Instrument development of causalitic thinking approach in physics learning to increase problem solving ability of pre-service teachers

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Instrument Development of Causalitic Thinking Approach in Physics Learning to Increase Problem Solving Ability of Pre-service Teachers

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Abstract. It has been developed instruments of Causalitic Thinking Approach (CTA) in Physics learning to increase Problem Solving Ability (PSA) of pre-service teachers (low and high groups). Causalitic means causality and analytic. Implementation of the CTA at kinematics and Newton’s law about movement increased the PSA of students (significance 5%) and the increases were not different between the low and high groups. PSA includes abilities of understanding (IPSA-1), selecting (IPSA-2), differentiating (IPSA-3), determining (IPSA-4), applying (IPSA-5), and identifying (IPSA-6). The differences between pre-test (initial PSA) and post-test (final PSA), and between PSA-gain of low and high groups were tested using Wilcoxon signed-ranks test. Pairs of $t_{counted}$ and $t_{table}$ at IPSA-1 to IPSA-6 for low group were (2,-), (0,5), (0,2), (0,0), (0,0) at kinematics and (0,5), (0,5), (0,2), (0,0) at Newton’s law. While, for high group, the pairs were (0,5), (0,5), (0,3), (0,2), (0,0) at kinematics and (0,5), (0,5), (0,2), (0,3) at Newton’s law. Finally, pairs of $t_{counted}$ and $t_{table}$ for the PSA gain differences were (0,3), (4,0), (5,2), (13,5,5), (5,2), (5,2) at kinematics and (3,2), (12,5), (10,5,5), (2,0), (8,5,5), (10,5,5) at Newton’s law. The value of $t_{table}$ is related to the number of effective data pairs (for 6, 7, 8, and 9 pairs, the $t_{table}$ respectively are 0, 2, 3, and 5). This first of three year research used mixed method of embedded experimental two-phase design and involved 49 students (39 females). The CTA facilitated students to develop ability of causality and analytic thinking. To solve phenomenon, students determined all causes and deductively predicted all possible effects, and finally identified conditions of each causes which resulted in each effects. This paper will focus at three focus discussions, i.e. instruments of CTA, PSA increases, and responds of students to the instruments.

INTRODUCTION

Strategies to increase quality of Physics learning has been developed by some researchers. The strategies, such as using conflict-cognitive learning [1], implementing meta-conceptual, awareness, monitoring, and conceptual evaluation [2], applying Interactive Engagement (IE) [3], and using theorem-in-action [4]. Other strategies are demonstrating three accelerated movements [5], using Technology Enabled Active Learning (TEAL)-studio format [6], applying power point presentation and experimental demonstration [7], developing causal reasoning [8], also developing Physics Lecturing Program (PLP) designed to increase the ability of analyzing and creating [9], and implementing Student Work Sheet (SWS) based causality and analytical thinking [10].

In Physics lecturing, we found that Students have difficulties in learning Physics conceptually. This fact nothing other than the Students were unusual do it when studied Physics at senior high school. The difficulties included in understanding idea, selecting and/or predicting all possible effects, differentiating and selecting the causes, determining concept, principle, theory, and/or laws of Physics, as well as identifying the causes why an effect occurred. All of the difficulties are elements of Problem Solving Ability (PSA) (ibid). Refering to the title above,
this paper focused to answer two questions: 1) What are the instruments of CTA in Physics learning; and 2) How the PSA increased as result from the CTA implementation.

THEORETICAL FRAMING

Relating to the question above, we focus this literature review on two topics. Those are Causalitic Thinking Approach (CTA) and Problem Solving Ability (PSA).

Causalitic Thinking Approach (CTA)

Approach is a way of beginning something. In learning, it means a point of view of its process. In general, based on which more active in the learning, student or teacher, there are two sorts of learning approach, i.e. student centered approach and teacher centered approach. Some characteristics of the former include teachers as facilitator and students explore information by their selves. While, characteristics of the latter, teachers as a source of information so they actively transfer teach students.

Causalitic thinking is alias of causality and analytical thinking. Paul & Elder stated that thinking has eight elements, i.e. generating objective, proposing question, applying information, needing concept, making conclusion, making assumption, generating understanding, and realizing a point of view [11]. While Gopnik & Schulz mentioned about one philosophy approach of causation theory that is difference-making [12]. This approach agrees that every cause create a different effect. It has to result in or at least change possibility for effect to happen. Lenzen stated two views of causality concept, first is that two events are in a series and second is that two events occur in the same time. He also stated two principles of causality, first is that causality is reproducible in a space and time. This principle means the effect that will be resulted from some causes is independent from space and time. The second agreed that the same initial conditions will result in the same phenomenon series [13]. Beside the two, there is one more principle of causality [14]. The principle agreed that one event of cause will produce event of effect and if the events are separated by space so they also have to be separated by time.

Marzano & Kendall stated that in Bloom taxonomy, analytical thinking as higher order thinking [15]. While, Amer mentioned that analytical thinking is related to creative thinking [16]. He defined that analytical thinking also, as a tool of thinking, strongly useful for understanding a phenomenon. The basic idea of analytical thinking is making a handful of its elements, comparing them, making a rank, and selecting the most valuable, also discarding the remaining. Indicator of analytical thinking is how far students can identify the conditions of causes so they result in a determined effect. Kasser stated that for identifying, it needs explanation which is related to facts and/or events in Physics and when make its explanation it has to be derived from fact, concept, principle, theory, and/or law of Physics [17].

In Causalitic Thinking (CT), students do some activities which are to do with the causality thinking and analytical thinking as above. Activities which are closely related to causality thinking include understanding phenomenon, determining causes, deductively predicting effects, and differentiating all causes which are to do with each predicted effect. While, activities which are closely related to analytical thinking include identifying each of causes so result in each of the predicted effect, codifying explanation which is correlating causes and each predicted effect, also write argument down why each of the predicted effects happen. When codify explanation it has to be derived from fact, concept, principle, theory, and/or law of Physics which is related to the causes and/or predicted effect. Thus, the analytical thinking includes determining and applying fact, concept, principle, theory, and/or law of Physics and finally use them to identifying or compiling explanation why the predicted effect happens.

Elements of the CT are in line with some elements of thinking, especially from Paul & Elder [11] and Kasser [17]. The congenialities between CT and eight elements of thinking from Paul & Elder [11] as follow: Understanding phenomenon in CT agree with generating objective and generating understanding; determining causes and predicting effect in line with generating objective, proposing question, applying information, and needing concept; differentiating causes agree with proposing question and needing concept. While, congenialities between CT and the ideas from Kasser [17] at least at two elements, identifying causes and explaining relation between causes and each predicted effect. Thus, elements of the CT are at least in lines with nine of the eleven (81%) elements of thinking that Paul & Elder [11] and Kasser [17] stated.
Problem Solving Ability (PSA)

In this paper, terminology of Problem Solving Ability (PSA) is derived from many opinions, such as Marzano and Kendall [15] and Marzano and Brown [18]. Marzano & Brown [18] mentioned that in a problem solving, students are necessary to use their knowledge in generating and stanching their opinion. While, Marzano & Kendall [15] recommended seven questions which are needed to encourage problem solving. The questions were about objective, obstacle, the way to handle obstacle, determining best solution, the real event, the congeniality of the result and solution, and/or the best way to change thought.

Marquardt [19] proposed two approaches in problem solving. The first is analytic approach which agreed only one solution of a phenomenon. This approach recommends us to develop strategy based on analytical process. The second is integrative approach which followed many solutions in one phenomenon. This approach recommends us to develop a multi-effect phenomenon, that is one or more elements of causes in the phenomenon are variable. By implementing this phenomenon, the leaner is facilitated to identify all cause conditions and determine all effects which have possibility to occur.

Based on the two paragraphs above Problem Solving Ability (PSA) is defined in two abilities. The former, ability to use knowledge in selecting and/or predicting all possible effects when solve a phenomenon. The later, ability in identifying how the causes can result in each effects.

In relation with Causalitic Thinking (CT), the PSA is defined in six indicators. The indicators include understanding, selecting, differentiating, determining, applying, and identifying [10]. The first four indicators respectively show ability to understand an idea of a problem, select and/or predict all effects, differentiate and select causes as the factors of each effects, and ability to determine concept, principle, theory, and/or law of Physics useful in identifying of all causes. The two others respectively show ability to apply the concept, principle, theory, and/or law of Physics in identifying causes and ability to identify conditions of causes that result in each effect.

Relation between Causalitic Thinking and Problem Solving Ability: When analyze a phenomenon into its causes and its effects it needs an understanding of idea and objective of the phenomenon, as well as consideration and ability in analysis its difference. The needs of understanding, consideration, and ability are included in analytical thinking. As the result, ability of analytical thinking has a significant role to the ability of causality thinking. This fact agrees with Paul & Elder [11], Amer [16], Zschunke [20], Cohen [21], and Hamilton [22].

The first three of the six PSA indicators and interpretation of problem solving are derived from indicators of analytical thinking included in statements of Amer [16], Zschunke [20], Cohen [21], Parselle [23] and Hamilton [22]. The fourth and fifth indicators support ability of students when they identify causes.

Based on descriptions above it is clear that ability of causality and analytical thinking supports the PSA. Causality thinking directly supports ability of student in selecting and/or predicting all possible effects in a phenomenon. While, analytical thinking supports students when they identify how causes can result in a determined effect. Thus, Causality and Analytical Thinking (CAT) support the PSA.

METHOD

This first (of the three years) research used mixed method of embedded experimental design with two phase approaches, qualitative was the main approach with quantitative was embedded in it. The process of this research consisted four main activities, i.e. analysis subject matter, design instruments, expert and empirical validations, and the last activity was making analysis and interpretation of the developed instruments [24] (Figure 1).
Figure 1 shows part year I design of one group pre-test–post-test [25] which is modified from Creswell & Clark [24]. This design has quantitative data which is embedded in the qualitative data. Qualitative data was gathered in analysing subject, developing instruments, and in expert validating, also in analysing and interpreting output of this research. While, quantitative data was gathered from pre-test and post-test. The pre and post-tests were conducted in process of empirically instrument validation. On the other hand, the qualitative data was used to analyse information resulted from filling attitude scale, observation, and of interviews. These data were especially about instrument of Causalitic Thinking (CT) and its quality and its restrictiveness. While, quantitative data was used to analyse the increase of Problem Solving Ability (PSA). Finally, information about quality and restrictiveness of the CT instruments also about the PSA increase were used to make recommendations to develop better instruments of Physics learning with approach of Causalitic Thinking.

Subject of this research was Students of Physics Educational Program joining in class of Fundamental Physics I, in one University in Mataram of year 2015/2016. The subject consisted of 49 students, 39 females and 10 males. In the phase of empirical validation (intervention and its discussion), the students were devided into 10 groups based on results of grouping test, nine groups comprised five members and one another comprised four members. For analysis data of research, the subjects were devided into three groups (approximately homogeneous). Group one consisted students of rank 1 to 9, group two of rank 10 to 40, and the last, group three of rank 41 to 49. We announced the first grouping but for the second, we did not announce it. Next, we named the first and the third groups respectively as the high and low groups. The high and low groups were needed to analyze increase of PSA while all students were needed to qualitatively validate instruments of the CT approach. To analyze the increase and its difference between the two groups of students it used non parametric statistic (test of location for two dependent groups), the Wilcoxon signed-ranks test [26].

RESULTS

As objectives of this paper, results of the first year research that will be discussed are consisted of three focuses, those are instruments of Causalitic Thinking Approach (CTA) in Physics learning, the increase of Problem Solving Ability (PSA), and student responses to the instruments. The results will be separately presented.

Instruments Causalitic Thinking Approach (CTA)

Final instruments of CTA for Physics learning that will have been resulted after the third year research include 1) model of Causalitic Learning, 2) set of pre-face tasks (PT), 3) set of Student Work Sheet (SWS), 4) learning book of Fundamental Physics I which is based on CTA, 4) some example of learning plan based on the CTA, and 5) text book of Causalitic Learning model. While, this first year research results draft of Causalitic Learning model, eleven PT, twenty four SWS, and draft of learning book of Fundamental Physics I based on CTA. Considering that the learning model and learning book still in draft, we will not make further presentation of the two results.
Characteristics of PT and SWS

1. Characteristic of Pre-face Task (PT)

Pre-face task (PT) aims to teach students Physics concept so they have had initial conception about subject matter that will be discussed in face to face learning. The problems in the PT are structurally designed to bridge student in effort of understanding the concepts. The problems are presented starts from terminologies which are usually used in the concept, its understanding, up to its implementation in daily life. Students are advisable collectively to solve problems in PT one or more days before face to face learning with the CTA. However, the students have to report their tasks individually. This strategy aims to assure that every student experience learning process so it has a possibility the students have knowledge and initial conception about subject matter will be discussed before they join face to face learning.

2. Characteristic of Student Work Sheet (SWS)

Rokhmat (2013) mentioned that the SWS aims to foster students develop their Problem Solving Ability (PSA) through process of “Causalitic” Thinking. The process consists of cause prediction and determination of effects having possibility to happen. The causes and effects are placed into causality table so form one causal model, such as Simple Causal Model (SCM), Divergent Causal Model (DCM), Convergent Causal Model (CCM), Chain Causal Model (ChCM), or Composite Causal Model (CoCM). In addition, the SWS also foster their PSA through process of analytical thinking when they identify how the conditions of causes which result in each effect.

The SWS consist of five main part, those are instruction, sample of the five forms of causal table, Physics phenomena, blank of general causality table, and blank of cause identification for each effect. In general, in each work sheet, there are two Physics phenomena, which are arranged from the phenomenon with high level of assistance (one sort of scaffolding Causalitic Thinking) up to the low one. The SWS without any assistance phase is called as the SWS of standard formed.

The Increase of Problem Solving Ability (PSA)

The increase of problem solving ability (PSA) is resulted from post-test minus pre-test. Its significance depends values of $t_{\text{counted}}$ (value of $t$ calculated from Wilxocon signed rank test) and $t_{\text{table}}$ (value of $t$ from table). The null hypothesis is ejected if the $t_{\text{counted}}$ equals or is less than $t_{\text{table}}$ [26].

Table 1 and Table 2 show percentage of problem solving ability (PSA) from pre-test and post-test respectively for low and high groups of students at subjects of kinematics and Newton’s law. While, table 3 shows its normal gain (low and high groups) at the subjects. Visually, all indicators of the PSA (IPSA-1 to IPSA-6) increased as well as its gain.

Table 4 and 5 show list of $t_{\text{counted}}$ ($t_c$), number of effective pairs ($n$), and of $t_{\text{table}}$ ($t_t$) of the PSA increase and its gain difference, respectively at kinematics and Newton’s law. It is clear that, except in IPSA-1 of low group at kinematics, $t_c$ in all IPSA is less than $t_t$. Conversely, also except in IPSA-1 of low group at kinematics, $t_c$ in all N-gain is greater than $t_t$.

The facts above mean that, except in IPSA-1 of low group at kinematics, all of null hypothesis of pre-test and post-test score differences are rejected but all of null hypothesis of the N-gain differences are accepted. Thus, with the same exception, all indicators of the PSA were significantly increased and the increases of low group were not different from the high one.

<table>
<thead>
<tr>
<th>Subject</th>
<th>IPSA-1</th>
<th>IPSA-2</th>
<th>IPSA-3</th>
<th>IPSA-4</th>
<th>IPSA-5</th>
<th>IPSA-6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pe</td>
<td>Po</td>
<td>Pe</td>
<td>Po</td>
<td>Pe</td>
<td>Po</td>
</tr>
<tr>
<td>Kinematics</td>
<td>58</td>
<td>72</td>
<td>4</td>
<td>53</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>Newton’s law</td>
<td>42</td>
<td>82</td>
<td>11</td>
<td>53</td>
<td>6</td>
<td>26</td>
</tr>
</tbody>
</table>

TABLE 1. Problem Solving Ability (Psa) (%) from Pre-Test (Pe) & Post-Test (Po) of Low Group
TABLE 2. Problem Solving Ability (PsA) (%) from Pre-Test (Pe) & Post-Test (Po) of High Group

<table>
<thead>
<tr>
<th>Subject</th>
<th>IPSA-1</th>
<th>IPSA-2</th>
<th>IPSA-3</th>
<th>IPSA-4</th>
<th>IPSA-5</th>
<th>IPSA-6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pe</td>
<td>Po</td>
<td>Pe</td>
<td>Po</td>
<td>Pe</td>
<td>Po</td>
</tr>
<tr>
<td>Kinematics</td>
<td>56</td>
<td>89</td>
<td>8</td>
<td>69</td>
<td>6</td>
<td>56</td>
</tr>
<tr>
<td>Newton’s law</td>
<td>75</td>
<td>97</td>
<td>43</td>
<td>78</td>
<td>29</td>
<td>56</td>
</tr>
</tbody>
</table>

TABLE 3. Normal Gain of PsA for Low Group (Lo) And High Group (Hi)

<table>
<thead>
<tr>
<th>Subject</th>
<th>IPSA-1</th>
<th>IPSA-2</th>
<th>IPSA-3</th>
<th>IPSA-4</th>
<th>IPSA-5</th>
<th>IPSA-6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lo</td>
<td>Hi</td>
<td>Lo</td>
<td>Hi</td>
<td>Lo</td>
<td>Hi</td>
</tr>
<tr>
<td>Kinematics</td>
<td>0.33</td>
<td>0.75</td>
<td>0.51</td>
<td>0.67</td>
<td>0.31</td>
<td>0.53</td>
</tr>
<tr>
<td>Newton’s law</td>
<td>0.69</td>
<td>0.89</td>
<td>0.47</td>
<td>0.61</td>
<td>0.22</td>
<td>0.37</td>
</tr>
</tbody>
</table>

TABLE 4. List of $T_{counted}$ ($T_c$), Number of Effective Data Pairs ($N$), and $T_{table}$ ($T_i$) Resulted from Wilcoxon Signed Rank Test of Each PsA Indicators At Kinematics

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>IPSA-1</th>
<th>IPSA-2</th>
<th>IPSA-3</th>
<th>IPSA-4</th>
<th>IPSA-5</th>
<th>IPSA-6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$t_i$</td>
<td>$n$</td>
<td>$t_i$</td>
<td>$n$</td>
<td>$t_i$</td>
<td>$n$</td>
</tr>
<tr>
<td>Low group</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>9</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>High group</td>
<td>0</td>
<td>9</td>
<td>5</td>
<td>0</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>N-gain diff.</td>
<td>0</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: N-gain = normalized gain and diff = difference.

TABLE 5. List Of $T_{counted}$ ($T_c$), Number of Effective Data Pairs ($N$), and $T_{table}$ ($T_i$) Resulted from Wilcoxon Signed Rank Test Of Each PsA Indicators At Newton’s Law

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>IPSA-1</th>
<th>IPSA-2</th>
<th>IPSA-3</th>
<th>IPSA-4</th>
<th>IPSA-5</th>
<th>IPSA-6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$t_i$</td>
<td>$n$</td>
<td>$t_i$</td>
<td>$n$</td>
<td>$t_i$</td>
<td>$n$</td>
</tr>
<tr>
<td>Low group</td>
<td>0</td>
<td>9</td>
<td>5</td>
<td>0</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>High group</td>
<td>0</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>N-gain diff.</td>
<td>3</td>
<td>7</td>
<td>2</td>
<td>12</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>

Responds of Students to PT and SWS

We gather responds of students to qualitatively validate all instruments of CTA. We provided closed questions and opened questions (statements) then students filled them. For the closed questions, there were five choices, Very Agree (VA), Agree (A), Neutral (N), Not Agree (NA), and Very Not Agree (VNA), then we asked for them to choose regarding to their opinion. We scored every choice (VA, A, N, NA, and VNA) in the closed questions respectively 5, 4, 3, 2, and 1 for positive statements and 1, 2, 3, 4, and 5 for negative statements. Result of the closed questions about Pre-face Tasks (PT) is that three positive statements (number 1, 2, and 5) got score 4.4, 4.1, and 4.7 and three negative statements (number 6, 7, and 10) got score 4.4, 4.1, and 4.4. While the four others (positive statement number 3 and 4, negative one number 8 and 9) respectively got score of 3.6, 3.6, 3.5, and 3.4. Result of the closed questions about Student Work Sheet (SWS) is that all of eight positive statements got score 4.0 up to 4.5. For negative statements, eight of the ten got score 4.1 up to 4.4 but statements number 10 and 11 respectively got score of 3.3 and 2.7.

We also asked for students to give opened statements about the PT and SWS. Among 49 students, there are only fourteen persons who filled the opened questions about PT. Those are students with label as S1, S3, S6, S10, S19, S21, S22, S23, S26, S30, S33, S34, S35, and S37. Regarding implementation of student work sheet (SWS), among
the 49 students, there are only thirteen persons who filled the opened questions. The students are labeled as S1, S2, S3, S6, S8, S10, S21, S22, S23, S30, S34, S35, and S37.

DISCUSSION

Effectiveness of Instruments TP

Students gave good responses (agreed up to very agreed to positive statements and not agreed up to very not agreed to the negative ones) about the use of Pre-face Tasks (PT) in Physics learning. Based on content of statements, it means students agreed up to very agreed that: the PT is useful to give students an initial conception, the PT facilitates students to understand concept, the problems in the PT are solvable, students solve the PT one or more days before face to face learning, learning Physics has to start from concepts before implement them into quantification problems. Regarding with negative statements in the PT, students not agreed up to very not agreed with the statements. This fact means that the students were consistent when they responded the PT.

The positive responses to Pre-face Tasks (PT) that students gave indicates that implementation of it is effective to facilitate students to learn Physics conceptually. However, it needs some betterment. Actions of the perfecting include: reorder structure from concept having easier explanation and easier examples, it is considerable there is a hand out so it facilitate students to solve every problem in the PT, fewer questions in it, and give more time (more than one day) to do it.

Effectiveness of Instruments SWS

Students also gave good responses (very agreed to positive statements and in general very not agreed to the negative ones) about implementation of SWS with CTA in Physics learning. In exception, for negative one, students were between neutral and not agreed to statement 10 and between agreed and neutral to statement 11. Based on content of statements, it means that students very agreed that: students enjoyed to learn Physics by using the SWS, the SWS made the Physics learning becomes clearer and more meaningful, facilitated students to be more understand concepts, fostered students to carefully solve more complex problem, and the SWS caused students have capability to analyze all possible effects on a subject when the subject experiences an intervention. While the three other positive statements showed that there was an advantage when we implement the SWS in learning than other form of SWS (we tend solve problem more comprehensive and complete), this SWS was more effective and efficient than the others when we try to learn every problem completely, and increased creativity of students. Regarding with negative statements in the SWS, in general, students very agreed with the statements. This fact means that the students were consistent when they responded the SWS. In exception, statement 10 and 11, students stated that the problems in the SWS still too difficult, on the other hand, it was needed to reconstruct the problems become easier and also simpler.

The positive responses to SWS that students gave indicates that implementation of the SWS is effective to facilitate students to learn Physics conceptually. However, it still needs some repairs. Actions of the perfecting that students proposed include: add an example how to verbalize an idea with simple sentences, it needs more assistance (scaffolding stages), and fewer phenomenon in the SWS.

Effectiveness of CTA instruments to increase PSA

Implementation Causalitic Thinking Approach (CTA) in Physics learning at subjects of kinematics and Newton’s law was significantly effective in increasing Problem Solving Ability (PSA) of pre-service students. In addition, there was no difference gain of the increases between students of low group and high group. Thus, the CTA implementation gave the same advantage to the two groups.

From the 24 indicators (2 sub-subjects, 6 levels of indicator, and low group (Lo) and high group (Hi)) of Problem Solving Ability (IPSA) there are 23 (11 (92%) on Lo and 12 (100%) on Hi) (96%) which increased significantly. In addition, only 8% of all IPSA which was significantly difference between the N-gain at Lo and Hi.

Description above indicates that the implementation of instruments of CTA in Physics learning is effective to increase PSA for the two groups of students. However, its final attainment, in average, is only 17% which is high (82 at IPSA-1 (kinematics) of Lo, and 89 at IPSA-1 (kinematics), 97 at IPSA-1 and IPSA-4 (Newton’s law) of Hi). The others 46% is moderate (56 up to 78) and 37% is low (17 up to 53).
Implementation Restrictiveness of CTA instruments

Some restrictiveness of the CTA when we implemented it was that: needs longer time so lecturer had less time to discuss student work, and type of its problems remains difficult for students. Regarding with preparation of instruments and its strategy of implementation, the restrictiveness includes some phenomena were described with long description and there was no hand out accompanying the pre-face tasks.

The restrictiveness, in general, did not foster the development of causalitic thinking ability of students in learning process. This fact is caused the process to select and/or deductively predict all possible effects needs initial knowledge regarding with related concept. Then, students may have initial knowledge provided that when they did pre-face tasks there was hand out about the concept so the students could use it as reference.

To Save the Restrictiveness of CTA instruments

It is advisable some actions of perfecting the instruments of the CTA. Those are: preparation of hand out, use shorter description for phenomenon in SWS and for problems in Pre-face Tasks (PT), and for 90 minutes learning it is only one phenomenon in SWS. In addition, based on PSA attainment (in average is moderate) it is also advisable to design instruments of the CTA in scaffolding form, that is any some assistances to facilitate students solve phenomenon. Furthermore, it needs quite time (two or three days) between the students solve the PT and process of face to face learning.

CONCLUSION

It has developed a number of instruments of Physics learning with CTA which is significantly effective to increase PSA of students at sub subjects of kinematics, Newton’s law about movement. All of the instruments that have been developed include pre-face tasks, student work sheet special for the CTA, some multi-effect phenomena, and set of problems for testing PSA of students.

The PSA includes ability to understand problem, select causes and effects, differentiate which causes in phenomenon as variables of determined effect, determine which concepts, principles, theories, and/or laws of Physics, apply the concepts, principles, theories, and/or laws of Physics for identifying causes, and the sixth is ability to identify conditions of all causes so they result in determined effect when students solve problem or phenomenon. Furthermore, to increase effectiveness of the instruments it needs some actions of perfecting including perfecting its design and strategy for implementing

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