review stage and students in the one-on-one setting, Prototype I was altered such that Prototype II could be used in the small group stage.

In the small-group phase, students will be split into two groups, each consisting of 3 people. Students are required to discuss the problems in prototype II with their peers in order to solve them. This trial intends to assess the practicality of the developed questions. PISA-like numerical problems can be practical if the questions presented are easy to use, can be applied, and can be interpreted by a small group of students. The test results and comments from the small group of students were used as material for revising the prototype to produce prototype III. Furthermore, a field test phase will be carried out. At this stage, the prototype is administered to the research subject class to determine the potential impact of PISA-like numerical problems on change and relationships using the vaccine context on students' mathematical literacy.

This study employs the methodologies of walkthrough, interview, and test to obtain data. These are the data analysis methods used for this study: analyze all walkthroughs from expert reviews and one-to-one, which then the results are used as material for repairing prototype obtained prototype and presented in the results of the study, Analyzing all data from observations made during both the small group and field testing, with the small group survey focusing on the applicability of the PISA-like numerical problems that were designed. During the field test, the study subject's activities in answering the produced questions are analyzed to identify the complexity and potential impacts of the PISA-like arithmetic problems created. Then the results are presented in the research results, and the reporting of these results is triangulated with other data used in small groups and field tests.

RESULT AND DISCUSSION

This study developed valid and practical PISA-like numerical problem with change and relationships content using vaccine context during a pandemic that having a potential effect on mathematical literacy skills. The problems consisted of three questions; table distribute of vaccine (2 items), graphic of vaccine distribution (1 items).
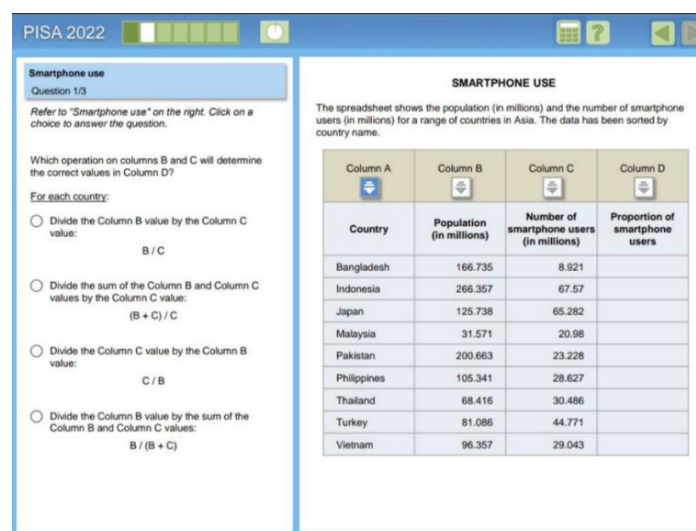
Preliminary

In the preliminary stage, the researcher conducted several analyzes including analysis of research subjects, curriculum analysis, content analysis, and making instruments. The results of the research subject analysis stage showed that the students used as research subjects were eight grade students with various abilities (high, medium, low) consisting of 3 people for the one-to-one stage and 6 people for the small stage. group and 20 students for the field test stage. Furthermore, the result of the curriculum analysis stage is the use of the 2013 emergency curriculum during the COVID-19 pandemic. The content analysis used in this study is the content that is most closely related to the real world, namely *Change and Relationship*. Next, the researcher designs and evaluates the set of questions that have been developed which refers to the PISA 2022 framework along with the scoring rubric to be used as an initial prototype draft.

Formative evaluation

Self-Evaluations

The researcher reviewed the initial prototype design with peer validation based on the 2022 PISA content, construct, and language framework at this stage. The result of the development in this stage is called Prototype 1 which will be used in the next stage. The issue of the draft 2022 framework with the smartphone context was developed using the vaccine context during the pandemic, which can be seen in Figure 1 (a) and (b).

Figure 2. Draft of the 2022 framework (OECD, 2018)

Figure 2 is a draft of the 2022 framework question using the smartphone context which was later developed into Figure 3. Figure 3 is vaccine accumulation data that will be used to find the percentage of the number of people who have vaccinated in several sub-districts in Jakarta and to see the distribution of vaccines.

Vaccine Coverage Dose-1 per Subdistrict in Jakarta (13 Juli 2021)

Coloumn A	Coloumn B	Coloumn C	Coloumn D
District	Total Target	Accumulated Coverage Dose-1	Vaccine percentage
Cakung	393.257	130.210	
Cempaka Putih	74.156	50.950	
Cengkareng	400.577	166.591	
Cilandak	163.026	132.661	
Cilincing	297.146	118717	
Cipayung	201.654	146.585	
Ciracas	221.198	75.234	
Duren Sawit	316.352	94.150	
Gambir	74.839	175.659	
Jatinegara	235.252	129.116	

3a. Which is the correct operation to determine the result in column D?

    a. C/B
    b. (B+C)/C
    c. B/C
    d. B/(B+C)

3b. Determine whether the statements below are true or false? and give your reasons.

➤ The sub-district with the largest total vaccination target also has a large accumulation of dose-1 coverage **(B/S)**
➤ The sub-district with the smallest total vaccination target also has a small accumulation of dose-1 coverage **(B/S)**
➤ The sub-districts with the highest vaccination percentages also have a small total vaccination target **(B/S)**
➤ The sub-districts with a median percentage of vaccinations also have a median value of the total vaccination target **(B/S)**

Figure 3. Prototype PISA I

Expert Review and One-to-One

At this stage, validation of prototype 1 will be carried out as a result of self-evaluation by conducting one-to-one and expert review stages at the same time. The researcher gave prototype 1 to the expert to validate the content, construct and language aspects. The results of expert validation can be seen that the contents of the questions developed are based on the current emergency curriculum with *Change and Relationship* content, in the construction aspect, in terms of constructs to determine the suitability of the questions with the level of students' ability to understand the questions, and in terms of language, the suitability of writing questions with the rules is seen. EYD, effective use of sentences so as not to contain double meanings. In line with the expert review stage, the researcher also carried out stage one to see comments and suggestions by students in the development of prototype 1. The results of the

validation by the expert review and one-to-one will be revised based on the comments and suggestions given which will then produce prototype 2.

Table 1. Comments/Suggestions and Revision Decisions

Validation	Comments and Suggestions	Revision Decisions
Experts	It is recommended that the data used is based on existing facts with a reliable source attached, because these covers sub-districts in a large area.	A source has been added under the image.
	There are no clear question instructions, later it will make students confused whether the two questions are related or whether the questions use the same picture, it is necessary to add instructions for working on the questions	Instructions are added by looking at the pictures to answer the two questions.
Students	I do not understand what is meant by the total median and median percentage	Students find it difficult to solve the questions on the fourth point regarding the total median and median presentation because they have not studied in more detail how to find the median beforehand, so the questions are not used in the study.

The qualitative validity is evaluated based on three factors. The first aspect is the relationship between broad and circular material and the context of vaccines during a pandemic, which is contained in the content. The second factor is the appropriateness of the PISA mathematics, literacy, and strategy levels and frameworks. The third aspect relates to the linguistic characteristics of good and correct language (Zulkardi, 2002).

When carrying out the one-to-one stage the researcher also conducted interviews with students, students stated questions that were made related to the conditions being experienced so that they were easier to understand because it uses real contexts in everyday life. The following are the results of interviews with students in the one-to-one stage

(Note: R: Researcher; S: Student)

S   : Are questions a and b related to each other, ma'am?

R   : Yes, that's right, but both questions still refer to the picture that has been given.

S   : Is the percentage different from the usual comparison, ma'am?

R   : Almost the same but the percentage is a comparison to express fractions of one hundred

S   : What is the median value ma'am?

R   : The median value is the middle value of the sorted data

S   : I am still confused about what is meant by the second question ma'am and how to solve it because I am still unfamiliar with the term median.

Based on the results of interviews, it can be seen that students in this case feel confused in solving the problems given, but the researcher provides an explanation of the information provided and invites students to determine the solution again by using the data information provided correctly.

Small Group

The revised results of comments and suggestions at the expert review and one-to-one stages are called prototype 2, which will be used in the next stage, namely small groups. The following are the results of the revision of the prototype development 1.

Look at the table below to answer questions 3a and 3b!

Vaccine Coverage Dose-1 per Subdistrict in Jakarta (13 Juli 2021)

Column A	Coloumn B	Coloumn C	Coloumn D
District	Total Target	Accumulated Coverage Dose-1	Vaccine percentage
Cakung	393.257	130.210	
Cempaka Putih	74.156	50.950	
Cengkareng	400.577	166.591	
Cilandak	163.026	132.661	
Cilincing	297.146	118717	
Cipayung	201.654	146.585	
Ciracas	221.198	75.234	
Duren Sawit	316.352	94.150	
Gambir	74.839	175.659	
Jatinegara	235.252	129.116	

Source : corona.jakarta.go.id

3a. Which is the correct operation to determine the result in column D?

    a. C/B
    b. (B+C)/C
    c. B/C
    d. B/(B+C)

3b. Determine whether the statements below are true or false? and give your reasons.

➤ The sub-district with the largest total vaccination target also has a large accumulation of dose-1 coverage (B/S)
➤ The sub-district with the smallest total vaccination target also has a small accumulation of dose-1 coverage (B/S)
➤ The sub-districts with the highest vaccination percentages also have a small total vaccination target (B/S)

Figure 4. Prototype PISA II

Figure 4 is prototype 2 used in the small group stage consisting of students consist of 6 people who are divided into 2 groups with each group consisting of 3 people with high, medium, low abilities. Students discuss the problem with their group mates to solve it. Students understand the idea and purpose of the questions, but some are still confused by the answer options since they are asked to find the percentage in the table, but there is no percentage in the multiplication in the solution. After the small group discussion, the questions were revised and prototype 3 was created for use in the field test phase. The following is a picture of prototype 3 development.

Look at the table below to answer questions 3a and 3b!

Vaccine Coverage Dose-1 per Subdistrict in Jakarta (13 Juli 2021)

Column A	Coloumn B	Coloumn C	Coloumn D
District	Total Target	Accumulated Coverage Dose-1	Proportion of Vaccine Coverage Dose-1
Cakung	393.257	130.210	
Cempaka Putih	74.156	50.950	
Cengkareng	400.577	166.591	
Cilandak	163.026	132.661	
Cilincing	297.146	118717	
Cipayung	201.654	146.585	
Ciracas	221.198	75.234	
Duren Sawit	316.352	94.150	
Gambir	74.839	175.659	
Jatinegara	235.252	129.116	

Source : corona.jakarta.go.id

3a. Which is the correct operation to determine the result in column D?

    a. C/B
    b. (B+C)/C
    c. B/C
    d. B/(B+C)

3b. Determine whether the statements below are true or false? and give your reasons.

> The sub-district with the largest total vaccination target also has a large accumulation of dose-1 coverage (B/S)
> The sub-district with the smallest total vaccination target also has a small accumulation of dose-1 coverage (B/S)
> The sub-districts with the highest vaccination percentages also have a small total vaccination target (B/S)

Figure 5. Prototype PISA III

Figure 5 is the result of the revision in the observation of small group activities. The researcher added the percent multiplication in the answer choices, so that students were not confused in understanding the information provided and what was asked in the question.

Field Test

The learning mechanism used in the field trial phase in accordance with inquiry learning includes orientation, formulating problems, making hypotheses, collecting data, retesting hypotheses and making conclusions. Twenty students with high, medium, and low abilities from eighth grade participated in the field test. One of the goals of the field test is to evaluate the potential impact of the questions on students' mathematical literacy skills.

At the orientation stage, the researcher conveys the learning objectives and then does a flashback to the material to be tested so that students can recall the material that has been studied previously. Researchers use a series of activities to make it easier for students to understand the material and attract students' attention to work on it. Then the researcher gave several questions to direct students' minds to the learning objectives, students were given the opportunity to formulate problems and provide

hypotheses to the questions given, but the answers have not been tested whether they are acceptable or not. To find out more about the accuracy of the answers, students will continue at the data collection stage. At this stage, students will explore to get new references related to the problems given. Based on the data collected in the previous stage, students will analyze the answers to get the right results. Finally, each student draws conclusions from the answers to the questions and activities that have been given.

The following are the results of students' answers to questions and activities related to the vaccine context during the COVID-19 pandemic which is illustrated in Figures 4 and 5.

Translate into English :

3. a) C/B

3. b)
» False, because the sub-district with a total vaccination total of 40,577 Cengkareng has an accumulated dose coverage of 166,591 while the largest accumulated dose coverage is in the Gambir sub-district of 175. 659
» False, sub-disrict with a total vaccination the smallest is gambier, but gambier has a large dose coverage compared to other sub-district
» True because the highest percentage of vaccination is

Figure 6. Results of students' AR answer of vaccine context

Based on Figure 6, it is obvious that the students can read the data provided properly, and be able to give statements accompanied by supporting reasons, showing the work involved in solving solutions or summarizing mathematical results and using an understanding of the context of the problems presented to help and speed up the process of solving mathematics and also be able to use argumentation and reasoning abilities where students are able to explain and provide justification for those identified by using their assumptions. AR students justify their assumptions descriptively, link pieces of information to reach mathematical solutions, and make generalizations at various levels of the arguments they give.

Translate into English:

b. (B+C)/C

- False, because dose-1 is more
- True, because the smallest vaccine
- True
- False

(a)

(b)

Figure 7. Results of student answers (a) VA (b) AP

Figure 7 shows that students have been able to understand the intent and purpose of the questions. Students can also convert contextual problems into mathematical form. However, VA students have not answered the questions correctly. Students mistakenly use the word accumulation; students perform addition operations related to the word accumulation. However, what is being asked in the question is what is the percentage of vaccination? Students are also able to give reasons for the statements given, but only a few statements are given reasons. Students AP give the correct answer but do not provide reasons in more detail that can support their statement. Factors that cause student errors in doing calculations are because students are less thorough and, in a hurry, to solve the problems given so that students do not re-check the process that was done previously. Another factor is that students' difficulty in answering questions is also due to their lack of experience in practicing math skills by answering various types of PISA type questions (Dasaprawira et al., 2019).

According to the results of the field test analysis, students' mathematical literacy skills are evident in the completion of each item. Students use good literacy and numeracy skills in answering questions, this can be seen from how to read data and convert it into the form of mathematical operations. Students are able to read, understand code, understand statements, questions, assignments, objects or pictures to form a model of the situation presented; mathematization skills where students are able to identify the mathematical structure that underlies real-world problems and make assumptions to use variables and structures, presentation skills where Students are able to use variables, symbols, diagrams, and appropriate standard models to represent real-world problems using symbolic/formal language. Students are able to make mathematical representations of the information presented in real-world problems. The implementation of the field test stage can be carried out after the mathematical problems of the PISA model that have been developed have been valid and practical. PISA basic skills through mathematical literacy skills (OECD, 2017). After conducting one-on-one, small group, and field trials, the results of this study indicate whether or not the questions and developments developed can be classified as valid and practical. This can be seen from the one-to-one process, small groups to field tests where it is seen that students can answer questions according to the desired direction. Mathematical literacy can be analyzed in three aspects, namely; (1) the process that includes communication, mathematization, representation, reasoning and argument, designing problem-solving strategies, using

language and symbolic, formal, and technical operations, and employing mathematical tools; (2) content, which includes changes and relationships, space and form, quantity, and uncertainty and data; and (3) context, which includes personal, work, community, and scientific (OECD, 2019b).

According to the results of an analysis of student responses, the use of everyday contexts assists students in comprehending questions and thinking mathematically (Zulkardi et al., 2020). The use of IBL in developing questions has a significant impact on the development of students' mathematical literacy. (. et al., 2017) stated that, inquiry learning is a form of student-oriented learning. An inquiry learning model that requires students to be able to think critically and be able to carry out their analysis in group learning activities and be able to communicate the conclusions they make as an answer to a problem solving (Sa'diyah & Aini, 2021).

Students are not only required to master the lesson but how they can utilize their reasoning skills The environment is intended to emphasize student actions in the search, discovery, and data collection processes. Students not only act as recipients of lessons; students also play a role in finding their own core subject matter and determining their own learning styles by utilizing the surrounding environment as a learning resource. Thus, students are able to build their own knowledge through various active and creative activities. The same thing according to (Wahyuni, Sri. Darsono, 2016) that students will learn better and meaningfully if students experience what is learned and not just know it. The application of the steps of the inquiry learning model can provide opportunities for students to argue in conveying the results of scientific analysis of a problem. To achieve effective learning, teachers must create a class atmosphere that is fun, active, and provides mutual exchange. With a fun atmosphere students become active and enjoy each class.

Of the 20 research subjects, 9 obtained full credit, as evidenced by correct answers with justifications, whereas 6 received partial credit because students could only provide answers but not the complete outcome, Students were able to comprehend the text and reason by combining context information; they were also able to translate and calculate contextual problems into mathematical calculations; however, they were unable to make correct mathematical calculations, and five subjects received no credit for being unable to answer questions.

CONCLUSION

Based on the characteristics of the PISA items developed, namely the exploration of change and relationships content with vaccine context during pandemic, which includes social context, the questions produced are valid and applicable. When problems are used to enhance mathematical literacy, they can have an effect. Argumentation and reasoning are the dominant skill of students, as they are able to relate facts using these abilities. In the meantime, mathematization skills remain low because students are less thorough and, in a hurry to solve problems, so that they do not double-check their previous work. The inquiry-based learning model is used to motivate students in learning and practicing.

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