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3D PAGE-FLIPPED WORKSHEET ON IMPULSE-MOMENTUM TO DEVELOP STUDENTS' SCIENTIFIC COMMUNICATION SKILLS

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ABSTRACT

Students' developmental skills, including critical thinking skills, problem-solving skills, creativity, metacognitive skills, communication skills-collaboration, digital literacy-technology are integrated into current issues discussed at the 21st-century skills. Utilization of digital technology as media and learning resources reflects a transition of X generation to Y generation learners. The use of digital technology in learning can be an excellent opportunity to improve the 21st-century skills, particularly in the development of scientific communication skills in learning physics. This study employed 3D Page-Flipped Worksheet on impulse and momentum to improve students' scientific communication skills. This research belongs to a developmental study with 4D development model covering Define, Design, Develop, and Disseminate. The subjects were students senior high school grade X in Yogyakarta. The results showed that 72.5% of students had excellent verbal communication skills, and 65.6% had good written communication skills. Based on the results, the use of 3D Page-Flipped Worksheet is successful in constructing the students' understanding and communication skills, both oral and written.

Keywords: 3D Page-Flipped, scientific communication, 21st-century skill, technology in education

INTRODUCTION

A learning process is closely related to the method of communication between teachers and students. Communication is the way teachers and students interact in conveying information (Sadiman et al., 2010). Hence, the achievement of learning objectives is in line with the success of communication between teachers and students. The success of communication is identified by the coherency of information conveyed by the teacher and knowledge received by the students. Nevertheless, teachers sometimes fail to send information to students during the learning process, as there are differences between the delivered concepts and collected information. This situation often results in misconception and failure in achieving learning objectives (Fischhoff, 2013).

Moreover, it also leads students to face difficulty in learning and decrease their learning motivation. This is parallel with Yusuf (2010), who connected the communication process with the goal of school learning. He found that erroneous communication would cause failure in accomplishing learning goals. Furthermore, Waldrip et al. (2013) stated that misconception is the result of the negligence of a person in understanding information they have seen, read, heard, and observed learners.

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A misconception is something to be prevented, and no exception in physics learning. Physics has numerous abstract concepts (Fathurohman, 2014; Fikri & Susilo, 2012; Ugur et al., 2012); therefore, building an effective communication is a must (Arief et al., 2012; Azizah et al., 2015).

Prior to this study, the researchers conducted a preliminary survey of students' difficulties in physics learning. The initial investigation revealed that 79.8% of 112 students experienced problems in physics learning at school. The challenges experienced by each student are very diverse; in general, they have difficulties in mathematical representation as their teachers only use this type of image. Conversely, Ismet (2013) explained that a productive teaching strategy is to provide a variety of representations about a physical process. The same thing also expressed by Hubber et al. (2010) that the effectiveness of the science learning process may be achieved by using various types of representations and learning processes; visual representation is one of a kind. Besides, Rau et al. (2014) also confirmed that there is no single representation that can represent all aspects of instructions; hence, multiple representations have to be adopted in understanding concepts (Rau et al., 2014).

Furthermore, the survey results also indicated that 58.3% of the students better understood the physics concepts through images, while 58% of them better understood the physics concepts through video/animation. Therefore, the teacher can use visual representations in the form of graphs, tables, or technology- aided media with video, animation. In short, the construction of the physics concepts with a visual representation can be a solution for defining abstract physics concepts, as well as building effective communication between teachers and students.

Greenstein (2012) explained that students' developmental skills, including critical thinking skills, problem-solving skills, creativity, metacognitive skills, communication skills-collaboration, digital literacy-technology are integrated into current issues discussed at the 21st-century skills. Utilization of digital technology as media and learning resources reflects a transition of X generation to Y generation learners. Therefore, the use of various types of learning that is relevant to students' development in the 21st-century digital technology such as the development of 3D Page-Flipped Worksheet as media and learning resources students are needed. This research is also relevant to the development of 21st-century education, which demands technical, innovation skills, as well as information, media, and technology literacy (Bakri, 2016). Moreover, Frye et al. (2010) elucidated that the use of technology is a potentially significant teaching tool in achieving the teaching and learning objectives when everything is integrated into the social studies curriculum and instruction.

As visual media, 3D technology was employed as a stimulus in Page-Flipped Worksheet for the students' scientific communication skills. Science education and scientific communication are the same two currencies (McKinnon & Vos, 2015). As Kim & Lee (2013) stated that scientific communication programs focus on high-level learning skills. There are two general approaches to developing scientific communication skills, namely developing written and oral presentations (Divan & Mason, 2016). This worksheet presents a pack of animations, interactive simulations, and videos where students could learn to construct an understanding of physics concepts through observation. Therefore, both conceptual understanding and communication skills could be increased in parallel. In sum, the above explanation underlying the development of 3D Page-Flipped Worksheet.

METHODS

This study employed research & development developed by Thiagarajan & Semmel (1974), which includes four stages of define, design, develop, and disseminate. The product developed was 3D Page-Flipped Worksheet on impulse and momentum for X high school students. The relationship between the research design, the demands of 21st-century skills, the use of digital technology, and communication skills in scientific inquiry learning activities is shown in Figure 1.

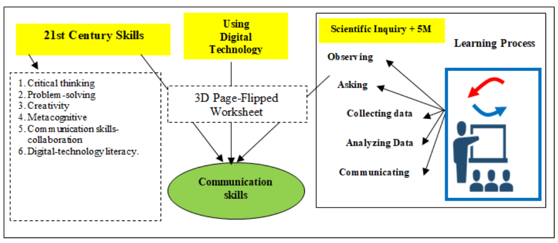

Figure 1. Research Design of the Relationship between of Research Variable

The research procedure was conducted in SMAN 1 Prambanan. The research subjects were 28 from 112 students of X grade at SMAN 1 Prambanan. The study lasted from February to May 2018. At the beginning of the study, the respondents were given questionnaires relating to the initial perception of the students' interest in learning physics. The results of this questionnaire were referred to as the basis of need analysis of 3D Page-Flipped on impulse and momentum. This process was included in the define stage.

The process of 3D Page-Flipped Worksheet on impulse and momentum development resulted in a prototype 1, and the discussion in this study is limited only to the developmental stage.

Mechanical and Instrumental Research

Some data were collected at this stage of development; they were product validation, observation, students' oral and written communication, and the trial results of the 3D Page-Flipped worksheet. Validation sheet, as seen in Table 1, was employed to assess the feasibility of 3D Page-Flipped Worksheet.

Table 1. Validation of 3D Page-Flipped Worksheet

No.	Competence	Statement
	Content Feasibility	
1	Compliance with the basic competencies and learning indicators	1, 2, 3
2	Conformity with the needs of students	4,5,6
3	Compliance with the requirements of 3D Page-Flipped Worksheet	7.8
4	The substance of the truth	9,10,11
5	Benefits to the students' insight	12,13
	Design	
6	Clarity of learning indicators	1.2
7	The order of 3D Page-Flipped Worksheet presentation	3.4
8	Motivation	5.6
9	Font: type and size	7.8
10	Lay out	9,10,11
11	Design	12,13,14

The evaluation of 3D Page-Flipped Worksheet refers to Table 1, which consists of content and design validation. In general, it was developed into 14 indicators (statements) according to Table 1. The validation results of the developed worksheets are shown in Table 6. Furthermore, the validity of product development, in the form of validators' assessment was interpreted into interval categories, as displayed in Table 2.

Table 2. Interpretation of Evaluation Criteria

Interval Scores	Score	Category
$x > (\bar{x}_i + 1{,}8Sb_i)$	A	Very high
$(\bar{x}_i + 0{,}6Sb_i) < x \le (\bar{x}_i + 1{,}8Sb_i)$	B	High
$(\bar{x}_i - 0{,}6Sb_i) < x \le (\bar{x}_i + 0{,}6Sb_i)$	C	Enough
$(\bar{x}_i - 1{,}8Sb_i) < x \le (\bar{x}_i - 0{,}6Sb_i)$	D	Low
$x \le (\bar{x}_i - 1{,}8Sb_i)$	E	Very low

Information :
X : Empirical Score
x _I : The average ideal
Formula :1 / 2 (max score min ideal base + score)
sb_i : Standard deviation ideal
Formula : 1 / 6 (score-score min max ideal base)

The assessment of students' scientific communication skills was divided into verbal and written. The oral communication was assessed when the students have a presentation by the observer using observation sheets. As for the written communication, the students' work on the 3D Page-Flipped Worksheet. The instruments for assessing students' communication skills are displayed in Table 3.

Table 3. Communication skills assessment instruments

No.	Competence	Statement
	Oral Communication Skills	
1	Impart information or ideas	1, 2, 3
2	Group discussions	4,5,6
3	ability inquiry	7,8,9
4	Answering capability	10,11,12
	Written Communication Skills	
5	Representational	13,14
6	Argumentative	15,16,17,18

There were 4 indicators in assessing the students' scientific communication skills. Then 4 indicators of oral communication skills were augmented into 12 sub-indicators. Furthermore, the assessment of written communication skills consisted of 2 indicators which were broken down into 6 indicators. The assessment category is presented in Table 4.

In more detail, the assessment of students' verbal communication skills is shown in Table 5, while the written evaluation of the students' scientific communication skills is shown in Table 7.

Table 4. The Assessment Category of Students' Communication Skills

Value Percentage	Category
81-100	Very good
61-80	Good
41-60	Pretty good
21-40	Less
0-20	Very less

RESULTS AND DISCUSSION

Based on the developmental research, the 3D Page-Flipped Worksheet was declared valid with an average value of 4.3 and categorized as 'good.' The results of 3D Page-Flipped Worksheet assessment based on the content (materials) and design by experts. Next, the worksheet was used to develop oral and written scientific communication skills in physics learning activities in the classroom. The results of students' oral and written scientific communication skills are discussed in the discussion below.

3D Page-Flipped Worksheet on Impulse and Momentum was designed for X-grade high school students. There are three concepts presented, namely, impulse and momentum, momentum relations, and the law of momentum conservation. The display of the product is presented in Figure 2.

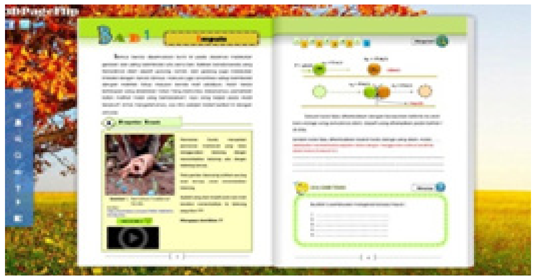

Figure 2. The Display of 3D PageFlipp Worksheet

The 3D Page-Flipped Worksheet was developed on the basis of expert validators' evaluations in the content, language, and design. The final validation results of the product are shown in Table 5.

Table 5. The Validation Results of 3D PageFlipp Worksheet

No.	Validation	Average
1.	The contents (Content)	4.4
2.	Design	4.2
	Total	8.6
	Average	4.3
	Criteria	Good

Based on the results of expert validation, the 3D Page-Flipped Worksheet was categorized as good. Therefore, it can be used to know the students' scientific communication skills in physics learning.

The Observation Results of the Students' Oral Communication Skills

The students' oral communication skills were observed during group discussions and presentations. There were 28 students found, who were also divided into 8 groups. The assessment rubric for this observation is presented in Table 6.

Table 6. Indicators of Students' Oral Communication Skills

Competence	Indicator	Number of Respondents (28 Student)								Interp. Data
		1	2	3	4	5	6	7	8	
		ASDF	GHJK	LZXC	VBNM	QEW	RTY	UIO	PBC	
Imparting information or ideas	q.1 Stating the purpose/information to be presented with good and clear sentences.	4423	2433	2443	2344	433	343	343	344	high
	q.2 Being able to establish communication during the presentation	4433	3433	3443	3344	433	343	343	344	very high
	q.3 Stating ideas or arguments with appropriate sentences	4423	2433	2443	2344	433	343	343	334	high

Group discussions	q.4 Giving attention when others speak	3334	3343	3432	3334	243	434	432	233	high
	q.5 Respect the opinion/feed-back/ questions from other people	3333	3333	3333	3333	333	333	333	223	high
	q.6 Providing ideas or feed-back accompanied by clear reasons	3424	2343	2343	2433	444	433	443	334	high
Inquiry skill	q.7 Showing enthusiasm in asking questions	3433	3433	3343	3334	433	332	332	223	high
	q.8 Proposing clear and un-derstandable questions	2332	3322	3232	3223	322	222	232	223	enough
	q.9 Asking questions in ac-cordance with the topic being discussed	2332	3324	3343	4433	222	232	332	222	enough
Answering skill	q.10 Understanding other people's questions easily	3223	3233	3323	2324	323	323	232	223	enough
	q.11 Precisely answering the questions	3233	3323	2233	2324	333	333	333	333	enough
	q.12 Arguing against what is seemed incompatible with his thinking	2322	2232	3222	3333	322	222	232	223	enough
	Average value									2.9
	Category									good

The assessment of students' oral scientific communication skills hinged on the indicators of scientific communication skills that have been displayed in Table 3. Furthermore, each indicator was developed into a sub-indicator consisting of 12 items, as shown in Table 6.

Based on the observation results, the students' oral scientific communication had an average value of 2.9 and categorized as 'good.' In more detail, based on Table 6, the idea/argument reinforcement had an average score of 2.4, and justification to argument achieved and an average value of 2.4 as well. On the other hand, giving supporting reasons related to the answers given got an average value of 2.3. These scores showed that argumentative skill requires further concern.

Oral communication skills become an essential part of the learning process. Yusuf (2010) connected the communication process as a learning process. Reconstruction of verbal communication skills is built when students present the results of their discussion in front of the class. The students who have good concept understanding tend to have excellent communication skills, and vice versa.

Argumentative skill becomes an integral part of the communication process. The excellent communication process is created from favorable arguments which come from an excellent understanding of the concepts. Oral communication skills indicators cover four significant indicators, namely (1) imparting information or ideas; (2) group discussion; (3) skill in asking questions; and (4) skill in answering questions. Students' ability to communicate information or ideas determine the level of student understanding related to the materials being studied. Presentations of students in developing communication skills are shown in Figure 3 and Figure 4.

Figure 3. Discussion Activity

To support their presentation, the students also build their oral communication skills by using multiple representations to express their ideas, as shown in Figure 5.

Figure 4. Presentation Activity

Representations used by the students during a presentation were pictures and graphics. Some of the complicated and challenging physics concepts were represented using mathematical representation/verbal, but it became more comfortable when they employed photographs or diagrams. This fact is line with Ainsworth et al. (2011) who stated that particular representation image/visual is useful to help visualize abstract concepts. In other words, the use of 3D Page-Flipped Worksheet supported the development of students' scientific communication skills. This is also relevant to the results of the research by Lau & Yuen (2014), Khlaisang & Koraneekij (2019), and Bingimlas (2009) who confirmed that the use of technology in learning could support the optimization of student skills and learning interest.

The Observation Results of the Students' Written Communication Skills

Written communication skills were observed using the appropriate assessment rubric in Table 7. The assessment of written communication skills was more devoted to the students' ability to use a variety of representations in answering the problem given in the developed 3D Page-Flipped Worksheet.

The assessment of students' written scientific communication skills hinged on the indicators of scientific communication skills that have been displayed in Table 3. Furthermore, each indicator was developed into 6 sub-indicators, as shown in Table 7.

Table 7. Indicators of Students' Written Communication Skills

Competence	INDICATOR	Number of Respondent (28 Student)								Interp. Data
		1	2	3	4	5	6	7	8	
		ASDF	GHJK	LZXC	VBNM	QEW	RTY	UIO	PBC	
Representational Skills	q.1 Writing opinions/arguments with clear and understandable sentences	3333	3333	3333	3333	333	333	333	333	High
	q.2 Using multiple representations in presenting their opinions/arguments	3433	3443	3343	3344	333	333	343	334	High
Argumentative skills	q.3 Providing data to strengthen the opinions/ arguments	2332	3332	3232	3233	222	222	232	223	High
	q.4 Justifying a relationship between an argument with the data	2322	2332	2232	2233	222	222	332	323	Enough
	q.5 Providing supporting reasons related to the given answers	2322	2332	2232	2233	222	222	232	223	Enough
	q.6 Drawing up conclusions	2332	3332	3232	3233	222	222	232	222	Enough
	Average value	2.6								
	Category	Good								

Based on Table 7, the average score of the students' written communication skill was 2.6 or categorized as good. However, there were three items in which the students scored the lowest, i.e., included in 'enough' category. First, justifying a relationship between an argument with the data', followed by 'providing supporting reasons related to the given answers' and 'drawing up conclusions.' In other words, the students' remained to face challenges to support their argument with relevant data. This, therefore, needs to be taken into account by the teacher.

Written communication skills of learners were assessed based on two indicators of assessment, namely (1) representational skills, (2) argumentative skills. As has been stated before, learning will be more productive when presented with various representations. The ability to use multiple representations supports multiple intelligences of students, and this claim has been confirmed by some studies which concluded that there is no single representation to describe all aspects of mathematical concepts, instruction in understanding the concept typically uses multiple representations. The results suggested that multiple representations can have significant benefits for student learning (Hubber et al., 2010; Rau et al., 2014; Rau & Matthews, 2017).

The two indicators were honed through questions contained in 3D Page-Flipped Worksheet on Impulse-Momentum. Some of the questions are:

1. Why do the boxers wear boxing gloves?
2. Based on what consideration you choose the form of illustration (pictures, graphs, and mathematical)?
3. Give supporting data following your opinion.
4. What physics principle is used in the above events?
5. Conclude by connecting the employed principle and your opinion.

The researchers took two samples of answers from Student A and Student B, as displayed in the following figures.

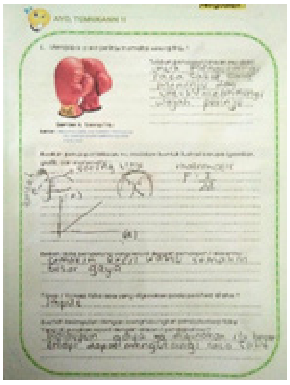

Figure 5. The Student A's Answers

The two sample answers show different representational and argumentative skills. According to Rau & Matthews (2017), there are four elements of representations that must be achieved including (1) visual understanding; (2) visual fluency; (3) the connectional comprehension; and (4) the connectional fluency. Student A was able to construct three forms of representation, i.e., images, graphics, and mathematics. However, the types of representation written by student A have not yet built the concept of impulse and momentum. Descriptions for each representation were irrelevant as they have not accomplished the four elements. Instead, the representational image given by student A should provide a visual understanding of the impulse concept for then connected to other mapping concepts. Impulse is influenced by two quantities, i.e., contact force (F) and time interval (Δt), which are then developed into the graph. Therefore, the chart has to depict the relationship between contact force (F) and time interval (Δt).

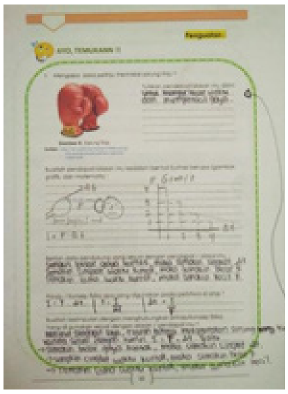

Figure 6. The Student B's Answers

Furthermore, the ability to use multiple representations of student B is shown in Figure 6. Student B constructed three forms of representation; images, graphics, and mathematics, which could reflect the concept of impulse and momentum; yet the picture remained to have a slightly improper description. The impulse position should be in between the boxing glove and the boxer's face. However, as seen in Figure 7, student B wrote an incorrect caption of impulse position. If connected to the mapping concept, student B's answer to impulse has two quantities; contact force (F) and time interval (Δt). Thus, student B was on the right track in relating image and graph representation, and mathematical concept to explain impulse. As a result, student B was more comfortable to build an argument/ opinion.

Moreover, Table 8 informs the comparison of oral and written communication skills of the students. The written communication scored 65.6%, while oral communication achieved 72.5%. Both were categorized as 'good.'

Table 8. The communication skills of students

No.	Skills	Percentage
1.	Oral communication	72.5%
2.	Written communication	65.6%
	Category	Good

In more detail, the distibution of the students' communication skills are displayed in Figure 7.

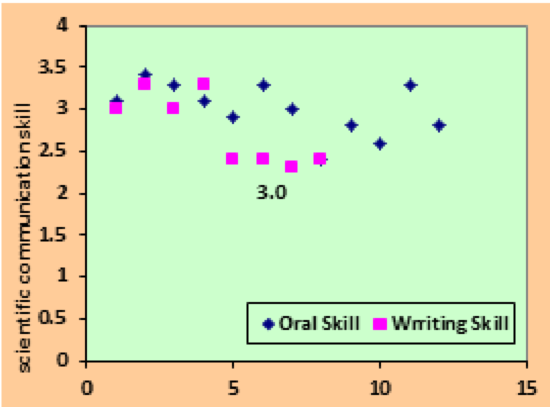

Figure 8. The Distribution of Students' Communication Skills

Scientific communication skills significantly affect students' understanding of a concept, and students' communication skills could be developed using digital technology (Kulsum & Nugroho, 2014). Teachers' belief about technology assistance would affect their learning design; however, their readiness to use digital-based is the most vital element (Howard & Yang, 2016). Teachers have to familiarize themselves with images, graphs, tables, and mathematical representations to maximize learning sequence as an effort to accomplish learning objectives. This claim is relevant to Nitz et al. (2014), who explained that students' skills in using a variety of representations depend on the teachers' habit in using various models of representation in the classroom.

Moreover, the existence of multiple representations in classroom learning is one of the 21st-century pedagogical challenges (Hubber et al., 2010; Rau & Matthews, 2017), and the accomplishment of learning with multiple representations, nowadays, highly relies on the use of technology. This is also relevant to the characteristic of Y-generation learners. In this study, the use of a digital-aid worksheet, which had been adjusted with the curriculum applied in school has proven to develop students' communication skills. Hence, this study support other prior studies by Usrotin & Nugroho (2013), Wijayanti & Hindarto, (2010), Oktaviani et al. (2015) and Prahani et al. (2016) which asserted that technology assistance media have a significant influence on students' conceptual understanding that leads to the betterment of learning outcomes.

CONCLUSION

The results showed that 72.5% of students had excellent verbal communication skills, and 65.6% of them had excellent written communication skills. Based on the research findings, the use of 3D Page-Flipped Worksheet on Impulse-Momentum was effective in ameliorating students' scientific verbal and written communication skills.

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