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Implementing Physical Learning Based On Momentum and Impulse Stem Materials to Develop Collaboration Skills

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ABSTRACT

The challenges of the 21st-century life require that every individual must master 21st-century skills. The 21st-century learning, and innovation (4C) skills are among the skills that rank first among other skills. Collaboration skills are part of 4C skills that are important for students to develop. The 2013 curriculum policy and STEM-based learning are solutions to the challenges of the 21st-century development. The results of a survey of 16 high schools in the city of Semarang, show that schools have not applied to learn with the STEM approach and have not specifically developed collaboration skills. The purpose of this study is to investigate the development of student collaboration skills through the application of STEM-based physics learning. The research method used was quasi experimental with a form of nonequivalent control group design. The subjects of this study were students of class X MIPA SMA 11 Semarang, class X MIPA 5 as an experimental class, and class X MIPA 7 as a control class. Retrieval of data using observation and documentation methods. Analysis of research data using observation sheet analysis with the help of SPSS and Microsoft Office Excel programs. The results showed that collaboration skills after applying STEM-based physics learning developed in the medium category.

Tantangan kehidupan abad 21 menuntut setiap individu harus menguasai keterampilan abad 21. Keterampilan belajar dan inovasi abad 21 (4C) merupakan salah satu keterampilan yang menjadi urutan teratas dari keterampilan lainnya. Keterampilan kolaborasi bagian dari keterampilan 4C yang penting untuk dikembangkan peserta didik. Kebijakan kurikulum 2013 dan pembelajaran berbasis STEM merupakan solusi menghadapi tantangan perkembangan abad 21. Hasil survei pada 16 Sekolah Menengah Atas di Kota Semarang, menunjukkan bahwa sekolah belum menerapkan pembelajaran dengan pendekatan STEM dan belum mengembangkan secara khusus keterampilan kolaborasi. Tujuan dari penelitian ini adalah untuk mengetahui pengembangan keterampilan kolaborasi siswa melalui penerapan pembelajaran fisika berbasis STEM. Metode penelitian yang digunakan adalah quasi experimental dengan ben-tuk nonequivalent control group design. Subjek penelitian ini adalah siswa kelas X MIPA SMA Negeri 11 Semarang, kelas X MIPA 5 sebagai kelas eksperimen dan kelas X MIPA 7 sebagai kelas kontrol. Pengambilan data menggunakan metode observasi dan dokumentasi. Analisis data penelitian menggunakan analisis lembar observasi dengan bantuan program SPSS dan microsoft office excel. Hasil penelitian menunjukkan bahwa keterampilan kolaborasi setelah diterapkan pembelajaran fisika berbasis STEM, berkembang pada kategori sedang.

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I. Introduction

The 21st-century is based on science and technology, so it demands human resources to master various forms of skills (Mendikbud, 2017). The 21st-century learning, and innovation skills are stated as the key to unlocking lifelong learning and creative work. 21st-century learning and innovation (4C) skills are at the top of the skills that every individual need to master to face the demands and challenges of the 21st-century (Trilling & Fadel, 2009). 4C skills need to be owned and

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developed by students for the present and the future. (The Partnership for 21st Century Skills, 2015) states that learning skills and innovation (4C) are important for students to help them prepare for more complex life and work environment in the 21st-century. (Motallebzadeh et al., 2018) also states that 21st-century skills (4C) will enhance learning mechanisms by creating engaging learning environments. 4C skills consist of four skills, one of which is a collaboration skill.

Collaboration is expressed as a coordinated and synchronous activity, the result of ongoing efforts to build and maintain a shared conception of a problem (Rosen et al., 2016). The work done through collaborative activities is different from the work done individually. (Jones et al., 2014) states that collaboration produces the ability to create something new and is more robust than what can be achieved by individuals. The role of collaboration in learning stated by (Ronfeldt et al., 2015), can provide benefits for students. Students will get a better achievement if they study in a strong collaborative environment. (Woodland & Hutton, 2012) states that collaboration can produce more significant innovation and preserve resources to achieve common goals. (Trilling & Fadel, 2009), explains that students who have collaboration skills can show their ability in collaboration or groups, be flexible and contribute to having a personal role, are responsible, and can appreciate any difference.

The development of collaborative skills is pursued in the application of the 2013 curriculum. (Susianna, 2014). States that the competencies developed in the 2013 curriculum have been adapted to the 21st-century skills. STEM is an acronym for the fields of science, technology, engineering, and mathematics (Information resources management association (Irma), 2014).

STEM and 4C skills, including collaboration skills, are presented as solutions to face the 21st century life. STEM facilitates students to develop 21st-century learning and innovation (4C) skills. STEM emphasis, which refers to as a means for future success, is an essential reason for mastery of STEM to be owned by students (Hwang & Taylor, 2016). Students, who are proficient in STEM, prepare the nation to become leaders in an increasingly global economy (Hughes, 2010). Research conducted by (Suwarma et al., 2015) revealed that STEM-based physics learning could increase students' motivation and learning creations and increase conceptual understanding. Furthermore, learning physics by using the STEM approach can improve the ability to solve problems (Dewi et al., 2018). One of the physics materials, which are momentum and impulse, in the 2013 curriculum is one of the essential competencies that students must master (Susianna, 2014).

The results of a survey of 16 high schools in the city of Semarang show that schools have not applied to learn with the STEM approach and have not explicitly developed collaboration skills. The purpose of this study was to investigate the development of student collaboration skills through the application of STEM-based physics learning.

II. Method

The method used was a quasi-experimental with nonequivalent control group design. A random sampling technique was carried out in Semarang 11 Public High School located at Jl. Lamper Tengah XIV, RT 01 RW 01, and Semarang 50248. The participants in this study were class X MIPA 5 as an experimental class and class X MIPA 7 as a control class. The procedure of this study was divided into three stages: the initial stage, the implementation stage, and the final stage.

Observation and documentation methods were used in generating data. The analysis of these data employed observation sheet analysis with the help of SPSS and Microsoft Office Excel programs. Collaborative skills during the learning process take place, assessed based on observations made by several observers. Learning is equipped with STEM-based learning tools, RPP, LKS, and teaching materials. The tools have been tested for eligibility based on the expert judgment of lecturers, the feasibility test by one other skilled lecturer, and physics subject teachers in high school. Physics material taught is limited only to the material momentum and impulses.

III. Results and Discussion

Collaborative skills are assessed based on several indicators, namely working effectively and respectfully in group work, contributing to making agreements for common goals, and being responsible for group work. The results of the analysis of collaboration skills are presented in Table 1.

Table 1. Analysis of Collaboration Skills

Classes	Average Score (%)		N – Gain	N – Gain
	Pre	*Post*		
Experiment	71	82	0.37	Medium
Criteria of Average Score	High	High		
Control	38	42	0.06	Low
Criteria of Average Score	Low	Low		

Based on Table 1, the collaboration skills of students in the experimental class have an average value that is higher than in the control class. The results of N-Gain also showed that students in the experimental class experienced higher collaboration skills (N-Gain was in the medium criteria) than in the control class (N-Gain was in the low standard). The results of the collaboration skills analysis of each indicator can be seen in "Fig. 1", while the results of the N-Gain test of the skills of each indicator are presented in "Fig. 2".

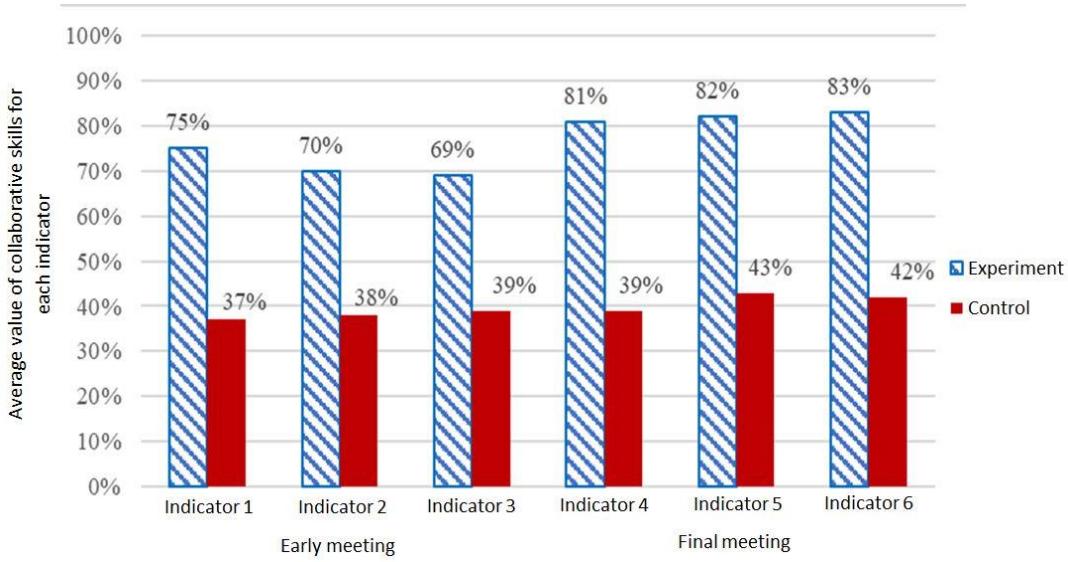


Fig. 1. Graph of Average Score of Collaboration Skills for Each Indicator

[a] Notes :
[b] indicator 1: work effectively and respectfully in groups
[c] indicator 2: contribute to making a deal for a common goal
[d] indicator 3: responsible

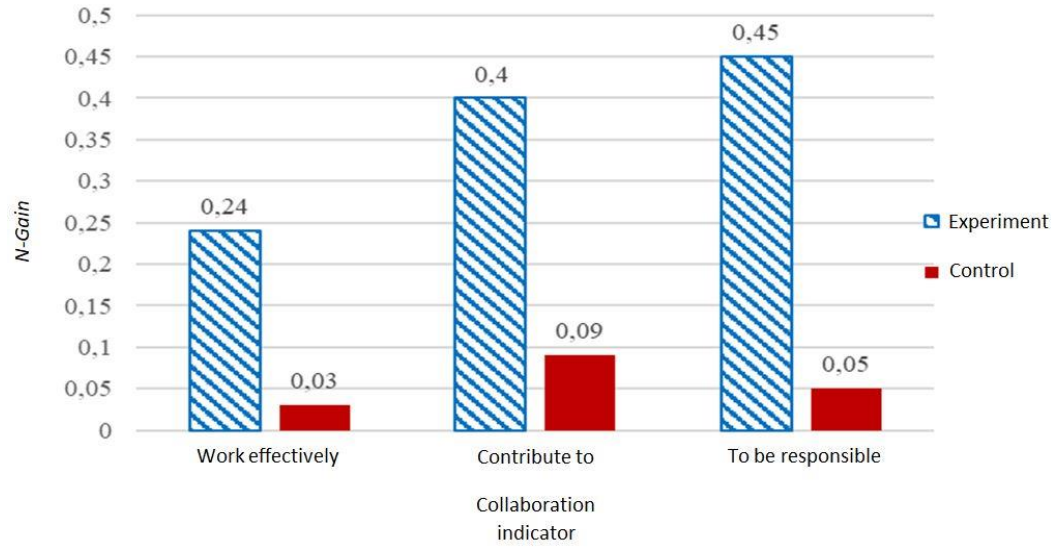


Fig. 2. Graph of Test Results for N-gain Collaboration Skills for Each Indicator

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Analysis of collaboration skills on each of the indicators gives the result that students in the control class have increased collaboration skills at low criteria for indicator 1, indicator 2, and indicator 3. Whereas students in the experimental class have increased collaboration skills at moderate criteria for indicator 2 and indicator 3 and has increased with low criteria only on indicator 1.

In general, learning in the experimental class facilitates the development of collaboration skills more than the control class. This is supported by the average value of the results of observations and N-Gain test results, which indicate the acquisition of higher numbers in the experimental class. Learning in the experimental class is almost entirely implemented with a well-organized group learning system. Learning activities in groups and supported by STEM-based teaching materials that contain the presentation of problems to be solved together help students more easily find solutions to problems. In accordance with the research done by (Honggowiyono et al., 2017; Nurhayati et al., 2019), it is concluded that group learning benefits students to find solutions to problems.

Improved collaboration skills for indicators working effectively in groups in the experimental class and the control class showed low standard. Collaborative skills on indicators working effectively in groups are observed as students conduct discussion activities to understand the definition of momentum and impulse material, discussion of the application of momentum and impulse in the fields of technology and engineering, and collision material. In addition to discussion activities, collaboration skills on indicators work effectively, and groups are also observed. At the same time, students carry out simple experimental activities to determine the coefficient of restitution of objects.

The results of the increase in the low criteria in the experimental class are caused by the presence of some students who are not very active in group work. In addition, there are still group members who enter other groups to ask answers and interfere with the performance of the group. Each group, consist of 5 to 6 students, are too many for a small group. The group condition. A study done by (Leinonen et al., 2017) revealed that in a larger group, there was a potential weakness of student participation in the smooth discussion. The recommended number of students in each group is 3 to 4 students. In the control class, increased collaboration skills for this indicator have low criteria caused by the learning that is applied does not adequately facilitate collaborative activities.

Collaborative skills on indicators contribute to making agreements, observed as students conduct group discussion activities answering questions and finding solutions to the problems given. The results of the analysis based on N-Gain scores on indicators contribute to making agreements for shared goals, showing that students in the experimental class experienced higher collaboration skills than the control class. Students in the experimental class experienced an increase in collaboration skills for this indicator on medium criteria, while students in the control class experienced an increase in low criteria.

The learning process that is accompanied by collaborative activities becomes one of the efforts to develop academic competencies and individual abilities of each student. (Castillo et al., 2017) state that there is a positive relationship between collaborative workability and academic ability, which allows direct interaction in collaborative activities and the high participation of each group member in learning activities.

Collaboration skills on indicators responsible for group work, increased higher in students in the experimental class with moderate criteria, than in the control class. In other words learning in the experimental class facilitates collaboration skills for responsible indicators in the group rather than the control class. (Castillo et al., 2017) state that the existence of collaborative activities in the learning process that can create conditions of a mutual need for roles between individuals, personal responsibility, and mutual agreement, resulting in groups working strategically and on time in completing tasks. Learning in the experimental class is more student-centered, involving students in organized discussion activities by forming learning groups, and conducting simple experiments, encouraging students to take responsibility for their work so that they can understand learning material well. Students actively built the knowledge while and learning is a shared experience, not an individual experience (Thibaut et al., 2018). The results of the test analysis of differences in increased collaboration skills between students in the experi-

mental class and students in the control class are presented in Table 2.

Table 2. Analysis of Differences in Collaboration Skills Enhancement Tests

Skills	Mean		Significance (Sig.2–*tailed*) T - *test*	Notes
	Experimental Class	*Control Class*		
Collaboration	0.376	0.053	0.000	Significantly different

The results of the analysis using the Independent Sample T-test shown in Table 2, show that there are significant differences in the improvement of collaboration skills, between the experimental class and the control class. This is based on the significance value (Sig. 2-tailed), which shows a number less than 0.05. Based on the mean value, it shows that in general, the improvement of experimental class collaboration skills is bigger than the control. Learning in the experimental class that is student-centered and supported by STEM-based learning tools, has a more significant positive impact in facilitating the development of collaboration skills and then the conventional teacher-centered learning dominant.

IV. Conclusion

The application of STEM-based physics learning can facilitate the development of student collaboration skills. The results of the test differences in the improvement of collaboration skills show there are significant differences between the control class and the experimental class. The average increase in student collaboration skills in the experimental class is higher than in the control class. The collaboration skills of students after applying STEM-based physics learning develops with an increase in the medium category based on the N-Gain value obtained by 0.37. In the experimental class, collaboration skills on indicators work effectively in groups, developing in the low category. Indicators contribute to making agreements for common goals, and indicators are responsible in groups, developing in the medium category. The application of STEM-based learning to develop collaboration skills needs to be done in a longer period of time so that the development of student skills will look more leverage. In addition, in group activities, each group should only consist of 3-4 students. Teachers need to give more examples of applications in the elements of engineering and technology, related to the material to be taught.

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