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The causalitic learning model to increase students' problem-solving ability

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Abstract. This research aimed to describe the causalitic-learning-model and its' implementation to increase the Problem-solving Ability (PSA) (causalitic = causality-and-analytic). This research used mixed method of embedded experimental two phases. The model has been implemented at three universities and seven senior high schools (SHS) in Mataram-Lombok-Indonesia in physics on seven undergraduate-subjects (kinematics, Newton's law of motion, work and energy, impule and momentum, gravity, rigid equilibrium, thermodynamics) and six SHS-subjects (fluid, optical geometry, impulse and momentum, heat, rigid equilibrium, and direct electrical-current). The instruments consisted of pre-learning-task, learner-worksheet, PSA's problems, and questionnaire. The score of PSA of pre-service-teachers were analyzed with t-test of sign ranks by Wilcoxon but the PSA of SHS-students were analyzed with t-tests, while the responses of questionnaire were analyzed descriptively. The results show that the model is effective to increase the PSA (with significance-level 5%); for pre-service-teachers, the normalized-gain average 0.15-0.53 for low-group and 0.29–0.77 for high-group, while for the SHS' students, the normalized-gains is 0.20-0.83 and all students give positive responses. The phases of the learning-model include orientation, exploration and causality-development, argument-preparation, and evaluation. This learning-model is very useful as a reference when constructing learning using this model at any discipline and any level of education.

1. Introduction

1.1. Shift of physics learning orientation as the basic idea of developing causalitic-learning model

Development of the causalitic learning-model is particularly to anticipate on the phenomenon of physics education has developed in our country, Indonesia. In general, learning of physics has shifted into learning formula. One factor of the shift is that the policies of the government and other institutions of education that tend to develop evaluation tools mostly as problems which need formulas to solve them. As an example, in 2018, thirty-two of the forty problems (80%) on the national physics examination (at senior high school level) needed mathematics formulas to solve [1]. Especially for the pre-service teachers, one of the learning outcomes is a capability to explain concepts of subject to their students. This learning outcome is much different from that the learning outcomes of other undergraduate students which merely tend to understand the concepts for the need of their selves [2].

1.2. What is learning model?
Learning model means as a conceptual frame useful for guiding students in learning. The guide has a systematic arrangement to achieve the objective of the learning including syntax, social system, reaction principle, and supporting system [3]. Another opinion stated that the learning model is a plan or pattern used as a guide to planning to learn in a class [4]. Basically, the former meaning is included in the statement of Arends [5], i.e. that the former as a part of detail representation of the latter one. Next, the discussion of the causalitic-learning model refers to the first statement.

1.3. Understanding of the causalitic-learning model
The causalitic learning model is arranged with orientation for guiding students in learning which emphasizes the development of capability analyzing elements of causes and effects in a phenomenon and compile an argument to explain how the condition of the causes so results in each determined effect. Causalitic is an abbreviation of causality and analytical. In statistical review, the causes as independent variables while the effects as dependent variables. Next, the argument is a rationale to relate the condition of the causes and each effect.

The emphasizing of competence to be achieved through implementation of this learning model primarily is that students learn the concept of each subject comprehensively. This achievement is very useful and needed by the pre-service teachers because later they will have to capable to explain every concept of the subject to their students.

1.4. The meaning of Problem-solving Ability (PSA)
This learning model is based on the development of thinking of causality and analytical. The causality thinking is orientated to facilitate students determine elements of causes in every phenomenon or problem and predict all possible effects deductively while the analytical thinking is aimed to facilitate students compiling an argument to explain how the condition of the causes which result in each predicted effect [4]. Finally, through implementation the learning model, students capable to develop their Problem-solving Ability (PSA) which consists of understanding (IPSA-1), selecting (IPSA-2), differentiating (IPSA-3), determining (IPSA-4), applying (IPSA-5), and identifying (IPSA-6). Qualitatively, the PSA means the capability of students to use their knowledge in determining the elements of causes and effects of every phenomenon or problem and deductively predict each effect which are possible occurred, also means the capability to identify how conditions of each cause as mentioned above [4] and [6], [7], [8], [9], & [10].

1.5. Problems of Research
Based on some explanations above, this paper focuses on the following problems: (1) How the causalitic-learning model enhances the problem-solving ability of students?, (2) What are the syntaxes of the causalitic-learning model?, and (3) How the strategy to implement this learning model?

1.6. Research focus
As described in the literature review and problems of research, this paper focuses on three main discussions. One basic reason resulting in these foci is the fact that the orientation of physics learning mostly has shifted to mathematics learning [1]. The focuses are how the causalitic-learning model facilitates students to increase their problem-solving ability, understanding the stages in learning with this causalitic-learning model and understanding the strategy to implement it.

2. Methodology of research

2.1. General Background of Research
As we found, in Indonesia, 80% of the physics examination problems for senior high school students in 2018 needs a mathematic formula to solve them [1]. This condition affects the process of learning

that tends to train the students on how to implement the formula to solve the problems. As a result, the students do not have the capability of solving the physics problems conceptually.

The development of this causalitic-learning model is oriented to facilitate students learning physics conceptually through which they have to analyze every problem. The students need to determine its causes and predict deductively its possible effects. Statistically, the causes are independent variables while the effects are dependent ones. Next, they also have to select among the causes, which are as the factors of each every effect predicted. Finally, the students need to compile an argument or reason how should be the conditions of each cause so they result to the predicted effect. Note, the problem or phenomenon that is used in this learning model is recommended has more than one answer (multi-effect problem or phenomenon) [4], [6], [7], [8], [9], [10], [11], [12], & [13].

2.2. Sample of Research
The subject of this research is undergraduate students at three high education institutions (two of them as government institution) and students of Senior High Schools (SHS) at seven schools (five of them as government school). All of the institutions and schools are located in the city of Mataram, Lombok Island, Indonesia. The undergraduate students are of the first year Physics Educational Program in 2011/2012 (26 males and 19 females), 2015/2016 (11 males and 37 females), and in 2016/2017 (12 males and 28 females) while the SHS students are of the second year in 2016/2017, 89 male and 152 female students as the experimental group, and 101 male and 144 female students as the control group, also 16 male and 48 female students who are divided into the group of experimental-1 (9 men and 23 women students) and experimental-2 (7 male and 25 female students).

2.3. Instrument and Procedures
This study uses a mixed method embedded with experimental design and a two-phase approach. The main approach is quantitative while the qualitative approach is as supporting one. This method includes four main activities, namely analyzing the needs of a learning model, designing a hypothetical model and its instruments, validating them (expert and empirical), and analyzing and interpreting the research results for designing the final model of causalitic-learning [14].

The qualitative approach is used when exploring all information about the needs of a learning model, validating the hypothetical model of the causalitic learning expertly, analyzing and interpreting the results of this study, and when compiling the final model of this causalitic-learning. The second, quantitative approach is used when validating the hypothetical model of learning above empirically and when analyzing its effectiveness to increase the students' problem-solving abilities (PSA).

Instruments of this research consist of the design of causalitic-learning model, preliminary-task, learner-worksheet, PSA test-kits, and questionnaire for the pre-service students. The preliminary-task is used to prepare learners before face-to-face learning in class. The learner-worksheets are used to guide the learning process in class. PSA test kits are used to measure the ability of beginning and end learners in solving problems. Furthermore, the questionnaire is used to get students and lecturers' responses to the implementation of this learning model.

2.4. Data Analysis
For empirical validation, in the learning process, we group students in each academic year into ten groups based on the results of the initial test about physics concept. Furthermore, for the need for data analysis, pre-service teachers are divided into three groups (each group approaches homogeneity). For this second grouping, we use the results of the initial test. The pre-service teachers are ranked from the highest to lowest scores and we name 25% of the highest scores as high group (Hi) while 25% of the lowest is a low group (Lo) and 50% remaining in the moderate group. This grouping is not informed to the pre-service teachers and is used to analyze the increase in PSA. For qualitative validation, we collect information about the responses of all them to the design of the hypothetical model of causalitic-learning. Finally, in quantitative analysis, the research hypothesis is tested using non-parametric statistics (test of location for two dependent groups), Wilcoxon signed-ranks test [15], to

analyze the increase in PSA and the differences of normalized gain (N-gain) between the pre-service teachers of Hi and Lo groups.

Next in another way, empirical validation for the model of causalitic-learning on the SHS students, we compared data (final PSA test) for students in the experimental class with data from students in the control class. Data from these two groups (experimental and control classes) were tested using parametric statistics, the t-test between two means [15], to analyze the impact of the model of causalitic-learning above in increasing student PSA. For the qualitative validation, we also use all responses from the SHS student about the implementation of this model.

Finally, from all qualitative and quantitative data covering effectiveness, excellence, and barriers to its application in higher education institutions and in the senior high schools, we designed this causalitic-learning model. This design is oriented to determine what phases are appropriate and recommended for learning models that are effective and efficient in improving Problem Solving Abilities (PSA).For the need of validation, the causalitic-learning model has been implemented on seven subjects (kinematics, Newton's law of motion, work and energy, impulse and momentum, gravity, rigid equilibrium, and thermodynamics) on the pre-service teachers and six subjects (fluid, optical geometry, impulse and momentum, heat, rigid equilibrium, and direct current) on the students of senior high school (SHS).

3. Results of research

In accordance with the purpose of this paper, presentation of the results of this study covers three things related to causalitic-learning model, namely their effectiveness in improving problem-solving abilities of students, syntaxes of the learning model, and strategy to implement the model of causalitic-learning. However, before presenting these three results, as an introduction, a number of important things were discussed related to the characteristics of the causalitic-learning model, i.e. the principle of this causalitic-learning model and characteristics of its phenomena or questions.

3.1. The Principle of causalitic-learning model

The causalitik-learning model (causality and analytic) has been implemented. Implementation of this learning model is done by confronting learners (the pre-service teachers and the SHS students) on physics phenomena or problems and giving them the opportunity to determine the appropriate causality-table model, determine the causal component and predict the components of the effects associated with the phenomenon or problem above as well as the causality-table model which has been specified. Furthermore, learners are asked to provide an explanation of the condition of each cause so that it can produce every effect that has been predicted.

3.2. Common characteristics of phenomena or problems physics in this learning model

Every physics phenomenon or problem in a worksheet is generally a verbal description. Most of them have more than one answer and are equipped with conceptual images that are useful for clarifying the mean. The answer which is more than one of these is caused one or several causes that have more than one state. Every particular state of each cause tends to produce one certain effect. With some of these states, several combinations of cause state are produced. Every combination of states for these causes will produce one particular effect but it is also possible that some or all of the combinations above the only result in one same effect. So, sum combination of the states of the cause above will be the maximum amount of the effects possible to occur. In this study, phenomena or problems of physics with these characters are hereinafter referred to as multi-effect phenomena or problems.

3.3. Effectiveness The Causalitic-learning Model

The effectiveness of the causalitic-learning model is based on the significance of the improvement of problem-solving abilities (PSA) in pre-service teachers and students of senior high school (SMA / MA). Furthermore, specifically for pre-service teachers, this effectiveness is also seen from the difference in the value of normalized gain (GD) between the pre-service teachers of low (Lo) and high

(Hi) groups. This difference should not be significant which can be interpreted that the implementation of this learning model has the same positive effect on all groups of learners.

3.4. Data of Problem-solving Ability (PSA)
In assessing the problem-solving ability (PSA) and its value of the normalized gain (N-gain) we used a category respectively adopted from [16] and [17]. The PSA scores (in percent) are categorized high for the PSA ≥ 66, moderate for 55 < PSA < 66, and low for the PSA ≤ 55 while for the N-gain categorized as high for N-gain ≥ 0.7, moderate for 0.3 < N-gain < 0.7, and low for N-gain ≤ 0.3. These assessing is used for both, the PSA for the pre-service teachers and the students of senior high school.

3.5. The problem-solving ability of pre-service teachers
For the pre-service-teachers of the low group (Lo), the value of normalized-gain (N-gain) of the Problem-solving Ability (PSA) on the seven subjects (kinematics, Newton's law of motion, work and energy, impulse and momentum, gravity, rigid equilibrium, and thermodynamics) reaches 0.15 to 0.53. While for the high group (Hi), the value of N-gain of the PSA reaches 0.29 to 0.77. Based on these achievement percentage of PSA, the average post-test results on the seven subjects are categorized low to high. In the Lo group, the achievement of the first indicator of PSA (IPSA-1) is in the medium category, which is 64%, but the other five indicators are in a low category, 16% to 51%. Meanwhile, for Hi group the achievement of the IPSA-1 and IPM-4 were high, respectively 85% and 77%, the achievement of the IPSA-2 was moderate, 57%, but the achievement of the other three IPSAs was low, 35% to 49% (Table 1 & 2).

Table 1. Achievement (%) the Indicators of Problem-solving Ability (IPSA) of Pre-test, Post-test, and Its N-Gain (NG) in Low Group of Students on Seven Subjects [4]

IPSA-1			IPSA-2			IPSA-3			IPSA-4			IPSA-5			IPSA-6		
Pre	Post	NG	Pre	Post	NG	Pre	Post	NG	Pre	Post	NG	Pre	Post	NG	Pre	Post	NG
24	64	0.53	13	43	0.35	1	19	0.19	18	51	0.41	1	22	0.22	1	16	0.15

Table 2. Achievement (%) the Indicators of Problem-solving Ability (IPSA) of Pre-test, Post-test, and Its N-Gain in High Group of Students on Seven Subjects [4]

IPSA-1			IPSA-2			IPSA-3			IPSA-4			IPSA-5			IPSA-6		
Pre	Post	NG	Pre	Post	NG	Pre	Post	NG	Pre	Post	NG	Pre	Post	NG	Pre	Post	NG
43	85	0.77	24	58	0.44	11	42	0.35	37	77	0.69	12	49	0.42	9	36	0.29

With a significance level of 5%, the implementation of the causalitic-learning model is effective to increase the students' problem-solving ability (PSA). However, it is only 48% (20 of 42 opportunities) for Lo group and 67% (28 of 42 opportunities) for Hi group in which indicators of the PSA are increased (Table 3). The indicators, IPSA-1, IPSA-2, IPSA-3, IPSA-4, IPSA-5, and IPSA-6, that significantly increased, respectively are 57%, 29%, 43%, 57%, 43%, and 57% for Lo group and 71%, 57%, 71%, 86%, 71%, and 43% for Hi group (Table 4). Furthermore, the difference of normalized-gain (GD) between the Lo and Hi groups, from 42 opportunities (IPSA-1 to IPSA-6, with seven subjects) is only 17% (for the six indicators) were different significantly (Table 3 & 5) with percentage in each indicator, respectively are 43%, 29%, 0%, 14%, 14% and 0% (Table 4).

Table 3. Significance Recapitulation the increase of Indicators of Problem-solving Ability (IPSA) and N-gain Difference (GD) in Low (Lo) and High (Hi) Groups of Students [4]

Subject	IPSA-1			IPSA-2			IPSA-3			IPSA-4			IPSA-5			IPSA-6		
	Lo	Hi	GD	Lo	Hi	GD	Lo	Hi	GD	Lo	Hi	GD	Lo	Hi	GD	Lo	Hi	GD
Kinematics	NS	S	S	S	S	NS	S	S	NS	S	S	NS	S	S	NS	S	S	NS
Newton's law of Motion	S	S	NS	S	S	NS	S	S	NS	S	S	NS	S	S	NS	S	S	NS
Work and Energy	NS	S	S	NS	S	S	NS	S	NS	NS	S	S	NS	S	S	S	S	NS
Impulse and momentum	S	S	NS	NS	NS	NS	NS	S	NS	S	S	NS	NS	S	NS	NS	NS	NS
Gravity	S	NS	S	NS	NS	S	NS	NS	NS	NS	S	NS	NS	NS	NS	NS	NS	NS
Rigid equilibrium	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Thermodynamics	S	S	NS	NS	S	NS	S	S	NS	S	S	NS	S	S	NS	S	NS	NS

Note: IPSA = Indicator of Problem-solving Ability, IPSA-1 = Ability to understand, IPSA-2 = Ability to select, IPSA-3 = Ability to differentiate, IPSA-4 = Ability to determine, IPSA-5 = Ability to apply, IPSA-6 = Ability to identify, Lo = Students of lower group, Hi = Students of Higher group, GD = Normalized gain difference, S = Significant, dan NS = Not significant

Table 4. Achievement (%) the Indicators of Problem-solving Ability (IPSA) in Seven Subjects that Significantly Increased and the Difference that Significant Between N-gain (GD) of Low (Lo) and High (Hi) Groups of Students [4]

IPSA-1			IPSA-2			IPSA-3			IPSA-4			IPSA-5			IPSA-6		
Lo	Hi	GD	Lo	Hi	GD	Lo	Hi	GD	Lo	Hi	GD	Lo	Hi	GD	Lo	Hi	GD
57	71	43	29	57	29	43	71	0	57	86	14	43	71	14	57	43	0

Table 5. Percentage the PSA's Indicators that Increased Significantly and the Normalized-gain Difference (GD) that Significant between Low (Lo) and High (Hi) Group Students for Each Subject [4]

Subject	Group of Students		GD
	Lo	Hi	
Kinematics	83	100	17
Newton's law of Motion	100	100	0.0
Work and Energy	17	100	67
Impulse and momentum	33	67	0.0
Gravity	17	17	33
Rigid equilibrium	0.0	0.0	0.0
Thermodynamics	83	83	0.0
Average	**48**	**67**	**17**

For the Lo group students, the number of indicators of problem-solving-ability (PSA) that experienced a significant increase from the least to the most, respectively, occurred on the subject of work and energy and gravity (17%), impulse and momentum (33%), kinematics and thermodynamics (83%), and Newton's law of motion (100%). While for the Hi group students, this situation, respectively, happened on the subject of gravity (17%), impulse and momentum (67%), thermodynamics (83%), and Newton's law of motion, and work and energy (100%). On the subject of rigid equilibrium, both for the Lo and Hi groups of students, all of the indicators are not increased significantly. The indicators in which the difference of normalized-gain (GD) between the Lo and Hi groups is significant, from the least to the most occurs on the subject of kinematics (17%), gravity (33%), and on work and energy (67%) while on the other four subjects namely Newton's law of motion, impulse and momentum, rigid equilibrium, and thermodynamics, the GD is not significant (Table 5).

Table 6. Achievement (%) the IPSA-1 up to IPSA-6 [4]

Subject	Lo Group		Hi Group	
	Pre-test	*Post-test*	*Pre-test*	*Post-test*
Kinematics	17	44	20	65
Newton's law of Motion	17	50	39	62
Work and Energy	5	24	14	70
Impulse and momentum	7	32	36	61
Gravity	11	38	25	57
Rigid equilibrium	0	9	0	21
Thermodynamics	11	53	16	56
Average	**10**	**36**	**22**	**56**

3.6. The Problem-solving ability of the students of senior high schools
In the students of senior high school (SHS), problem-solving ability (PSA) increases significantly on six subjects, fluid, optical geometry, impulse and momentum, heat, rigid equilibrium, and direct electrical-current. In this case, the PSA score tested was the average of PSA final score for all indicators (IPSA-1 to IPSA-6) between the experimental group students and the control group (Table 8, 9, 11, 12, and 14) (specifically for impulse and momentum also rigid equilibrium subjects, the tested score was PSA final in students of experimental group 1 and experiment-2, Table 10 and 13). Furthermore, all of the tables (seven tables for the final PSA score and five tables for the initial PSA score) are summarized in the form of averages then calculated the value of its normalized gain (Table 7). All of the *t*-tests on the Table 8 to Table 14 are with a significance level of 5%.

Table 7. Achievement (%) the Indicators of Problem-solving Ability (IPSA) and Its Average of The Senior High School Students and Its Normalized gain (N-gain) of All the Six Subjects

Test	Group	IPSA-1	IPSA-2	IPSA-3	IPSA-4	IPSA-5	IPSA-6	Average
Initial	Eksperiment	80.1	37.7	12.6	16.6	5.7	4.5	26.2
	Control	83.3	43.9	17.1	16.5	6.1	6.1	28.8
Final	Eksperiment	96.6	81.1	59.3	43.6	24.7	20.9	54.4
	Control	93.8	73.4	46.3	32.0	11.2	8.9	44.3
N-gain	Eksperiment	0.83	0.70	0.53	0.32	0.20	0.17	0.46
	Control	0.63	0.53	0.35	0.19	0.06	0.03	0.30

The final score for each indicator of problem-solving ability (PSA) has increased in both the experimental class and the control class. This is indicated, among others, with the value of normalized gain (N-gain), all of which are positive. However, based on the eventual achievement, in the experimental class (the class whose learning used causalitic-learning models), only two indicators (IPSA-1 and IPSA-2) with high PSA achievement (96.6% and 81.1%) and one indicator (IPSA-3) with moderate PSA achievement (59.3%) while the other three (IPSA-4, IPSA-5, and IPSA-6) with low PSA achievement (43.6%, 24.7%, and 20.9%) and the average of all indicators at this class is still relatively low (54.4%). The final achievement category of the PSA is in line with the average values of the normalized gain (N-gain) for the high to low categories, high for IPSA-1 and IPSA-2, moderate for IPSA-3, and low for the other three IPSAs. The inclusion of initial PSA data and PSA for the control class is solely as a comparison of the final PSA and as a basis for calculating the N-gain value (Table 7).

Tables 8, 9, 11, and 14 show the initial and final achievements (in percent), as well as the t_{count} and t_{table} values of each problem-solving ability indicator (IPSA-1 to IPSA-6) for the students of the experimental and control groups, each on the subject of fluid, optical geometry, heat, and direct current at senior high school MAN 1 Mataram, SMAN 1 Mataram, SMAN 1 Central Lombok, and at SMAN 3 Mataram. Furthermore, Tables 10 and 13 show the final achievement (in percent), as well as the t_{count} and t_{table} values of each problem-solving ability indicator (IPSA-1 to IPSA-6) for the students of the experimental and control groups, each on the subject of impulse and momentum and rigid equilibrium at SMAN 8 Mataram and MAN 2 Praya. The final table, Table 12 shows the initial and final achievements (in percent), as well as the t_{count} and t_{table} values of each indicator of problem-solving ability (IPSA-1 to IPSA-6) on the students of group experimental-1 and experiment-2 on the subject of optical geometry in MAN 2 Mataram. In the seven tables, it can be seen that with a significance level of 5%, the value of $t_{count}$is greater than t_{table} and means that the implementation of the causalitic-learning model significantly influences the improvement of students' problem-solving abilities (PSA).

Table 8. Achievement (%) the Indicators of Problem-solving Ability (IPSA) and the Value of the t_{count} and t_{table} from the Hypothesis Test (on Fluids for The Students of Senior High Schools, MAN 1 Mataram, Indonesia) [18]

Test	Group	IPSA-1	IPSA-2	IPSA-3	IPSA-4	IPSA-5	IPSA-6	Average
Initial	Eksperiment	95	40	25	19	9	3	31.8
	Control	94	61	42	26	14	4	40.2
Final	Eksperiment	100	91	59	53	26	15	57.3
	Control	100	67	47	42	14	5	45.8
t_{count}				2.8795				
t_{table}				1,9987				

Table 9. Achievement (%) the Indicators of Problem-solving Ability (IPSA) and the Value of the t_{count} and t_{table} from the Hypothesis Test (on Optical Geometry for The Students of Senior High Schools, SMAN 1 Mataram, Indonesia) [19]

Test	Group	IPSA-1	IPSA-2	IPSA-3	IPSA-4	IPSA-5	IPSA-6	Average
Initial	Eksperiment	93.7	51.4	7.4	13.1	6.9	18.9	31.9
	Control	86.9	44.0	17.7	8.6	0.0	21.7	29.8
Final	Eksperiment	98.3	85.7	23.4	50.3	23.4	57.7	56.5
	Control	85.7	68.0	37.1	12.6	3.4	40.0	41.1
t_{count}				4.5453				
t_{table}				1,9954				

Table 10. Achievement (%) the Indicators of Problem-solving Ability (IPSA) and the Value of the t_{count} and t_{table} from the Hypothesis Test (on Impulses and Momentum for The Students of Senior High Schools, SMAN 8 Mataram, Indonesia) [20]

Test	Group	IPSA-1	IPSA-2	IPSA-3	IPSA-4	IPSA-5	IPSA-6	Average
Initial	Eksperiment	-	-	-	-	-	-	-
	Control	-	-	-	-	-	-	-
Final	Eksperiment	100	96	82	44	41	25	64.7
	Control	96	95	80	22	15	1	51.5
t_{count}				3.3690				
t_{table}				1,9987				

Table 11. Achievement (%) the Indicators of Problem-solving Ability (IPSA) and the Value of the t_{count} and t_{table} from the Hypothesis Test (on Heat for The Students of Senior High Schools, SMAN 1 Lombok Tengah, Indonesia) [21]

Test	Group	IPSA-1	IPSA-2	IPSA-3	IPSA-4	IPSA-5	IPSA-6	Average
Initial	Eksperiment	70.4	32.4	1.9	26.9	5.6	0.0	22.9
	Control	83.9	37.5	2.7	32.1	6.3	4.5	27.8
Final	Eksperiment	98.1	90.7	56.5	32.4	23.1	19.4	53.4
	Control	93.8	76.8	15.2	57.1	16.1	8.9	44.7
t_{count}				2.02				
t_{table}				2,00				

Table 12. Achievement (%) the Indicators of Problem-solving Ability (IPSA) and the Value of the t_{count} and t_{table} from the Hypothesis Test (on Optical Geometry for The Students of Senior High Schools, MAN 2 Mataram, Indonesia) [22]

Test	Group	IPSA-1	IPSA-2	IPSA-3	IPSA-4	IPSA-5	IPSA-6	Average
Initial	Eksp-1	83.2	20.0	15.0	20.0	5.0	0.4	23.9
	Eksp-2	91	25	16	15	10	0.4	26.2
Final	Eksp-1	100	42	44	37	25	9	42.8
	Eksp-2	100	52	55	34	13	2	42.7
t_{count}				7.15				
t_{table}				2,04				

Table 13. Achievement (%) the Indicators of Problem-solving Ability (IPSA) and the Value of the t_{count} and t_{table} from the Hypothesis Test (on Rigid Equilibrium for The Students of Senior High Schools, MAN 2 Praya, Indonesia) [23]

Test	Group	IPSA-1	IPSA-2	IPSA-3	IPSA-4	IPSA-5	IPSA-6	Average
Initial	Eksperiment	-	-	-	-	-	-	-
	Control	-	-	-	-	-	-	-
Final	Eksperiment	98	97	79	60	15	9	59.7
	Control	96	94	60	41	11	3	50.8
t_{count}				2,33				
t_{table}				2,02				

Table 14. Achievement (%) the Indicators of Problem-solving Ability (IPSA) and the Value of the t_{count} and t_{table} from the Hypothesis Test (on Direct Current for The Students of Senior High Schools, SMAN 3 Mataram, Indonesia**)** [24]

Test	Group	IPSA-1	IPSA-2	IPSA-3	IPSA-4	IPSA-5	IPSA-6	Average
Initial	Eksperiment	58.2	44.8	13.9	4.2	1.8	0.0	20.5
	Control	60.6	52.1	7.3	0.6	0.0	0.0	20.1
Final	Eksperiment	81.8	65.5	71.5	28.5	19.4	10.9	46.3
	Control	84.8	61.2	29.7	15.2	6.1	2.4	33.2
t_{count}				4,44				
t_{table}				1,997				

3.7. The responses of students to the causalitic-learning model

Responses to this learning model be presented in this paper is of the pre-service students which taken from 18 students divided into two groups, low (Lo, students number 1 to 9) and high (Hi, students number 37 to 45) groups. The student attitude scale is taken from 18 students, 9 students in the lower group and the other in the upper group which was taken using 17 statements (statement 1 to 8 as positive statements while the rest were negative ones). Thus the attitude scale for these students become three groups: 1) Students' responses to positive statements regarding the development of causalitic-thinking (CT); 2) Student responses to negative statements regarding the thinking; and 3) Additional responses that are free. The results of the attitude scale percentage of the first and second sections are shown in Table 15 and Table 16, respectively. Next, responses of the third group, are shown in Table 17 (for the Hi group) and Table 18 (for the Lo group).

Table 15. Average Score and Percentage of Student Responses to Positive Statement of CT Development [4]

Data	Groups	The Questionnaire number							
		1	2	3	4	5	6	7	8
Average Score	Lo	4,4	4,0	4,6	4,4	4,7	4,1	3,9	4,2
	Hi	3,9	4,3	4,4	4,7	4,4	3,4	3,7	4,0
Percentage	Lo	82	74	84	82	86	76	71	78
	Hi	71	80	82	86	82	63	67	74

Table 16. Average Score and Percentage of Student Responses to Negative Statement of CT Development [4]

Data	Groups	The Questionnaire number								
		9	10	11	12	13	14	15	16	17
Average Score	Lo	3,2	3,2	1,9	3,6	3,8	3,7	3,6	3,9	4,0
	Hi	3,2	3,7	2,8	3,8	3,2	3,4	3,9	4,1	4,1
Percentage	Lo	59	59	35	65	69	67	65	71	74
	Hi	59	67	51	69	59	63	71	76	76

Table 17. Additional Responses from Hi Students to the Development of CT

Code of Student	Responses
S1	No respons
S2	With CT, I understand better that physics is not just a matter of fact that physics is also an analysis so students also understand more about the concept of physics.
S3	I feel happy with learning physics using this CT Development method, because it can increase the creativity and thinking power of students because besides counting we can also analyze the physics lesson.
S4	No respons
S5	1. The development of CT is a learning strategy that is quite interesting and challenging. 2. One of the most prominent advantages of developing CT is that it helps students understand a physical phenomenon completely. 3. However, CT requires a relatively long time to discuss a phenomenon. For this reason, it's better if CT is run outside of school hours. 4. 4. Apart from that overall CT is an interesting and helpful strategy.
S6	No respons
S7	CT is fun.
S8	The development of CT is indeed good but maybe I still cannot take the lessons well because my knowledge is still lacking, but actually I am interested in this method.
S9	With the CT development strategy, I understand and can remember a formula that initially made no sense (due to lack of understanding) to make sense and understand.

Table 18. Additional Responses from Lo Students to the Development of CT

Code of Student	Responses
S37	This lecture should be rearranged, because we (not Basic Physics I) can all do physics so that it is difficult to explore the theory.
S38	1. The CT development strategy can help me understand the concept of physics and analyze a problem. 2. It would be nice if applied phenomena that are solved by calculations, so that in addition to understanding the concept of a physical problem we are also able to solve these problems with calculations.
S39	1. Physics is a fairly complex lesson, so far students can only use certain formulas and can only understand the decline in formulas, however, through this method can help students in assessing the cause and effect that exists on the problem, especially complex questions, 2. Besides, it can help students in understanding the concept of physics as a whole from its roots, 3. If necessary, concepts like this continue to be held even if they can be included in the student curriculum so that in understanding and solving complex physics problems it is easier to find solutions to these problems.
S40	1. When developing CT, it must at least be supported by knowledge and advance notice so that the acceleration produced is more optimal. 2. In using CT, I feel more than before. Initially I was very unable to understand every phenomenon that was given, it was very complicated to understand, but with the help of PBK-A, now I better understand the concepts of physics.
S41	By using the CT system I feel more helped in resolving the phenomena in physics, because by using this system these phenomena are discussed in detail and thoroughly and I also really like this learning system because I am very much less understanding more.
S42	This CT strategy makes me drain my mind but in my opinion this strategy is truly extraordinary in solving physical phenomena.
S43	1. It is better if physics learning is done together / followed by the ability of students. 2. It will be useless / in vain if students are unable to master the learning media. 3. 3. It will be easier if each learning medium is carried out in stages.
S44	No respons
S45	I like the PBK-A strategy, because it looks more at existing problems in physics more thoroughly. The method is different from the ones that can be made easier to understand.

3.8. The syntax of the causalitic-learning model
Referring to the results of empirical tests and input from pre-service teachers and senior high school students as research subjects, and based on input from physics education lecturers in the working environment of researchers (Universitas Mataram), there are four main phases in the model of causalitic-learning. The four phases are orientation, exploration and development of the concept of causality, preparation of arguments, and evaluation [25] & [26].

Furthermore, the activities of the teacher or lecturer (facilitator), and the activities of students are as follows:The orientation phase: Facilitator carries out two activities, (1) conveying the learning objectives and (2) briefly discussing the results of the preliminary task (PT). Learners (1) listen to the contents of the learning objectives and (2) equate the perceptions of the concepts in the PT.

The phase of exploration and development of the concept of causality: Facilitator carries out three activities, (1) introducing concepts in the form of phenomenon, (2) informing the stages of completion of the phenomena presented in learner worksheet (LWS), and (3) providing guidance by showing some examples of the resolving process of the phenomenon using scaffolding. Learners carry out six activities, namely (1) analyzing phenomenon in terms of the causality concept, (2) identifying elements of the phenomenon which are causes, (3) predicting deductively the various effects, (4) writing down all elements of the causes and effects into the causality tables in the SWS, (5) identifying groups of causes that directly affect the occurrence of each effect above, and (6) identifying and determining concepts, principles, theories, and or laws relating to the phenomenon.

In this third phase, facilitator (1) reminding learners to identify the conditions of each of the causal elements. Meanwhile, the learners carry out five activities, namely (1) identifying the possibility of condition for each cause element, (2) identifying possibility of the combination of conditions possible to occur for each cause, (3) determining the possible effects of each combination, (4) applying concepts, principles, theories and / or laws to explain why each effect can occur, and (5) compile an argument as to why each effect occurs by including the above concepts, principles, theories and or laws.

In the fourth phase, facilitator (1) facilitating students to equate perceptions and/or revise wrong perceptions of the subject being discussed, (2) strengthening concept by developing constructive follow-up questions, and (3) facilitating students to do enrichment through further assignments. Learners: (1) conveying their respective perceptions and reviewing the perceptions of other students regarding the subject being discussed, (2) answering constructive questions further in order to strengthen the mastery of the concept, and (3) classically concluding all of the answers in the SWS.

3.9. The strategy to implement the causalitic-learning model
Strategies can be interpreted into four elements, namely: 1) identification and determination, specifications and qualifications of the results and objectives to be achieved, 2) consideration and selection of effective approaches, 3) consideration and determination of steps to be taken, and 4) consideration and determination of benchmarks and benchmark determination [27]. Determination of the implementation strategy of this learning model is based on the interpretation of the Makmun's opinion and adapted to the characteristics of the causalitic-learning model as well as the facts of learner input which have relatively inadequate mastery of physics concepts because previously tend to be more familiar with the phenomenon of the application matter of count.

With this set out an implementation strategy that includes four stages, namely: (1) mastery of concepts into key target competencies, then equipped with competencies in applying these concepts into count problems, (2) based on developing causalitic-thinking processes, in learning is used a problem-solving approach to multi-effect phenomena, (3) it needs supporting of the Preliminary Task (PT) and Learner Worksheet (LWS) instruments. Thus, the five main steps of learning with causalitic models are: a) development of initial conception through the performance of PT, b) development of causalitic-thinking and knowledge construction through LWS performance, c) confirmation, correction of misconceptions, and reinforcement of concepts through classical discussion with lecturer/teacher guidance, d) determination of strategies for implementing concepts into a problems of count, and (e) need an evaluation tool to measure students' problem-solving abilities which include the ability to understand problems, to select the causes and effects of the problem, to differentiate which causes as the factors of a particular effect, to determine what concepts, principles, theories, and or law relating to the issues discussed, to apply the concepts, principles, theories, and or laws to identify the relationship of the causes with certain effect, and the ability to identify how the conditions of each cause as a factor of each effect so the effect occurs, and (5) group the learners heterogeneously.

4. Discussion

4.1. The increase of Problem-solving Ability (PSA)

The implementation of the causalitic-learning model (CLM) has been shown to improve the problem-solving abilities (PSA) of pre-service teachers and senior high school (SHS) students. The problem-solving ability includes six indicators, namely understanding, selecting, differentiating, determining, applying, and identifying. The indicator of understanding is interpreted as the ability of learners to understand the problems faced while the indicator of selecting describes the ability of learners to determine the causes and effects that are likely to occur in a phenomenon. The indicator of differentiating means that the learner is able to determine which causes as the factor of each effect that has been predicted or chosen. Furthermore, the indicator of determining means the learner is able to determine what concepts, principles, theories and or laws of physics are related to the phenomena being faced while the indicator of applying is interpreted as the learner's ability to apply those of concepts, principles, theories, and or laws. Finally, the indicator of identifying is interpreted as the learner's ability to compile arguments by which relate how the conditions of each cause element so that each effect occurs [4].

Based on a result of research, the achievement of the final PSA is still relatively low. For the pre-service teachers, the PSA is 36% for the lower group (Lo) and 56% for the upper group (Hi) (Table 6) while for the senior high school students (SHS), the PSA is 44% for the control class and 54% for the experimental class (Table 7). Those four achievements are only one medium category (56%) the others are classified as low. However, the average of the PSA achievement for the pre-service teachers for groups Lo and Hi is 46% which is also low even lower than the achievement of the final PSA of the senior high school students (SHS) in the experimental group (54%). This makes sense because, at the pre-service teachers, the learning instruments are arranged in a standard form while at the SHS students the learning instruments are arranged with the help of scaffolding. This situation is in line with the opinion of Joyce, Weil, & Calhoun [28] that scaffolding facilitates teachers, lecturers, or other instructors to encourage learners to go beyond difficulties to achieve a higher level of learning.

The effort to restore physics learning to the conceptual discussion is very important. Alanazi [29] suggested the importance of overcoming misinterpretation and poor scientific understanding which was allegedly caused by a lack of philosophical content of science in education programs for teachers. The content of philosophy of science is the basis of the concept of a field of science, including the field of physics. Thus, this opinion supports the orientation of the causal learning model, namely prioritizing new conceptual exposure and then proceeding to the application of concepts into the phenomenon or problem of count.

4.2. Development of Kreative Thinking through Implementation of Causalitic-learning Model

In addition to improving problem-solving ability (PSA), the implementation of this learning model also improves the ability of students' creative thinking. This is indicated by the beginnings of students completing work on problems that have more than one correct answer. The aforementioned problems directly encourage creative thinking that is that an open-ended task will result in fluency, flexibility and/or originality [30]. Besides these three influences, the open-ended problems also encourage the development of elaboration [31]. This fact agrees with Rokhmat, Marzuki, Hikmawati, & Verawati [10] who stated that the implementation of causalitic-thinking approaches improves students' creative thinking. They stated that the approach encourages the use of phenomena of problems with more than one answer (multi-effect phenomenon) that is directly related to one indicator of creative thinking, namely an indicator of fluency. The fluency indicator illustrates how many answers students have predicted, the more answers predicted the more creative the students are.

The design of the instruments used for this causalitic-learning model has conceptually been pioneered through a number of studies conducted since 2013. The study included doctoral research (2013) [4], research on the development of learning models for three years (2015-2017) [6], [7], [8], [9], & [10] and research on the development of supporting instruments for senior-high-school education (2017-2019) [12] & [13] and higher education (2018-2020) [11], some of which are currently ongoing.

4.3. The Syntax of the Causalitic-learning Model

The causalitic-learning model has four phases, namely (1) orientation, (2) exploration and development of the concept of causality, (3) compiling of arguments, and (4) evaluation. The phase of orientation: These activities, especially inform learning objectives, is in line with Newman and Logan as quoted by Makmun [27] who stated that in learning needs to identify and determine learning outcomes. Next, the use of preliminary task (PT) is for guiding students in developing their abilities in completing the tasks. The brief discussion about PT is in line with Vygotsky as quoted by Wertsch [32] who state that giving guidance is to facilitate students in completing tasks related to material that students have learned.

The second phase is exploration and development of the concept of causality. The endorser theory to this phase: From the point of information processing, this phase as a process of coding and developing perceptions of the concepts that students learn and also storing information in sensory memory [33]. This is also in line with the statement of Shuell (1986) cited by Schunk [34] that in identifying the causes, learners will focus their attention on the attributes implicit in the phenomenon which that students are solving. Furthermore, the results of this identification will be sent to short-term memory [35]. Provision of causality table is guidance. The provision of guidance is in line with Vygotsky's opinion as quoted by Wertsch [32] and Slavin [36]. Guidance or scaffolding is also expressed in the concept of learning [3]. From the point of view of information processing, the identification of groups of causes which are factors of each effect is a continuation of the determination of these causes. In this phase, the ability of student critical thinking also develops in line with the opinion of Beyer (1985) that distinguishing between the relevant from the irrelevant is also part of critical thinking. In this process, cognitive information is assimilated and the results are stored in long-term memory. This memory can someday be recalled if needed. This is in line with the opinion of Baddeley (1998) as quoted by Schunk [34].

The third phase is compiling of arguments. The activity of identifying each cause element is in line with the process of assimilation and or accommodation on which as part of the process of knowledge construction (Piaget, as quoted by Dahar [37]. In accordance with the compilation of arguments, Kasser [38] and Hempel in Kasser [38] stated that they justify an explanation if they derive from concepts, principles, theories, and or laws of physics. In this phase, critical thinking skills also develop. This is in line with Ennis [39] who stated that thinking is reasonable and reflective by emphasizing decision making that includes critical thinking. Furthermore, Hossoubah [40] stated that part of thinking is giving reasons in an organized manner and evaluating the quality of a reason systematically.

The fourth phase is the evaluation. Overton [41] supported this phase, namely that evaluation as a process of gathering information to monitor the process further for the need for a decision. Meanwhile, Palomba & Banta [42], as well as Frey, Barbara, and Susan W. Alman [43] stated that evaluation (assessment) is a process of collecting, reviewing and using information systematically with the aim of improving the quality of learning.

4.4. The Strategy of Implement of the Causalitic-learning Model

The principle of the implementation strategy of the causalitic-learning model is already reflected in the syntax. All of this is due to the development of this learning models, specifically the preparation of phases of implementation, namely that the learner has developed an initial conception about the subject through the preliminary task (PT) before class learning. In addition, we compile the learning instruments with the assistance of scaffolding. In learning, we advise to dividing learners into discussion groups with heterogeneous members. We also advise compiling the phenomenon as multi-effect, namely a phenomenon with more than one answer. Thus, this learning strategy is also in line with the above opinions, such as Vygotsky as quoted by Wertsch [32], Shuell (1986) as cited by Schunk [34], Vygotsky's opinion as quoted by Wertsch [32] and Slavin [36], Joyce, Weil, and Calhoun [3], Kasser [38] and Hempel in Kasser [38], Overton [41] supported this phase, namely that evaluation as a process of gathering information to monitor the process further for the need for a decision. Meanwhile, Palomba and Banta [42], as well as Frey, Barbara, and Susan [43].

5. Conclusions

We have developed a causalitic-learning model as a result of research conducted since 2013. This learning model aims to direct the learning process to the comprehensive mastery of concept. This model has four phases, namely (1) learning orientation, (2) exploration and development of the concept of causality, (3) compiling of arguments, and (4) evaluation. Supporting instruments of this learning model include preliminary tasks (PT), learner worksheets (LWS) on the basis of multi-effect phenomena. Empirically, the causalitic-learning model proved effective for improving problem-solving abilities (PSA) of pre-service teachers and senior high school (SHS) students in physics. The PSA includes the ability to understand, select, differentiate, determine, apply, and to identify. In addition, the use of phenomena multi-effect in this learning model directly enhances learners' creative thinking skills, as well as other higher-order thinking, such as critical and systemic thinking. In implementing this model, the following are suggested: (1) compile the instruments with the help of scaffolding, (2) before class learning students do a preliminary task (PT), (3) dividing learners into heterogeneous discussion groups, and (4) each LWS maximum contains two phenomena, and (5) providing handouts or sourcebooks that facilitate the development of concepts of learners.

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