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REFLECTIVE THINKING SKILLS OF ENGINEERING STUDENTS IN LEARNING STATISTICS

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Abstract

Reflective thinking is known as assessing what they know, what they need to know, and how they bridge that gap during learning situations. Relating what students knew with what they learn today is not easy, sometimes they forget or just cannot make a connection between it. This study will analyze how the students actively participating in reflective thinking by creating project-based learning on statistics lesson based on design research. Thirty-nine engineering students, in a group of four, were asked to make their own data, analyze and transfer it into a poster to inform the readers about the use of statistics in daily life. This study used the measurement of reflective thinking scales by Kember to analyze students answer through the worksheet and instructional activity. The instructional activity succeeds to reveals students thinking of all four skills; habitual action, understanding, reflection, and critical reflection. Furthermore, it also discovered the misuse of some terms when used in daily life.

Keywords: reflective thinking, engineering students, statistics, design research

Abstrak

Berpikir reflektif dapat diartikan sebagai mengevaluasi apa yang sudah mahasiswa ketahui, apa yang harus mahasiswa ketahui dan bagaimana mahasiswa menjembatani perbedaan informasi tersebut selama proses pembelajaran. Proses penghubungan informasi lama dan informasi baru tidaklah mudah, terkadang mahasiswa lupa atau tidak dapat menghubungkannya. Penelitian ini akan menganalisa bagaimana mahasiswa secara aktif berpartisipasi dalam berpikir reflektif dengan mendesain suatu pembelajaran berbasis proyek pada mata kuliah Statistika yang didasari oleh desain riset. Tiga puluh Sembilan mahasiswa teknik, yang dibagi dalam kelompok beranggotakan empat mahasiswa, diminta untuk membuat atau mencari data mereka sendiri, kemudian menganalisis dan merepresentasikannya ke dalam poster. Poster tersebut ditujukan untuk memberikan informasi kepada pembaca tentang penggunaan statistika di kehidupan sehari – hari. Skala berpikir reflektif yang dilakukan oleh Kember digunakan untuk menganalisis jawaban mahasiswa melalui lembar kerja mahasiswa dan kegiatan pembelajaran. Kegiatan pembelajaran yang dilakukan telah berhasil untuk memunculkan 4 kemampuan berpikir reflektif mahasiswa yaitu, *habitual action, understanding, reflection* dan *critical reflection*. Lebih lanjut, penelitian ini juga menemukan kesalahan penggunaan istilah statistika ketika digunakan dalam kehidupan sehari-hari.

Kata kunci: berpikir reflektif, mahasiswa teknik, statistika, desain riset

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Learning nowadays is becoming more complex, information is becoming available and changing more fast that promote learners to constantly rethink, switch directions, and change problem-solving strategies (Porntaweekul, Raksasataya, & Nethanomsak, 2015; Shahrill et al., 2018). These support the suggestions to need learning which implemented to train the students think (Palinussa, 2013). It indicates that during the process of thinking students should reflected by empower and allow the skills which he has, so that he could understood and mastered what he does. Therefore, it is important to reveal reflective

thinking during learning to help learners develop strategies to apply new knowledge to the complex situations in their day-to-day activities.

Reflective thinking is a skill which will help learners to express tacit learning habits (Kizilkaya & Askar, 2009) which is an inability to actually explain what they know because they just know but not understand (Kuswandono, 2017). These skills also have significant role in the development of critical thinking (Kizilkaya & Askar, 2009) and critical thinking is one of the criteria that support high- order thinking (Ahmad et al., 2018). Then reflective thinking will help learners to develop higher-order thinking skill by encourage students to connect new knowledge to prior understanding, to think in both abstract and conceptual terms, to demonstrate specific strategies in novel tasks, and to understand their own thinking and learning strategies

Reflective thinking could support students to experience meaningful learning process (Van Es, 2006). Since students usually seeing a way to take on the future challenges by reflecting on their accomplishments and the opportunities for refinement. Ambrose (2004) and Gelter (2003) stated that reflective thinking gives opportunities for students to improve their weakness such as justifying misconceptions by helping students to think about what they did and why they did it. It indicates that the reflective thinking can occurs after mathematical problem solving conducted with the aim checking the error of the concepts used and try to justify these misconceptions, so that it can give meaningful learning process on mathematical concepts (Betne, 2009). In addition, Agustan (2017) stated that reflective thinking can be investigated after someone did a mathematical problem solving. Furthermore, reflective thinking can rise the accuracy and concentration when the students solve a mathematical problem.

Practicing reflective thinking in the learning process can be seen by where one question is answered by another question since it is a deliberate process of undertaking or cycles of inquiry (Ramsey, 2006). It will easily be followed under discussion process. Reflective practice has also become part of the movement for 'active learning' (McCoy, 2013). Project based learning, or PBL, is one of the best way to ginger students to have active learning. It is because the instructional approach in PBL built upon learning activities and real tasks that have brought challenges for students to solve. Moreover, these activities generally reflect the types of learning and work people do in the everyday world outside the classroom. Problem-based learning engages students with complex, real-world projects that teach significant subject content and require the use of a variety of 21st century skills (Grant, 2002; Ahamad et al., 2018). PBL also allows students to reflect upon their own ideas and opinions, and make decisions that affect project outcomes and the learning process in general. Thus, the model of project based learning accordance to the concept of reflective thinking.

In the college, statistics course is the development of statistical material that students got in the Senior High School. This development will be used for research analyzing to do thesis. Therefore, if students could not get the essential knowledge of the concept so they will tend to just follow the formula without a proper understanding of the meaning (Palinussa, 2013; Tanujaya et al., 2018). It is still could

be categorized as accomplishment of meaningful understanding in students (Dündar & Gündüz, 2017; Kusumaningsih et al., 2018). Usually, in this case students do not know what they are doing, why they are doing this and what is they doing for. Like when students who can cite the definition of a parallelogram but they could mention that rectangle is not a parallelogram is still categorized as meaningful understanding (Muhtadi et al., 2017; Saleh et al., 2018). One solution to help students have better understanding on statistics is to integrate active-learning strategies that grants students to apprehend what they have heard and read about statistics (Smith, 1998; Tanujaya et al., 2018).

Finally, reflective thinking answers the need of incorporate of what students' have heard, read and learn with what they will learn today. Therefore, the purpose of this study was to develop an instructional activity which can support students' reflective thinking skills and to measure their reflective thinking by using the instructional activity. Investigate subject' thinking can give description and insight how reflective thinking can be applied in learning mathematical concept. Since when students doing the project, the teacher can observe students' processes of learning and student's mathematical reflective thinking (Anwar et al., 2012). As a result, we can develop the best way to teach the students in providing a chance to reflect their prior knowledge and connect it with the future.

METHOD

This study designed instructional activity based on design research, an approach that envisions a tighter, more rigorous connection between learning principles and feature of the educational innovation (Walker, 2006), to reveal students' reflective thinking skills. The aims of this study in line with design research is to discover ways to develop a design, such as learning activity, based on theory and to determine the effectiveness of this design in practice (Funny, 2019). Hence, the design of instructional activity of this study will help to improve the mathematics education toward the reflective thinking skills. Combining with project based learning, the innovative design will give an intervention for the students to learn statistics while reveal their reflective thinking skills.

The participants of this study consisted of 39 of second year students in Adisutjipto College of Technology majoring on Aerospace Engineering who take statistics and probability course in the academic year of 2018/2019. Participants were divided into groups of four students to do the instructional activity based on project based learning.

Instruments to measure the reflective thinking skills when the students learning statistics was adopted from Kember et al. (2000). The worksheet as this instrument was the opposite of Kember Reflective Thinking Scale' Questionnaire. If the questionnaire provides a statements that should be answered in five degree of Likert Scale, our worksheet will ask questions with various answers. The main idea of the worksheet both for poster maker and visitors is writing questions to reveal the reflective thinking of learning process of statistics. The students' answers which will be examined using reflective

thinking scales by Kember that consists of four constructs or skills (Habitual Action (HA), Understanding (UN), Reflection (RE) and Critical Reflection (CR)).

The experiment was administered to the participants in their regular classrooms by the researcher. The project was delivered to the students begin on the second meeting of the course then it will continue until the Exhibition Day on the seventh meeting. This project consumed 6 weeks of the course. On the fourth until sixth meeting participant was having group discussion to analyze the data. This group discussion was paper-based recorded in the worksheet and by the researcher. In the exhibition day, the participants were divided into two roles, poster maker and visitor. The worksheet has to be completed while they were playing their roles.

The participants' responses were recorded by the researcher both in paper-based and digital-based like taking a photo and recording a video. These data were analyzed using qualitative approach in order to describe the implementation of learning activities and processes to reveal the reflective thinking skills clearly.

RESULT AND DISCUSSION

The Instructional Activity in Learning Statistics which Promote Students' Reflective Thinking

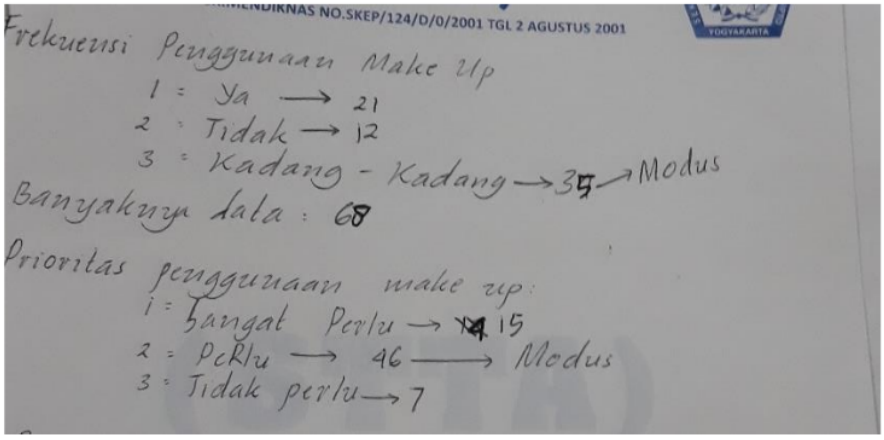
Table 1 shows the instructional activity which is designed in this study. It consists of three phase which are planning, analysing and displaying. This activity referred to project-based learning method as a small project in a short period. The focus on this project is to reveal students' reflective thinking skills. Therefore, statistics is selected as the teaching material since students have already learn the basic skills of statistics since Elementary Schools. So, it is expected to ease students recalling their prior knowledge and connecting with their problem now. This project call "Say it with Data". Furthermore, the instructional activity which was designed by this study is briefly summarised in Table 1.

Table 1. Main Instructional activity in the project 'Say it with Data'

Phase	Duration	Teaching Activities
Planning	Week 1 – Week 2	a. Group Formation b. Observe environment c. Identify issues or problem in their daily school activity d. Determine the title of the data e. Pose questioner to collect a data (Data Collection) f. Taking a photo while collecting data as a proof that the data is collected by their own
Analysing Data	Week 3 – Week 5	a. Writing all info that you want to know from the data b. Discussing how to answer questions (a) c. Find the answer of questions (a) d. Summarize it all in a poster
Displaying the Data	Week 6	a. Display all the posters in Exhibition Day of "Say it with Data". b. One students each group have to be a poster maker and have to answer all visitor questions. c. Others are being the visitor to examine every poster d. Each student, while doing his role, will complete the worksheet. e. Submit the worksheet.

Table 1 shows the results of the instructional activity which could reveal students' reflective thinking skills. Although the students' response shows misconception of their prior knowledge but it can prove that students reflect the problems in the project with their existing knowledge. Like the concept of Mode. It is known in school that mode means the value that appears most often.

For example, the mode of a set [2, 4, 6, 6, 6, 6, 9, 9, 11, 11, 15] is 6. This concept has already learnt by students in Junior High School. They also learnt that mode could not just one number, can be two numbers or three numbers that appears with same often. Such as, given a set of data [3, 3, 5, 7, 7] the mode is not unique – the data set may be said to be bimodal, while a set with more than two modes may be described as multimodal. This will not be a problem until one group in the project come up with the data 'The importance of using Makeup' (see Figure 1). The data shows that 15 students said 'Very Important', 46 argued 'Just Important' while just 7 students considered 'It does not necessary'. Looking the set of number [15, 46, 7], students easily conclude that the 46 is the mode of this data. Some students argued that 46 is the Maximum Value of the data, not the Mode. Others also have different opinion that said this data does not have Mode since all the number appears once. It leads students to have class discussion. They recalled all their prior knowledge about the Mode and connected into their current problems (Figure 1).



Frequency using make-up:
1. *Yes = 21*
2. *No = 12*
3. *Sometimes = 35 (means "modus")*

The number of all data = 68
Make-up utilization priority:
1. *Very important = 15*
2. *Important = 46 (means "modus)*
3. *Not Important = 7*

Figure 1. Data of 'The importance of using Makeup'

After several debates, the discussion drawn a conclusion that Mode in discrete data is the value that appears most often. Meanwhile, Mode in the continuous data is a locally maximum value, so any peak is a mode. In order to estimate the mode of the underlying distribution, the usual practice is to discretize the data by assigning frequency values to intervals of equal distance, as for making a histogram, effectively replacing the values by the midpoints of the intervals they are assigned to. The mode is then the value where the histogram reaches its peak (Rumsey, 2006)

This discussion shows that the activity in the project could reveal reflective thinking skills of the students. It has been successfully indicated students of four skills of Reflective Thinking by Kember et al. (2000), namely Habitual Action, Understanding, Reflection and Critical Reflection (see Table 2). The Habitual Action (HA) addressing the students who disagree that 46 is the Mode as their dependency on what their School teachers says as the only source of learning. While Understanding (UN) is addressed by students' opinion that 46 is Maximum Value or the data does not have Mode as their continuous thinking of the concept and content of the problem. Furthermore, the Reflection (RE) can be showed in the class discussion which students concern on questioning the way other argued, thinking of alternative ways of argument, reflecting and re-appraising experience within others. Last, the Critical Reflection (CR) pointed out by the conclusion that the "Importance of using Makeup" cannot be seen as a usual discrete data. The CR that shown in this case deal with changing students' outlook and challenging their firmly held ideas. Actually, there were several cases in applying this instructional activity which can reveal students' reflective thinking skills. Parsimony, we leave the other cases in this paper.

Table 2. Construction of Reflective Thinking Process and Questionnaire (Kember et al, 2000)

Dewey (1998)	Lee (2000)	Agustan et.al (2017)	Kember et.al (2000)
• An experience • Spontaneous interpretation of the experience • Naming the problem • Generating possible explanations for the problem • Ramifying the explanations into full-blown Hypotheses	• Problem context • Problem definition/reframing • Seeking possible solution	• Formulation and synthesis of experience • Orderliness of experience • Evaluating the experience	• Habitual Action (HA): behaviour knowing-in action • Understanding (UN): makes use of existing knowledge • Reflection (RE): engage to explore their experiences in order to lead to new understanding
• Experimenting or testing the selected hypotheses	• Experimentation • Evaluation • Acceptance / rejection	• Testing selected solution based on the experience	• Critical Reflection (CR): becoming aware of why we perceive, think, fell or act as we do

Hence, the result of the worksheet that given in the Exhibition Day shows the effect of instructional activity into reflective thinking skills of the students. Moreover, students were very

enthusiastic in playing their roles. The visitors truly bombarded the poster maker with many questions in the middle of hot class air as seen in the Figure 2. The poster maker should be able to explain all about the poster of their group made, the content, the process, the analysis or the conclusion.

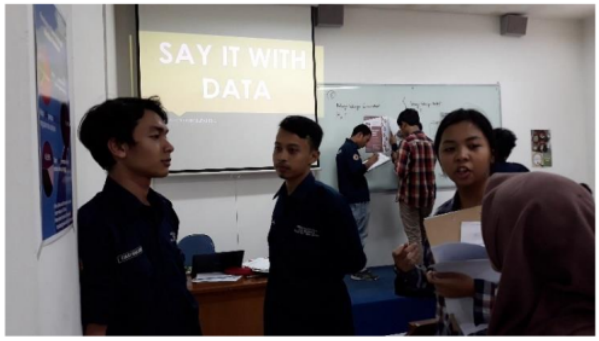


Figure 2. The poster maker answers visitor questions

While students got around the exhibition, they have to write down all the questions and answers they have done (see Figure 3). Since this study will examine student's reflective thinking skills based on their answer in the worksheet.

Figure 3. The participants record the answer and the question on the worksheet

The design of the poster also become one of attractive point in the exhibition. The visitors usually come into their favorite poster first then asking some questions. In this phase, visitors tried to pay full attention into poster makers' explanation (see Figure 4).

Figure 4. The visitors observe the poster maker explanation seriously

The Students' Reflective Thinking Analysis Using the Instructional Activity

The result of the worksheet shows all of reflective thinking skills appears on students. Refer to Table 2 of Construction of Reflective Thinking Process and the Questionnaire of Kember et.al (2000), this study is naming the categories emerging from the analysis with the four skills as described below:

a. Questions that belong to Habitual Action (HA) appears when the questions are such a habit of repetition and their dependency on what the teacher says as the only source of learning. In other words, it is such a common questions or using questions that have been given as an example before.
b. Questions that belong to Understanding (UN) appears when the questions show their understanding of the concept and content continuous thinking of material taught. We could say it such a developed question that has deep comprehension.
c. Questions that belong to Reflection (RE) appears when the students' questioning the way others do, thinking of alternative ways, reflection on actions and re-appraising. Let say 'out of the box' questions.
d. Questions that belong to Critical Reflection (CR) appears when the questions changing students' outlook, challenging their firmly held ideas, changing their routines as well as finding faults with their belief. This types of challenge question or badly called as deadly questions.

From all the participants we found more than 173 questions, 122 from visitors and 51 from poster maker. Since a visitor can visit more than one poster, so he will collect several questions. Here the briefly number about four s of questions that we have found in the worksheet.

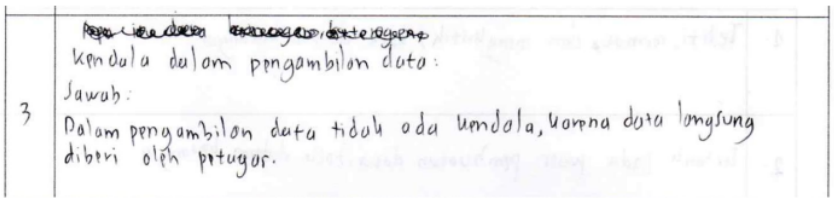
Table 3. The results of reflective thinking skills among students' questions

	Visitors (asking questions)		Poster maker (being questioned)	
HA	66	54%	29	57%
UN	29	24%	11	22%
RE	20	16%	7	14%
CR	7	6%	4	8%

Table 3 shows that more than half of students' questions still belongs to the first skill, HA. The questions that belonging to habitual action skills are listed below:

'How do you get the data?',
'What methods do you use to collect your data?',
'Is there any difficulties in collecting the data?',
'What is the aims of your data?' and etc.

It shows that students just asking for an ordinary question, that they actually have already known the answer without asking to the poster maker. Since one students can ask several questions, it found that almost on every student question appeared this skills (see Figure 5), habitual action.



"Q: Did you find any problem in collecting the data? "

"A: No, I did not. Since it is given by the officer. "

Figure 5. Question belongs to Habitual Action

Furthermore, quarter of questions stand in UN skills by asking the material of the poster information related with statistics. It is questions about something deeper from the poster such as:

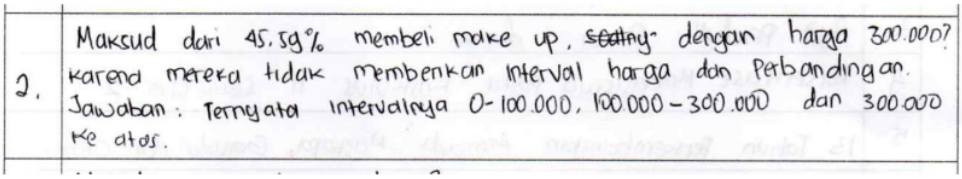
'How long do you take the data?'

'How many sample do you take to complete your data?'

'Is the data homogenous?'

'Did you taking a part in collecting the data?' and etc.

These question not only asking about how do you get the data but also the story behind it. These students have applied their knowledge about collecting the data, types of data, and the roles of researcher and so on. Therefore, these kinds of questions (see Figure 6) are belongs to UN.



"Q: What is the meaning of 45.59% buying make up for Rp. 300.000? Since the poster did not give the price interval or comparison. "

"A: Actually, the interval used in this research are 0-100.000, 100,000- 300.00 and more than 300.000"

Figure 6. Questions belongs to Understanding

Meanwhile, the Reflection (RE) skills come from questions about relating students' old knowledge to get new understanding like:

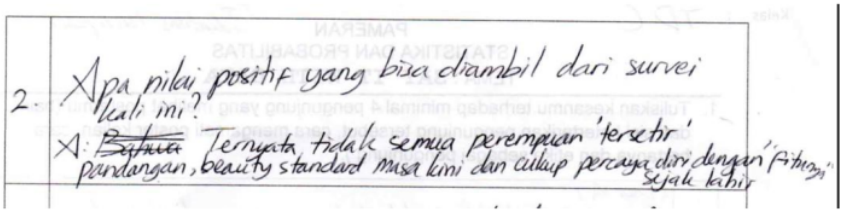
'Why for boys, the class is distributed fairly?'

'Why women using make up?'

'Could blood being expired?'

'Why the participant using social media?' and etc.

The point is, the questions reflect information that not appear in the poster but they can consider it from the poster. They reflect the poster whether it could be improved or could be done in a better way with more information. Therefore, these types of questions are Reflection (see Figure 7).



"Q: What is the positive conclusion from your Survey? "

"A: Not all woman is driven by beauty stigma. Some of them are confident with their inner beauty. "

Figure 7. Questions belong to Reflection

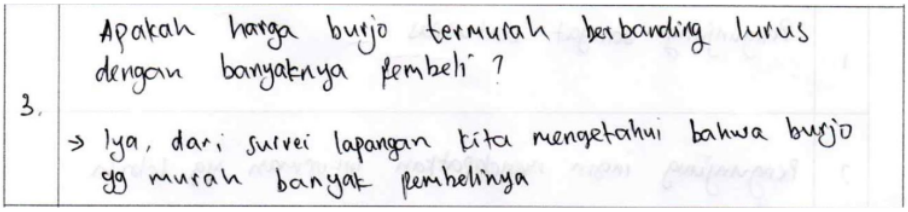
The last question skill that appears in the worksheet is CR skill. The questions that belongs this skill must go through various experience, reflection and thought also related with testing other knowledge, for example:

'What is the meaning of deviation coefficient that you wrote on your poster?'

'What is the meaning of heterogeneous and homogeneous from the library visitors?'

'How does the way to improve passenger' safety in the flight?'

This kind of questions often need additional explanation after the first answers. So, it could frighten the answerer or it could not be answered. Thus, sometimes it become a deadly question like the question on Figure 8.

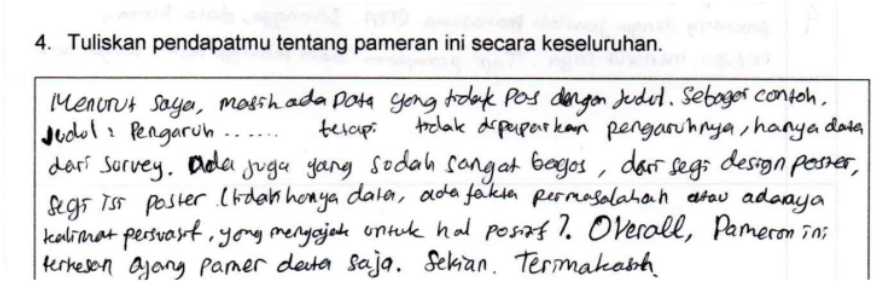


"Q: Is the price of Burjo (Mung Bean Porridge) rise as long as the customer demand?"

"A: Yes, we had surveyed that the cheaper Burjo make more customer come to buy."

Figure 8. Questions belong to Critical Reflection

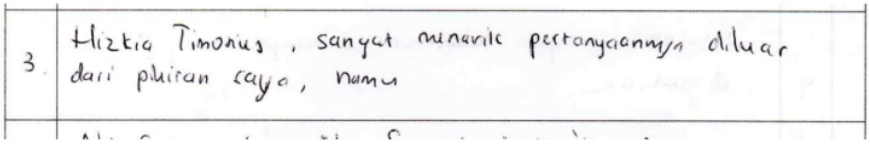
In addition, the reflective thinking also found on the students' opinion of the learning process like shows in Figure 9.



"In my opinion, there is some data that insufficient with the title. For example, the title is "The impact of ….." but they did not put it out in the poster. The design of the poster was well -turned, while the content not only show data but also problem facts. Moreover, it has persuasive sentence which leads to positive things. Overall, this exhibition seemed a data showcase."

Figure 9. Students Opinion that shows Reflective Thinking

Figure 9 showed students notion about the exhibition they had. All of the students gave reflection on this part. Some of them just gave common reflection but many of them gave deeper reflection of what they like and dislike from this project, what they feel about the way of learning and also their recommendation to have better project next time. Critical reflection not only showed from the opinion about the project but also from the opinions of the poster maker about the visitor character. When they asked to give their impression from the visitor that came to their poster, they told us positive response. Most of them showed that the visitors were very interested to their poster by asking many questions that sometimes unpredictable for the poster maker (see Figure 10).



"Hizkia Timotius have a catchy question which out of my mind."

Figure 10. Poster Maker Opinion That Belong to Critical Reflection.

Reflective thinking skill of this engineering students' mostly still in Habitual Action (HA) skill. Although, some of them success to reveal the other three skills, Understanding (UN), Reflection (RE) and Critical Reflection (CR). But it happened as the prompting of the instructional activity on the project designed. Reflective thinking usually is not spontaneous; it must be stimulated intentionally by the educational context (Khalid et al., 2015). Lecturers should be able to allow for approaches that put forward learners' mental activities like reflective and critical thinking now and later in their classroom learning process (Tuncer & Ozeren, 2012).

CONCLUSION

The Instructional Activities which made in this study were success to reveal students Reflective Thinking skills. But students still need encouragement to reflect spontaneously on their learning process. Therefore, lecturers and learning activities still play an important role in guiding students to develop better reflective thinking skill. Also, it found that the coding scheme of Kember et al (2000), with refinement, could be used to analyze and categorized types of questions in students' reflections thinking skills. Revealing student' reflective thinking skill is not an easy job. If it has appeared, try to maintain and improve it. Because we know that learning is a lifelong journey.

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