Implementing Project-based Learning in making a weight meter

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Abstract – Project-based learning (PjBL) is an activity, which can be done individually or in groups, that goes on over a period of time and its objective can be a product, presentation, or performance. It can make students develop their skills and become more engaged in learning because they can solve problems that are met in real life through a project. The project was a weight meter using a d.c. deflection-type bridge circuit and a VU meter, which was realized by a group of three students (the first three authors). We were of the 2nd year of undergraduate physics program that are taking the Measurement and Data Processing Techniques course in the period of January to April 2015. We worked together with our lecturer and tutor as our advisers. In making the weight meter, we have done the following roles in PjBL: 1. Planning the project and setting a timeline, 2. Doing research, 3. Creating first draft, 4. Rewriting the project report, and 5. Submitting the project. Under the guidance of timeline, the project has been completed timely. A force sensing resistor (FSR) sensor was employed to convert a body mass to resistance of the bridge circuit and the VU meter was modified to be a display of the weight meter. The weight meter could be used to measure a body mass up to 5 kg.

1. Introduction
In this era, quality in higher education of a country plays an important role for the economic growth. If it is good, then that country’s economy will be able to compete globally [1]. The boom of lifelong learning leads the change of learning process. The teaching-learning process moves from ‘product-based’ to ‘process-based’ learning and it encourages students to engage in active learning [2]. Research on coaching concept is proven to provide better results compared with the other teaching methods [3]. It can help teachers improving their understanding by offering ongoing support to teachers as they implement their new understandings through project and practicing some importance skills that are demanded by the workplace such as work organizations [4].

As one of learning methods, project-based learning (PjBL) is an activity, which can be done individually or in groups, that goes on over a period of time. This main objective can be a product, presentation, or performance [5]. When students apply PjBL, they will be faced with a real life problem. To solve that, they need critical knowledge and problem solving proficiency. As a result, students develop skills and become more engaged in learning. Very recently, PjBL in higher education has been discussed
thoroughly [6]. Moreover, PjBL was applied to students of the 5th year of the Agronomic Engineer Technical School of the Technical University of Madrid for a long time [7]. The students had to learn actively as they were responsible for designing, planning, and finding solutions of their projects.

In this paper, we report an implementation of PjBL to realize a weight meter, which is basically a deflection-type d.c. bridge instrument equipped with a VU (volume unit) meter. The instrument has been made by a small group of students (the first three authors) of the 2nd year of undergraduate physics program that have taken the Measurement and Data Processing Techniques course at Institut Teknologi Bandung, Indonesia in the period of January to April 2015.

2. Learning Method
As PjBL is a student-centered learning strategy and the role of students must therefore be considered. A project in PjBL is usually beyond what students already know about it. Consequently, research from a wide variety of sources including books, papers and internet will be needed. In addition, students will be required to carry out a series of important skills such as searching literature, collecting information from a wide variety of sources, analyzing data and working as part of team. Besides, other skills such as communication and time management will be essential.

Three students (the first three authors) worked in a group using PjBL to complete a project of weight meter. In making the weight meter, the group of three students has done the following roles in PjBL [5]:

1. Planning the project and setting a timeline
   Before we started the project, we made sure that we understand about the project by reading it carefully several times and writing down the preliminary concepts. We discussed more about our project in our group and the discussion was sometimes done with our advisers. It aimed to make sure we understand what we need for the project and what we must do to finish it.

2. Doing research
   We collected literatures including papers and book chapters with the help of internet search engines, did literature review, built the instrument, tested and improved it, and gathered experimental data. To make this project easier, we distributed tasks to each member.

3. Creating first draft
   We wrote the draft of our project report. It consisted of introduction, main body including theory, results and discussion, and conclusion.

4. Rewriting the project report
   We edited and revised our first draft repeatedly until the report achieved objectives, had a logical flow, fulfilled formal academic language to make it clear to readers.

5. Submitting the project
   We submitted the final project report to our lecturer and presented the project in our classroom.

The project has been done in the period of January to April 2015 while we were taking the Measurement and Data Processing Techniques. It is a compulsory course in the fourth semester of undergraduate program in Department of Physics at Institut Teknologi Bandung. Our tutor and lecturer (the last two authors) acted as our advisers in realizing the project of weight meter.

3. Results and Discussion

3.1. Planning the project and setting a timeline
The project was to make a useful instrument that employs a d.c. bridge and a volume unit (V.U) meter. Among the useful instruments, it was selected a weight meter that is used in our daily life. Before we
began research, we had to make our project plan that consists of setting a timeline, making a blueprint of the instrument, and giving job descriptions for each member so that we could finish this project on time [8, 9]. We needed 14 weeks for finishing the project, started it in the 5th week of January and ended in the 5th week of April 2015. The timeline must include the students’ five roles in the methodology. As given in Table 1, the first task i.e. planning the project and setting a timeline took a week. The second task was doing research; it took 10 weeks. While doing research in the last week, we created the first draft of our project report for a week. The next task was editing and revising the first draft; we did it in the next four weeks. In the last week of the timeline, we did the final task in which the final project report was submitted to our lecturer and presented in our classroom.

Since doing research consisted of collecting literatures either papers and book chapters with the help of internet search engines, doing literature review, building the instrument, testing and improving it, and gathering experimental data, we made a specific timeline for the second task. In allocating time, we made it as follows: collecting literatures and doing literature review in the first week, building the instrument in the next five weeks, testing and improving it in the next three weeks, and gathering experimental data in the last two weeks. Unfortunately, the specific timeline of the second task was not followed properly because the phases of building, testing, and improving the instrument were repeated unexpectedly. However, the time for completing the project was obeyed.

### Table 1. Timeline of weight meter project.

| Activities                     | Jan 5th | Feb 1st | Feb 2nd | Feb 3rd | Feb 4th | Mar 1st | Mar 2nd | Mar 3rd | Mar 4th | Apr 1st | Apr 2nd | Apr 3rd | Apr 4th | Apr 5th |
|-------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Planning and setting a timeline |         |   |         |         |         |         |         |         |         |         |         |         |         |         |
| Doing research                |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Creating first draft          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Rewriting the project report  |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Submitting the project        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |

#### 3.2. Doing Research

Mass is one of the fundamental physical quantities [10]. In order to measure mass in our daily life, we need a weight meter. Therefore, we decided to make a simple instrument to measure mass. Our specific objective was to make a good weight meter that can measure weight accurately up to 5 kilograms. Our advisers attached additional requirements to the weight meter in which it must be accurate and reproducible. Note that reproducibility denotes the closeness of the covenant between independent results that we got under different condition on the identical subject test [11].

We collected literatures either papers and book chapters with the help of internet search engines such as Google and Yahoo. A textbook of the course [12] was used as guidance for further searching. It was found that bridge circuits are commonly used as a variable conversion element in measurement systems because they can detect a small change of resistance. A d.c. bridge circuit is divided into two types: deflection and null, in which the null-type bridge circuit is used for calibration purposes while the deflection-type one is used for measurement purposes [13]. For our objective, we therefore chose the deflection type bridge circuit shown in Fig. 1. The conversion element $R_U$ was a force sensing resistor (FSR) and the output...
reading $V_O$ was a VU meter. Intensive searching of the literatures was done in the first week of February 2015 and searching-on-demand was made whenever we needed to know new terms.

![Figure 1](image)

**Figure 1.** A d.c. deflection-type bridge circuit.

The schematic diagram of a d.c. deflection type bridge circuit shown in Fig. 1 consists of four resistors, where $R_u$ is the FSR with an unknown resistance, $R_1$, $R_2$, and $R_3$ are fixed resistors, and $V_I$ is the d.c. input voltage. The d.c. output voltage $V_O$ is given by Eq. (1).

$$
V_O = V_I \left( \frac{R_u}{R_u + R_3} - \frac{R_1}{R_1 + R_2} \right)
$$

(1)

Setting that $R_2$ is equal to $R_3$, the output voltage $V_O$ depends only on $R_u$ and $R_1$. When $R_u$ is equal to $R_1$, the output voltage is zero. The output voltage has positive values that vary in a non-linear way with $R_u$ when $R_u$ is higher than $R_1$. If a VU meter is connected to the output voltage, then VU meter’s pointer deviates properly. We designed the bridge circuit to use $R_2$ and $R_3$ of 550 Ω and $R_1$ was selected as follows.

Figure 2.(a) shows an FSR, which is made of a thin polymer and used as a conversion element of the bridge circuit in Fig. 1, bought from a local electronic component shop. When pressure is applied to the FSR, its resistance will change. The more the pressure is given its resistance will be smaller [14]. Because the objective of our weight meter is to measure up to 5 kilograms, the FSR characteristics is shown in Fig. 2.(b) gives the FSR resistance of about 350 Ω. In order to make the VU meter’s pointer deviates clockwise, $R_1$ must be lower than $R_u$ of 350 Ω. It was selected $R_1$ of 180 Ω. A battery of 5 V was used as an input voltage $V_I$. 
Figure 2. (a) A force sensing resistor (FSR) and (b) its characteristics [14].

A VU meter given in Fig. 3 was purchased from a local electronic component shop. It is usually used for metering audio signals. Its original scale is in the range of -20 to +3 dB. When a positive d.c. electric current is applied to the meter, its pointer deviates clockwise. The higher the voltage is applied the pointer’s deviation will be greater. A white paper was then attached to mask the original scale. The VU meter was then connected to the output voltage of the bridge circuit.

Figure 3. A VU meter that is usually used for metering audio signals.

A holder to support a body (mass) to be weighted is illustrated in Fig. 4.(a) It consisted of a base made of a square board to locate the FSR sensor, another square upper board where the body is placed, and a pressing tool attached to the board to concentrate pressure exerted to the sensor. Unfortunately, we could not get good data using the holder because it was difficult to make the board to stand perfectly. We then added four pillars placed to the edges of the board to overcome the problem. We made a small hole at each edge of the board so that the board could be lifted and pressed freely but the body is still concentrated on the sensor as shown in Fig. 4.(b).
In the 3\textsuperscript{rd} week of March 2015, we tested our weight meter. We placed a body of 0.5 kg on the upper board and the upper board was steady. The output voltage of the bridge circuit was measured by using a voltmeter. In addition, the pointer’s position was marked by giving a short line on the white paper. We continued the testing by increasing the body mass up to 5 kilograms. The increase of output voltage with increasing the body mass was not linear as shown in Fig. 5.(a). This is consistent with that given by Eq. (1) in which $V_O = 0.086 \ln m + 0.1061$, where $m$ is the body mass, with $R^2$ of 0.9866 as represented by a line in Fig. 5.(a). The non-linear pattern is shown for the increase of weight scale on the white paper as depicted in Fig. 5.(b).

3.3. Creating first draft
In order to produce a good project report, we should begin with creating a draft. Firstly, we wrote all of our ideas into draft without considering about grammar, coherence of each paragraph, or other writing rules. Our concern was only writing format and we ensured there is no plagiarism in our project report draft. It consisted of introduction, theory, results and discussion, and conclusion.

3.4. Rewriting the project report
Editing and rewriting the project report draft are very important for us to obtain a better project report. The revision had to be done repeatedly to make sure that requirements such as the objectives are achieved, it had a logical flow, and it fulfilled formal academic language. Once the requirements were satisfied, the final project report becomes clear to readers.
3.5. Submitting the project
The final project report was ultimately submitted to our lecturer. A presentation of the project was also made in our classroom at the end of semester.

4. Conclusions
A project of simple weight meter employing a d.c. deflection-type bridge circuit and a VU meter has successfully been made under the project-based learning method. Under the guidance of timeline, the project has been completed timely. A force sensing resistor (FSR) was used as a sensor to convert a body mass to resistance of the bridge circuit and a display was made by modifying the VU meter. The weight meter could be used to measure a body mass up to 5 kg.

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