Integration of technology in project based learning with tracker on practicum activities

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Abstract. This research reports the utilization of Tracker as one of the media used in the application of project-based learning on practicum activities. The purpose of this research is to improve the learning and innovating skills and science process skills of physics education students at STKIP Nurul Huda in practicum activities that are still considered low. Integration of technology in project based learning with tracker can provide an opportunity for students to engage in learning activities with the framework of scientists, creative and innovative work. Students perform activities by making project in the form of experimental video for further analyzed it using Tracker. During the learning activities, the researcher observed students' learning and innovating skills as well as students' science process skills. The results showed that the use of Tracker in project-based practicum activities can train students to be able to associate abstract physics concepts with real life using video analysis, in addition, the use of Tracker on practicum activities provide a students' discretion to make practical projects that will be done and effective to used in shaping the science process skills of practicum activities.

1. Introduction

Learning skills, innovation and science process skills are an achievement that must be done in practicum activities in physics learning. Trilling and Fadel [1] affirms that learning and innovation skills are achievements of skills that must be met in 21st century education, while learning and innovation skills include: 1) Critical thinking and problem solving; 2) Communication and collaboration; and 3) Creativity and innovation. While the science process skills as an instructional impact must be gained in practical activities, the skills of the scientific process include skills that each individual can use in every step of his/her daily life by being scientifically literate and increasing the quality and standard of life by comprehending the nature of science [2][3][4].

Achievement of learning skills, innovation and science process skills play a strong role in shaping the character of students as prospective professional teachers in the 21st century by integrating the development of ICT in learning. While based on the results of observations of researchers when taught at STKIP Nurul Huda, achievement of learning skills, innovation and science process skills are qualified low. To achieve these objectives requires a learning model and the right media in the
Implementation of learning. Learning models with performance practices (projects) have great benefits in shaping a meaningful student learning experience, as well as teaching 21st century skills such as collaboration, critical thinking, problem solving, and presentation [5][6][7]. Project in the learning process will develop students' knowledge through the construction of direct learning experience, [8][9][10]. Furthermore, project-based learning model focuses on learning involving students through various stages of complex activity around authentic issues.

Project-based learning (PjBL) learning methods help students acquire knowledge and skills by engaging in work activities over a long learning period to investigate and respond to complex problem questions or challenges [11][12][13]. To meet the demands of 21st century skills where learning skills and innovation must be oriented towards ICT literacy, the learning process must be organized and managed and produce a new learning environment. The application of the PjBL model must be integrated with technology, where technology is seen as an appropriate learning media of PjBL learning model. The use of Tracker as learning media is a manifestation of the development of learning technology from Open Source Physics (OSP) which is effectively used in practicum activities through learning projects [14][15][16]. The practicum project with Tracker can be lifted from problems emerging from the real world around students, so it can be emphasized that physics has a close relationship with daily life. With the implementation of the learning model project based learning integrated Tracker-assisted technology in the activities of physics practicum is expected to improve learning skills, innovate and science process skills appropriate with the demands of education in the 21st century.

2. Literature Review

2.1. Project based learning in practicum activities

Project-based learning provides a meaningful learning experience for students in gaining knowledge during the learning process, [17][18] five characteristics that become the advantages of learning model PjBL are:

- project-based learning centered on students as learners, and lecturers as learning facilitators;
- project-based learning focuses on questions or problems that encourage students to discover key concepts and principles of knowledge;
- project-based learning involves students in constructive inquiry;
- project-based learning encourages students in meaningful learning environments to obtain material retention; and
- the project to be studied is taken from the problem of the students daily life.

Characteristics of project-based learning is considered suitable to be used as a model of learning in practical activities, Colley [18] projects undertaken in practicum activities will shape learning and innovation skills whereby students should be accustomed to solving problems and critical thinking in learning activities. In addition, projects that have been designed will also have an impact on students' science process skills such as the ability to ask questions that can be researched, identifying and formulating hypotheses, designing and conducting investigations, collecting and analyzing data, drawing conclusions, and documenting and reporting findings.

Skills that become other instructional impacts in the application of PjBL are put forward by Condliffe et al. [19] including intra-interpersonal competence: communicative, collaborative, cooperative, meta-cognitive, and self-regulatory skills (also called soft skills). Of these skills that complement the education of the 21st century is the literacy towards ICT. There are recommends of how importance of integrating technology in the process of implementing PjBL so that the learning process is effectively implemented [18][20]. The stages to be implemented in project-based learning on practical activities can be shown in Figure 1.
Stages performed in practical activities on project-based learning as in Figure 1 are generally classified into three groups: planning, implementing and evaluating.

**Planning:**
- Phase 1. Apperception
- Phase 2. Formation of working group (Collaborative / Cooperative)
- Phase 3. Formulation of project and selection of appropriate technology use in practicum activities

**Implementing:**
- Phase 4. The process of project implementation
- Phase 5. Makes project activity report
- Phase 6. Presentation of the work project activity

**Evaluating: “Ongoing assessment”**
- Learning and Innovating Skill
- Science Process Skills

*Figure 1. Stages of project-based learning in practicum*

2.1.1. **Planning.** The planning activities in consist of three phases of them: 1) phase 1 Apperception in lecturer apperception activities checking knowledge with some questions relating to practice materials to see the knowledge scheme held by students; 2) phase 2 Formation of working group (collaborative / cooperative), in this phase lecturers use careful consideration to form groups of collaborative / cooperative work projects based on the results of apperception activities, whether the ability of study groups from students spread in homogeneous / heterogeneous; and 3) phase 3 is the formulation of the project and the selection of appropriate technology usage in practicum activities to be implemented, in this phase to develop ideas related to the practicum project that the lecturer started by giving some questions and problems in real life students, in the hope that students can introduce ideas that will be the design of practical projects that will be done in groups. Three stages in this planning activity become the main determinant in the implementation of learning activities.

2.1.2. **Implementing.** The application of PjBL to the practicum activity consists of three phases: 1) phase 4 The process of implementation of the practice project, implementation in phase 4 students start to make work project in the form of video of practicum activity which will diaanaisis using Tracker, individually within the designated group. In the process of implementation in phase 4 consists of several activities such as observing, measuring, the ability to ask questions that can be researched, identifying and formulating hypotheses, designing and conducting investigations, as well as collecting and documenting data. 2) phase 5 making of the project activity report, in phase 5 students began to analyze the data, drawing conclusions from the project activities practicum he has done; and 3) phase 6 Presentation of project activity project results, the last phase of the student communicates and
discusses the group from the activity report of the practicum project that it does, as well as reviewing the findings obtained from each group.

2.1.3. Evaluating. Evaluation of learning is done to see the ability of learning and innovating skill and science process skills as an impact in the application of PjBL model. Evaluation is done by ongoing assessment technique, assessment is not only done at the end of the lesson, but also during the learning process and continuously through the feedback of all members of the learning environment [21][22]. Ongoing assessment can be done in the learning activities when students do project work in practice activities and discussion activities of the findings of each group. Ongoing assessment technique is expected to be able to see the ability of Learning and Inovating Skill and Science Process Skills that students have during the learning process.

2.2. Tracker in physics learning
Tracker is a software developed by Java Open Source Physics (OSP) with the aim as a medium of physics learning that is used as a tool of analysis and modeling of video in practicum [23][24][25]. Trackers are very effectively used in physics learning, the advantages of using Tracker in learning: 1) video projects can be explored by students in the classroom, or as homework assignments to improve students' understanding of specific content; 2) lecturers can involve their students by asking them to perform simple experiments in the form of videos that will be able to be analyzed using the Tracker; 3) students can do experimental analysis at any time, as much as they want to add understanding to the taught material; and 4) students apply and associate physical concepts in real situations [25][26]. Based on these advantages, Tracker is considered very suitable to be used as a medium of learning in applying the model PjBL.

3. Research Methodology

3.1. Research design
The design used is The One-Group Pretest-Posttest Design [27][28], the approach is used with the aim of analyzing descriptively quantitative about the impact of application of integrated technology model PjBL with Tracker on student activities of STKIP Nurul Huda. Interpretation of descriptive data refer to table 1.

| Equation                                                                 | Average Scores | Interpretation   |
|-------------------------------------------------------------------------|----------------|------------------|
| \( \bar{X} > \bar{X}_i + 1.8 \times S_{bi} \)                         | \( \bar{X} > 4.2 \) | Master           |
| \( \bar{X}_i + 0.6 \times S_{bi} < \bar{X} \leq \bar{X}_i + 1.8 \times S_{bi} \) | \( \bar{X} > 3.4 - 4.2 \) | Expert           |
| \( \bar{X}_i - 0.6 \times S_{bi} < \bar{X} \leq \bar{X}_i + 0.6 \times S_{bi} \) | \( \bar{X} > 2.6 - 3.4 \) | Proficient       |
| \( \bar{X}_i - 1.8 \times S_{bi} < \bar{X} \leq \bar{X}_i - 0.6 \times S_{bi} \) | \( \bar{X} > 1.8 - 2.6 \) | Familiar         |
| \( \bar{X} \leq \bar{X}_i - 1.8 \times S_{bi} \)                      | \( \bar{X} \leq 1.8 \) | Beginner         |

*Master* mean Students already have skills with professionals and know these skills thoroughly. *Expert* mean Students are trained and able to apply the skills they acquire and develop them. *Proficient* mean Students are accustomed to using these skills in routine activities. *Familiar* mean Students have only basic skills on the skills acquired but are eager to learn more. *Beginner* mean The student will start exploring the new skills she gets.
3.2. Participants
Participants in this study amounted to 26 students, 5 laboran, and 4 observers of learning activities. The students who are subjected to the research object are the second semester students of physics education at STKIP Nurul Huda.

3.3. Data collection instruments
Instrument used to collect data in this research that are: 1) observation sheet, used to see the instructional impact of improving learning and innovating skills and science process skills; 2) test sheets, used to measure the understanding of teaching materials as a projection of the instructional impact of applying the model PjBL integrated technology with media learning Tracker.

3.4. Data analysis
Data analysis used in this research is descriptive analysis in the form of calculation of mean of learning achievement and standard deviation [29][30], while to see the improvement of student learning outcomes is done paired data test of pretest and postes that have been taken with

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    t = \frac{\bar{W}}{s_w / \sqrt{n}}
\]  

3.5. Formulation of research hypothesis:
H_0: The posttest result of the student is no better than the pretest result of the students who learn by using integrated PjBL Technology Method.
H_1: The posttest result of the students is better than the pretest result of the students who learn by using integrated PjBL Technology Method.

4. Research Result

4.1. Result of practicum project activity
The practicum project is set at the beginning of the learning activity, with reference to the material set. The practicum project implemented by 26 students with 6 working groups are:

4.1.1. Determination of gravity by pendulum method. The first practicum project was carried out by group 1 and group 6 with the topic of determining the value of gravity by the pendulum method. The work results of group 1 and group 6 practicum projects can be seen in Figure 2 and Figure 3.

Figure 2. Display project pendulum harmonic motion on the practicum of determination of gravity value

Figure 3. Display of data analysis of pendulum harmonic motion on the practicum of gravity value
Figure 2 is an activity about tracking the data taken from a practicum project video, the video selected for tracking data should in high resolution so there is no error in retrieving data. Figure 3 is the tracking video data obtained by groups 1 and group 6, in this section students must be able to choose the value of which variable will be used to determine the gravitational constant. Besides the level of deviation from tracking data also can be seen from the graph formed, in figure 3 the practicum project results data is relatively good, so that in the written report the gravitational value obtained by students is $(9.75 \pm 0.02) \text{ m/s}^2$ close to the value of gravity theoretically.

4.1.2. Determination of gravity by free fall method. The second topic is the practical project of determining the value of gravity by the free fall method carried out by groups 2 and group 4. The work of groups 2 and group 4 can be seen in Figure 4 and Figure 5.

Figure 4 is tracking the best video projects from group 2 and group 4, from this simple project it turns out that the tracking data is quite satisfactory as shown in Figure 5 with an accurate half parabol graph. But from the results of the analysis of Figure 5 reported in writing group 2 and group 4 obtained the value of gravity $(10.66 \pm 0.14) \text{ m/s}^2$, based on these results group 2 and group 4 must analyze several factors that influence the value of gravity in the free fall motion project.

4.1.3. Determination of spring constants through simple harmonic oscillation. The third practical project is to determine spring constants through simple harmonic motion carried out by group 3 and group 5. The work of group 3 and group 5 can be seen in Figures 6 and Figure 7.

Figure 6. Display project of simple harmonic motion in practice of determining spring constant value

Figure 7. Display analysis of simple harmonic motion data on practicum determination of spring constant value
Based on figure 6 and figure 7 the graph formed in harmonic motion on the spring is not very good, this occur because in the process of implementing group 3 and group 5 found some obstacles such as 1) video resolution that used to tracked is not very sharp, 2) difficulties in the process tracking data, 3) springs used are not elastic.

4.2. Description of learning achievement

The learning achievement in this study based on literature review is Learning and Inovating Skill, and Science Process Skills. Description of learning outcomes can be presented in Tables 2, 3 and 4.

| No | Learning achievement | Average | Interpretation |
|----|-----------------------|---------|----------------|
| 1  | Critical thinking and problem solving | 2.08 | Familiar |
|    | a. confront and understanding problem | 2.12 | Familiar |
|    | b. diagnose or define problem | 2.08 | Familiar |
|    | c. inventory several solutions | 2.04 | Familiar |
| 2  | Communication and collaboration / cooperative | 2.50 | Familiar |
|    | a. participants educate each other or teach one another | 2.42 | Familiar |
|    | b. be able to identify and test against sharing options in groups | 2.42 | Familiar |
|    | c. participants always respect differences of opinion and are flexible to knowledge | 2.65 | Good |
| 3  | Creativity and innovation | 2.08 | Familiar |
|    | a. be able to concentrate and generate a number of ideas | 2.12 | Familiar |
|    | b. independent in consideration, thought, and action | 2.04 | Familiar |
| 4  | Ability to present the results of the practice project | 2.75 | Proficient |
|    | a. accepting and adjusting that seems to be opposite and acceptable to differences | 2.65 | Proficient |
|    | b. believing in yourself and open to experience / knowledge in discussion | 2.85 | Proficient |

Total averages 2.35 Familiar

Table 2 explains that in general the resulting learning outcomes as an instructional impact of applying the integrated PjBL Tracker model are identified Familiar. Interpretation of this assessment is enhanced by the achievement of learning achievement learning and inovating skill points 1 and point 3 where the average results of Critical thinking and problem solving and Creativity and innovation obtained 2.08. While the highest average is on points Ability to present the results of the practice project with a value of 2.75.

| No | Learning achievement | Average | Interpretation |
|----|-----------------------|---------|----------------|
| 1  | Observing | 2.42 | Familiar |
| 2  | Measuring | 2.42 | Familiar |
| 3  | Ability to ask questions | 2.15 | Familiar |
| 4  | Identify and formulate hypotheses | 2.15 | Familiar |
| 5  | Design and conduct investigations | 2.42 | Familiar |
| 6  | Collect and analyze data | 1.85 | Familiar |
| 7  | Make a conclusion | 1.73 | Beginner |
| 8  | Documenting and reporting findings | 1.85 | Familiar |
The result of observation of the science process skill shown in Table 3 is the overall qualification Familiar, with the highest average of 2.42 in Observing, Measuring and Design and conduct investigations. While the lowest average in Make a conclusion with a value of 1.73, this is because the basic understanding of students related to practical materials and the use of tracker is not so good.

**Table 4. Descriptive statistics learning outcomes in the cognitive domain**

| Descriptive statistics | Pretest ($X_{pre}$) | Posttest ($X_{pos}$) | W ($X_{pos} - X_{pre}$) |
|------------------------|---------------------|----------------------|-------------------------|
| Minimum value          | 40                  | 40                   | -5                      |
| Maximum value          | 70                  | 80                   | 30                      |
| Average                | 52.88               | 61.54                | 8.65                    |
| Standard Deviation     | 10.12               | 10.84                | 7.94                    |
| Varians                | 102.35              | 117.54               | 63.12                   |

N=25; $\alpha$=5% $t_{count}(5.554)$ $t_{table}(2.060)$

Description of data analysis in Table 4 gives information that there is difference of mean pretest and postes value of students learning using PjBL method with help of Tracker in practicum activity. Where the mean of posttest value > pretest value mean this gives meaning that there is increasing of mean value of pretest and posttes of student as impact of application of model of PjBL in practice activity using media Tracker. While based on t test for paired data with the number of participants (N=25) significance level $\alpha$= 5% was applied $t_{count} = 5.554 > t_{table} = 2.060$ indicating that reject $H_0$ and receive $H_1$, the results of this test give meaning the posttest result of the student is better than the pretest result of the students who learn by using integrated PjBL Technology Method.

5. Discussion

5.1. Reflection of students on PjBL integrated with tracker

Student's opinion related to the use of the Tracker in the PjBL model on the practicum activities is disclosed during the Phase 6. The opinions are:

**Table 5. Students' opinions about the implementation of PjBL integrated technology with Tracker**

| Group of origin | Opinions about learning activities using PjBL with Tracker |
|-----------------|----------------------------------------------------------|
| Group 1         | Learning activities using Tracker in the PjBL model are very fun, we can learn something with the ideas we propose with such that we can raise our skills in innovating individuals or groups. |
| Group 2         | The use of the Tracker as a learning medium used in analyzing a practical project in the form of video is very useful, because the practicum project is done directly related to real life and Tracker is very helpful in taking the data we do in practicum. |
| Group 3         | Learning using the PjBL model teaches independence, explores ideas from each student's mesing, but in the use of the Tracker requires a special direction of the lecturer so that students are not constrained in the collection of practicum data. |
| Group 4         | The taught concept in practicum activities through the PjBL model is very interesting, especially added using the Tracker as a learning media is very helpful for us in practicum activities and get accurate data and precision in real time. |
| Group 5         | Learning using Tracker is very helpful in the activities of practical projects that we will carry out, but for beginners like us in using Tracker it takes a special explanation in understanding the Tracker. |
Group 6  The project that we do in the practicum activities is very helpful and allows us to understand the lessons and gain knowledge, because with the existence of work project in practice activities teach us how to behave and think like scientist.

5.2. Revised of PjBL integrated tracker in implementation of learning
Revised implementation of integrated PjBL Tracker in the learning process can be done on the continuation of this research. Revised implementation of integrated PjBL Tracker in the learning process can be done on the continuation of this research, but in general Learning achievement learning and inovating skills and Learning achievement Qualified science process skills Familiar which means that students still have basic skills only on skills acquired and need to learn more. The revision is done on the syntax of learning model can be shown in Table 6.

Table 6. Revised syntax of integrated learning model PjBL technology

| Planning activities | Description |
|---------------------|-------------|
| **Phase 1.** Apperception | **Revision:** In apperception not only the lecturers process in connecting knowledge already possessed by students with knowledge to be taught, but the lecturers do needs analysis of learning. Analysis of learning needs include three aspects: 1) content analysis, 2) analysis of student characteristics; 3) analysis of learning environment. |
| **Phase 2.** Formation of working group (colaboratif / cooperative) | **Not revised** |
| **Phase 3.** Formulation of project and selection of appropriate technology use in practicum activities | **Revision:** After the formulation of the project and the selection of appropriate technology use in the lab activities should lecturers make the design of instructional messages to facilitate students in implementing work projects and media that will be used in the learning process. |

| Implementing activities | Description |
|-------------------------|-------------|
| **Phase 4.** The process of project implementation | **Not revised** |
| **Phase 5.** Preparation of project activity report | **Not revised** |
| **Phase 6.** Presentation of the work project activity results | **Not revised** |
| **Evaluating activities** | **Not revised** |
| Ongoing assessment | |

6. Conclusion
Application of integrated PjBL technology model by using Tracker media in practicum activity is considered effective to improve student learning outcomes, this condition is evidenced from the result of $t$ test for paired data with the number of participants ($N = 25$) and significance level $\alpha = 5\%$ is $t_{\text{count}} = 5.554 > t_{\text{table}} = 2.060$. This gives the meaning of posttest result of the students better than the result of pretest of students who learn by using integrated PjBL Method Technology.
However, for learning achievement of learning skill and innovation and science process skill, the students are still qualified familiar which means that the students only have basic skill on the skills they get and need to learn more.

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