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The strategy of student-worksheet design with a causalitic-learning model to improve creative-thinking ability

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Abstract. This study aims to identify preparation strategies a causalitic model of student-worksheet (SW) to improve students' creative thinking ability (CTA). This type of research is a Research and Development with a 4-D model. The research procedure refers to the stages in the 4-D model, namely the stages of defining, designing, developing, and disseminating. The instrument used was the SW validation questionnaire with a Likert scale of 1 to 4. The data were obtained from the SW validation by a validator consisting of 2 expert lecturers and 3 high school physics teachers. The validation result is 86% with very valid criteria. Based on the values and validation criteria, the causal model SW to improve the creative thinking ability of students is suitable for use in learning. The SW preparation strategy includes curriculum analysis, making needs maps, determining the SW title, basic competencies and indicators of competency achievement, central themes, and assessment tools, as well as compiling materials, and paying attention to the SW structure of the eight sets of strategies, there are three are uniques, namely the second, sixth, and eighth steps.

1. Introduction

The world is currently experiencing the fourth industrial revolution or what is known as the industrial revolution 4.0. The industrial revolution 4.0 is a rapid industrial increase marked by the full use of digital technology in various fields. Indonesia started the adaptation process to the 4.0 industrial revolution by increasing the competence of human resources through a link and match program between education and industry [1]. Education is the main sector that is expected to be able to produce competent, superior, and competitive human resources. Realizing this, the education curriculum has led to the development of higher-order thinking skills (HOTS) in every lesson, which is intended as an effort to equip students in facing the flow of globalization.

Higher-order thinking skills are divided into critical thinking, creative thinking, and metacognitive thinking skills [2]. Each of these abilities has different characteristics. The creative thinking ability (CTA) has divergent characteristics. The divergent characteristic in question is the ability to think openly. CTA indicators consist of fluency, flexibility, original thinking, and elaboration [3]. Students who meet these indicators can be said to have the ability to think creatively. Mursidik, Samsiyah, & Rudyanto [4] explained that creative thinking competence for students is very important in the era of global competition because the level of complexity of problems in all aspects of modern life is getting



higher. Based on this, the creative thinking ability of students are very important to be trained and developed in learning activities, especially in learning physics. Physics is important to teach to equip students to face the times because physics is part of the science that underlies technological developments.

Facts in the field show that physics learning in schools has not facilitated students to develop open thinking ability. One of the causes is the selection of a learning model that is dominated by direct instruction so that students are less actively involved during the learning process. The teacher also emphasizes that learning physics is only based on mathematical calculations. This results in students thinking that physics is difficult.

Besides, the Covid-19 outbreak in Indonesia has had an impact on the learning system in schools. The social distancing policy issued by the government requires all educational institutions to change face-to-face learning methods to online [5]. This is based on Circular Number 4 of 2020 concerning the Implementation of Education Policies in the emergency period of the spread of the virus, the Minister of Education and Culture urges all educational institutions not to carry out a face-to-face (direct) teaching and learning process but to be carried out indirectly or remotely [6].

This situation has an impact on changes in the learning process, teachers and students who initially interact directly in the classroom must move to limited virtual space. This poses a challenge for teachers to be able to deliver learning effectively and efficiently so that learning objectives can still be achieved. One of the strategies that can be applied by teachers is to provide student worksheets (SW) intensively to help students in implementing online learning.

SW can be in the form of a guide for cognitive aspect development exercises as well as a guide for developing all aspects of learning in the form of an experimental or demonstration guide [7] SW according to Trianto [8] is a guide that can be used to carry out investigative or problem-solving activities. Therefore SW can be used as an alternative media that can be used by teachers to carry out learning activities. Learning activities equipped with SW fully support the involvement of students in the learning process [9]. Besides, Antasari, Sukardi, & Rispawati [10] explained that SW can support the learning process of students either individually or in groups and can build their knowledge with various learning sources.

According to Prastowo [11] SW has four functions, namely: (1) as a teaching material that can minimize the role of educators, but activate students; (2) as teaching materials that make it easier for students to understand the material provided; (3) as concise and task-rich teaching material for practicing; and (4) facilitate the implementation of teaching to students. SW is compiled using several criteria that aim to attract students to be more active in the learning process [9]. For that, we need an SW that facilitates students to be active and improve higher-order thinking skills and is effective and efficient to use in learning activities, one of which is the causalitic model SW.

The causalitic model is a learning model developed from a causal thinking approach. The causalitic-learning model is structured with an orientation to guide students in learning which emphasizes the development of the ability to analyze cause and effect elements in a phenomenon and develop arguments to explain how the causal conditions produce each determined effect [12]. This causalitic-learning model is packaged on a basis of physics problems based on the ability to think causality and think analytically. Causality thinking emphasizes a way of thinking to analyze the possible causes and effects of a physical phenomenon. There are three models of causality according to Gopnik and Schulz [13], namely common-cause, causal-chain, and common-effect. While the causality model according to Rokhmat, Marzuki, Hikmawati, & Verawati [14] is the simple causal model (SCM), the divergent causal model (DCM), the convergent causal model (CCM), the chain causal model (ChCM), the composite causal model (CoCM), and chain composite causal model (ChCoCM). Furthermore, analytical thinking is a conceptual and procedural thinking process to be able to provide arguments and conclusions on a phenomenon. Amer [15] explained that analytical

thinking is included in the components of systematic thinking and critical thinking. Analytical thinking is at a high enough level, namely at the C-4 level (analysis) in Bloom's taxonomy [16].

The SW causalitic model is a worksheet design based on the characteristics of the causalitic model, which contains physics phenomena to analyze the causes and possible effects that can occur from these causes by students. In each SW, a scaffolding table is provided for the causal and effect components. Students are asked to complete the table on the components of cause and effect according to the number that has been determined and complete the explanation of each component of the effect that is written.

The availability of the causalitic model SW can be an alternative for teachers in learning activities to improve students' creative thinking ability (CTA). Some of the results of research conducted by Rokhmat (2013) [17], Tamami, Rokhmat, & Gunada (2017) [18], Yuliana, Rokhmat, & Gunada (2017) [19], Helmi, Rokhmat, & 'Ardhuha (2017) [20], and Anshori, Rokmat, & Gunada (2019) [21] proved that the causal learning model affects increasing the problem-solving abilities and creative thinking abilities of students. Before being used in learning, a validity analysis is needed which is intended to determine whether or not SW is used in learning activities.

2. Method

This research is research and development (Research and Development). The instrument developed was SW for a causalitic model on momentum and impulse material for class X Senior High Schools. This research design uses a 4-D model developed by Tiagarajan, Semmel & Semmel (1974) [9]. The research procedure consists of define, design, develop, and disseminate it. Of the four stages, the dissemination stage was not carried out due to time and cost limitations.

The define stage aims to define and define the requirements of learning. At this stage, there are 5 main steps taken, namely: (1) The initial analysis/survey aims to determine the basic problems needed in SW development; (2) Student Analysis aims to determine the characteristics of students; (3) Task analysis aims to identify the main tasks or skills that students perform during learning, then analyze them into a more specific sub-skill framework; (4) Concept analysis aims to identify, detail, and systematically arrange the concepts on the SW to be designed; (5) Specification of Learning Objectives aims to formulate learning objectives based on Core Competencies and Basic Competencies which then determine the studies to be displayed in the SW.

The design stage aims to design causalitic model SW. The action is taken to arrange the components that will be contained in the SW. The development stage aims to produce a causalitic model SW product. At this stage, there are 2 steps were taken, namely: (1) Product preparation aims to produce a causalitic model SW product, and (2) Product validation aims to determine whether the SW developed is valid or not. The validators involved consisted of 2 expert lecturers in Physics Education of Mataram University. After being validated by expert validators, the SW product also validated by 3 physics teachers consisting of 2 physics teachers at SMAN 1 Namada, and 1 physics teacher at SMKN 1 Narmada.

The product of this research and development is the causalitic model SW. The instrument used was the SW validation sheet. The data in this study were collected using a validation questionnaire by the validator. The validator consists of 2 expert lecturers and 3 high school physics teachers. The validation questionnaire uses a Likert scale with a scale of 1 to 4. The rules for scoring the validity of SW products are a score of 4 for the very good category, a score of 3 for the good category, a score of 2 for the poor category, and a score of 1 for the very poor category [22].

The formula for calculating the percentage of SW product validation is as follows.

$$Validity (V) = \frac{Total\ validation\ score}{Maximum\ total\ score} \times 100\% \quad (1)$$

Then the percentage of data obtained was matched with the following validity criteria [23].

Table 1. Criteria for the Validity of Student-worksheet

No	Percentage	Criteria
1	85,01-100,00%	Very Valid
2	70,01-85,00%	Quite Valid
3	50,01-70,00%	Less Valid
4	01,00-50,00%	Invalid

3. Result and Discussion

3.1 Result

3.1.1 *Expert Validation Results.* SW validation by the validator aims to determine the validity level of the designed SW. The validators involved in this study consisted of two expert lecturers and three high school physics teachers. The results of the SW validation are as follows.

Table 2. Results of the Validation SW

No	Assessment Aspects	Rating Score					Mea n	Percen -tage	Criteria
		V1	V2	V3	V4	V5			
1.	The integrity of the identity of students	4	4	4	4	4	4	100%	Very Valid
2.	Easy to understand SW settlement instructions	4	4	4	4	4	4	100%	Very Valid
3.	Clarity of images and illustrations	4	2	3	3	3	3	75%	Quite Valid
4.	conformity to the questions and/or phenomena presented with Basic Competencies	4	2	4	4	4	3,6	90%	Very Valid
5.	suitability of the questions and/or phenomena presented with Indicators of Competence Achievement	4	2	4	3	4	3,4	85%	Quite Valid
6.	The practicality of SW to measure the achievement of learning objectives	4	3	3	3	3	3,2	80%	Quite Valid
7.	Questions and/or phenomena contained in SW can facilitate students to develop creative thinking skills	4	3	4	3	3	3,4	85%	Quite Valid
8.	The problems raised in the SW are in accordance with the phenomena in everyday life	3	3	3	3	3	3	75%	Quite Valid
9.	The correct use of standard language and according to the rules of the Indonesian language	3	4	4	3	4	3,6	90%	Very Valid
10.	The sentence questions and/or phenomena used in SW are clear and easy to understand	4	3	3	3	3	3,2	80%	Quite Valid
Percentage mean								86%	
Criteria									Very Valid

Information: V1 and V2: Expert Lecturers, V3, V4, and V5: High School Physics Teacher

3.1.2 SW Example for a Causalitic Model.

An example of a causalitic SW model to support momentum and impulse learning is as follows.

Student-worksheet (SW) Momentum and Impulse

Class :

Group name :

Aim:

Through discussion activities, students can analyze the phenomenon of momentum and impulse appropriately.

Basic Competencies:

- 3.10 Applying the concepts of momentum and impulse, as well as the law of conservation of momentum in everyday life.
- 4.10 Presenting the results of testing the application of the law of conservation of momentum, for example a free ball falling to the floor or a simple rocket.

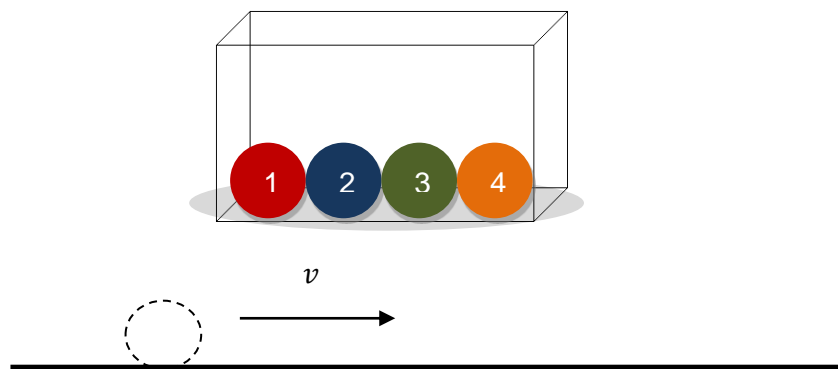
Competency Achievement Indicators:

1. Analyze the phenomena related to the concept of momentum.
2. Presenting the results of group discussions in solving phenomena related to the concept of momentum.

Instructions:

1. Discuss the following questions with your group.
2. Answer the questions in the column provided, with the following conditions:
 - a. The cause column is a column containing the components that affect the phenomenon.
 - b. The effect column is a column containing the possible consequences that can occur with the phenomenon.
3. Please answer the following questions correctly and correctly.
4. Use a concept, principle, theory, or law of physics if there is anything related to the explanation of your answer.
5. Copy the answers from your discussion sheets into your respective exercise books.

Phenomenon No.1 SW-1



There are 4 balls with the same size as the mass $m_1 < m_2 < m_3$ and $m_3 = m_4$ in a box. Ardi and Dito each take one of the balls in the box randomly, then throw it horizontally on the slippery floor at the same speed, it's v . What are the possible comparisons of a given momentum Ardi (p_A) and Dito (p_D)? Explain how that possibility occurs and don't forget to state the concepts, principles, theories, and/or laws of physics associated with the explanation!

Cause (there are 5)	Effect (there are 3)
1. All four balls are the same size 2. $m_1 < m_2 < m_3$ 3. $m_3 = m_4$ 4. Ardi and Dito take the ball randomly 5. The speed of the balls thrown by Ardi and Dito was the same, that is v	1. $p_A < p_B$ 2. $p_A = p_B$ 3. $p_A > p_B$

Argumentation :

Effect 1 : This event is likely to occur if:

- a. Ardi takes the ball 2, while Dito takes ball 1 or 4. Because $m_2 < m_3 = m_4$ and the speed of the ball after being thrown is the same. Based on the concept of momentum is directly proportional to mass ($p = mv$), so that the momentum of the ball thrown by Ardi is smaller than the momentum of the ball thrown by Dito.
- b. Ardi mengambil bola 1 while Dito takes balls 2, 3, or 4. Because $m_1 < m_2 < m_3 = m_4$ and the speed of the ball after being thrown is the same. Based on the concept of momentum is directly proportional to mass and velocity ($p = mv$), so that the momentum of the ball thrown by Ardi is smaller than the momentum of the ball thrown by Dito.

Effect 2 : This event has the opportunity to occur if the balls picked up by Ardi and Dito are balls 3 and 4 or vice versa, because $m_3 = m_4$ so that the momentum of the ball that was thrown by Ardi was the same as Dito.

Effect 3 : This event is likely to occur if:

- a. Ardi takes ball 3 or 4, while Dito takes ball 2. Because $m_3 = m_4 > m_2$ and the speed of the ball after being thrown is the same. Based on the concept of momentum is directly proportional to mass ($p = mv$), so that the momentum of the ball thrown by Ardi is greater than the momentum of the ball thrown by Dito.
- b. Ardi takes ball 2, 3, or 4 while Dito takes ball 1. Because $m_3 = m_4 > m_2 > m_1$ and the speed of the ball after being thrown is the same. Based on the concept of momentum is directly proportional to mass ($p = mv$), so that the momentum of the ball thrown by Ardi is greater than the momentum of the ball thrown by Dito.

3.1.3 Causalistic Model SW Compilation Strategy.

The general SW preparation strategy and the causal model can be seen in Table 3, which is as follows.

Table 3. General SW Formulation Strategy and Causalistic Model

No.	Strategy	Analysis Results	
		General SW	Causalistic Model SW
1.	Perform curriculum analysis	The main materials used in SW are Momentum and Impulse	The main materials used in SW are Momentum and Impulse
2.	Create a needs map	Determine the cognitive competencies and skills that need to be mastered by students	Determining the cognitive competencies that students need to master, including applying (C3), analyzing (C4), evaluating (C5), and creating (C6) as well as skill competencies that students need to master, namely presenting the results of discussions in solving a physical phenomenon. Students are also facilitated to develop their thinking skills by determining the cause and effect of the phenomena presented and providing arguments by related concepts, principles, theories, and/or physical laws
3.	Specifies the SW title	Student-worksheet Momentum and Impulse	Student-worksheet Momentum and Impulse
4.	Determine basic competencies (BC) and competency achievement indicators	BC 3.10 Applying the concepts of momentum and impulse, as well as the law of conservation of momentum in everyday life. Competency achievement indicators: <ol style="list-style-type: none"> 1. Analyze the phenomena related to the concept of momentum. 2. Analyze the phenomena related to the law of conservation of momentum. 3. Analyze the phenomena associated with the types of collisions. BC 4.10 Presenting the results of testing the application of the law of conservation of momentum, for example a free ball falling to the floor or a simple rocket. competency achievement indicators: <ol style="list-style-type: none"> 1. Presenting the results of group discussions in solving phenomena related to the concept of momentum. 	BC 3.10 Applying the concepts of momentum and impulse, as well as the law of conservation of momentum in everyday life. Competency achievement indicators: <ol style="list-style-type: none"> 4. Analyze the phenomena related to the concept of momentum. 5. Analyze the phenomena related to the law of conservation of momentum. 6. Analyze the phenomena associated with the types of collisions. BC 4.10 Presenting the results of testing the application of the law of conservation of momentum, for example a free ball falling to the floor or a simple rocket. competency achievement indicators: <ol style="list-style-type: none"> 4. Presenting the results of group discussions in solving phenomena related to the concept of momentum.

		2. Presenting the results of group discussions in solving phenomena related to the law of conservation of momentum.	5. Presenting the results of group discussions in solving phenomena related to the law of conservation of momentum.
		3. Presenting the results of group discussions in solving phenomena related to the types of collisions.	6. Presenting the results of group discussions in solving phenomena related to the types of collisions.
5. Determine the central theme and subject matter	The concept of momentum and impulse, the law of conservation of momentum, and types of collisions.		The concept of momentum and impulse, the law of conservation of momentum, and types of collisions.
6. Determine assessment tools	The assessment tool is in the form of a test instrument that contains only one correct answer		The assessment tool is in the form of a creative thinking ability test instrument in the form of a description. Each question in the assessment instrument contains more than one potential correct answer
7. Arrange material	Analysis of momentum and impulse material as well as power points that can be used as learning guidelines and resources. There are also pictures/illustrations of phenomena that make it easier for students to complete SW		Analysis of momentum and impulse material as well as power points that can be used as learning guidelines and resources. There are also pictures/illustrations of phenomena that make it easier for students to complete SW
8. Pay attention to the SW structure	Presenting SW components, namely, title, student identity, objectives, basic competencies and indicators of competency achievement, as well as SW completion instructions		Presenting the SW components, namely, the title, student identity, objectives, basic competencies, and competency achievement indicators, SW completion instructions, phenomena, causality tables, and argumentation space

3.2 Discussion

This study aims to design a causalitic model SW to improve students' creative thinking ability (CTA). In the validation stage, it is intended to determine the level of SW validity that is designed. There are 10 aspects of assessment to measure the validity of the SW including (1) the integrity of the identity of students; (2) easy to understand SW settlement instructions; (3) clarity of images and illustrations; (4) conformity to the questions and/or phenomena presented with Basic Competence; (5) conformity to the questions and/or phenomena presented with indicators of competency achievement; (6) practicality of SW to measure the achievement of learning objectives; (7) questions and/or phenomena contained in SW can facilitate students to develop creative thinking skills; (8) the problems raised in the SW is by the phenomena in everyday life; (9) the correct use of standard language and according to the rules of the Indonesian language; and (10) the sentence questions and/or phenomena used in SW are clear and easy to understand.

Aspects no.1 and no.2 get a validity percentage of 100% with a very valid category. These values and categories indicate that the SW compiled contains the identities of students and the instructions for completion are easy to understand. Furthermore, aspect no.3 on SW gets a validity percentage of 75% with a fairly valid category. This is because the presentation of images and illustrations used in SW is

not very clear and cannot represent the phenomena presented. The revision results are based on comments and suggestions from the validator, namely adding images and illustrations that are clear and interesting and can represent the phenomena in the developed SW. Aspect no. 4 obtained a validity percentage score of 90% with a very valid category. This shows that the questions and/or phenomena presented are following the basic competencies, namely Basic Competencies 3.10 and 4.10 on momentum and impulse material.

Furthermore, on the aspects of assessment no.5 and no.6, respectively, the percentage of validity is 85% and 80% with the same category, which is quite valid. The revision results are based on the validator's suggestions and input, namely improving the Competency Achievement Indicators and completing the phenomena presented so that they are suitable and practical to use to measure the achievement of the expected learning objectives. Aspect no.7 gets a validity percentage of 85% with fairly valid criteria. This is because the validators 2, 3, and 5 give a score of 3. Then the percentage of validity is 75% with the criteria valid enough on aspect no.8 because all validators give a score of 3, so it needs a little revision. In aspect no.9 the percentage of validity reaches a value of 90% with very valid validity criteria. This criterion is to present the question sentences or phenomena in SW using standard language and according to Indonesian rules correctly. Teaching materials must use good and correct language to make it easier for readers to obtain information. The last aspect, namely no.10, obtained an assessment percentage of 80% with sufficiently valid criteria. Based on these criteria, it is necessary to have a small revision of the use of sentence questions on SW so that it is easier for students to understand [25].

Based on Table 2, the overall average percentage of SW validity is 86%. This value indicates very valid criteria. These criteria indicate that the developed SW can be used in learning activities on the momentum and impulse subject matter of class X Senior High School.

There are 8 SW components for the causal model consisting of, 1) SW title, 2) student identity, 3) objectives, 4) basic competencies and competency achievement indicators, 5) SW completion instructions, 6) phenomena, 7) causality tables, and 8) argumentation space. These components are based on SW components in general according to Prastowo [11], namely titles, study instructions, competencies to be achieved, supporting information, assignments and work steps, and assessments.

Furthermore, giving the blue color to the SW example for a causal model interpreting the parts filled by students. The causality table is assisted (scaffolding) for the components of cause and effect. The scaffolding developed in physics learning with a causal model is 1) The causality table is provided; 2) The sum of all causes and effects in the causality table is informed; 3) several causes and effects are listed, and 4) Sample arguments are also given [24]. In this study, the scaffolding given in SW is points number 1), 2), and 3).

In the SW causal model, students are asked to complete all the components of cause and effect with a predetermined number, thus forming a simple composite causal model (SCoCM), where there are two or more causes that cause two or more effects [14]. In this case, students are facilitated to provide various answers in filling in the causality table. The activities above can improve students' creative thinking ability, especially on flexibility indicators (flexible thinking). According to Munandar, [3] flexibility is the ability to provide various ideas. Besides, students are also asked to provide explanations as arguments for the various possible consequences that can occur in the phenomena presented. In this activity, students are facilitated to develop creative thinking ability, especially on fluency indicators (because students are facilitated to provide as many explanations as possible), originality indicators (students are allowed to provide explanations in their own/original language without following books or other sources), and elaboration indicators (students are directed to provide detailed explanations involving related concepts, theories, and/or physical laws). Fluency is the ability to give a lot of ideas smoothly, originality is the ability to provide ideas by showing authenticity (original), which is different from others and using different delivery methods, while elaboration is the ability to describe problems accurately and in detail [3]. Referring to the indicators of creative thinking ability (CTA) described by Munandar [3], it can be concluded that the causal model SW can improve students' creative thinking ability.

In designing SW, a strategy or steps are needed in its preparation. The strategy or technical steps for the preparation of a causal model of SW disrupts in the preparation of SW in general which consists of (1) Analyzing the curriculum; (2) Prepare an SW needs map; (3) Determine the SW title; (4) Determine Basic Competencies and Competency Achievement Indicators; (5) Determining the central theme and subject matter; (6) Determine the assessment tools; (7) Arranging materials, and (8) paying attention to the structure of SW [11]. Based on these two strategies, the formulation of the causal model SW has special characteristics in steps 2, 6, and 8 which can distinguish it from SW in general. The causal model SW has special characteristics in the preparation of the SW needs a map. This distinctive feature is to facilitate students to develop cognitive competencies from C3 to C6 by providing facilities to determine and provide causal arguments for a phenomenon based on related concepts, principles, theories, and/or physical laws. Besides, the assessment tool on the causal model SW is a test instrument that has the potential to have more than one correct answer. This can develop the creative thinking skills of students because it is given space to think divergent. Furthermore, in the stage of looking at the structure of the presentation, the SW causal model has several special components.

4. Conclusion

Based on data analysis, the SW average percentage compiled is 86% with very valid criteria. This shows that the causal model SW is feasible to use in learning. The results of the analysis concluded that the strategy for drafting a causal model of SW compared to SW in general, of the eight steps, there are three different, namely in the second, sixth, and eighth steps. Overall, the strategy of reducing the SW of the causal model is: 1) curriculum analysis, 2) making a needs a map, 3) determining the SW title, 4) determining the Basic Competencies and Competency Achievement Indicators, 5) determining the central theme, 6) determining the assessment tools, 7) compiling material, and 8) paying attention to the SW structure. There are 8 SW components of the causal model, namely, 1) SW title, 2) student identity, 3) objectives, 4) basic competencies and indicators of competency achievement, 5) SW completion instructions, 6) phenomena, 7) causality tables and 8) explanations. . The sixth, seventh, and eighth components are the uniqueness of this SW model.

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