The Development of Mechanics Problem-Based Learning Model with Multi Representation Approach to Practice Students’ Critical Thinking Skill of Elasticity and Hooke’s Law, And Static Fluid Concepts in Senior High School

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Abstract: This research aims to develop instructional model problem-based mechanics with multi representation approach (the instructional model of Orientation IPA) to practice students’ critical thinking skill. The used method is research and development referring to Borg & Gall. This development research includes three stages, namely preliminary study stage, the development of model design and trials stage, and model evaluation stage. The focus of this research is in preliminary study and model design development stages resulting the instructional model of Orientation IPA. The expert validation is conducted by three experts and eight teachers of model users. The trial stage is conducted to students of 10th grade of Science Mathematics department of three classes. The sample determination uses Simple Random Sampling technique. The data analysis uses quantitative descriptive technique. The research results show that the instructional model of Orientation IPA meets the validation, practice and effectiveness requirements.

Keywords: critical thinking skill, instructional model of Orientation IPA, multi representation

I. INTRODUCTION

The educational goals emphasize on knowledge acquisition and must describe the result study until to the high level of thinking, even to the ability to solve problems. In line with this, Gagne (1985) has opinion that the study condition has to be directed to problem solving which is the highest capability in thinking skill. The learning must be directed not only to get understanding achievement but also to improve the critical thinking skill. The development of critical thinking is considered as one of the most important goals from educational knowledge for more than one century (Forawi, 2012). The definitions of critical thinking vary from the simple one to the complex one. Ennis (1991) defines the critical thinking as reflective and reasonable thinking focusing on deciding what have to do. Halpern (1996), the critical thinking is defined as cognitive ability utilization or strategy improving the desired possible result. Other definitions include; the formulation of logical summary (Simon & Kaplan, 1989), to develop careful and logical reasoning (Stall & Stall, 1991), to decide what must be conducted or what must be trusted by natural reflective thinking (Ennis, 1991) and the goal determines what to be accepted, rejected or postpone the assessment (Moore & Parker, 1994).

Related to the improvement of process and its result quality, there are important problems facing by education world today, they are how to attempt to build the understanding (Brooks dan Brooks, 1993) and to empower students’ critical thinking skill by learning (Krulik & Rudnick, 1996; Marzano, 1993). These are required to be done because it is assumed that many students do not have high level of critical thinking (Berger et al., 1987). The reality is that the mean score achievement of Science students in Indonesia is still low, they are only able to recognize an amount of basic facts but they are not yet able to communicate and relate various science topics, event to apply the complex and abstract concepts (TIMSS, 2011). The preliminary study result to find out students’ critical thinking skill in Senior High School in Jember Regency is ranging (13,28 % - 45,50 %). This result shows that students’ critical thinking skill is still low (Rosyid et al., 2013). This low students’ critical thinking skill must be improved. The low students’ critical thinking and study achievement are suspected that there is relationship with the on going learning process. Thus, it is required an alternative solution to improve this. One of which is by using instructional model of problem-based mechanics with multi representation approach. The problem-based learning has been used effectively to improve study retention causing the increase Physics understanding (Maloney, 1994; Hobden, 1999; Gaigher, 2004) and to affect the students’ conceptual development positively (Kumar et al., 2010), also it is advised as the promising strategy to improve students’ critical thinking skill and problem solving skill (Tiwari, 1999; Chan, 2013). Based on the above explanation, to improve students’ critical thinking skill, it is required a development of “Instructional Model of Problem-Based Learning through
Multi Representation Approach”. This research aims to develop the problem-based mechanics by multi representation approach which can be used to teach critical thinking skill of senior high school students.

II. RESEARCH METHODS

The used method is research and development, referring to Borg & Gall model. The development of this research includes three stages, namely preliminary study stage, the development of model design and trials stage, and model evaluation stage. The development design is presented in Figure 1. The developed product is the instruction model of Orientation IPA for 10th grade Mathematic Science (MS) senior high school’s student meeting the validity, practice and effectiveness requirements. This research is conducted in State Senior High School in Jember Regency, East Java, namely State Senior High School 3 Jember (trial). The used sample for model trial is 3 classes. The sample selection uses Simple Random Sampling technique to determined the will-be-researched classes. The research data collection uses observation, questionnaire, interview and test techniques. The critical thinking skill test uses 18 questions essay.

III. RESULT AND DISCUSSION

The Initial Design Model

The instructional model problem-based mechanics with multi representation approach is built from some basic theories that problem-based learning can give chances for students to involve the multi intelligences (Fogarty, 2007; Arends,2007;Gardner, 1999) and is based on constructivism learning theory (Piaget,1952; Vygotsky,1978), to improve critical thinking skill (Tiwari, 1999; Arends, 2004; Hasting, 2001; Rindell, 1999), and cognitive study theory. While the multi representations have three main functions in learning, namely as the complementary, interpretation limit and understanding builder (Ainsworth, 1999). The representation like demonstration method can help to limit the difficulty in Physics study insisting more to involve physical knowledge and mathematic logics (Dahar 1989; Van den Berg, 1991). Izsak and Saherin (2003) state that learning by involving multi representations gives plentiful contexts for students to understand a concept. Tytler et al. (2013), states that student’s effort to understand or explain Science concepts requires representational work and study on new concept which can not be separated from studying how to represent the concepts in a representation. Anderson (2001) states that students can be said to understand if they have thinking ability to construct meanings from learning materials like verbal, written and graph communication, or meaning based on initial knowledge possessed, or to interpret new knowledge to scheme which has been in students’ thought.

Standing on these theories, so in this research, it will be developed a mechanics instructional model referring to Arends’s (1997) problem-based learning with multi representation approach of IF-SO framework from Corolan et al. (2008), developed by Tytler et al., (2013), so it rises learning order (syntax), namely problem orientation and identification, problem representation in group, investigation, observation result presentation in various representation, and process analysis and evaluation of problem solving. Based on this learning order, so the mechanics instructional model is named by instructional model of ORIENTATION IPA (based on the acronym; Orientation, Representation, Investigation, Presentation, and Analysis). This implementation in class, this syntax can be developed, especially about teacher’s and students’ activity in proposing and hypothesis test, design, and also experiment implementation or observation process in its relation to practice concept understanding and critical thinking skill. The syntax of instructional model of Orientation IPA (hypothetic model) is presented in table 1.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Teacher’s actions</th>
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| Phase 1: Problem orientation and identification | 1. Teacher informs learning goals and describes study demands  
2. Motivates students to involve in problem solving activity  
3. Teacher identifies key problems from topic to build student’s representation  
4. Teacher focuses explicitly on delivering different functions and representation forms |
| Phase 2: Problem representation in group | 1. Organizes students to form groups, each group consists of 5-6 students  
2. Teacher helps students to determine and regulate study tasks relating to problems  
3. Teacher gives representational challenge order to raise ideas in developing concept understanding |
| Phase 3: Investigation | 1. Teacher helps students to collect suitable information  
2. Teacher guides students to conduct research stage by stage, look for explanation and solution to develop critical thinking skill |
| Phase 4: Observation result presentation in various representations | 1. Teacher guides students to make conclusion and discussion from observation result in various representations  
2. Teacher helps students to plan, prepare, and present work results such as experiment report, model and helps them to share their works |
| Phase 5: Analysis and evaluation of problem solving process | 1. Teacher helps students conduct analysis and evaluation of problem solving process for observation and process they use in various representation forms (Multi representations).  
2. Teacher must see students’ representation work as the study proofs |

Table 1. The Initial syntax of Instructional model of Orientation IPA
The Model Design and Trial Stage

The Characteristics of Instructional Model of Orientation IPA

The characteristics of instructional model of Orientation IPA are formulated based on theory study results and preliminary study & development. The instructional model of Orientation IPA is developed referring to instructional model characteristics according to Arends (1997), which mention that there are minimum four specific characteristics of instructional model which can be used to achieve learning goals, namely logical theoretic rationale from its design, learning goals which want to be achieved, the required teacher’s behaviour in teaching to implement learning, and the required study environment to achieve learning goals. In summary, the instructional model characteristics of Orientation IPA as follow:

a. The Theory Rationale

The instructional model of Orientation IPA is built from some basic theories, namely multiple intelligence theory, constructivism learning theory, cognitive learning theory, and multi representation theory (IF-SO framework). These four theories are the main base in developing the instructional model of Orientation IPA enabling to practice concept understanding and critical thinking skills by scientific work in various representation forms. These theories are consideration in arranging steps in problem orientation and identification, problem representation, investigation, presentation, and analysis-evaluation and follow-up. The relationships of theories above to instructional model are explained as follow:

1) Multiple Intelligence Theory

The Multiple Intelligence theory is theory as the base of instructional model of Orientation IPA that various child intelligences must be facilitated by teacher in selecting strategy, approach, model, learning method. This is related to the 2nd phase in learning syntax of instructional model of Orientation IPA namely problem representation phase. The problem must be represented in various forms namely verbal, graph, figure, and mathematics.

2) The Cognitive Study Theory

The unique characteristic of cognitive study is on study to obtain and use representation forms (2nd phase) representing the facing objects, whether the objects are people, things or events. These objects are represented or presented in one person by responds, ideas or symbols which are all mentally. In thinking, the objects are in the form of representation, like responds, definitions (concepts), and verbal symbols. In studying to think, students are faced to a problem they have to solve (1st Phase, problem orientation and identification). The figure creation is one of heuristic forms often found in completing mechanics problems (2nd phase, problem representation). The cognitive strategy is a way possessed by students to manage study process. If a student is faced to a new problem, so to solve this problem, he/she must relate not only previous study results, namely information and intellectual skill which have been learned (1st phase: problem orientation and identification), he/she also must have strategy to solve this new problem. The student may regulate his/her thinking process by internally organized strategies, for example by investigation (3rd phase).

The findings from cognitive psychology provide theoretical base for instructional model of Orientation IPA. The basic premise in cognitive psychology is study which is a new knowledge construction based on current knowledge. These cognitive processes affect knowledge utilization; and social and conceptual factors affect learning. This theory underlies 1st phase (problem orientation and identification).

3) Constructivism learning theory

Jean Piaget learns how students think and about processes relating to intellectual development to try to understand their surrounding world. This curiosity motivates them to construct actively representations about their environment (2nd phase). In all their development stages, students’ demand to understand their environment motivates them to investigate and construct the explaining theory (3rd phase: investigation). Lev Vygotsky believes that intellectual develops when an individual faces new and confusing experiences and when they try to solve the arising problems from these experiences. In the effort to get this understanding, an individual relates new knowledge to previous knowledge and constructs the new one. Vygostky emphasizes on the importance of study social aspect because social interaction with other encourage the new idea construction and improve students’ intellectual development (Nur, 2008). This theory is the base for 5th phase: Analysis, Evaluation and follow-up.

The view about education with school as bigger society reflection and class will be laboratory for observation and problem solving of real life (3rd phase: Investigation). The Dewey pedagogy supports teacher to involve students in various problem-oriented projects and help them to investigate various social and important intellectual problems. Dewey and his followers (Nur, 2000) assure that learning at school should be purposeful, not too abstract. The purposeful learning vision in problem centred supported by student nature curiosity to explore situations which mean personally for them (1st phase: problem orientation). Bruner emphasizes on inductive reasoning and observation process as the unique characteristics of scientific method (3rd phase: investigation).

4) Multi representations

Multi representations have three main functions, namely complementary, interpretation limit and understanding builder (Ainsworth, 1999). As the complementary, multi representations are used to give representation containing complementary information or help to complete cognitive process. The representation is a thing to represent, describe or summary object and/or process. Multi representation also means to represent again the same concept with different
format, including verbal, mathematic, figure and graph (Prain & Waldrip, 2007). Thus, the view above has meaning that multi representations are a way to state a concept in various ways and forms. Standing on these theories, so **multi representations** are the choice to be attached in problem-based learning.

b. **The achieved learning goals**

The goals of the instructional model development of Orientation IPA are to practice concept understanding and critical thinking skill, and other goals are to encourage students’ activity and respond in learning, and to improve students’ motivation and activity in learning. To achieve these goals, the instructional model of Orientation IPA is conducted by collaborative and cooperative activities by scientific approach, social interaction by independent and group study experience and by presentation of conceptual problem in various representations.

c. **Syntax**

a) **Problem Orientation and Identification**

The goals of this step are to attract students’ interest and motivate them to actively involve in learning process. Before doing problem orientation and identification, teacher communicates the learning goals to student based on Lesson Plan. Based on curriculum of 2013, these learning goals include the core competency, basic competency and indicators. Then, teacher presents physical events, incidents and phenomenon often seen and experienced by students in their daily life. This aims to prepare study students by attracting their interest, centring the students’ interest at topic which will be discussed, and reminding students about their relevant study result to the will-be discussed topics (apperception).

b) **Problem representation**

Students are prepared with model representation and demonstration from the physical phenomenon seen by its goals to help students to understand mechanics materials and solve problems which will be discussed. The presentation and demonstration of mechanics material can be done by various approaches which can be adjusted to learning goals and deliver material characteristics. Teacher presents various representations (verbal, figure, mathematic, and graphs) and is strengthened by animation presentation/physical simulation to embed concept in interactive setting, such as PhET Simulator. This information is delivered only for its outline so it will not waste the learning time. The detail explanations about material are in BAS. Teacher needs to master the overall concepts or skills so he/she can demonstrate a concept or skill well.

c) **Investigation**

In this stage, the students are encouraged to collect information with assistance of Student Work Sheet (3rd Attachment), then, teacher guides them to conduct observation stage by stage, look for explanation, and solution to build critical thinking skills including (1) formulating problems (2) formulating hypothesis (3) identifying variables (4) writing operational definition of variables (5) writing experiment tools and materials (6) conducting experiment (7) organizing the experiment result data (8) analysing experiment result data and (9) making conclusion. Then, teacher guides them to discuss and make conclusion from the investigation result in various representations.

d) **Presentation**

One of the unique stages in syntax of instructional model of Orientation IPA to improve concept understanding and critical thinking skill is to conduct presentation of investigation results. It is required to be noticed that teacher’s duty is to guide in making conclusion and discussion from observation results in various representations and help in planning, preparing and presenting work result.

e) **Analysis, Evaluation and Follow-up**

In this phase, teacher helps to analysis and evaluate problem solving process of the observation and processes in various representation forms (multi representations), sees students’ works as the study proofs (the Student Work Sheet is collected), and facilitates the study follow-up by giving structural task (task in BAS).

d. **The Study Environment and Task Management**

As in general instructional models, teaching and learning activity using instructional model of Orientation IPA to practice concept understanding and critical thinking skill, teacher plans the activity structurally and strictly. The success of this instructional model utilization is also determined by environment preparation and good instructional media to support each teacher’s and students’ activity in each stage in syntax. Teacher has a role to manage class to ensure the conducive learning environment and situation, such as forming group, regulating how students communicate, regulating presentation time, regulating students’ active involvement especially in investigation and presentation, and solving any students’ deviation behaviour. This instructional model has these following principles:

1) **Making Groups**

Teacher makes groups consisting of 5-6 students in one group. The group formation can be done in the first meeting, so the students have had fixed group during the learning process which implements Orientation IPA model. This is to save time in the next meeting.

2) **Regulating Students To Speak**

Teacher needs to have rules about prohibition of talking any inappropriate topics with the concept in class and determines it consistently to handle and avoid the students who like to talk about things beyond the learning context. Besides, teacher also gives the same chances to all students to comment,
deliver advices, or questions, so there will no domination of clever students. Teacher’s task is to guide or direct and to be motivator.

3) Regulating Presentation

The Physics learning implementation in class is limited by time, so not all groups can present in front of class. So, this requires regulation, for example, in first meeting, there are two groups which are presenting and other groups will be on the next meeting. The provided time for the two groups is 10 minutes for each group. The teacher’s role is to motivate students to ask and respond students’ presentation to give strengthened.

4) Regulating Participation

Teacher as the motivator/fasilitator has duty to activate students’ participation. For passive students, it is required some things, for example, by using ‘activity zone’. This activity zone is certain area in class where students are more active. In this activity zone, teacher can conduct better eye contact. Teacher is required to give evenly attention and supervision for each student during the investigation and presentation.

5) Handling behaviour Deviation

If this instructional model is implemented in big class, so it is possible that there are students doing deviation behaviour. Teacher is advised to centre attention directly to the behaviour deviation, for example by reprimanding or coming to the student.

The expert assessment result to the validity / properness of instructional model of Orientation IPA

Based on expert assessment, it shows that the developed instructional model of Orientation IPA has high content validity and construct of 91.54%; the components of instructional model of Orientation IPA has high theoretical base robustness; and the components of instructional model (syntax, reaction principle, social system, supporting system, and instructional effect also following effects) internally have high consistency (90.95%) so it is reliable to be used in Physics learning in Senior high school. While, all practitioner valuators give assessment that instructional model of Orientation IPA has content validation of 91.40 and construct validation of 91.70. The decision of these eight valuators is that the instructional model of Orientation IPA is reliable to be used in Physics learning in senior high school and in accordance to curriculum of 2013.

The learning tool validity is conducted to Lesson Plan (RPP), Student Work Sheet (LKS), BAS, Competency-Based Curriculum test, Observation sheet, interview guidance, and questionnaire; the validity for all these tools are consecutively the RPP validity reaches the mean of 93.97 % (RPP of elasticity & Hooke Law) and 93.45 % (RPP of static fluid), LKS for elasticity & Hooke law of 90.05 %, LKS for static fluid of 88.80 %, while BAS, Competency-Based Curriculum (KBK) test, Observation sheet, interview guidance, and questionnaire are stated to be valid and reliable to be used. The trial result test of critical thinking skill instrument is stated to be valid ranging 0.389 – 0.439, and reliable (0.825-0.842), with sensitivity level of each question of PK for elasticity & Hooke Law, KBK for elasticity & Hooke Law, PK for static fluid and KBK for static fluid consecutively are 0.51; 0.47; 0.54; and 0.45 stated to be sensitive. So, it can be concluded that the instructional model of Orientation IPA and its tools are reliable to be used with high validity level.

The expert assessment results to the instructional model of Orientation IPA by model book and its learning tools (RPP, LKS, BAS, and assessment tools) result model have high content validity and construct validity, the percentage achievement of expert assessment is 91.54% (content validity) and 90.95% (construct validity) based on expert assessment of State University lecturers, while the assessment from model teachers (the practitioners) for content validity and construct validity consecutively are 91.40 % and 91.70 %. Based on validity achievement criteria (Ratumanan, 2003), so the results of content and construct validity are ranging from 85 % - 100 %, so, it is said to be very valid. The instructional model of Orientation IPA is reliable to be used in Physics learning enabling to improve students’ critical thinking skill. The Instructional model of Orientation IPA can be well implemented by model teachers by guiding to development result tools which have been stated to be valid. The expert validity results for all RPP of elasticity & Hooke Law, and static fluid concepts are ranging from 91.93 % – 95.31 %, so it is said to be very valid based on Ratumanan’s opinion (2003) and almost all Physics teacher in MGMP- Discipline Teacher Discussion Forum state that this model is accordance to the requirement of Curriculum 2013 referring to scientific approach, so, it is reliable to be used. The expert assessment to LKS is ranging from 88.19 % - 90.63 %, so it is stated to be valid based on validity achievement criteria. The expert assessment to the test for content validity, question construction and question language and writing is stated to be valid. While, from instrument trial result, all questions are stated to be sensitive. The expert assessment to BAS, observation sheet, interview guidance and questionnaires, all are stated to be valid. The test validity and reliability to concept understanding and critical thinking skill are also valid and reliable based on alpha cronbach’s using SPSS program version 17. All questions of sensitive test has the lowest sensitivity index of 0.31 and the highest one of 0.63.

The learning using instructional model of Orientation IPA can give study chances to students having different abilities in understanding Physics concepts. This is also the same opinion in theory delivered by experts that problem-based learning gives chances to involve multiple intelligences possessed by students (Fogarty, 1997; Gardner, 1999). The involvement of multiple intelligences in problem solving with problem approach can be a tool for students to have various multiple intelligences to involve their ability optimally in problem solving.
The trial result of the instructional model of Orientation IPA is in line with the research conducted by Adesoji (1995, 1997) that problem solving is an effective strategy in teaching students with different ability levels. The research results of Çalışcan et al., (2010) and Selçuk, G.S., (2010) also show that teaching with problem solving strategy has positive effects to problem solving performance and students’ physics achievement. While, related to concept multi representation ability, Ainsworth, (2004) says that multi representations are as a tool for improving students’ understanding especially to complex knowledge. Corolan, J. et al., (2008) opinion also supports the research conducted by the writer that skilful students often use qualitative representations like figure, graphs, and diagram to help understanding questions before using mathematic equations to solve problems quantitatively.

The learning implementation to limited trials

a. The feasibility of instructional model of Orientation

This model feasibility is seen from observer observation results to the learning implementation by lesson plan. The elements which are seen are learning syntax, social system and reaction principle. The achievement percentages of 1st trial class for syntax component consecutively are 74.04 % - 81.73% (class_A), 77.88 % - 85.58 % (class _B), and 80.77 % - 87.50 % (class _C). The percentage mean achievement of social system component for each class are 80 % - 87.50 % (class_A), 82.50 % - 90,00 % (class _B), and 85 % - 95.00 % (class _C). The percentage averages of teacher’s behaviour component are 80,00 % - 90 % (class _A), 80 % - 97,50 % (class _B), and 90.00 % - 97.50 % (class _C). The learning feasibility data with instructional model of Orientation IPA of elasticity and Hooke law topics is described in Figure 1.

Figure 1 shows that the feasibility percentage achievement of Orientation IPA tends to be consistent in all trial classes with score above 74.04 % - 97.50 %, meaning that lesson plan can be implemented well.

While, the 2nd trial, the percentage ranges of learning feasibility to syntax component consecutively are 82.69 % - 93.27% (class_A), 79.81% - 90.38% (class _B), and 85.58% - 94.23% (class _C). The percentage mean achievement of social system component for each class is 80 % - 87.50 % (class_A), 82.50 % - 95,00 % (class B), and 85 % - 95,00 % (class _C). The percentage averages of teacher’s behaviour component are 80.00 % - 90 % (class _A), 80 % - 97,50 % (class _B), and 90.00% - 97.50 % (class _C). The learning feasibility data with instructional model of Orientation IPA of static fluid topic is described in Figure 2.

Figure 2 shows the learning component achievements for all trial classes are consistent and high category based in model feasibility level criteria. All 2nd trial classes get score above 79.81%, it means that lesson plan can be implemented well. The model development results in limited trial create phase revision in model syntax like in table 2.
Table 2. The syntax Revision result of the instructional model of Orientation IPA

<table>
<thead>
<tr>
<th>Phase</th>
<th>Teacher’s activities</th>
<th>Students’ activities</th>
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| 1st Phase: Problem orientation | 1. Conduct apperception  
2. Present physical event, incident, phenomenon which are often seen and experienced by students in their daily life.  
3. Explain learning goals and competency  
4. Present and demonstrate model from the reviewed physical phenomenon. | 1. Students listen to and pay attention to teacher’s explanation  
2. Students observe physical phenomenon  
3. Students listen to explanation  
4. Students observe and try model, for example PhET Simulator and media |
| 2nd Phase : Problem representation in groups | 1. Organize students to form groups, each group consists of 5-6 students  
2. Present various representations (verbal, figure, mathematic, diagram and graph) strengthened by animation / simulation display to embed concept in interactive setting, for example using PhET Simulator. | 1. Students form groups  
2. Students pay attention and try to represent problems |
| 3rd phase : Investigation | 1. Support to collect suitable information  
2. Guide to conduct investigation stage by stage, look for explanation and solution to build critical thinking skill  
3. Guide in making conclusion and discussion from investigation result in various representations. | 1. Students collect information for investigation  
2. Students try to conduct investigation  
3. Students relate and conclude investigation |
| 4th phase: Presentation of investigation results in various representations | 1. Help to plan, prepare, and present investigation results and discussion results.  
2. Direct and guide the | 1. Students plan and prepare to the presentation  
2. Students work together to actively involve in presentation activity |
| 5th phase: Analysis, evaluation of problem solving and follow-up process | 1. Help to conduct analysis and evaluation of problem solving process and processes in various representations (Multi representations).  
2. See the students’ work as study proofs.  
3. Facilitate the study follow-up by giving structural tasks. | 1. Students analysis the discussion results based on investigation data in Student Work Sheet  
2. Students collect individual and group work results.  
3. Students accept tasks from teacher. |

Analysis to the feasibility of the instructional model of Orientation IPA is seen from the implementation of the Lesson Plan during the learning, both at trial or implementation of the instructional model of Orientation IPA. The conducted trial and implementation of learning activity in this research are seven Lesson Plans namely 3 Lesson Plans for elasticity and Hooke Law topics, and the four lesson plans for static fluid topic. The result analysis of lesson plan’s provided during the trial and at the time of implementation show that the learning process goes well and consistently to all experiment classes, meaning that all phases of the learning model syntax on all topics (elasticity and Hooke Law, and static Fluid) based on feasibility level have a high feasibility ranging from 80% - 100%. This fact indicates that all elements in the instructional model of Orientation IPA including syntax, social systems, and reaction principle are properly implemented and in accordance with the principles of the instructional model of Orientation IPA. The feasibility of Instructional model of Orientation IPA from the first meeting until the seventh meeting raises obstacles in learning process which can be directly solved by the teacher models. These constraints for example are students who speak for themselves, and the discrepancy of planned presentation time based on lesson plan. These obstacles are solved by giving attention and adjusting students’ seat positions; and the one which is associated with time, there is rearrangement in presentation implementation.

Social system in the instructional model of Orientation IPA is focused on interaction and norms between teachers and students, and students with students in the feasibility of learning in the class. Teacher’s interaction with students and students with students are very good and communicative, open, and democratic. The Instructional model of Orientation IPA emphasizes on the effort to develop the students’ ability to have competencies to interact with others as an effort to build a democratic student attitudes respecting differences in learning. The learning is directed in efforts to involve students to understand, study, apply and receive social functions and role in the group. This model requires students to cooperate; teacher guides students to define problems, collects relevant data, and formulates hypotheses. This is in line with Vygotsky’s opinion emphasizing on the importance of the social study aspect because social interaction with other people encourages new ideas and enhance the students’ intellectual development (Nur, 2008).

While the reaction principle relates to teacher’s behaviour patterns in giving a reaction to students’ behaviour in learning, for example, how the teacher gives the student questions and responds to students’ answer, and teacher’s role as a whole in learning. Reaction principle goes well, where the teacher acts...
as a facilitator, motivator, and a good companion in improving student learning in order to achieve concept understanding of the mechanics concept and raise students' critical thinking skills. During the lesson, the teacher has given support emphasizing on students' hypothesis and discussions. In this learning, the teacher provides assistance in considering the hypothesis, directs students on specific examples, as well as provides support and assesses the used critical thinking strategies by students. The conclusion of the instructional model of Orientation IPA the feasibility associated with the reaction principle indicates that the mean formed students’ motivation is high.

b. The Students’ Respond to the Learning Implementation using Instructional Model of Orientation IPA

Students’ respond to the attractiveness of teaching materials, innovation of teaching materials, interest in learning methods, the impact of teaching material utilization, clarity of learning models, problem solving skill, and the ability to work on 1st and 2nd trials questions are summarized in Figure 3.

Figure 3. The bar diagram of students' response to instructional model of Orientation IPA.

Figure 3 illustrates that students’ response in learning using the developed instructional model of orientation IPA has high category, both in 1st and 2nd trials. Student responses are always increasing and tend to be consistent for all observed aspects by observer.

The observations results are responses given by students to learning implementation using instructional model of Orientation IPA during the trial and implementation. The observation results of students’ response to the attractiveness and innovation of teaching materials, interest in learning methods, clarity of learning models, the impact of teaching material utilization, problem solving skill, and the ability to work on the problems show very high response to learning. The high response illustrates the attractiveness of the students at learning model. The mean students’ positive response to learning is always increased in every meeting, over 80.21% meaning that the implementation of the instructional model of orientation IPA is able to evoke interest, motivation, passion, and great curiosity in learning.

Student’s responses which are presented related to the interest and innovation (material / content of the lesson, BAS, worksheets, learning atmosphere), students’ interest at learning methods are very high and consistent for all experiment classes. Response to BAS that book helps to support students develop thinking skills, teacher’s teaching model is very clear, the problem-solving skills is not a difficult, and the ability to answer the test item is not difficult. These facts illustrate that the attractiveness of the developed instructional model of orientation IPA is very high.

These results support Nieveen’s idea (1999) that the practicality of a learning model in terms of the observer assessment results based on its observer states that, the model implementation feasibility level in learning implementation in classroom has good category. The model feasibility in learning implementation in class is in terms of three observation aspects, namely: (a) the learning syntax feasibility, (b) the social system feasibility, and (c) the feasibility of management reaction principles to the provided support system.

c. The effectiveness of instructional model of Orientation IPA

The model effectiveness indicators are seen from teacher’s ability in managing learning, students’ activity during the learning process, the achievement of concept understanding and students’ critical thinking skill.

1) Teacher’s ability in managing learning

Teacher’s ability in managing learning includes all activities in class, from the introduction to closing, including teacher’s ability in managing learning time and situation in class which has high category and consistent to all trial classes. This is described in Figure 4.
The observation results show that students activity in learning are very high and consistent, supported by the percentage mean achievement of relevant students’ activity above 96.12%. The high activity achievement reflects that instructional model of Orientation IPA has been well implemented. This achievement is because there are complete facility and infrastructure supports from school as the conducted research place, and the model teacher’s understanding to Orientation IPA model is very good. This research results are in line with the research conducted by Kumar et al., (2010) that the effects of problem-based active learning in Science education to 7th class academic achievement and concept learning find out that the implementation of problem-based active learning model affects positively to students’ academic achievement and behaviour toward Science learning. In general, it can be concluded that the instructional model of Orientation IPA is effective in increasing students’ activity in learning process.

3) Students’ critical thinking skill

The N-gain achievement results of students’ critical thinking skill for all trial classes are presented in figure 6.

Figure 6 shows N-gain score mean results of critical thinking skill in 1st trial (elasticity and Hooke law) are in medium category, while the N-gain score mean for 2nd trial (static fluid) for all classes get high category of N-gain and also consistent for all trial classes.

The development result of Instructional model of Orientation IPA is based on multiple intellectual theory, constructivism learning theory, cognitive theory and multi representation theory. The instructional model of Orientation IPA has unique characteristics which are problem-based, collaborative and cooperative, and scientific work-based approach enabling to improve concept understanding and students’ critical thinking skill. Like general instructional model, the instructional model of Orientation IPA has syntax, social system, reaction principle, supporting system, instructional effects and following effects. This is in line with Joyce et al.’s, (2009), Arends’s (1997) opinions. The syntax from instructional model of Orientation IPA are problem orientation and identification (1st phase), problem representation (2nd phase),
group investigation (3rd phase), work result presentation (4th phase) and analysis-evaluation & follow-up (5th phase). These five phases can be conducted in Physics learning in senior high school.

The development result of this instructional model has been proven to be able to increase students’ critical thinking skill, especially how students solve problems in mechanic concepts in various representations. The presented problem is generally presented in the verbal and mathematic forms; in reality, the students are seldom brought to understand concepts from other representations, for example from figure to verbal, from verbal to figure, from verbal to graph or combination from verbal, figure, graphs, mathematic or other representation forms. It is usual that students who are clever at verbal representation but sometime they are low in graph or figure understanding. These conditions are at school based on preliminary study result which students are insisted in concept understanding from verbal only to mathematic and also forget about other representation, this is proven from multi representation test results which is low (Rosyid et al., 2013). This model can clearly improve concept understanding in various representation forms. This is in line with Russel’s opinion in Soesanto (2009) and Bowen (1998) stating that to be able to understanding Physics conceptually, it is required an ability to represent and translate physical problem and phenomenon into representation in the forms of macroscopic, symbolic, and microscopic simultaneously. From the trial results of instructional model of Orientation IPA conducted both in 1st and 2nd trials, it is obtained that the results of 2 instructional model of Orientation IPA are valid, practical and effective to be implemented.

IV. FINDINGS

Based on analysis results and research discussion of this instructional model of Orientation development, there are some findings, namely:

1. The Instructional model of Orientation IPA is an instructional model of problem-based mechanics by multi representation approach based on multiple intelligence theory, constructivism learning theory, cognitive theory and multi representation theory. The instructional model of Orientation IPA has 5 syntax, namely Problem Orientation and Identification, problem representation, group investigation, presentation and analysis-evaluation and follow-up. This instructional model is also able to practice concept understanding by various multi presentations (verbal, figure, graphs, mathematic, and others) and can improve critical thinking skill by scientific works, namely including (1) formulating problems (2) formulating hypothesis (3) identifying variables (4) writing operational definition of variables (5) writing experiment tools and materials (6) conducting experiment (7) organizing the experiment result data (8) analysing experiment result data and (9) making conclusion. The instructional model of Orientation IPA has characteristics, namely (1) problem-oriented, (2) collaborative-cooperative, and (3) scientific work approach.

2. The instructional model of Orientation IPA has high content and construct validity based on expert and practitioner’s discussion and assessment.

3. The instructional model of Orientation IPA has high practicality, shown by feasibility and attractiveness level (students’ response) by observation from observers.

4. The learning effectiveness of instructional model of Orientation IPA is high, based on teacher’s ability in managing learning and students’ activity by observer observation.

V. SUMMARY

Based on research results, it can be concluded that instructional model of Orientation IPA has high content and construct validity implemented in 5 learning steps (syntax), namely Problem Orientation and Identification, problem representation, group investigation, presentation and analysis-evaluation and follow-up. The trial results of instructional model of Orientation IPA can improve critical thinking skill in elasticity, Hooke law and static fluid topics, namely:

The practicality and effectiveness level of instructional model of Orientation IPA has high category in practicing critical thinking skill.

The obtained critical thinking skill by instructional model of Orientation IPA is effective in high category of N-gain achievement.

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