Implementing Microcontroller-Based Straight Motion Practicum Media For Improving Scientific Processing Skills

D.T. Istiantara1, I. Mafudi2, J. Handhika2, F. Huriawati2, S.W. Astutik1, N.F. Rachman1

1)Indonesian Railways Academy Madiun, Indonesia
2)Physics Education, PGRI University Madiun, Indonesia

E-mail: dedik@api.ac.id; Innalmafudi9@gmail.com,

Abstract. The study is conducted in order to identify the influence of microcontroller-based straight motion practicum media on the students’ scientific processing skills. The study is a quasi-experimental research using non-equivalent control group. Then, when the study was conducted the population that had been involved was 24 students of Grade KR 1 Negeri 1 State Vocational High School Wonoasri as the control group and 30 students of Grade X IL 1 Negeri 1 State Vocational High School Wonoasri and 27 students of Grade X TPMI GulaRajawali Vocational High School Madiun as the experimental groups. The data gathering technique that had been implemented was written test on scientific processing skills with the following indicators: observing, hypothesizing, experiment designing, concluding and communicating. The results of the study show that in the control group the N-gain was 0.3 with “Moderate” category. On the contrary, in the experimental groups the implementation of microcontroller-based straight motion practicum media has influenced the improvement of the students’ scientific processing skills; for the experimental groups, the N-gain is 0.6 with “Moderate” category.

1. Introduction
Physics is a lesson that might not be separated from experimental activities in laboratory. Such experimental activities will encourage the students to take active participation in the learning process and through these activities they will train themselves to solve any problem that they find independently. In the same time, through the lesson the process of discovering concept directly will also retain the students’ long-term memory [1]. In addition, the students’ practicum activities will help them expand their experiences, creative thinking skills and cooperation [2]. Furthermore, students will also be able to hone their skills, including the scientific process skills [3].

The selection of practicum media as an effort of improving the students’ skills is based on several studies that have been previously conducted and the results of these studies show that multi-function optical media might improve the students’ scientific process skills and that stationer wave practicum equipment is able to provide significant influence toward the improvement of scientific processing skills with “Good” category [4,5]. The results of several other studies also show that practicum
activities provide positive influence toward the students’ scientific processing skills and learning motivation [6,7]. Based on these results, the researchers would like to assume that the use of practicum will have certain impact on the scientific processing skills of Grade X IL students from Negeri 1 State Vocational High School Wonoasri and Grade X TPMI students from GulaRajawali Vocational High School Madiun.

The practicum activities might be well conducted if these activities are supported by well-qualified and highly accurate learning media. The good qualification and high accuracy are necessary for reducing the percentage of errors within the data gathering activities. In the present study, the media that will be selected is microcontroller-based straight motion practicum media. These learning media have many advantages and one of them is that the use of microcontroller in the experiment will gather the necessary data more accurately and efficiently. Similarly, through the visual basic display the evaluation process will be more effective and efficient so that the students will be able to identify the experiment results directly [8]. In addition, the microcontroller itself has reliable system and low cost as well as small power consumption for the system operation [9].

The scientific processing skills refer the skills of both implementing scientific methods for discovering new scientific concept and understanding the already existing scientific concepts [10]. The scientific processing skills consist of 10 indicators namely observing, classifying, predicting, hypothesizing, experimenting, operating equipment, experimenting, concluding and communicating.

Such skills are very important for training highly flexible-attitude in dealing with the changes in the surrounding environment such as the one that might occur in association, occupation and institution/organization. Another advantage that might be gained from training the scientific processing skills is that individuals will have honesty and accuracy as part of their attitude so that they will be able to adapt well into their society [12]. Being able to adapt well in a society is an important step in equipping the students to deal with numerous challenges in the 21st Century.

2. Method

The study was a quasi-experimental research using Non-Equivalent Control Group Design. In the Non-Equivalent Control Group Design, the sample from both the control group and the experimental groups was not selected randomly [13]. Then, the activities in the control group were as follows: the subjects were provided with a pre-test in the beginning of the learning process and the pre-test was followed by a lecture and a post-test at the end of the learning process; in other words, the subjects in the control group were not provided with the treatment. On the other hand, the activities in the experimental groups were as follows: the subjects were provided with a pre-test in the beginning of the learning process and the pre-test was followed by the treatment, namely the use of microcontroller-based straight motion practicum media, and a post-test in the end of the learning process. In conducting the study, the population that had been involved in the study was 24 students of Grade X KRI Negeri 1 State Vocational High School Wonoasri as the control group, 24 students of Grade X IL 1 Negeri 1 State Vocational High School Wonoasri as the experimental groups and also 27 students of Grade X TPMI GulaRajawali Vocational High School as the experimental groups. The data gathering instrument that had been used in the study was scientific processing skills written test with 5 inquiry-based essay test items and the following indicators: observing, hypothesizing, experimenting, concluding and communicating. The data from the pre-test and the post-test on the scientific processing skills were analysing using the N-Gain Test from [14] and Adoption Criteria from [15].

3. Results and Discussions

The study has been conducted in order to identify the influence of microcontroller-based straight motion practicum media on the improvement of the students’ scientific-processing skills. The microcontroller-based straight motion practicum media is one of the learning media that have been innovated by the researchers under the effort of creating learning media with practicum guidelines so that the students will be assisted in the conduct of straight motion experiment.
The learning media have 5 LED sensors that are installed in the same level with the LED light source on 80 cm long-track. These sensors are connected to the microcontroller which serves as both the control and the data generator. From this process, the experiment data will be generated through the computer in the visual basic application form with \( v \) (velocity), \( t \) (time), \( s \) (distance) and average velocity. The design of the practicum media might be consulted in the following figures.

![Figure 1. The design of microcontroller-based straight motion practicum media](image)

![Figure 2. Visual Basic Form](image)

Then, the aspects of scientific processing skills that have been observed in the study are as follows: 1) observing; 2) hypothesizing; 3) experimenting; 4) concluding; and 5) communicating. The results of
N-Gain Mean Test on the scientific processing skills that both the control group and the experimental groups have performed might be consulted in the following graphic.

![N-Gain Mean Score from the Scientific Processing Skills Data](image)

**Figure 3.** Graphic of N-Gain Mean Score from the Scientific Processing Skills Data

Based on the results in the above graphic, the N-Gain Mean Score from the 5 aspects of scientific processing skills are lower for the control group in comparison to the experimental groups. Each aspect will be explained further in the following paragraphs.

First, the observing skills refer to the skills that benefit the five senses in order to attain the necessary information. These skills are highly decisive in developing the other skills. Based on the results in the above graphic, it might be concluded that the observing skills of the experimental groups are higher than those of the control group because in the practicum activities the students in the experimental groups are provided with the freedom to gather the information that will be necessary for serving as the underlying theoretical foundation in solving the given problems. The results of another study also show that the use of practicum media in a learning process is able to help the students in training their observing skills [16].

Second, the hypothesizing skills are the continuation of the observing skills. In the stage of mastering these skills, the students are trained to be able to find contemporary answers from the information that they have attained when they are conducting their observation. The hypothesizing skills might also be considered as a compulsory skill that the students should have while they are performing an experiment. Based on the analysis that has been conducted, it might be concluded that the hypothesizing skills of the experimental groups are higher than those of the control group. These results are in line with a study that has been conducted previously, which results show that a hypothesis that has been based on the observational data will generate good results [3].
The experimenting skills refer to the skills of selecting and preparing the necessary tools and equipment for testing the hypotheses that have been prepared based on both the imagination and the existing experiment. Based on the results that have been displayed, it might be concluded that the experimenting skills of the experimental groups are better than those of the control group because in the experimental groups the subjects are accustomed to using tools and materials and thus the students improve their experimenting skills indirectly [17].

The skills that have been previously discussed will be incomplete if the concluding skills are not added into the discussion. The concluding skills refer to the manner of explaining the data that have been attained from the experiments along with the existing concepts and theories. The results of the study show that the concluding skills of the control group are 0.4 (“Moderate” category) while the concluding skills of the experimental groups are 0.8 and 0.9 (“High” category) respectively. Thereby, it might be concluded that the concluding skills of the experimental groups is higher than the concluding skills of the control group because the subjects in the experimental groups are trained to construct the knowledge in their own paradigm. In addition, the subjects in the experimental groups experience and attain the data from their own conclusion [7].

Last but not the least, the communicating skills become very necessary since human beings have social attitudes that demand interaction from one to another within their life. As a result, human beings need to deliver both ideas and information that they have attained to the others so that the knowledge that has been attained might be beneficial for the science development. Then, based on the results of the study it might be concluded that the communicating skills of the experimental groups are higher than those of the control group because the subjects in the experimental groups are more able to communicate the results of their own investigation. Therefore, these subjects improve their self-confidence indirectly when they deliver their presentation [18].

Based on the explanation in the previous paragraphs, in overall the aspects of scientific processing skills (that include observing, hypothesizing, experimenting, concluding and communicating) that the experimental groups have are higher than those that the control group has. It means that by using the microcontroller-based straight motion practicum media the students’ scientific processing skills attain good improvement.

Furthermore, in order to view the overall influence of media implementation a recapitulation toward the N-Gain score form the aspects of scientific processing skills should be conducted. The results of the recapitulation might be consulted in the following table:

| Control Group | First Experimental Group | Second Experimental Group |
|---------------|--------------------------|---------------------------|
| N-Gain        | Category                 | N-gain                    | Category |
| 0.3           | Moderate                 | 0.6                       | Moderate |
|               |                          | 0.6                       | Moderate |

Referring to the N-Gain Mean Score recapitulation of scientific processing skills between the control group and the experimental groups in Table 1, it is apparent that the subjects in the experimental groups earns 0.6 (“Moderate” category) which is higher than the subjects in the control group (0.3, “Moderate” category). The reason is that the students in the experimental groups are provided with the microcontroller-based straight motion practicum media while the students in the control group are not. These results are in line with the results of several studies that have been previously conducted, which show that the use of practicum media is able to improve the students’ scientific processing skills [3,19].
The higher N-Gain Mean Score in the experimental group has been caused by the fact that in the learning process by means of the practicum media use the students are provided with the freedom to develop the skills that they have attained and in the same time the students are also directly involved in discovering the concept that they have been studying. This result confirms the results of the other studies that have been conducted: by providing the opportunities for exploring the practicum media both in solving problems and in discovering new knowledge the students’ scientific processing skills might be improved [4].

Taking a closer view, the improvement of both the control group and the experimental groups belong to the “Moderate” category and the only difference is found in the N-Gain Mean Score between the control group and the experimental groups. The reasons behind the less maximum development that has been found in the experimental groups are namely: 1) the students perform the microcontroller-based straight motion practicum media for the first time and consequently they are not skilled yet in operating the practicum media; 2) the students have not been able to understand the practicum guidelines that have been provided; and 3) the amount of practicum media and the time allotment are still limited. These obstacles have caused the learning process to be less maximum. Similarly, these obstacles have been proposed in other studies that have been conducted: the inability to meet the passing grade requirement within the effort of improving the scientific processing skills has occurred because the students are not accustomed to operating the practicum media, the students do not study the practicum guidelines well and the students have insufficient time allotment [20]. The scientific processing skills might be maximally improved if the students are accustomed to repetitively performing experiments [21].

4. Conclusions
Within the study, the microcontroller-based straight motion practicum media has been applied in order to improve the students’ scientific processing skills. The results of the study show that after the microcontroller-based straight motion practicum media has been applied the students’ scientific processing skills have improved significantly in comparison to the absence of microcontroller-based straight motion practicum media.

5. Acknowledgement
The researchers would like to show their gratitude to Indonesian Railways Academy Madiun and PGRI University Madiun who have been willing to collaborate so that the study might be well conducted.

6. List of References
[1] Irwanto, Rohaeti, E., Widjajanti, E., & Suyanta. “Students Science Process Skill and Analytical Thinking Ability in Chemistry Learning” 1, 2016.
[2] S. K. M. Badri Yadav*, “A Study of the Impact of Laboratory Approach on Achievement and Process Skills in Science among Is Standart Student,” vol. 3, no. 1, pp. 1–6, 2013.
[3] P. M. and R. S. I. S S Edie, Masturi, H N Safitri, D Alighiri, Susilawati, L M E K Sari, “The effect of using bomb calorimeter in improving science process skills of physics students The effect of using bomb calorimeter in improving science process skills of physics students,” 2018.
[4] P. Oktafiani, B. Subali, and S. S. Edie, “Pengembangan Alat Peraga Kit Optik Serbaguna ( AP-KOS ) untuk Meningkatkan Keterampilan Proses Sains,” J. Inov. Pendidik. IPA, vol. 3, no. 2, pp. 189–200, 2017.
[5] M. Khristi Widiaeastutik, “Pengembangan Alat Praktikum Gelombang Stasioner untuk Melatihkan Keterampilan Proses Siswa SMA Kelas XI,” urnal Inov. Pendidik. Fis., vol. 3, no. 2, pp. 201–207, 2014.
[6] E. W. and R. Kustijono, “The use of physics practicum to train science process skills and its effect on scientific attitude of vocational high school students The use of physics practicum
to train science process skills and its effect on scientific attitude of vocational high sch,”
Semin. Nas. Fis., 2017.
[7]  S. Prajoko, M. Amin, F. Rohman, and M. Gipayana, “The Effect Of Local Materials Usage For Science Practicum On Students ’ Science Process Skills,” vol. 5, no. November, pp. 1–10, 2016.
[8]  H. S. Setiawan, E. R. Agustin, and S. Wahyuni, “Physics Experiment and Evaluation Method Based Microcontroller Atmega and Microsoft Visual Studio,” vol. 2, no. 2, pp. 111–116, 2016.
[9]  K. Zachariadou, K. Yiasemides, and N. Trougkakos, “A low-cost computer-controlled Arduino-based educational laboratory system for teaching the fundamentals of photovoltaic cells,” Eur. J. Phys., vol. 33, no. 6, pp. 1599–1610, 2012.
[10] Malik, A., Handayani, W., & Nuraini, R. (2015). Model Praktikum Problem Solving Laboratory untuk Meningkatkan Keterampilan Proses Sains. Prosiding Simposium Nasional Inovasi dan Pembelajaran Sains (p. 194). Bandung: Institut Teknologi Bandung.
[11] Rustaman, N. (2005). Setrategi Belajar Mengajar Biologi. Malang: Universitas Negeri Malang.
[12] W. Ambarsari and S. Santosa, “Penerapan Pembelajaran Inkuiri Terbimbing Terhadap Keterampilan Proses Sains Dasar Pada Pelajaran Biologi Siswa Kelas VIII SMP Negeri 7 Surakarta,” J. Pendidik. Biol., vol. 5, no. 1, pp. 81–95, 2013.
[13] Sugiyono. (2009). Metode Penelitian Kuantitatif Kualitatif dan R&D . Jakarta: Rajawali.
[14] D. E. Meltzer, “The relationship between mathematics preparation and conceptual learning gains in physics: A possible ‘hidden variable’ in diagnostic pretest scores,” Am. J. Phys., vol. 70, no. 12, pp. 1259–1268, 2002.
[15] R. R. Hake, “Analyzing change/gain scores,” Unpubl. URL http://www. physics. indiana. edu/~sdi/AnalyzingChange-Gain. pdf, vol. 16, no. 7, pp. 1073–80, 1999.
[16] R. Chebii, S. Wachanga, and J. Kiboss, “Effects of Science Process Skills Mastery Learning Approach on Students ’ Acquisition of Selected Chemistry Practical Skills in,” Creat. Educ., vol. 3, no. 8, pp. 1291–1296, 2012.
[17] Widayanto, “Pengembangan keterampilan proses dan pemahaman siswa kelas x melalui kit optik,” J. Pendidik. Fis. Indones. (Indonesian J. Phys. Educ.), vol. 5, no. 1, pp. 1–7, 2009.
[18] Hanisa, Desy, and M.Sutarno, “Problem Solving Pada Pembelajaran Gelombang Dan Optik Untuk Meningkatkan Keterampilan Proses Sains Mahasiswa,” J. Exata, vol. X, no. 2, 2013.
[19] M. M. Ratamun and K. Osman, “The Effectiveness Of Virtual Lab Compared To Physical Lab In The Mastery Of Science Process Skills,” vol. 76, no. 4, 2018.
[20] F. Huriawati, J. Handhika, and Luthfiaturohmah, “Penerapan media praktikm gerak harmonik seerhana menggunakan osilator digital detector untuk meningkatkan hasil belajar dan keterampilan proses sains,” in prosiding SNFA (sennar nasional fisika dan aplikasinya), 2016.
[21] E. S. dan A. S. P Siahaan, A Suryani, Aku Kaniawati, “Meningkatkan Keterampilan Proses Sains Siswa melalui Sederhana Simulasi Komputer di Linear Gerak Konsepsi Meningkatkan Keterampilan Proses Sains Siswa melalui Sederhana Simulasi Komputer di Linear Gerak Konsepsi,” J. Phys. Konf. Ser. 755, no. konverensi internasional tentang tren terbaru di fisika 2016, pp. 8–13, 2017.