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The Proportion of Problem Solving and Scientific Reasoning Skills in Biology References

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ABSTRACT

Problem-solving is a vital component under the cognitive standard of the 21st century skills for preparing students to face global competition. Problem-solving supported by another skill, one of which is scientific reasoning. Research objective is to analysis profile content and context of Biology references by interaction of problem-solving and scientific reasoning aspects. Research procedure applied Toulmin Argument Pattern (TAP) as a basic framework to identify the scientific reasoning aspects. Data obtained from the questionnaire, survey, and analyzed descriptively. Result indicates that the majority of Biology references does not required of balance proportion between problem-solving and scientific reasoning aspects. The lower aspect both of content and context was located in explore and Look back for Ground and Rebuttal aspects. In addition, this result can be used to inform future development of instruction and assessment problem solving and scientific reasoning skills.

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1. INTRODUCTION

The 21st century offers new challenges competencies and skills which needed in globalization such as problem solving skills [1]. Problem-solving is a vital component under the cognitive skills beside the ways of thinking in order to give the accurate, logic and systematic solutions [2]. Bransford and Stein [3] stated that problem solving skills into five aspects called by IDEAL indicators, as follows; identify the problem, define and represent the problem, explore possible strategies, act on the strategies, look back and evaluate the effects. Problem-solving skills supported by another skill, such as critical thinking [4], analytical thinking [5], creative thinking [6] and logical argumentation which called by scientific reasoning [7].

Scientific reasoning is one of the essential elements for obtaining problem solutions [8] through some arguments based on factual claim, evidence/ ground and rebuttal as main aspect of scientific reasoning [7] [9]. All aspects of scientific reasoning can be explored and exercised throughout student activities by using ills structured problem [10]. The ills problem required reasoning and analysis of multi-disciplinary science knowledge [6], moreover it can be solved through investigated activities to foster the curiosity and science literacy, and also to explore multi knowledge [11]. Exploration and organizational of knowledge used to build ideas or solutions that can be facilitated by reading references [12].

References in problem solving process are required as exploration source credibility to support of scientific processes [13]. References serve to relate scientific facts with multiple interrelated knowledge, so it can deliver conclusion or arguments which have evidence to support the claim [14], therefore references based on problem-solving activities and scientific reasoning are important to set up the skills needed in this globalization era [15]. How the profiles of reference for grade 10 biology subjects in Indonesia, based on

problem-solving aspects in order to enhancing scientific reasoning skills. Student and teacher in Biology class usually used textbooks as the most cited as a reference to solve some questions and solve the problem in the classroom [16]. References that contain of problem solving indicators was facilitated by problem solving activities in classroom which has impacts to students' scientific reasoning skills [8].

Scientific reasoning was analyzed through students' arguments by using Toulmin Argumentation Pattern (TAP) [17]. The component of Toulmin Argument Pattern, consist of claim, data, warrant, backing, source credibility, exception and rebuttal [18]. The evaluation according to evaluation system score of scientific reasoning by Gracia-Mila [17], so the purpose of the research is to obtain a reference profile based on the problem solving aspects to improve students' scientific reasoning skills.

2. RESEARCH METHOD

The research is a qualitative descriptive to analyze the reference profile commonly used in Indonesia senior high school. Research subjects are five reference types used in Grade 10 Biology lesson. The research procedure begins by constructing indicators based interaction of aspects of IDEAL problem solving [3] and scientific reasoning skill [9]. The indicators can be used to analyzed content and context of immune system topic in Biology references. Immune system topics was selected based on; 1) student polling related the most difficult topics in the references used by teacher and students; 2) survey of Minimal standard competencies in order to knowing base mark of Biology lesson; 3) teacher and pupils interview to identifying type of references that they used.

Result of students' polling, survey and interviews shown that 53% students selected immune system as the most difficult topics in Biology, 85% students gain mark of system immune less than minimal standard competencies. The result of teachers' interviewed shown; 1) The character of immune system material were abstract and complex; 2) there were many lower order thinking skill questions; 3) references contain less case study activities, 4) student activity commonly rewriting and repetition matter, so the students less activity to exercised problem solving and scientific reasoning skills. Based on empirically activity students need to analyze of references that used. Analysis of references used indicator of IDEAL problem solving indicators [3] and scientific reasoning [9], shown in Table 1.

Table 1. The Interaction of IDEAL Problem Solving and Scientific Reasoning Aspects

Problem Solving Aspect	Scientific Reasoning Aspect		
	C (Claim)	G (Ground)	R(Rebuttal)
I (Identify)	Identify – Claim (IC)	Identify – Ground (IC)	Identify – Rebuttal (IR)
D (Define)	Define – Claim (DC)	Define – Ground (DG)	Define – Rebuttal (DR)
E (Explore)	Explore – Claim (EC)	Explore – Ground (EG)	Explore – Rebuttal (ER)
A (Act)	Act – Claim (AC)	Act – Ground (AG)	Act – Rebuttal (AR)
L (Look back)	Look back – Claim (LC)	Look back – Ground (LG)	Look back – Rebuttal (LR)

3. RESULTS AND ANALYSIS

Analysis carried through content and context of Biology references. Content was analyzed by looking at the achievement of indicators related to material which consists: learning objectives, description of the material, student activities and assessment. Context was analyzed by looking at the achievement indicators in terms of delivery and use of references by teachers and students.Biology materials constitute a study full of problem and complex theoretical which haven't been structured and happened in daily live such as: the outbreak of various diseases connected with human body and living organism, which analysis various sciences, but until today many references about the unstructured problem of immune system in senior high school in Indonesia was apprehensive currently. The references in senior high school generally oriented of transfer process that has been structured material, there is no ill-structured problem. Commonly, many students completed the worksheet by reading and rewriting the materials in reference that has been used. Anderson & Krathwohl stated that rewriting of materials content to worksheet was categorized lower order thinking processes. Materials repetition in learning processes was hampered the students' HOT.

HOT process is an analytic-based thinking process for linking scientific evidence [19], concluded and constructed knowledge of the concepts which contained in the content by using the sensory to catch on phenomenon [13], delivered the argument of conclusion in the learning context [20], so content and context in references becoming meaningful knowledge for getting HOT. Context relate to the formulation of real problems and topics learned, and real problem solving. Context relate to the ability of teachers to design and use the media in learning, especially the used of references by teachers in the learning process.

Contexts lead of facts or everything in real life that supports the process of constructing learned knowledge, so facts or phenomena became an important part of the learning process. Investigation process of complex phenomena in life required the organization of knowledge through many sources of references resulting in direct interaction with the object studied. The results of the research by Widoretno, Sajidan and Dwiastuti shown that the context has a positive effect on the interest of knowledge in the achievements of learner [21].

3.1. Case 1: Reference Type 1

Figure 1 below shown that the unproportional percentage between every aspect of problem solving interacted with scientific reasoning aspects. The best percentage both of content and context were identify and define. Act and look back lower than explore aspects. Generally, the percentage of content is better than the context. IR (identify-rebuttal), EG (explore-ground), AR (act-rebuttal), LG (look back-ground) and LR (look back-rebuttal) are completely invisible in the delivery process. LC (look back-claim), LG (look back-ground), LR (look back-rebuttal).

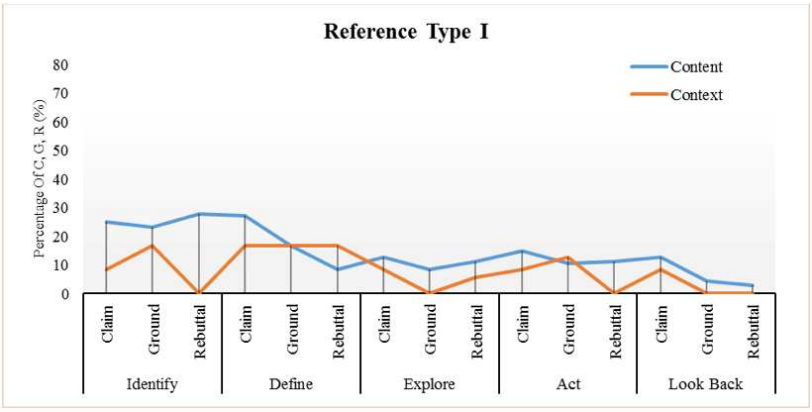

Figure 1. Percentage of interaction problem solving and scientific reasoning aspects based on content and context in reference type I

Based on figure 1, Context can't be separated with content, and pedagogy because it is a unity and independently [22], meaning that between one and the other has a causal linkage, so to develop content, context and pedagogy it's requires a dynamical relationships and cooperation of various elements in the learning process, including teachers, students and reference sources used by teachers and students [23].

Reference sources could be found on various media, in this case, researcher used printing media or books that was generally distributed in Indonesian Senior High school. Based on Biologycal Science Curriculum Study (BSCS), biology knowledge contained of unity, continuity, diversity dan interaction [24], all of the components were one of parts content and context that seen in reference. Book as references consist of any specific material content and context which refer to aim of the learning [25]. The aims that showed in references was associated with the material as content, pedagogy as learning science and context as a way to teach the materials to students contextually [26]. All of the aim in reference lead to curriculum in Indonesian senior high school. So, reference which didn't contain of completely aim was indicated imbalance of content and context.

3.2. Case 2: Reference Type II

Case 2 was studied by using refrence type II. Figure 2 shown a unproportional percentage between every aspect of problem solving aspect with scientific reasoning skills. The lowest aspect was explored the possible strategies both content and context of biology references. Identify the problem aspect and define the problem aspect better than act on and look back or evaluate the strategies. The percentage of claim better than ground and rebuttal. Interactions of EG, LG and LR aspects have not been seen in the delivery processed.

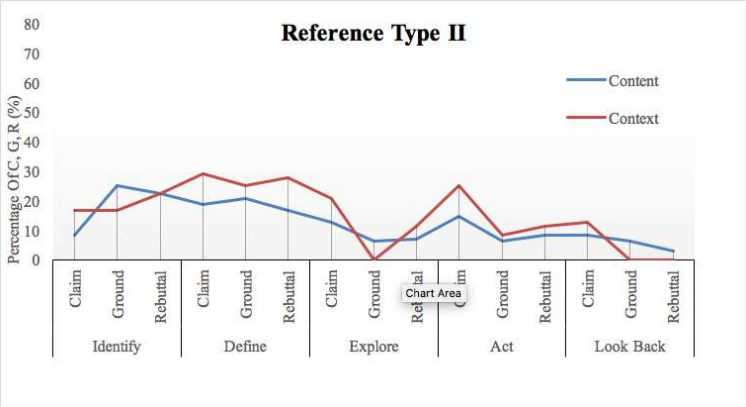

Figure 2. Percentage of interaction problem solving and scientific reasoning aspects based on content and context in reference type II

Imbalance between content, context and pedagogy caused difficulty for teacher and students in order to training HOT, especially problem solving and scientific reasoning skills. Context and content of materials in reference affect the psychology and student abilities to construct of knowledge [27] in order to solve problems [6] and state arguments or scientific reasoning. Content and contexts function in problem solving skills was determined on how motivated students with solving problem aspects that crucial to the learning outcomes [27].

According to the analyze content and context biology references for senior high school in Indonesian, based on interaction of IDEAL problem solving and scientific reasoning aspects, there are imbalance proportion with variance percentages. The lower aspects were Explore and Look back which correlated the ground and rebuttal. Ground or justify is the backing data or evidence for the claim and consists of empirical data or facts that are objective and public to the world. Toulmin Argument Pattern [28] defined data as the fact to be foundation for the claim. Ground and rebuttal has a potential to develop identified scientific reasoning and problem solving from the increase of explore and look back aspects in context and content references.

3.3. Case 3: Reference Type III

Case 3 was identified by using reference type 3, the result shown in figure 3. Figure 3 Shown that conent and context in reference type 3was balanced significant. the varying percentages on the interrelated aspects of solving IDEAL problems with scientific reasoning, as seen in percentage of claim, ground, rebuttal with aspect of I and D content better percentage. Aspects E (explore), A (act) and L (look back) to claim, ground, rebuttal percentages almost equally between content and context, but in general the percentage of content is better than the context. ER and LR are completely invisible in the delivery process. DR, LR, AR, LR are the lowest interaction in content.

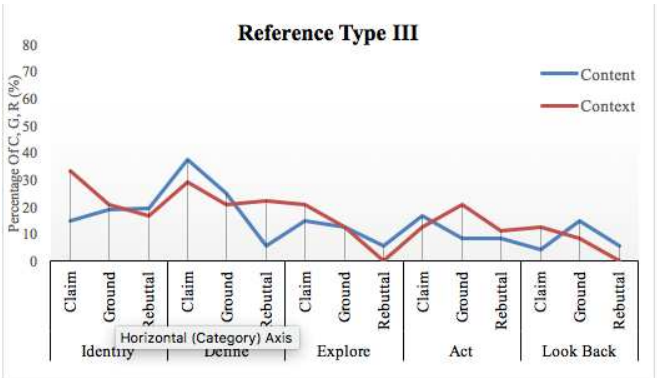

Figure 3. Percentage of interaction problem solving and scientific reasoning aspects based on content and context in reference type III

3.4. Case 4: Reference Type IV

Figure 4 shown the disproportionate percentage between each aspect of problem solving that interacts with scientific reasoning, as seen in percentage of scientific reasoning with content D aspect is better percentage, whereas in aspects I, E, A, and L show a balanced proportion of content and context in reference type IV. The proportion between problem solving aspect and scientific reasoning both content and context is still below 50% in every aspect, the highest interaction is DC aspect. The lowest aspect of reference type IV is seen in interaction R (Rebuttal) with IDEAL aspects both in content and context.

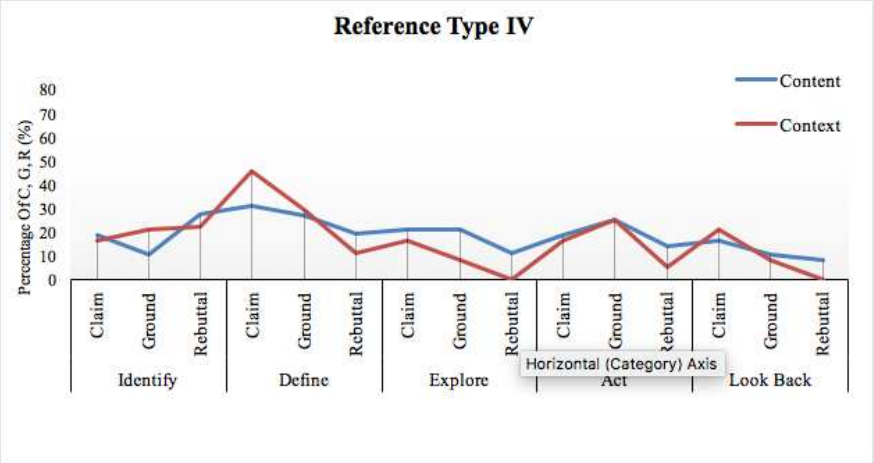

Figure 4. Percentage of interaction problem solving and scientific reasoning aspects based on content and context in reference type IV

3.5. Case 5: Reference Type V

Figure 5 shown the disproportionate percentage between each aspect of solving a problem that interacts with scientific reasoning in both content and context, as seen in percentage of scientific reasoning aspects with aspect I and D content better percentage. Aspects E, A and L to claim, ground, rebuttal percentages vary almost equally between content and context, but in general the percentage of content is better than the context. IR, EG, AR, LG and LR are completely invisible in the delivery process. LC, LG, LR are the least-present in terms of both content and context. Look back and evaluate the strategies have a role to develop the ability of scientific reasoning through the process of thinking by way of interpreting the solution according to the situation and condition [15].

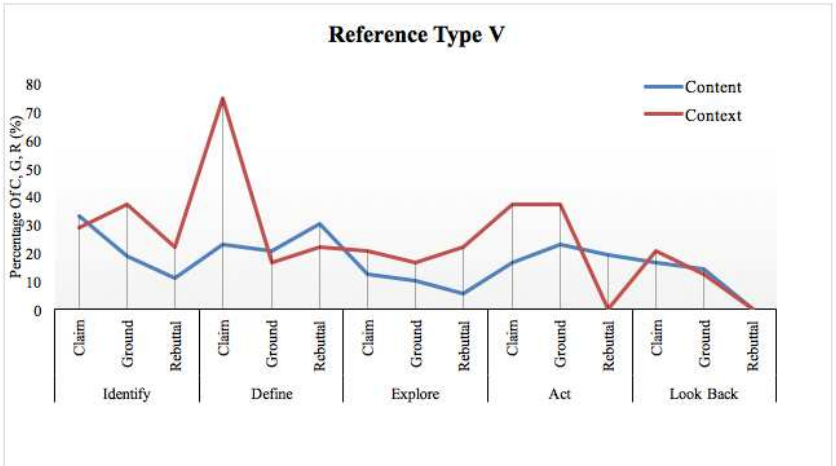

Figure 5. Percentage of interaction problem solving and scientific reasoning aspects based on content and context in reference type V

Reference type V has a composition similar to that of reference type IV. The interaction between the aspects of solving IDEAL problems with the highest scientific reasoning is dominated by DC, while the lowest is found in R (rebuttal) interaction with IDEAL. Aspect rebuttal to IDEAL relates to the final outcome of the problem-solving process in the form of organizational organizations that support or rebuttals against statements based on the identification of scientific facts as well as refutation, exception was contrary to claim [20].

Problem solving aspect based on IDEAL [3] related of identifying processes that done by some activities to search for the root of the problem through the fact of an ill-structured phenomenon [18]. Identify in scientific reasoning ability is concerned with observing activities, asking and interacting with the environment to collect facts from phenomena as the basic explanation of existing problems [21]. Identify aspects produce claim including build upon arguments consisting of IC, IG and IR. The define aspect plays a role in determining objectives and formulating the problem that has been identified. Define affects the determination of the wisdom of the various solutions provided [29]. Define in scientific reasoning acts to increase argumentation based on ground, evidence, warrant and source credibility as DC, DG and DR for correlation of problem solving [20]. The explore the possible strategies aspect is a search for the right reference and alternative strategy with the goal of providing a visual representation of the problem solution [30]. Appropriate strategies are obtained through the reasoning and causal reasoning of alternative solutions [31]. A diverse alternative solution emerges as a form of awareness of the problem's inequality (all problem are not equal) (31). Explore in the ability of scientific reasoning plays a role in analyzing the reason [30], conducting EC, EG and ER.

The act of possible strategies aspect is a step chosen from several possibilities with the highest estimated success among alternative solutions. Act is the result of scientific reasoning ability through the process of causal analogy [31]. The end result of the problem-solving process is an organization that supports or gives rebuttals based on the identification of scientific facts as well as refutation, exception which are contrary to claim [32], conducting AC, AG and AR.

The look back and evaluate the strategies aspect is a review of the steps that have been implemented by looking for potential improvements to obtain a more perfect solution [32]. Look back and evaluate the strategies have a role to develop the ability of scientific reasoning through the process of thinking by way of interpreting the solution according to the situation and condition [1], conducting LC, LG and LR.

4. CONCLUSION

Mastering the problem solving and scientific reasoning aspect for teachers and students on immune system material are influenced by the proportion of IDEAL problem solving and scientific reasoning aspects in content and context of references. The majority of Biology references doesn't required of balance proportion interaction of problem-solving and scientific reasoning aspects. The lower aspect both of content and context was located in aspect explore the strategies and Look back and evaluate for Ground and Rebuttal aspects, conducting EG, ER, LG and LR both of content and context in many references.

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