ICLICE 2015 33 Sudirman Sudirman

Enhancing Science Generic Skills in Vocational Secondary School by Using Generative Learning Model

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ABSTRACT

Vocational secondary school was designed to help students quickly enter the workforce with hands-on training based on generic science skills. The four generic science skills that will be addressed in this study include: symbolic functioning and language, logical consistency, mathematical modeling and concept formation. This paper presents a model of generative learning for examining and investigating how effective this model related to generic science skills in physics. The independent variable in this study is the generative learning model while the dependent variables are generic science skills in physics. The design study that was used in one group was the *pretest-post-test* design. The data was collected from students *(N = 33)* grade 10 from a vocational secondary school who adopted a learning process through the generative learning model. Descriptive analysis showed an average score on students' generic science skills test of 6.09 with a deviation standard of 2.55 before using the generative learning model. After the use of generative learning, the score was 16.48 with a deviation standard of 2.62. The results showed with N-Gain of 0.60. These findings suggest that the generative learning model can enhance generic science skills in vocational secondary school level.

Keywords: Generative Learning Model, Vocational Secondary School, Generic Science Skills

Introduction and Theoretical Background

For many years and in the current of globalization era as well, all humans' needs in various fields is rapidly increasing. By way of example is the requirement of Science and Technology. The progress of science is also influenced human life that makes human activity are challenged to think critically, effectively and efficiently to response the changes existing, particularly in the intellectual term. With this intention, education is one of the critical success factors of development, as an effort to improve the quality of human resources. In the field of education, one of the most enduring messages is that *"everything seems to work"* (Hattie, 2008). As the result of this, everyone (parent, politician, school leader) has an important role as the main part of globalization era as well as in education (Hattie, 2008 p.1).

Vocational Secondary School: Challenge and Opportunity

Unemployed was the big problem in globalization era. Indonesia was facing a crucial problem on this area. It means that educational system should be has responsibility to maintain this issue. One of the ways to solve this problem are prepare a human resources that ready to take a part of this. Including, vocational secondary

education could be solve all this issue. However, there is a global debate whether vocational education as a part of school based upper secondary education (Manfred et al., 2009). He argued that vocational and technical education is better placed in post-secondary education or at secondary level in the private sector. Even more, vocational school is a good choices for students interested in practical postsecondary education and job training. Thus, vocational schools typically offer relatively short, career-focused programs that quickly prepare graduates for the workforce.

In Indonesian context, vocational school be recognized in secondary program of educational system and generally known as the abbreviation of 'SMK' (Sekolah Menengah Kejuruan). It is hoped for those secondary school students whose are not intending to move into higher education, vocational courses can be very useful and indeed as the vital for economic development. Notwithstanding this, perhaps, is that while there is widespread recognition of the contribution made by vocational education, there is not yet a proper understanding of how this should be devised and structured, how exactly it is best equipped to support wider social and economic objectives, how vocational courses either do or do not support students as they progress to further or higher education, and what kind of courses really add value for the students' ability. The student can decide what they have and want to be. Thus, not only in academic orientation but also reason to support reforms of secondary level vocational education (Manfred et al., 2009). At this time of further labour market changes and economic uncertainties, getting all this right is really important. Ohiwerei and Nwsou (2009) believed that student should choose a vocation where he or she has intellectual, ability, aptitudes, and interest. All this things based on the vocational aspiration and vocational interest in educational system, particularly in vocational secondary school (Shoaib, 2013).

Understanding of Physics

For some reason, science more closed with humans from time to time. Firstly, science as the *'body of knowledge'* that describes the order within nature and causes of that order. Secondly, science is an ongoing human activity that represents *'the collective efforts findings, and wisdom of the human race'*- dedicated to gathering knowledge about the world and organizing and condensing it into (Paul, 2009).

As part of the oldest academic disciplines in science; physics through its modern subfield of astronomy it may the oldest of all (Andrew, 2010). Physics is one of science subjects which developed the ability to think analytically inductive and deductive in resolving issues related to the events surrounding the nature. Stevan Chapmen (2014) describes physics as *'the science of everything'*, physics relating to how to find out about the nature systematically or "naturally philosophy" (Andrew, 2010). Therefore, not only the mastery of physics knowledge in the form of a collection of facts, concepts, or principles, but also a process of discovery or inquiry. The term *inquiry* has figured prominently in science education refers to Gagne (1963) which called *"practice in enquiry"*. *The Oxford English Dictionary* defines physics as:

"The branch of science concerned with the nature and properties of non-living matter and energy, and so far as they are not dealt with by chemistry or biology; the science whose subject matter includes mechanics, heat, light and other radiation, sound, electricity, magnetism, gravity, the structure of atoms, the nature of subatomic particles, and the fundamental laws of the material universe. Also: the physical properties and phenomena of a thing"

Stevan Chapmen (2014) have listed some various common understanding in physics ideas based on The Institue of Physics as follows:

Reductionism. We can reduce physics to a few universal laws. In fact, the longer one studies physics, the fewer ideas needed. Compare with biology which gets more complicated as one studies it further.

Causality. An event caused by a previous event never precedes that event.

Universality. The laws of physics apply across the Whole Universe.

Mathematical modeling. We can use calculations to predict what real objects and system will do.

Conservation. There are some things that do not get used up, like charge or energy.

Equilibrium. How do things balance out?

Difference cause change. How do things start moving, or heat up or cold down?

Dissipation and irreversibility. The Second Law of Thermodynamics.

Symmetry and broken symmetry. Crucial to all kinds of physics, like crystallography.

As the study of natural phenomena, physics also gives us a ways to mankind our life or how do we lived in harmony with the law of nature. Managing of natural resources and the environment as well as reducing the impact of natural disasters will not run optimally without a deep understanding of physics. On the other hand, physics will showing the natural phenomena and help the human to understand its impact. Fatma Rohani (2006) believed that in fostering the level of interest on the students, it takes creativity from the teacher for planning the learning and teaching process, the teacher should be able to use an outstanding approaches and models in learning process. Therefore, the student can improve their ability in learning activities and one of the outstanding approaches that might increase their ability is the Generative Learning Model. According to this model when it went into the classroom to accept the lesson, students were not empty heads were ready to be filled with various kinds of knowledge by teachers. They have brought prior knowledge about the concept to be learned (Trianto, 2007). While the generative learning model emphasizes the need for teachers to recognized and identify prior knowledge of students, the context of the need to change the initial conception of students when they learn a science concept. Through this learning model is expected to develop creativity and direct involvement of students in the learning process optimally.

Generative Learning Model

Wittrock (1974a,b, 1990, 1991) was the pioneer of generative learning theories. Another According to Osborn and Wittrock (citied in Anwar, H., 2008), generative learning is a learning model that emphasizes the active integration of new knowledge using prior knowledge of the student. The new knowledge will be assessed by using it to answer the problems or related to the symptoms. If this new knowledge is answerred, it means that the new knowledge that will be stored in long term memory. Therefore, educators need to recognize and identify the learner's prior knowledge and context needs to change the initial conception of learners if there is a mistake in learning activities.

In addition, Wittrock (1992) stated that "The model of generative learning differs from cognitive theories of the storage of information in several ways. First, the focus in learning is on generating relations, rather than storing information. At the essence of this functional model are generative learning process that people use actively and

dynamically to (a) selectively attend to events (b) generate meaning for events (c) constructing relations between new or incoming information and previously acquired information, conceptions, and background knowledge. These active and dynamic generations lead to reorganizations and reconceptualization and to elaborations and relations that increase understanding".

The model of generative learning and teaching (Wittrock, 1990, 1991, 1992) is a functional model of learning from instruction that builds upon knowledge about the processes of the brain and upon cognitive research on comprehension, knowledge acquisition, attention, motivation and transfer. No doubt additional factors in generative learning will be discovered in the future. Generative teaching model does not imply that the teachers should avoid direct teaching. On the contrary, direct teaching of theories, concepts and principles often is an effective part of the process of getting learners to construct a better understanding by revising their previous conceptions.

Learning generative models have a pattern as depicted in the chart below

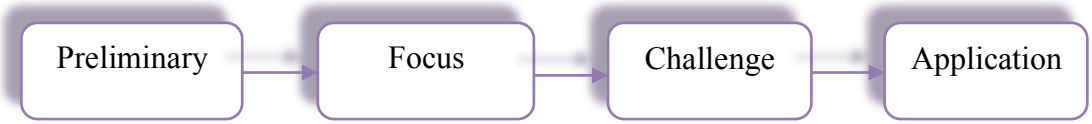

Figure 1. Phase of generative learning model (Muhammad Natsir, 2004: 89)

Phase - 1: Preliminary. In preliminary phase or in introduction, the teachers create the topics and engage the students to discuss this topic. In addition the teacher will try to ensure that there is a mixed range ability in each group so that students of different abilities work together. It is aimed to explore their understanding of the topics. They were invited to express their understanding and experience in daily life related to this topic. To create a good academic atmosphere, educators is hoped would not judge which opinion is *"wrong"* and what is *"right"*. All the educators need to make them dare express their opinions without fear of blame. Teachers should use an open question engage the student curiosity.

Phase - 2: Core Activities. In this stage, core activities are aimed to provide a context for further work. The context may include activities that engage learners to focus their attention. Since we know their own idea, then we invite them to express phenomena or symptoms are thought to arise from an event that will be demonstrated later. They were asked to put forward reasons to support their allegations. They were also invited to respond to the opinion of their classmate that might be different with his/her opinions. The role of educators in this stage is to provide learning experiences that motivate learners, helping students interpret their own responses, encouraging students to think through questions.

Phase - 3: Challenges. At this stage the students can present their opinions or ideas to their group or to the entire class. Educators are expected to record and classify the allegations and explanations that appear on the board. On the other hand, Educators is consciously contrasts the different opinions on it. After that educators implement demonstration and ask the students to carefully observe symptoms. Educators need to give them a chance to digest what they observed, they would feel disturbed and cognitive conflict in their mind. Afterwards, educators ask if the symptoms they observe or not in accordance with their minds. By using the way of dialogue and mutual complementarity, hopefully they can find the answers to the symptoms that they observed. In this case educators prepare the demonstration, display images, or charts that can help learners find an alternative answer to the symptoms which they observed.

Phase - 4: Concept Application. At this stage, educators provide a variety of problems with different contexts to be completed by learners with a conceptual framework that has undergone reconstruction. The intention is to give an opportunity for learners to apply their knowledge or skills to a new context (condition and situation). Their success applying knowledge in new situations will make the learners more convinced of the superiority of their conceptual framework. The training is also intended to further strengthen the relationship between the concepts in the frame of the new changes. (Muhammad Natsir, 2004 p. 90-91)

Generic Science Skills

Generic skills included problem solving, communication and teamwork which is integrated into the general education curriculum (Gordon, 2009). Main types of generic skills are thinking skills, learning strategies, and metacognitive skills According to Gagne (Gagne, 1961, as quoted in Widodo, 2007). There are three main sections of generic skills. The most common are the procedures, principles, and remembering. The indicators of generic science skills included:

Symbolic language. To clarify natural phenomena are studied by knowledge counterpart necessary symbolic language, so that communication skills takes place in this area. In science, for example in physics to know the existence of each scale, the scale used to recognize symbols, formulae - the equations of physics and more symbolic language that has been agreed even in the art area.

Inference or logical consistency. Logically was instrumental in the birth of the laws of science. Many facts that cannot be directly observed can be found through inferential logic of the logical consequences of the ideas in learning science. For example, the point of zero degrees Kelvin has yet to be realized existence, but people believe that it is true.

Mathematical modeling. To explain the observed relationships necessary support mathematical modeling in order to predict exactly how the trend of the relationship or change of natural phenomena.

Building a concept. Not all of the natural phenomena can be understood in daily life because it is required a specific term that might be called a '*concept*'. So learn science concepts requires the ability to build, to be studied further to require further understanding, these concepts were tested on this phase.

The study of learning process involved teachers and learners. In this context, learning physics that place in SMK Negeri 1 Galesong Selatan already concern with *teacher-centered* approach. Where the teacher explains the material while the students just listen and record what was presented by the teacher. The teacher was not giving an opportunity to the student to ask a question or express their opinion. Therefore, the learning activity is low, whereas the learning activity can help improve the generic science skills in physics. This suggests that the activity of learners who can describe the ability of students' generic science skills in physics are in low category. Thus the involvement of learners in less than optimal to follow the lessons and methods used to develop these generic skills are also lacking generic science skills in physics context.

Based on the observations to the teacher and students, we founded that there was some problems of the learning process in the physics class of SMKN 1 Galesong Selatan. These problem come and were identified as follows. Firstly, the incidence of errors students in learning so that the emergence of misconceptions, which are cognitive, psychomotor, and affective. When this misconception didn't have a good handling and true, it was caused the misconceptions will become increasingly complex and stable which could further contaminate the competence of construction of physics at

the students themselves to the fullest. Secondly, the learning activity was still dominated by teachers (teacher-centered), and most students didn't understand the calculation, analyzing the problems and understand the symbols and their application in daily life. It is caused that the students simply memorize instead find themselves in understanding the concepts that have been taught.

Research Question

As mentioned above, while the students in vocational secondary school learn science as well as physics, the teacher has an important role to enhance their generics skills in physics. Hence, our leading research questions are;

1. What is the generic science skills ability of students in grade 10 SMK Neg. 1 Galesong Selatan before they are taught using the generative learning model?
2. How has the generic skills ability improved in grade 10 SMK Neg. 1 Galesong Selatan after being taught using generative learning model?
3. To what extent has the generic science skills ability improved in students from grade 10 SMK Neg. 1 Galesong Selatan in teaching the generative learning model?

Methods

This study is a type of quasi-experiment (*pre-experimental design*) which used *Pretest-Posttest Only Control Design* (Sugiono, 2009). A single case is observed at two time points, one before the treatment and one after the treatment. Changes in the outcome of interest are presumed to be the result of the intervention or treatment. The independent variable in this study is the generative learning model while the dependent variables are generic science skills. The design study that was used in one group was the *pretest-post-test* design.

$$\mathbf{O_1 \quad X \quad O_2}$$

Where:

X : The treatment given to the learners through the learning of generative models

O_1 : Tests were given before given the treatment *(pre-test)*

O_2 : Tests were given after given the treatment *(post-test)*

Subjects in the study were selected directly *(Purposive sampling)* by taking the whole class. The subjects in this research were students of grade 10 TKJ_1 SMK Negeri 1 Galesong Selatan for academic year 2013/2014, odd semester with total of students *(N = 33)*. We were assuming that class X TKJ_1 has a good range ability among others. This research instruments or test such as instruments of generic science skills in physics with multiple choice test on the topic of *Work and Energy*. Some indicators which is included are: symbolic language, mathematical modeling, logical consistency, and developed concepts.

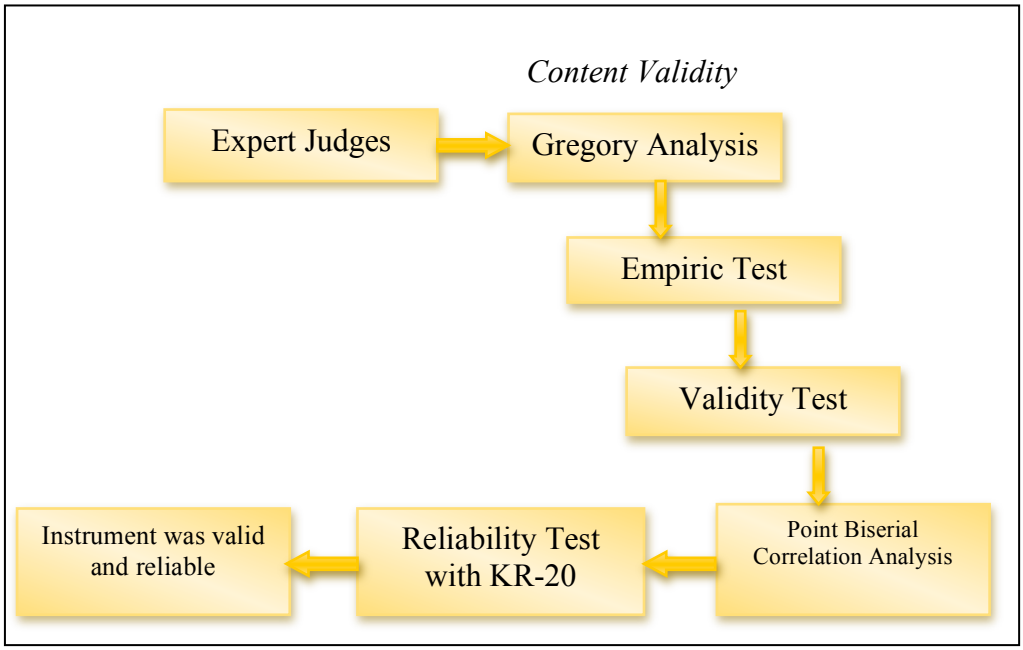

Figure 2. Developing Instrument

Based on the previous diagram, the first we do after making the instrument was assessed by an expert or the instrument called the test or Gregory test or test of content validity or the content test. Coefficient of content validity can sorted out in qualitatively and quantitatively by several experts (Gregory, 2000, in Koyan, 2000). To determine the content validity coefficient, the results from both of the expert assessment incorporated into the statistical factorial 2 x 2 design which consists of columns A, B, C, and D. Column A means that it is disagreed by both of expert judge. Columns B and C are the cells that showed different perspective (one of them agree and another disagree). Column D is agreed by both of assessor or expert judges agreed. Content Validity is the number of items on the column D divided by the number of items was column A + B + C + D. The following items were validated by two assessors, then analyzed by using the following formula according to Gregory. Calculations content validity by using 2 expert judges with the following formula:

$$Vc = D / (A + B + C + D)$$

Where:
Vc : Construct Validation
A : Judge I and II disagree
B : Judge I agree, Judges II disagree
C : Judge I disagree, Judges II agree
D : Judge I and II agree

Criterion of Content Validity:
0.80 - 1.00 : very high
0.60 - 0.79 : high
0.40 - 0.59 : medium
0.20 - 0.39 : low
0.00 - 019 : very low

The results of this calculation obtained content validity of 0.966 Gregory which mean the instrument or assessment has a high content validity. By using the Gregory analysis, only 1 of 30 that not valid to use in this test, 7 of 30 items were not valid. On the word, we only use 29 items to assess students' generic skills in physic area, particularly in topic *'Work and Energy'*. To test the validity of each item questions that have been tested to use point-biserial correlation equation as follows:

$$\gamma_{pb_1} = \frac{M_p - M_t}{S_t}\sqrt{\frac{p}{q}}$$

Where:
γ_{pb_1} : point-biserial correlation coefficient
M_p : mean score of subjects who responded well to the items sought validity.
M_t : the mean total score
S_t : standard deviation
p : the proportion of students who answered correctly
q : the proportion of students who answered incorrectly (q = 1-p)

(Arikunto, 2006: 79)

Criteria: Valid if γ (γ_ (pb_1)> r_tabel)

By using the rule (γ_ (pb_1)> 0.344) in order to obtain that of the 29 questions were validated, there are 23 questions are valid to assessed students' generic skills in physics. To calculate the reliabilities test at the end, we used physics Kuder-Ricahrdson - 0 (KR-20) as follows:

$$r_{11} = \left(\frac{n}{n-1}\right)\left(\frac{S^2 - \sum pq}{S^2}\right)$$

(Arikunto, 2006: 100-101)

Which:
r_{11} = Reliabilty of the test as a whole
p = proportion of subjects who answered correctly
q = proportion of subjects who answered the item about one $(q = 1 - p)$
$\sum pq$ = jumlah perkalian antara p dan q
n = number of valid items
S^2 = standard deviation of the test (standard deviation is the root of the variance)

Table 1
Criterion Level of Reliability Items

Range of Value	Category
0,801 – 1,000	Very High
0,601 – 0,800	High
0,501 – 0,600	Medium
0,201 – 0,500	Low
0,000 – 0,200	Very Low

From the calculations, the reliability test of generic skills in physics test is 0.85. On the other word, it is indicated that valid research instruments have a very high level. Furthermore, the results of this descriptive analysis is shown in the form of an ideal score, lowest score, highest score, range of scores, mean scores, deviation standard, variance, and percentage. The mean score is obtained from the equation:

$$\bar{x} = \frac{\sum_{i=1}^{n} X_i}{n}$$

(Subana, 2005:70)

Where:
$\bar{x}$ = Average
$\sum_{i=1}^{n} X_i$ = Total of Data
n = number of data

The equation for the range of scores and percentages obtained from the equation:

Score range = maximum score - minimum score
Percentage = frequency / (number of students) x 100%
To obtain standard variation and deviation (Sd) used the equation:

$$S^2 = \sqrt{\frac{(Xi-\bar{X})^2}{n-1}} \text{ and } S = \sqrt{S^2}$$

Where:
S^2 = Variance
S = Standard od Deviation
xi = score of the i − th
$\bar{x}$ = the average score
n = number of data

To determine the generic science skills in physics, it was analyzed by analysis of N-Gain normalized. The increase that occurred before and after the learning gain is calculated with the formula normalized (N-Gain) as follows:

$$g = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}}$$

Which:
S_{post} = end of test scores
S_{pre} = initial test scores
S_{maks} = maximum possible score achievable

N Gain criterion are as follows.

Table 2
N-Gain Category

Interval	Category
g > 0,7	Height
0,3 ≤ g ≤ 0,7	Medium
g < 0,3	Low

(Meltzer, 2002)

Once the value of the average normalized gain, we then compared to see an increase in generic skills of physical science. If the values are higher than previously obtained to see an increase in N-Gain is at medium and high criteria then learning is effective in improving the generic skills learning science compared with other (Ogilvie. 2000)

Results

Result of Descriptive Analysis

Descriptive statistical results for generic physic skills of students in grade 10 TKJ 1 SMK Negeri 1 Galesong Selatan 2013-2014 academic year before and after being taught the generative learning model.

Table 5.1
Overview of Pretest and Post-test Scores for the Generic Physics Skills of Students in Grade 10 TKJ SMK Negeri 1 Galesong Selatan

Statistics	Score Statistics descriptive analysis results	
	Pretest	Posttest
Total of subject	33	33
Ideal Score	23	23
Maximum Score	13	21
Minimum Score	3	11
Range of Score	10	10
Means of Score ($\bar{X}$)	6,09	16,48
Variants (S^2)	6,52	6,88
Deviation Standard (S)	2,55	2,62

Based on the results of the descriptive analysis, it showed that the average scores of students taught by the prior generative learning model was 6.09 while after being taught using the generative learning model the average score was 16.48. As for the frequency distribution of average scores before and after teaching, they can be seen in the following figure.

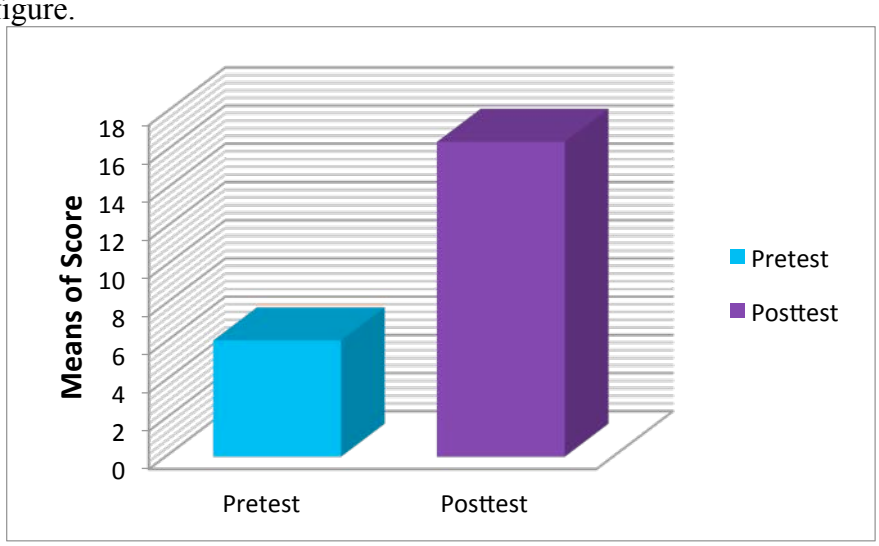

Figure 3. Comparison of mean scores of generic physics skills for students in the pretest and post-test

N-Gain Analysis

The increase in generic science skills is calculated using the normalized formula. The Gain Value was used to identify the increase in the generic physics skills pretest to post-test. The results obtained by testing N - Gain show that the generic physics skills have increased. The results of the generic physics skills test of 0.60 were compiled by manual calculation and by the Microsoft Office Excel. It shows the results of the test are in the medium category, which means the model is effective according to Ogilvie (2000). For more details, the following table presents the frequency distribution relationship for the pretest/post-test scores with the scores of generic physics skills.

Table 5.2
Frequency Distribution and Percentages of Generic Physics Skills for Students in Grade 10 TKJ 1 by N - Gain Value

No	Range	Category	Frequency	Percentage (%)
1	$g < 0,3$	Low	7	21,21
2	$0,3 \leq g \leq 0,7$	Medium	22	66,67
3	$g > 0,7$	High	4	12,12
	Total		33	100,00

This suggests that of the 33 students who became the research subject, there were 12.12 % of students in the low category, which means there were 12.12 % of students with low generic physics skills, even after being taught physics using generative learning model. The percentage of students in the middle category was 66.67 %, which means that there were 66.67 % of students who had improved generic physics skills once taught physics with the generative learning model. The percentage of students in the high category at 21.21 %, means about 21.21 % of students demonstrated an even higher level of improvement after being taught using the generative learning model.

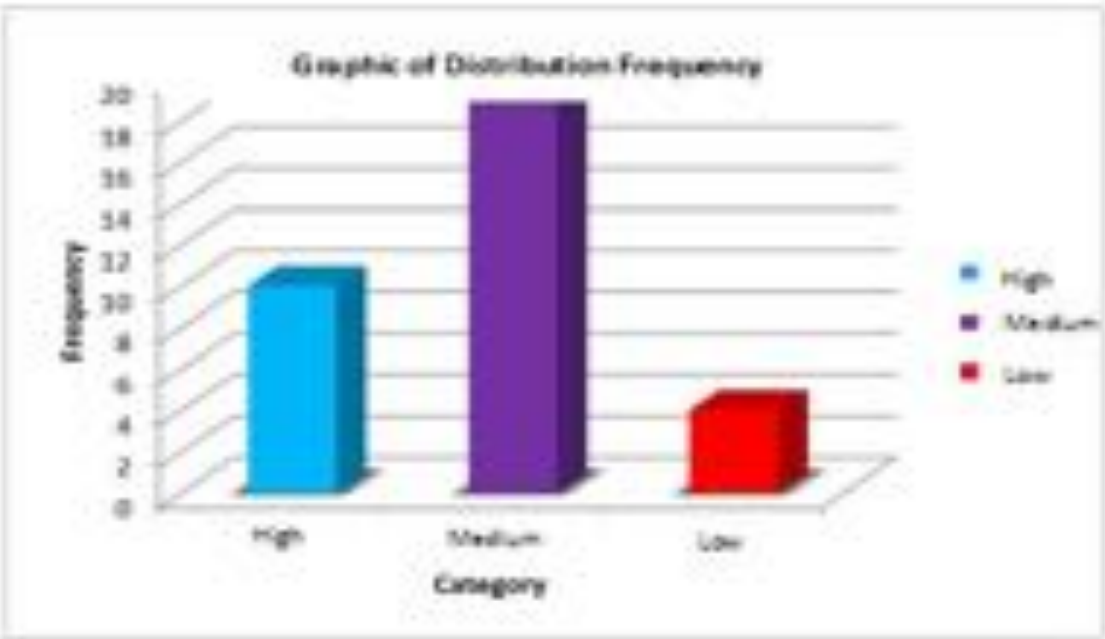

Figure 4. The Frequency of Generic Physics Skills of Students in Grade 10 TKJ 1 SMK Negeri 1 Galesong Selatan at Pretest and Post-Test

Discussion

This study was conducted over four sessions and aims to determine the improvement of generic science skills in physics of students (N=33) in Grade 10 TKJ 1 SMK Negeri 1 Galesong Selatan for the academic year 2013/2014 after being taught using the generative learning model. The data obtained from the pretest of generic physics skills includes these indicators of physics science: symbolic language, logical consistency, mathematical modeling, and developing concepts. The results of the pretest show that students did not have sufficient generic physics skills.

The learning process that took place in SMK Negeri 1 Galesong Selatan was still dominated by the teacher and a very traditional model of rote learning where the teacher explains the material as the students just listen and repeat the information taught to them. As a result, the generic science skills of students were not as advanced or well developed. Since teachers' involvement in the learning process was not as interactive, there was little opportunity for students to pose thoughtful questions. Students received solutions directly as opposed to investigating problems themselves.

The generative learning model improves student's generic physics skills. This requires students to use their knowledge and experience gained from the generative learning model to carry out the experiment/activity on their own, while the teacher acts as a facilitator in the learning process.

The generic physics skills test results showed an average gain value of 0.60. The medium frequency category (66.67%) had a greater value than the high frequency category (12.12 %) and low category (12.21%). Some factors affecting the acquisition of generic physics skills included; students' poor attendance, a noisy and unfocused learning environment, students' short attention span (especially during the last hour of the lesson), and students' perception of the subject as being irrelevant to them. Students who showed an improvement in their generic physics skills attended class more than 50% of the time.

Zohar, et al (as citied in Suriadi, 2005) generic physics skills are best developed through student-centered learning. Teachers design the learning so the students are able to develop one generic physics skill by asking questions. The teacher then guides the students as they build an understanding of the subject matter in a comprehensive way of thinking. In the first phase, teachers guide students to explore their knowledge about the topic. Their ideas or preconceptions are derived from experiences or the learning gained from a previous grade level; these ideas and preconceptions, which can often be inaccurate or misconceptions are then subsequently resolved by the students themselves through the investigative process. Here the students are required to think critically, and then ask thoughtful questions, which are both a part of the generative learning model. This then further stimulates the students' thinking process, as was proposed by Santrock (2009).

Furthermore, students also test hypotheses and exchange opinions within their group. After this, each group presents their findings within a class discussion and each group is then free to question the presenters. Students are expected to define the concepts learned, while the teacher then reaffirms these concepts. The hope is that by the end of the process, students realize that physics involves an active investigation on behalf of all group members and that these concepts and the process itself are relevant to their everyday lives.

Summary

This study addressed new topic: Generic Science Skills in Physics and Generative Learning Model. These method might be implemented to enhance generic science skills in physics of student in vocational secondary school. Based on the analysis

and discussion, it can be concluded as that before taught with generative learning model, generic science skills in physics of students exist in the *'low'* category. After taught with generative learning model, generic science skills in physics of students at the *'medium'* category (g = 0,60) which its percentage was 66.67 %. There was an increasing generic science skills when using generative learning model. There are some factors that influenced the students who still have low science generic skills such as; attendance, learning environment that is less conducive for learning process. Another factor or the unknown factor, it may be culture or local wisdom. The researcher cannot concluded specifically, but when the students had interviewed they argue that they more understand if they taught using an approach that correlated with their local wisdom or culture ones.

Acknowledgement

We thank all participating students and teachers of SMK Negeri 1 Galesong Selatan, Takalar; Dr.Kaharuddin Arafah and Dr. Ahmad Yani, (Department of Physics, Faculty of Mathematic and Natural Sciences, State University of Makassar, Indonesia. Dr. Declan Kennedy (School of Education, University College Cork, Ireland) and Joyce (Cork English World) for their help as proof reader in preparing this paper and check the English grammar; Masyita Hafid for collecting parts of the data.

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