THE USE OF INTERACTIVE MULTIMEDIA TO ENHANCE STUDENTS' GENERIC SCIENCE SKILLS

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Abstract

To face against challanges in the 21st century Indonesian people should be smart and competitive. Science education has an important role to reach those skills through scientific thinking. Scientific thinking can be created through generic science skills mastery. Teaching models used interactive multimedia software had been developed to enhance students' generic science skills in primary, secondary and tertiary education. Through quasi experimental method, three topics : Animal Reproduction (Biology) for junior high school, Chemical Bond (Chemistry) for senior high school and Elasticity (Physics) for physics education students had been chosen, to develop 7 indicators of the generic science skills; i.e. Indirect observation, symbolic language, causality, sense of scale, mathematical modelling, logical inference, and concept formation. All three topics consist of 41 essential concepts. The implementation of the models of teaching to 44 junior high school students in State Junior High School at Cimahi, 33 senior high school students in State Senior High School at Lembang, and 35 prospective physics teachers in State Teacher Training Institution at Mataram (NTB) showed that student easily mastered indirect observation, concept formation and causality, but difficult in mastery mathematical modelling and logical inference. The matery of generic science skills increased as well increasing of educational level. In fact generic science skills mastery helped students comprehend many science concepts. Therefore using interactive multimedia could enhance students' thinking skills from science concepts attainment to scientific thinking.

Key words: interactive multimedia, generic science skills, scientific thinking

Introduction

Global challenges should be faced by Indonesian people that make their life more difficult. Resession at the end of the year 2008 and further in 2009, caused vacancy hardly to be found. Only the smart and competitive people win on the competition at work. How to prepare smart and competitive people is a big problem in Indonesia. Smart people usually competitive. Therefore earlier development of youth thinking skills is needed to make smart people. Science (biology, physics, chemistry) education has an important role in the development of thinking skills.

Many Indonesian students learn science concepts and principles through recall. Their concepts' mastery usually low because the concepts are not meaningfull to them. On the other hand there are too many science concepts and principles that make students fed up to learn the subject. Learn science that way make students cannot applied the concepts in their everyday life. They have not competency that should be reach as hoped in content standard as stated in [1]. To reach the competency there should be new paradigm on learning science, to give students many experiences to master science and guide them to use science knowledge [2].

In order to overcome the problem, students need to learn science thinking skills to make their science knowledge application easier. The science thinking skills are described as generic science skills [3]. Therefore the alternative solution to enhance science education in Indonesia is to change science education paradigm from recall scientific concepts to generic science skills mastery.

Generic science skills consist of soft skills. It is abstract and hard to be learned. ICT has capacities to make the abstract concepts to be concreted. There are many of abstract concepts representations made easier by ICT. [4].The research problem is how can generic science skills mastered by the students through ICT based science instruction?

Science as Thinking Vechicle

As in [5] stated that science thinking frame consist of principles: (1) in the universe there are consistency and universal framework; (2) science is a proses to get knowledge that comprehend phenomenon; (3) science always change and not the end of truth: (4) science is only an approach to the "absolute" therefore it is not "values free" dan (5) science is limited, that cannot decided "true" or "false".

Science also has common themes, i.e. system, model, consistency, profile of change, and evolution.

Students should also be conscious on those science characteristics in learning science. Besides learning science full of thinking activities that developed through 8 indicator of generic science skills, e.i. (1) direct and indirect observation; (2) sense of scale; (3) symbolic language; (4) logical self consistency; (5) logical inference; (6) causality; (7) mathematical modeling; (8) concepts formation [3].
The ninth indicator of generic science skills, especially in chemistry is spatial [2].

Science learns nature phenomenon through **direct observation** to search causality of things that being observed. The limitation of human sense, make the direct observation should be helped by instruments. As an example in chemistry an indicator is needed to prove acid-base property of poisonous solution, amperemeter to observe electric current, tensimeter to measure blood pressure. The observation helped by instruments described as **indirect observation**.

There are several scales in nature that different size of many things in daily life. Protein has big molecular size and complex in structure. On the contrary electron has very small size and simple. Half life of radioactice element vary from $1,6 \times 10^{-4}$ seconds of Po to 5×10^{9} years half life of U-238. **Sense of scale** is needed to study those things.

Symbolic language is used in science communication all over the world**,** for example: elements' symbols as H, O, Na etc; ampere for electric current scale, arrow as symbol for male and plus for female. Long time observation of nature phenomenon will discover many scientific laws, but there will be several logically "anomali". **Logically self consistency** of natural laws answered the "anomali" by defined new theory. Difficult biochemistry reaction as an example can exist in vivo at the temperature lower than in-vitro. The answer of the phenomenon is the existence of enzyme as catalyst of couple reactions.

Many facts in science cannot be observed directly but it can be discovered through **logical inference** from logical consecuencies in science thinking, i.e. zero Kelvin degree is really right although it is not be proven in real life, but only proven by graphic. If concentration of the reactant larger, than rate of the reaction larger. If the temperature of the system is reduced, than exoterm reaction conducting in better way. Explanation of those phenomena can be answered by **causality**.

Mathematical modelling can help to explain a lot of phenomena relationship in nature. Through the modeling it is hoped to predict relationship or changes of the series nature phenomena tendency precisely. For example: gas pressure in the contrary with volume according to Boyle that formulated as PV = C. Not all nature phenomena coul be explained in daily language, therefore it is needed to explain in special terminology, named concept. Concepts formulation is needed to prove for their application in further development. The process in science named **concept formation**.

Chemistry as a science discipline needs another generic science skill that is **spatial view**. This generic science skill becomes important because chemistry studying structure and changes of the structure of matter. The structural change if there are changes in particles bonding direction in space.

Higher order thinking skills consist of critical thinking, creative thinking, problem solving, and decition making [6]. Students can develop higher order thinking skliis through the 9 generic science skills. Critical thinking can be developed by direct and indirect observation, sense of scale, mathematical modeling, dan concept formation. Creative thinking can be applied if students

formulate symbolic language, logical inference, and logical consistency of natural laws.

Problem solving can be applied if students learn about causality in several nature phenomena they observed. Further, decision making can be applied by students through concepts formation, mathematical modeling, and logical inference. Therefore if students learn science only by memorizing scientific terminology, they are not learning science at all. They cannot apply thinking science.

ICT can overcome the difficulties faced in developing higher order thinking. The abstract characteristic of scientific concepts should be learned through several representations. The computer flash program such as interactive multimedia can be used to make verbal, graphical, mathematical and symbolic representation more concrete and easy to understand (Heinich, et al 1996)

Method

Rapid developments of the science knowledge caused too many scientific concepts needed to be learned by students. Therefore it has been needed to choose essential science concepts to be learned. The chosen essential concepts based on importance of the concepts on students' daily life to give students enough scientific thinking skills.

Science education research has been done with R & D method. The research aimed to develop generic science skills on the three levels of education, e.i. junior high school, senior high school, and institute of teacher training. The reseach also conducted on different science disciplines i.e Biology oin junior high school, Chemistry on senior high school, and Physics on the institute of teacher training. The topics choosen are Animal Reproduction (Biology), Molecular Interaction (Chemistry), and Elasticity (Physics). Those topics learned through ICT based instruction. Interactive multimedia flash has been chosen to represent many abstract scientific concepts. Concepts analysis of the topics has been done before instructional development used descriptive method [6]-[11]. The analysis result and relationship between the concepts and generic science skills can be seen on table 1.

Tabel a. The relationship of topics, scientific concepts and generic science skills

No	Topics	Concepts	Generik science skills
1.	Animal reproduction	reproduction, asexual reproduction, spliting, sprouting, fragmenting, sexual reproduction, fertilisation, external fertilisation, animal reproduction system, invertebrata reproduction system, vertebrata reproduction system, pisces reproduction, amphibi reproduction, reptile reproduction, aves reproduction, mamalia reproduction,reproduksi human reproduction, man and woman reproduction ,ovulation, menstruation, contraseption, sexual desease	Logical inference, causality, modelling, concepts formation
2.	Molecular interaction	molecular interaction, intermolecular attraction, dipolar interaction, london force, hydrogen bond	Indirect observation , symbolic language, causality, mathematical modelling, concepts formation
3.	Elasticity	Elastic substance, plastiecs substance, tension, stretch, spiral potential energy, Young modulus, friction modulus, bulk modulus, energy strain density, Poisson comparablility	Indirect observation , sense of scale, logical inference, causality, mathematical modelling, concepts formation

Further concepts analysis shows concepts characteristics and generic science skills relationship. Analysis result given on table b.

Table b. Concepts characteristics and generic science skills relationship

No	Generik Science Skills	Concepts characteristics
1.	Indirect observation, modelling,causality, sense of scale, logical inference	Abstract concept, abstract concept that has tangible example, concepts that name process, concepts that related to properties
2.	Symbolic language, mathematical modelling, concepts formation	Principles based concept, concept that represents symbols

Table b shows that learning science concepts give students complex thinking skills. Usually each science concepts develop more than one kind of generic science skills. Therefore learning scientific concepts is parallel with the development of science thinking skills as higher order thinking skills. It shows that generic science skills as a way to develop students' higher order thinking skills that make them smart and make them competitive.

ICT based instruction planned in this research with interactive multimedia software aimed to develop scientific thinking and made microscopic aspect of the science topics chosen clearly. In learning science those aspects become important because they were scientific part that difficult to understand.

Implementation of the instructional models used quasi experiment method of the control group pretest-postttest design (except the implementation on senior high school because of the limited amount of students, used one group pretest-posttest design).

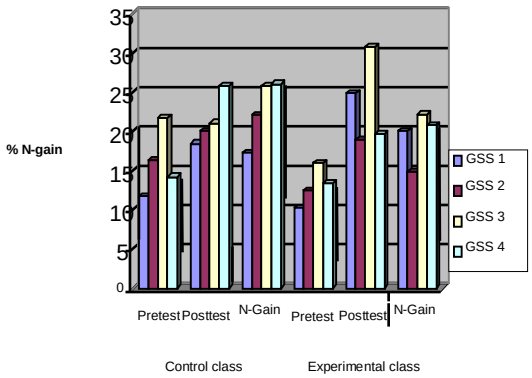
Subjects of the research in a state junior high school at Cimahi state are two of nine grade classes consist of 44 students, as an experimental and control classes.Topic learned was Animal Reproduction in Biology lesson. Other subjects were 33 students of eleven grade senior high school as experimental class on a state senior high school at Lembang. The topic learned was Molecular Interaction in Chemistry lesson. Elasticity topic of Fundamental Physics course in a state teacher training institution in Mataram West Nusatenggara was chosen as the third topic. Subjects of research were two classes first grade students consist of 35 students. Result of the research explained as follow.

Result and discussion

Students' generic science skills mean score of Animal Reproduction topic on experimental and control classes at junior high school school can be seen on the table c and figured on graph a. Further generic science skill mean score of Molecular Interaction topic on experimental class at senior high school can be seen on the table d and the figure on graph b. Generic scince skills mean score of Elasticity at teacher training program on experimental and control classes can be seen on table e and the figure on graph c.

Tabel c. Mean score of generic science skills on pretest, posttest dan N-gain students on Animal Reproduction topic [11]

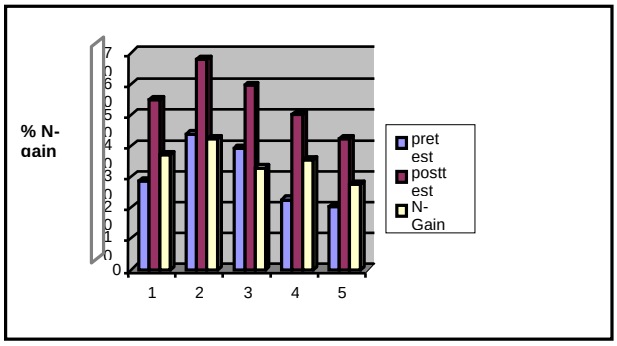
No	Generic science skills	No test	Control class mean score			Experimental class mean score		
			Pretest	Posttest	% N-Gain	Pretest	Posttest	% N-Gain
1.	Modelling	5, 8	11,76	18,54	17,33	10,26	24,88	20,09
2.	Concept formation	3, 7	16,43	20,15	22,14	12,47	18,97	14,92
3.	Logical inference	4, 6	21,73	21,11	25,78	16,02	30,80	22,22
4.	Causality	1, 2	14,24	25,84	26,10	13,40	19,76	20,79



Graph a. Mean score dan N-gain junior high school on each GSS of Animal Reproduction Topic

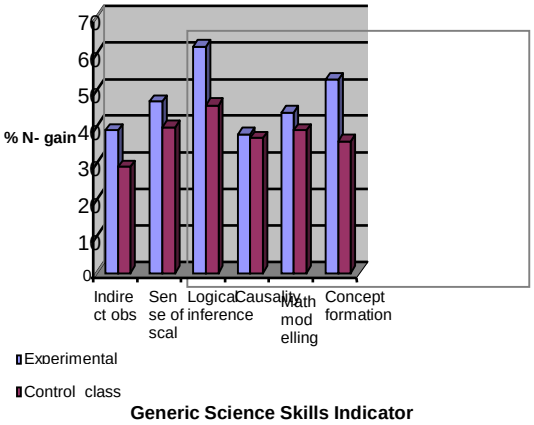
Tabel d. GSS mean score on pretes, postes of the Molecular Interaction topic (Agustin,2009)

No	Generic science skills	No test	Score		
			Pretest	Posttest	%N-Gain
1.	Concept formation	1, 2, 6,7, 13, 16, 22, 25,	28,79	55,05	36,87
2.	Modelling	3, 4, 11, 12, 15, 18	43,93	67,67	42,33
3.	Logical inference	9, 10, 19, 20, 24	39,39	59,39	32,99
4.	Indirect observation	5, 14	22,72	50	35,30
5.	Causality	8, 17, 21, 23	20,45	42,42	27,62



Grafik b. Mean GSS Score of pretest, posttest dan N-gain of Molecular Interaction topic [10].

Tabel e. GSS Mean score of pretes, postes dan N-Gain on Elasticity topic [8].



Graph c. GSS mean score on control and experimental classes of Elasticity topic

Tree science topics chosen have similarity on concepts characteristics. They all consist of abstract concept, abstract concept that have tangible examples, concept that represent process, concept related to properties, principles based concept, concept that involved symbol. On the other hand concepts that represent processes is the only concept that not found in Animal Reproduction topics.

Based on concepts characteristics, chemical concepts were more complex than biological and physics concepts. The consecuency of the similarities concepts characteristics of the three science disciplines, there are similar generic science skills developed on the three models of teaching. That means generic science skills covered science interdiciplines. Therefore generic science skills can unify all science disiplines. Related to the limited properties of concepts on the models of teaching, other generic science skills might be developed through different science topics on the further research.

The result of statistical analysis of students score on generic science skills shows that there were significantly differences between control class and experimental class of Animal Reproduction topics (Z= 4.809 and p = 0.05). N-gain of control class is Students'

generic science skills score shows significantly differences of posttest and pretest (p=0.05) and N-gain 42.33 % on Molecular Interaction topics. That shows a low generic science skills development. Generic science skills of prospective teacher students show the significantly different score between experimental class and the control class. The result of experimental class got N-gain 51.1 % and the control class got 29.3 % on the Elasticity topics.

These result shows generic science skills as higher order thinking skills less developed in junior high school. This fact was not in line with Piaget's cognitive development theory. The theory described that 11 year old students have a formal operational thinking stage [11].

On the senior high school and university research shows that generic science skills have been mastered. Although students of senior high school had not successful on all generic science skills developed. They had small score on mathematical modeling and symbolic language. On the contrary generic science skill 'causality' matered well by senior high school student, but fail to be mastered by the university students. That means the development of generic science skills not only determined by educational level of the students but also dependent to topic characteristic. Based on the research used 3 scientific topics consist of 41 concepts, could be developed 7 indicator of generic science skills. That means concepts variation larger than scientific thinking skills variation. Therefore through few scientific thinking activities students mastered many science concepts and thinking based learning science should be very important.

Conclusion

Based on research result several points was concluded, those are: (1) learning science in new paradigm through development of generic science skills as higher order thinking skills; (2) the development of generic science skills made students mastered scientific concepts; (3) Thinking science that consist of indirect observation, symbolic language, modeling, mathematical modeling, causality, logical inference, and concepts formation; could be learned through topics Animal Reproduction, Molecular Interaction, and Elasticity; (4) Generic science skills increased parallel with the increasing of educational level; (5) Scientific thinking mastery make learning science easier, because it can wrap a lot of scientific concepts. Therefore scientific thinking is a basic skill needed to enhance individual thinking skill.

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