Inverse problem on X-ray tomography: Building a learning model based on inverse

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ABSTRACT

The images of X-ray tomography can be obtained by back projections method. The process to obtain cross-sectional image of the object involved high order thinking process (HOT). This is consistent with the objectives of the curriculum that developed by Indonesian government. The new curriculum that Indonesian government developed needed the real support in order to reach HOT process. Inverse based learning model is a good choice for that. This research is a qualitative research. We analyzed various journals and reference books about inverse problem, X-ray tomography and higher order thinking. We also considered the indonesian government policy of learning and the characteristics of the material. The result of the research showed that the inverse model could be applied in high school learning, particularly in physics.

Keywords: Invers, learning model, tomography, HOT.

1 INTRODUCTION

Indonesian secondary school's learning has run into fundamental changes. The changes were begined with the curriculum. The reason of the changes were the failure of education to form perfect Indonesian human that could compete in international level. The failure occurred in many fields, among athers were : TIMSS test results conducted by the IEA (International Association for the Evaluation of Educational Achievement). The Indonesian value of the TIMSS test in 2011 in physics was 406. That was below the international average that reached

500. According to the average percentage of correct answers for the science content and cognitive domain, especially in physics, the percentage of correct answers in understanding quations was always higher than the percentage of correct answers in application quations and reasoning quations; a fight between secondary school students which caused casualties; the world economic crisis that spread to Indonesia; the slow progress of technology in Indonesia, etc.

In the X-ray tomography, images was obtained by solving inverse problems (Supurwoko, Fitriana, Wiyono, & Pujayanto, 2015) .There are many methods for obtained images of X-ray tomography including direct projection, analytic and iteration (Brook & Chiro G, 1976). Cognitive processes and activities to obtain an X-ray tomographic images give an idea to build a learning model in physics at high school level.

The purpose of this research was analyzing the learning model based on inverse problem of X-rays tomography. in addition it also was studied the possibility of its implementation in physics learning. The method that was used in this research was

literature study, which studied various scientific journals and reference books in depht. Criteria for success of the model was based on the compatibility between the components of the model being developed and the model components according joice and weils.

The formulation of the problems that was used in this study were as follows:

1. Did the concept of inverse on X-ray tomography can be used as a foundation to create a learning model which involved high-level cognitive processes?

2. Did the learning model based on inverse can be applied to physics education in high school?

2   RESEARCH METHOD

2.1 Inverse Problems on X-ray Tomography.

The non-diffractions X-ray tomography,s data is the intensity of X-ray's beams that had penetrated the object (Cong & Wang, 2011).The intensity of X- ray beam that had penetrated object depended on the intensity of X-ray source and characteristic of the material (Kumi, Hanping, Jianping, & Ullah, 2015).This phenomenon was the basis to develop non diffraction X ray tomography.

The first problem to analize the phenomenon was a theoretical foundation. why the intensity of X-ray decreased after penetrating an object. Based on a physics review,

the intensity of X- rays after penetrating the material is written as $I = I_0\, e^{-\int_0^x \mu\, dx}$, where "I" was the intensity of X-ray after penetrating the material, I0 was the intensity of X-ray before penetrating the material, is a absorption constant of material and x is the length of X ray penetrading (Kumi et al., 2015). I and I0 is the magnitude observed in the experiment, while the and x is the amount you want to know or wanted. The equation of

intensity can be written in other forms as $\ln\dfrac{I_0}{I} = \int_0^x \mu\, dx$. This quantity was called ray sum (Scarfe & Farman, 2008). In heterogeneous material, this equation can be written as

$\ln\dfrac{I_0}{I} = \sum_{i=1}^{N} \mu_i\, x_i$. The problem arised in this process is the path of X-rays when penetrated the object. Indeed, most of the X- ray path is a straight line, but there are some that had the scattered so that its trajectory is not a straight line (Daniel, Ogbanje, & Jonah, 2013).This resulted in the scattering of bias on the intensity of X-rays received by the detector.

The second problem that appeared on the non-diffractions X-ray tomography was digitizing the surface of object's slice that was penetrated by X-rays. The surface of object's slice is considered composed of pixels with the same shape and size. The pixel was usually in the form of a square. The density of pixel at a point comparable with the density of the object at the same point. Thus the density of surface of object's slice which penetraded by X-ray are represented by the value of related pixel. This is called digitization. If it was associated with X-ray absorption in an object, for more closer the pixels there were more X-rays are absorbed, whereas for less dense pixels there were fewer X-rays are absorbed. Based on the absorption equation that has been written on the

first issue, the pixel density is comparable with a material absorption constant. This proportionality is used as the basis of X-ray tomographic image reconstructing. On homogeneous object, problems of digitization process often appeared when reconstructed the image on the outskirts of object. There might have non single value for the pixels on the outskirts of object. In this case the value used was the average density of the object and the background. If the background was empty space or air then its value was half of the density of the object. The same thing applied to the boundary pixels of heterogeneous objects.

The third issue that appears on the X-ray tomography was weighted contribution of a pixel on raysum. X-ray that penetrated materials could be considered to consist of X-ray beams with the same intensity. The X-ray beams penetrated the material passing through the pixels of slices surface of material. Ideally, the X-ray beams penetrated the material passed through the center point of the pixels, but in fact it is difficult to implemented because of the X-ray beam penetrated the material does not always pass through the center point of the pixel. So there were necessary weighted to get the pixel contribution to raysum.

The fourth issue was density rescontruction of pixel which traversed by X ray. The main purpose of X ray tomography was getting pixel density which traversed by X ray and presenting it in the form of two or three dimension in the form of a flat field surface with a gradation or three dimension of solid form with gradation. In two dimensional X ray tomography, pixel position is expressed by matrix two dimension X (i,j) and the pixel density is presented with matrix p (i,j). As result projection data which required to get the pixels density on the cross sectional slice, must be two dimentional too. This dara can get with play back the source and detector together towards the center point of the object. Therefore raysum that obtained is two dimensional matrix which related to density of cross sectional object in its path. These raysum is input data which consists of detailed information about density on the cross sectional that transversed by X ray. Method which used to get density of the cross sectional object is "reverse side projection" method. Is based from the characteristic, the reverse side projection could be considered with invers method because meets with invers nature. These invers nature is expressed by statement: example f is a function of the A compilation to B compilation. When it can determined with f^{-1} function from B compilation to A compilation such that f^{-1} (f(a)) = a and f^{-1} (f(b))=b for each a in A and b in B then f^{-1} called invers function from f. On tomography reconstruction of X ray, the value of B can not be found. The obtained value with use reverse side projection was comparison value between one pixel with another one. So we don't know for sure the density of pixel cross sectional object. If used iteration method, the density pixel is not always be obtained easily, depending on the convergent nature of the equation which used to.

2.2 Learning model

Learning model is conceptual framework which depicts systematic procedures in organizing learning experience for achieveng spesific learning objectives and serves as a guide in planning and implementing learning (Joyce, weil and Calhoun, 2009).

Learning model that has been stated above, according to Joyce, weil and Calhoun (2009) has elements as follows:

1. Syntax

   Syntax is stage processing steps that must be done by the teacher when he uses the lesson model

2. Principles of reaction

   Principles which related with patterns of activity including to the response of the teacher to students behavior in the lesson

3. The social system

   The social system in the lesson model is a system that describes the pattern of relationship between teacher and students when the lesson. The pattern of relationships in social system can divided into three categories: high, middle, low. The pattern called high if the teacher be a main control in a lesson. The pattern called a middle if the teacher equal with students in a lesson activity. The pattern called low if the teacher give a freedom to students in a lesson activity.

4. Support system

   Support system is all means, materials and tools necessary for supporting the implementation of lesson process optimally. What is aim by support system is all means, materials and tools which is needed to implement a certain lesson model. Support system could also be the ability or skills and technical facilities. Support system downgraded from two source that is specificities role lesson and learning demands.

5. Instructional effect

   Instructional effect is learning outcomes which achieved or directly related to the material lesson by directing students on the expected goals.

6. Nurturant efferct

   Nurtunant effect is learning outcomes sideline which achieved as a result of using a certain lesson model. As for the nurtunant effect is another learning outcome which achieved from a learning process, as a result of the atmosphere creation which directly experienced by the students without a direction from the teacher.

2.3 High level thinking process

   High level thinking process according to Bloom – Anderson   consist of three components : analyze, evaluate, create

1. Analyze

   Analyze is solve the material into the constituent parts section and determine how the constituent parts section interconnected to one other. Kognitive process analyzing is divide in three point :

   A. Distinguish

      Distiguish the parts which construct a structure by relevancy, fungtion and important or not

   B. Organize

      Organizing or find a relation, integrate, outline, commentary and preparing a structured

   C. Atribute

      Determine a point of the problem, refraction, value or hidden purpose from existing material

2. Evaluate

Evaluate is doing a ratings based criteria and certain standart. Kognitive process for evaluation divide to two part :
   a. Checking
      Testing for internal consistency or fallacies on an operation or product
   b. Critiquing
      Judging a product or operation based an externally imposed criteria and standards
3. Create
   Put some element together for build a logical and fungtional whole, and arrange these elements into a new pattern or a structure. Kognitive process analyzing is divided to three poin:
   a. Raising or hypothesise : find a new criteria
   b. Planning or designing : find a solution
   c. Producing or making : make a original product by 6a and 6b pattern

3 RESULT AND DISCUSSION

Invers problem in tomography X ray emerged in an attempt to get the amount that causes observation phenomenon form X ray intesity reduction which penetrate an object. According to the author, this concept can use to be a foundation for developing a lesson model which support the development process of high level thinking process.
   Several analyze which be a reason for the aim is :

3.1 Noted the observed magnitude or phenomena

Inveris is part of science that much discussed in various disciplines. In general, invers can shaped in fungtion, matrix although an operation number. However, there characteristic that distinguish an invers with a another equation, the presence of unkonwn magnitude that can be obtained with conduct the reverse operation tothe observed magnitude.
   First step on thi model is note the observed phenomena or magnitude. These note must contains an information about dimentional source, object, and detector with the characterictic/nature. This step is very useful for the student for familiarize themself to do an observation the observed symptoms or phenomena in a lesson.
   Observations that i have done in colleger of Physics Education FKIP UNS fifth grade in 2016 show that they still can't yet describe physics phenomena that they observed in a class well. They still difficult to mentioned detail physics phenomena that the y observed. If a colleger of physics education is still having difficulty to describe the physics phenomena that they observed then it can be ascertained that the science student in senior high school have difficulty to describe the physics phenomena that they observed too. Therefore, this first step is main important step that should be concern the teacher in a lesson.
   In this first step, high level kognitive process which are involved is ability of analyze. The student must can distinguish assembels part which bulit a structure by relevancy, fungtion and important or not. In this part, the role of teacher as a motivator and mediator. The teacher is motivated the students so they interested and pay attention with the physics phenomana which learn, then direct with a indirect questions so the student can describe these phenomena completely.
   Social system which developed in this step is classified in middle class. Teacher and

student in equal footing. In there, the teacher just drove the student with a high motivation so the student can observed the phenomena which presented in the lesson, describe in details and discuss with the group. The teacher not directly involved in this process. The questions which presented by the teacher in this step is more use to open the road for the student so they get pedal for describe the observed phenomena. Support system in this lesson is lesson media which interact motivate and simple to use. If the media whice used to be animation or simulation then need device like computer, LCD, adequate electricit y network. In this situation, not less important is ability of the student and teacher to acess the media.

Instructional effect which are expected in this step is increasing ability of the student to describing every phenomena which they observed. While the nurtunant effecr is student easier to remember every phenomena which they observed.

3.2 Analyze the occurrence of a phenomenon

After describe the observed phenomenon, the next step is analyze process of the phenomena. The analyze be used in every part which describe. Question which use is "how the process of the phenomena?". Besides in this situation, the student is asking more question to themself. These question can be a discussion group.

3.3 Reviewed the literature

Reviewed the literature is used to understand the process of the phenomena. Reviewed the literature is used to answering the questions which is conducted by the student in the second step before. Example, in physics the occurrence of the phenomenon of harmonic motion in simple sling. Student can be ask a question "why the object moving back and forth ?"the answer of the question obtained by reviewed the literature. Learn causes of the motion, then continued with learn relation between causesthe motion with the characteristic of harmonic motion. Reviewed the literature is used to get the forward process not the transferring process.

In reviewed the literature process need library resources like lesson book, scientific journal, acces to online library, etc. Althought the teacher act as a partner for discussion the students doing the analyzation and disscusion, doing evaluation dan take a tentative conclution (hypothesis). The hypothesis be a foundation for evaluation and start use to footing the creating process.

Instructional effect in this activity is the student learn the process of back and forth motion in simple sling, knowing the force that causes dan knowing the magnitude which are involved in back and forth motion in simple sling

While the nurtunant effect in this activity is skills of the student for using analyze pattern and evaluation which obtained at this step for examines the phenomenon which observed.

3.4 Designing the experiment

In the reviewed the literature step, student already have get theoritical basis why the phenomena is happen, magnitude which are involved and unknown magnitude which

need to solve. This literature is used to invers proses for looking unknown magnitude which causes all happen

In this example, unkown magnitude is earth's gravity acceleration. The earth's gravit y acceleration is need to solve with do an experiment simple sling. In previous step, magnitude which involve in harmonic motion are identified. In this step, student separate the magnitude into free and dependent variable, then designing the experiment for solve the unknown magnitude

In this activity, kognitive process which involved is analyze, evaluation, create. In this step teacher act as consultan. The teacher give a direction and guidance to the student if they need. If not directly involve in designing experiment process then just can give comment and propose the necessary

Instructional effect in this activity is the student can designing the experiment for get the unknown magnitude. While the nurtunant effect in this activity is student's skill for create the designing experiment which related with invers problem.

3.5 Doing the experiment

Next, design that have been created in previous step was implemented in lesson in the form experiment. The purpose of experiment is for knowing the relation between free and dependent variable, and is an attempt to get the data which is needed to counting the unknown magnitude with invers process. In front of the example, of course measured the length of rope, amplitude and period of vibration. While the magnitude to be search is earth's gravity acceleration.

In this step the teacher act like partner (mitra), has same position with the student. The teacher just give a consideration if they needed. In this step doing experiment, need support like speciment and experimental tools. If in simple harmonic motion is used direct experiment, so the speciment and experimental tools which needed is rope, stopwatch, protactor, graph paper.

3.6 Implement the inverse equation

The data have been obtained in previous step is used to input equation which related with invers. This equation is obtain from previous equation which is obtain at reviewing the literature. While the output is content of the unkown magnitude which want to search.

In this step teacher act as friend. In this step the teacher act like partner (mitra), has same position with the student. The teacher just give a consideration if they needed. In this implementation step, invers equation is need in support system is student's skill in terms of statistical analysis

Instructional effect in this activity is the student can implemented invers equation for get the unkown magnitude. While the nurtunant effect is statistical skill is better and use it as foundation in make decisions.

3.7 Conclusion

Drawing conclution do together between a student and a teacher. In this step is still possible to have discussion and ask question until get a deal. In here teacher act as facilitator and motivator so any decision must have approval of the teacher, however as a

facilitator, teacher must have to bridge any differences that occur with the make sense explaining so the student more understanding main topics that are being experienced

4　CONCLUSION

From the discussion above, it can be conclude that :
1.　Invers concept in X ray tomography can be used as a basis for creating models involving high level kognitive product : analyze, evaluate, and create
2.　Invers based learning can be applied at physics lesson in senior high school

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