Project-based Learning Design: Developing Maritime Context-based Tasks in English for Mathematics Course

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Abstract. This research addresses analysis concerning and learning design of project-based learning (PjBL): how standardized PjBL implementation for student-centered learning supports the Merdeka Belajar-Kampus Merdeka policy and how PjBL design for the learning process of English for Mathematics Course. Literature reviews addressing policies in PjBL were examined to determine what and how the project of English for Mathematics Course. Results show that implementing PjBL in the Merdeka Belajar-Kampus Merdeka policy needs systematic students' collaboration to work on the project through a structured process with the lecturer's guidance and assessment process. Then, the form of this learning activity carried out in one semester of the English Mathematics course of the academic year 2022/2023 is designed to do a project of developing PISA-like problems with maritime context-based. This course learning method has resulted in some blocks of activities: first, students define problems, then design a project, schedule a series of activities to finish the project, active discussion with feedback from lecturer and peer in redesigning the group project, and evaluation.

1 Introduction

English for Mathematics is a compulsory course in the Mathematics Education study program of the Faculty of Teacher Training and Education (FKIP), Raja Ali Haji Maritime University (UMRAH). This course aims for students to undertake and develop self-capacity enhancement of English proficiency within the mathematics domain. This capacity is likely the contributor to students' success in understanding mathematics textbooks, journals, and other literature in English when studying other relevant subjects. The students are also hoping to write text in English around mathematics and mathematics education topics to be able to understand as well as solve mathematical problems and give an explanation for the solutions. In addition, students are prepared to gain some knowledge, competency, and skills in preparing, conducting, and evaluating presentations or teaching segments as the phases of students' preparation for real situations of mathematical classroom practice that uses English as the main language in classroom communication.

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With the course learning objectives, mathematics education program students should also prepare themselves with the knowledge and skills to become mathematics educators [1][2]. In alignment with that, the Indonesian government, particularly the Ministry of Education, Culture, Research, and Technology, has promoted student-centered learning by emphasizing flexible curriculum frameworks [3]. The most current learning policy in universities in Indonesia enhancing quality and flexibility is the Merdeka Belajar-Kampus Merdeka (MBKM) policy. The policy promotes a student-centered learning approach, meaning that students have more control over their educational process [4]. Merdeka Belajar translates to freedom to learn, while Kampus Merdeka means independent campus. This idea also encourages a learning experience in which students develop competencies and skills by practicing skills and competencies that are relevant to their future careers. This learning process promotes critical thinking, problem-solving, collaboration, and creativity to prepare pre-service teacher students better and, as a result, a better quality of Indonesian schools education to be more competitive on a global scale.

Accordingly, the MBKM integrates Project-based learning (PjBL) as an instructional approach to learning [5]. PjBL focuses on students' learning by actively engaging in real-world, meaningful tasks and projects. PjBL focuses on students' learning by actively engaging in real-world, meaningful tasks and projects. To do the projects, students experience investigating and solving problems in collaboration with other students. With those situated tasks, the PjBL promotes students' critical thinking, problem-solving, creativity, and ability to apply knowledge in authentic contexts. Therefore, conducting PjBL in class is becoming a main option. Research on PjBl has been conducted [6] showing positive perception on collaboration skills of pre-service teachers and suggesting effectiveness of learning [7] . However, there is limited research on describing how the design of PjBL lectures in mathematics education courses that can help students develop problem-solving.

Also, concerning the quality issue of Indonesian education, especially in school mathematics, and challenges of the MBKM, the PjBL approach needs to be further discussed in its application in English for Mathematics course. The course has an important role in preparing better-quality prospective mathematics teachers. Considering the course learning outcomes, the English for Mathematics course is suitable to incorporate PjBL. Nevertheless, how and what real-world project is relevant to students applying their knowledge ? The projects taught should be practical for students' prospective careers ; together with that, students can take part in solving school mathematics issues, especially those that are now in the spotlight of mathematics educators.

Therefore, this paper presents literature reviews on PjBL implementations and describes the PjBL design for English for Mathematics course.

2 Method

We use a design research model to design project-based learning (PjBL) activities for the English for Mathematics course. The stages involved are the preparation phase, design experiment, and retrospective analysis. Qualitative data in each stage are descriptively analysed. In the preparation phase, literature reviews in PjBL are conducted; subject research is determined, 32 students of mathematics education study program FKIP UMRAH following English for Mathematics course academic year 2022/2023; lesson plan and students' PjBL guideline is completed, including project framework, set of project activities, and assessments. In the design experiment phase, a 1-semester teaching experiment is conducted. In the retrospective analysis phase, the PjBL design is compared with the learning process in the actual class.

3 Results and Discussion

3.1 Preparation phase

Choosing the right learning methods for a course should align with the course's characteristics and the learning outcomes. As stated in the National Standards of Higher Education [8] the learning process must use effective learning methods by the characteristics of the course and facilitate student-centered learning (SCL). In the SCL environment, students are at the center of the learning process, emphasizing students' active involvement through discussion activities and problem-solving tasks. The role of the lecturer is to guide and to provide resources rather than the source of knowledge.

One of the potential methods involving both active participation from students and lecturer is project-based learning (PjBL). It facilitates students working on projects or tasks that require them to actively engage with real-world problems and challenges, starting with investigation and then presenting and being responsible for their products [9]. This method aligns with the lecturer's role in the Main Performance Indicators (IKU) of Higher Education, especially IKU 7, regarding conducting collaborative and participatory classes [10]. The outlined framework for PjBL adopted by the Ministry of Education, Culture, Research, and Technology in [9] is presented by The George Lucas Educational Foundation [11] and consists of 6 stages :

1. Start with the essential question : To begin the project by posing open-ended questions,
2. Design a plan for the project : To plan a project where teachers and students collaborate to set goals for the project,
3. Create a schedule : To manage the timeline,
4. Monitor the students and the progress of the project
5. Assess the outcome : Teachers and peers give feedback on their friends' projects, focusing on the process and the final product
6. Evaluate the experience

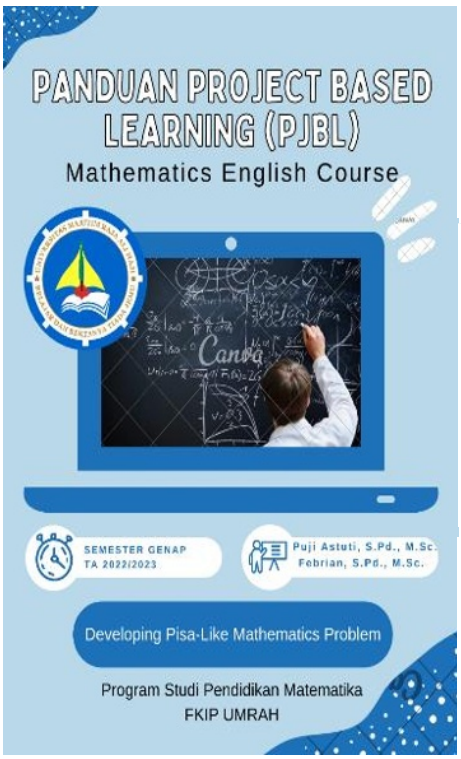
Not all courses are well suited to PjBL. However, in courses such as English for Mathematics as an in-fact-dominated and skill-dominated course [12], students can perform tasks considering their role as prospective mathematics teachers. Therefore, we take issue with school mathematics, which then and now still consumes much attention from globally to Indonesia, from the government to educators in schools, that is PISA-oriented mathematical literacy. Hence, this course project should prepare prospective mathematics teacher students to examine mathematics context-based tasks, mathematics PISA. With this aim, we think of putting students in a practical situation : developing a package of mathematics PISA test problems in which context is more relatable for Kepulauan Riau schools and maritime contexts to practice daily. The idea is that when students are in progress and finish the project, they experience rich competency development. Through this process, it is hoped that students thoroughly understand the essence of math PISA test and later can decide how to set teaching learning when they become mathematics teachers. As stated in some papers, the education system plays a role, especially teachers [13][14][15]. During the project process, the prospective teacher students develop their comprehension of English for mathematics as stated in the course learning outcome (CLO).

The PjBL project planning started with designing the lesson plan and students' guidelines containing activities. Design the structure of the PjBL in the lesson plan (Figure 1), including the overall project framework, milestones, and assessments. Also, in the student's guideline (Figure 2), we point out how students will collaborate in a working group, what resources they need, and how they will present their findings.

								• Observasi	
2	Menguasai teks singkat berbahasa inggris dalam topik *number and operation* diikuti mengevaluasi bacaan dan istilah matematis pada topik tersebut, menggunakannya serta mengeksplsorasi pengetahuan konseptual dalam topik tersebut yang disajikan dalam bahasa inggris	1. Mampu menceritakan ulang 2. Mampu mengingat sejumlah istilah 3. Ketepatan dalam mendefisinikan 4. Mengguna kan istilah dengan tepat 5. Menguasai materi	*Number and Operation*	**Bentuk:** *Student Centered Learning* berkelompok **Model:** PjBL 1 dengan sintaks 1. Pertanyaan mendasar 2. Mendesain rencana proyek dan menyusun jadwal 3. Mengerjakan proyek dan	Luring			**Kriteria** 1. Menyajikan dengan teknik paraphrase 2. Ketepatan defisini dan pengucapan, dan penggunaan istilah 3. Memecahkan masalah dengan benar 4. Mempresentasikan materi dengan lancar **Bentuk** • Tanya Jawab • Observasi • Penugasan	3 x 50'

Rencana Pembelajaran Semester (RPS) Mata Kuliah Bahasa Inggris untuk Matematika 5

Fig. 1. Lesson plan of English for Mathematics course.



2. **PISA Problems**

Dalam *Project Based Learning* (PjBL) 1, mahasiswa secara berkelompok akan

a. Menganalisis Framework Soal PISA Matematika
b. Menganalisis Domain Soal PISA Matematika
c. Memahami Rubrik Penilaian Soal PISA Matematika
d. Mengumpulkan 10 soal PISA dengan level dan domain konten, konteks yang lengkap.

Melalui soal-soal ini mahasiswa belajar memahami bagaimana soal literasi matematika, memahami maksud soal, menyelesaikan soal, dan memahami bagaimana assessment rubric soal tersebut. Soal ini nantinya akan digunakan lebih lanjut oleh mahasiswa untuk Project yang ke-2.

3. **Hasil Kegiatan Proyek**

Hasil kegiatan berupa kumpulan soal mathematical literacy PISA dengan berbagai level soal; berbagai tipe soal yakni Essay - Constructed Response, Essay – Reasonning, Simple Multiple Choice, Matching, True-False; memuat 4 konten yakni kuantitas; ruang dan bentuk, perubahan dan hubungan, serta ketidakpastian dan data; menerjemahkan keempat konten terkait dengan topik matematika pada kurikulum sekolah; dan memuat 4 konteks PISA yaitu personal, pekerjaan, sosial, dan saintifik/ ilmiah.

4. **Ketetapan terkait Proyek**

a. Setiap kelompok mengeksplor soal literasi matematika dari beberapa tahun ter-update
b. Soal harus memuat level 1-3 PISA atau diterjemahkan dari level 1-6 level kognitif.
c. Soal harus memuat 5 tipe soal PISA
d. Soal harus memuat 4 konten PISA
e. Soal harus memuat 4 konteks PISA
f. Soal harus berbeda dari kelompok lain.

B. Ketentuan dan Penjelasan

1. **Peran**

Mahasiswa adalah pusat dalam kegiatan pembelajaran berbasis proyek/kegiatan dengan bimbingan dosen pengampu mata kuliah. Dengan demikian, mahasiswa dalam kegiatan perkuliahan projek 1 ini berperan aktif memahami matematika dalam Bahasa Inggris melalui soal-soal Matematika ber Bahasa Inggris dan bertaraf internasional yakni PISA. Sehingga, sekaligus diharapkan mahasiswa juga memiliki kemampuan menyelesaikan soal matematika setaraf soal PISA yang saat ini oleh Kemendikbudristek bahkan diadaptasi ke dalam Asesmen Nasional. Penugasan dalam materi matematika bahasa inggris berkolaborasi dan dibimbing oleh dosen pembimbing. Mahasiswa setiap kelas dibagi dalam beberapa kelompok yang masing-masing terdiri dari 3-4 orang.

Fig. 2. PjBL guideline of English for Mathematics course.

We manage the block of activities of PjBL by following the stages of The George Lucas Educational Foundation [9][11]. We start the essential question stage by posing two meeting activities exploring and solving some mathematics PISA problems in the OECD PISA test website [16] and mathematics PISA released items [17] [18] [19] and understanding the PISA framework [20]. In designing a plan for the project stage, we ask students in groups (two meetings) to collect and choose 10 prospective mathematics PISA items to be adapted later, each content (Space and Shape, Change and Relationships, Uncertainty and Data, Quantity) consists of at least 2 problems and then categorize the contexts (Personal, Occupational, Societal, and Scientific), the question type (Essay - Constructed Response, Essay – Reasoning, Simple Multiple Choice, Matching, True-False), the mathematical process, and the question level, then students need to present their findings. Furthermore, two meetings were set for students to complete the PISA items with the assessment rubric.

In class, they solve peers' PISA problems and give constructive comments on the peers' item choices. In creating the schedule stage, we discussed the timeline : 3 meetings for students to develop PISA-like problems, 2 meetings for developing an assessment rubric, and 2 meetings for final project presentations. In monitoring the students and the progress of the project stage, for 3 meetings developing math PISA-like, students develop 3 items in each meeting, and present them in class. For two meetings developing an assessment rubric, in each meeting, students in progress develop their rubrics, and students' presentation is made. During the progress presentation, we assess the outcome stage and evaluate the experience stage by providing discussion in class: peer and lecturer feedback. The result of each meeting is iterative test item revisions. At the final, all groups can present their final PISA-like items in two meetings. Discussion and feedback are still being carried out at this block of activity. Students are also asked to pay attention to other groups' presentation points of revisions to self-reflect on their project product. The final product revision is assessed as the student's final test score.

3.2 Design experiment and retrospective analysis

As seen in Figure 3, we gave an orientation about the course and the PjBL process at early meeting. The course is designed so students learn the course materials in every meeting, finish exercises, and practice using English terms in mathematics. Students also, at the same time, experience the process of PjBL. Figure 3 gives an overview of the course in one semester.

English for Mathematics Education

3 SKS >> 2 SKS offline learning, 1 SKS individual learning

Meeting 1	Course Orientation
Meeting 2	2 SKS - Solving Real PISA Mathematics Problem (group work) - Presentation of group work - Exploring and understanding about PISA - Understanding Number and Operation 1 SKS + Individual Work - Book and Task "Number and Operation"
Meeting 3	2 SKS - Solving Real PISA Mathematics Problem: context, content, and level varied. - Presentation of group work - Understanding in detail about PISA domains in mathematics - Understanding Line, Cirve, and Angle 1 SKS + Individual Work - Book and Task "Line, Cirve, and Angle"
Meeting 4	2 SKS - Collecting PISA Problems in recent years - Progress Presentation and Discussion about mathematics PISA domains of the problems - Understanding Non-Circular Sided Two-Dimensional Object 1 SKS + Individual Work - Book and Task "Non-Circular Sided Two-Dimensional Object"
Meeting 5	2 SKS - Collecting PISA Problems in recent years - Progress Presentation and Discussion about mathematics PISA domains of the problems - Understanding Circular Sided Two-Dimensional Object 1 SKS + Individual Work - Book and Task "Circular Sided Two-Dimensional Object"
Meeting 6	2 SKS - Completing PISA Problems with assessment rubric - Solving Peer's PISA Problems - Checking other groups' answer of the problems - Understanding Area of Two-Dimensional Object and Its Application in Daily Life 1 SKS + Individual Work - Book and Task "Area of Two-Dimensional Object and Its Application in Daily Life"
Meeting 7	2 SKS - Completing PISA Problems with assessment rubric - Progress Presentation - Understanding Pythagorean Theorem 1 SKS + Individual Work - Book and Task "Pythagorean Theorem"
Meeting 8	Middle Term Test + Final Project 1
Meeting 9	2 SKS - Developing PISA-like Problems (3 problems) - Progress Presentation and Discussion 1 SKS + Individual Work - Book and Task "Three-Dimensional Object"
Meeting 10	2 SKS - Developing PISA-like Problems (3 problems) - Progress Presentation and Discussion 1 SKS + Individual Work - Book and Task "Volume of hree Dimensional Object and Its Application in Daily Life"
Meeting 11	2 SKS - Developing PISA-like Problems (4 problems) - Progress Presentation and Discussion 1 SKS + Individual Work - Book and Task "Historical Mathematics PART 1: Al-Khwarizmi's The Completing Square Technique"
Meeting 12	2 SKS - Developing Rubric Assessment of PISA-like Problems - Progress Presentation and Discussion 1 SKS + Individual Work - Book and Task "Historical Mathematics PART 2: Euclid's Construction"
Meeting 13	2 SKS - Developing Rubric Assessment of PISA-like Problems - Progress Presentation and Discussion 1 SKS - Book and Task "Solving Mathematical Problem"
Meeting 14	2 SKS - PISA-like problem presentation 1 SKS + Tugas Individu - Group Discussion from feedback of the presentation
Meeting 15	2 SKS - PISA-like problem presentation 1 SKS + Tugas Individu - Group Discussion from feedback of the presentation
Meeting 16	Final Term Test + Final Project 2

Team-based Project

Fig. 3. Course overview of English for Mathematics.

In the first meeting, we also assigned students to form a working group of 3-4. We considered students' strengths and diversity when creating groups to encourage

collaboration. The project in this course is analysing mathematics PISA problems and then developing mathematics PISA-like problems with maritime contexts. We ensured the students understand the expectations, roles, and responsibilities.

3.2.1 Start with the essential question

In meeting 2 and meeting 3, the lecturer and students explored the OECD website https://www.oecd.org/pisa/test/ to get a brief overview of what PISA is, what mathematics PISA is, and examples of math PISA question items. Also, the lecturer prepared some mathematics PISA problems to be discussed in the class. The students in groups were asked to brainstorm what information they could understand from the questions and what mathematical concepts were asked and needed to solve the problems. While students were working in groups investigating the solutions, the lecturer highlighted important mathematics terms and asked the students to practice saying the words together (done throughout the 1 semester of lectures). They also got the opportunity to present their findings to the class. The presentation helps students develop communicating and presenting mathematical problems in English and encourages students' mathematical concepts. Then, the lecturer asked students if they were familiar with this kind of mathematics problem and invited them to be more curious about how the mathematics PISA problem is structured. The students were allowed to convey their analysis.

However, the first block of activity we planned would open up many ideas; at the beginning, focus on translating the PISA problems and understanding the problems. Students also needed to be more confident in expressing themselves. This situation is perceptible because there might be such struggles at initial meetings. Students needed to be used to understanding English mathematics texts and were not used to facing unfamiliar context-based tasks. Moreover, one potential reason for this problem was that the subjects of this research were first-year students in the Mathematics Education study program who experienced online school (at SMA) during the pandemic. The same problem indeed is reported by PISA results of Indonesian students' low performance on math tests. In addition, many studies examine Indonesia problems are students' difficulties at the early stages of solving a context-based task: comprehending the task and transforming it into a mathematical problem [21], because of a lack of training on PISA questions with HOTS [22], and even happened to pre-service teachers who are still struggling with mathematical literacy problems [23].

Facing many obstacles in interpreting the math PISA problems and the time consumption in practicing solving the problems, we decided to redesign activity management for other activities. Students were given the course materials before class to do longer and freer small-group discussions. So that discussion in class would be well-developed.

3.2.2 Create a schedule

The block of activities in the actual experiment is similar to the block of activities we designed earlier. They are : 1) Two meetings for experiencing identifying math PISA problems and discussion, 2) Two meetings collecting and filtering prospective real PISA problems to be developed with Kepri context and presentation and revisions, 3) Two meetings for understanding assessment rubric and practice solving the peer's problems, 4) Three meetings to gradually and progressively develop PISA-like problems and presentation and iterative revisions, 5) Two meetings to develop assessment rubric of PISA-like problems and presentation and iterative revisions, and 6) Two meetings for final presentation of PISA-like problems and iterative revisions.

In this stage, we scheduled mechanisms of meetings, milestones, and deadlines. After each meeting, the students were reminded to notice what activity is coming for next week. The milestone of each meeting was given as a work assignment with a deadline one day before class. Therefore, the students had longer days rather than in class to work and discuss in their groups. Also, the lecturer had early time to check students' work, to prepare which group to choose to have a presentation, and to what points discussion in class is directed. Constructive feedback was also given at the students' submission tasks. This setting should be applied from the first block of activity. The detailed evaluation of each activity is presented in evaluating the experience stage.

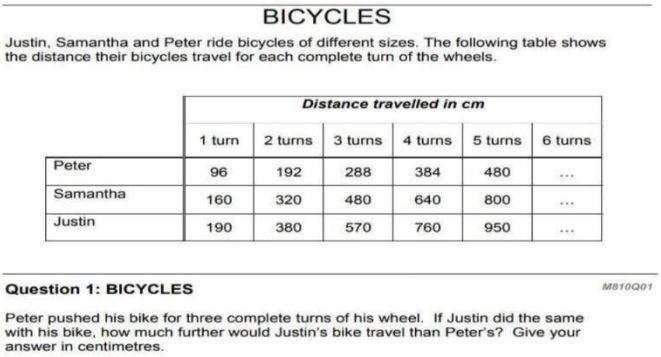
3.2.3 Monitor the students and the progress of the project, assess the outcome, and evaluate the experience

We continuously assessed student work at every meeting based on the predetermined rubric : students' English fluency with some indicators, teamwork, and quality of the assignment work. We provided constructive feedback and considered both individual and group assessments. We also ensured that students understand the assessment rubric.

In the second block of activity, collecting and filtering 10 prospective real PISA problems to be developed with Kepri context, in actual class, only some groups were on the same page. Students encountered various problems ; some have finished the assignment, and some needed help to fulfill it. Most of their problems were determining the item level. This case was already conjectured ; therefore, in class, only some questions from some groups were being discussed. From the discussion, the students were targeted to revise their work and learn from other group's presentation input. However, in this meeting, students progressively developed an understanding of the math problem itself, communicated the solutions of the problems, read the English math problems aloud and better, and learned to present their work in English. In line with [24] that stated PjBL improve students' mathematical communication skills.

The students gradually got used to English mathematics text and math PISA problems by the third block. In this block, they practiced solving other groups' problems, and then the group would check the answer by comparing it with the rubric they submitted in the assignment. In this activity, besides meeting the target project product, they also practiced solving math PISA problems.

In developing the math PISA-like problems with maritime contexts and its rubric, students were directed to develop 1 real math PISA question to 1 PISA-like question for all 10 questions they have collected. So, before this meeting, every group owned 10 developed PISA. As expected, their PISA problems were still far from perfect initially. Some challenges are 1) students only change technical things like names and numbers ; 2) students do not consider Kepri context for PISA-like; 3) students face difficulties in developing occupational and scientific contexts ; 4) students copy-paste context from difficult scientific articles but do not elaborate the information in the text to be useful in solving the question. These constraints were gradually discussed. Active discussion and focus were needed in this activity. Other students gave some comments, suggestions, and ideas. The lecturer also presented examples of developing PISA-like problems. Thus, the students did iterative reflections on their work and learn from each others' work. Nevertheless, in the meetings afterward : the project progress presentations, the students could progressively revise their work product (see Figure 4,5,6).



BICYCLES

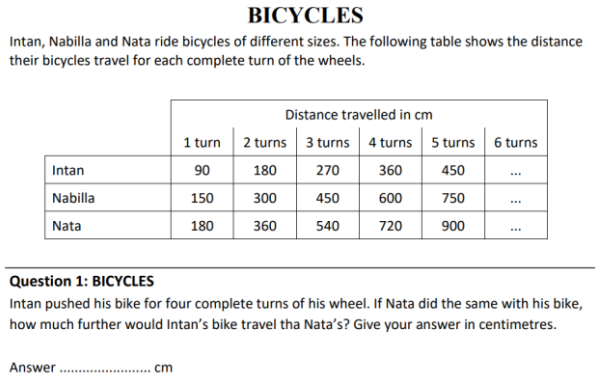
Justin, Samantha and Peter ride bicycles of different sizes. The following table shows the distance their bicycles travel for each complete turn of the wheels.

	Distance travelled in cm					
	1 turn	2 turns	3 turns	4 turns	5 turns	6 turns
Peter	96	192	288	384	480	...
Samantha	160	320	480	640	800	...
Justin	190	380	570	760	950	...

Question 1: BICYCLES M810Q01

Peter pushed his bike for three complete turns of his wheel. If Justin did the same with his bike, how much further would Justin's bike travel than Peter's? Give your answer in centimetres.

Fig. 4. Real PISA problem



BICYCLES

Intan, Nabilla and Nata ride bicycles of different sizes. The following table shows the distance their bicycles travel for each complete turn of the wheels.

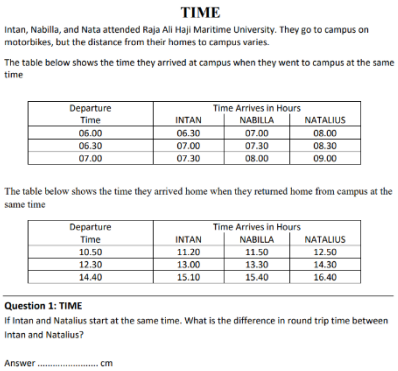
	Distance travelled in cm					
	1 turn	2 turns	3 turns	4 turns	5 turns	6 turns
Intan	90	180	270	360	450	...
Nabilla	150	300	450	600	750	...
Nata	180	360	540	720	900	...

Question 1: BICYCLES

Intan pushed his bike for four complete turns of his wheel. If Nata did the same with his bike, how much further would Intan's bike travel tha Nata's? Give your answer in centimetres.

Answer ..... cm

Fig. 5. Developed PISA problem draft 1



TIME

Intan, Nabilla, and Nata attended Raja Ali Haji Maritime University. They go to campus on motorbikes, but the distance from their homes to campus varies.

The table below shows the time they arrived at campus when they went to campus at the same time

Departure Time	Time Arrives in Hours		
	INTAN	NABILLA	NATALIUS
06.00	06.30	07.00	08.00
06.30	07.00	07.30	08.30
07.00	07.30	08.00	09.00

The table below shows the time they arrived home when they returned home from campus at the same time

Departure Time	Time Arrives in Hours		
	INTAN	NABILLA	NATALIUS
10.50	11.20	11.50	12.50
12.30	13.00	13.30	14.30
14.40	15.10	15.40	16.40

Question 1: TIME

If Intan and Natalius start at the same time. What is the difference in round trip time between Intan and Natalius?

Answer ..... cm

Fig. 6. Progress of developed PISA problem draft 2

4 Conclusion

The PjBL design in English for Mathematics course raises an important issue of Indonesian students' performance in mathematics PISA. Therefore, in line with the course learning outcome, the project is to develop mathematics PISA-like problems with maritime contexts. The PjBL design involves 6 stages: start with the essential question, design a plan for the project, create a schedule, monitor the students and the project's progress, assess the outcome, and evaluate the experience. Each stage is designed with a block of activities

showing the students' concept construction process. The results show that the prospective teacher students are gradually developing their competency in understanding the English mathematics text, practicing understanding mathematics PISA problem solutions, and developing the context-based mathematics problems adapted from mathematics PISA.

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