Comparison of argumentation skill in science and non-science undergraduate students

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Abstract. This research is aimed to evaluate and compare the argumentation skill in science and non-science students. This research is quantitative research which involved two classes including 30 science students who taught human physiology subject and 30 social and humanities students who taught curriculum development subject. Both classes using blended learning with “argueweb” for online learning and debate for offline learning. The data collected from argumentation score using argumentation observation sheet. The data collected then to analyze descriptively and statistically using t-test. The result showed that there are differences between argumentation skill in science and non-science students. There are differences in quality of argumentation in science and non-science students. Science students showed good and clear backing with so many evidences. While non-science students provide strong and arguable warrant. Thus the quality of both science and non-science students argumentation need improvement to achieve better argument and learning outcomes.

1. Introduction

Argumentation means a person's process of seeking knowledge, proving and analyzing information which is then communicated as an opinion to others [1,2]. Someone involved in the argumentation aims to find justification for his beliefs, attitudes, and values so that they can influence others [2]. Argumentation can also be interpreted as a systematic exploration of a theoretical confrontation through the coordination of evidence describing the results of empirical observations or experimental results about natural phenomena [3]. Scientific argumentation is a dialogue between two or more individuals who coordinate facts and theories to provide a deeper explanation of a model, prediction or an evaluation [4,5].

Today arguments are widely used in learning, namely to inform and persuade others to strengthen things. As an example in science learning, teachers provide scientific explanations to students to help them understand the scientific explanations as a reason [5]. The role of argumentation in learning and
student interaction has become a major component in education [6]. Argumentative or collaborative dialogue has proven to be a very effective teaching strategy [7,8] to improve students’ critical skills [9] and handle background knowledge [6]. Education experts begin to believe that the core of the way of thinking scientist is how he is able to present evidence as a basis for arguments or claims related to facts through a premise [6,7].

Research on argumentation in learning has been carried out, such as research on measuring students ‘argumentation skills in inquiry activities by assessing the structure and relevance of students’ arguments in using evidence [6]. Other research about process and quality debriefing in scientific inquiry of biology teacher prospective through argumentation [10]. Several studies have focused on the importance of the discourse of argumentation in building knowledge [7,11], and other research focuses on developing a framework for analyzing the discourse of argumentation in classroom learning [12].

In addition to the above studies, many other studies have been carried out by examining that scientific argumentation skills can be developed to measure more specific parameters, such as: variable depth [13], factual and conceptual [14,15], quality of argumentation [16,17], reasoning [16,18], concept integration [16], structure and relevance [6], science inquiry skills [19,20], self-efficacy [21,22].

After reviewing several studies that has been done before, researchers feel the need to conduct research that aims to compare argumentation skills to science and non-science undergraduate students. Technically, the research was carried out on two different classes, namely science classes which studied anatomy material of human body physiology and non science class which studied curriculum development. Learning in both classes uses blended learning, namely learning activities that are conducted online through "argueweb" and face to face off line learning.

2. Method
This research used quantitative approach by comparing argumentation scores between science and non-science undergraduate students. This research was held in Biology Education department, Universitas PGRI Semarang. Participant were 33 students from science class and 32 students from non-science class were involved in this research. The science class was undergone human physiology subject, while non-science class was taught by curriculum development sub.

Student’s argumentation result then classified in four categories consist of claim (C), rebuttal (R), warrant (W), and backing (B). Claim show support for the standpoint, and warrant is opinion or inference license that support claim, backing provide fact that supporting warrant, and rebuttal provide an exception for argument [25]. Give score for argumentation skill shown as follows: score 1 (if only show claim or rebuttal), score 2 (if only show warrant), score 3 (if show claim or rebuttal followed by warrant), score 4 (if show claim or rebuttal followed by backing), and score 5 (if show claim or rebuttal completed with warrant and backing). The data gathered then compared each other between science and non-science class descriptively. The data also analyzed using anova with the help of SPSS for windows 2.0.

3. Result and discussion
The result of student’s argumentation both in science and non-science class is describes in table 1 below.

| Argumentation subject class | N  | Mean  | Std. Deviation | Std. Error |
|----------------------------|----|-------|----------------|------------|
| Non-science                | 32 | 3.1562| 0.72332        | 0.12787    |
| Science                    | 33 | 2.6364| 1.53741        | 0.26763    |
| Total                      | 65 | 2.8923| 1.22631        | 0.15211    |
Figure 1. The distribution of argumentation pattern of (a) non-science class and (b) science class.

The score of students’ argumentation is in good level with average in 3.15 scores in non-science class and 2.64 in science class. From the table above it can be seen that non-science classes mostly give a good argument in a standpoint compared to science class. Furthermore, distribution of argumentation pattern in non-science and science class is quite different. Science class show more diverse argumentation levels in students compared to non-science class (figure 1). In non-science class, dominantly students give claim or rebuttal completed with warrant to argue the standpoint. As 85% students give claim/rebuttal with warrant, that means non-science students give their support for their choice with strong reason easily. But non-science students have some difficulties with providing fact and information to back up their opinion. It shows 3% students give claim and backing, and 9% students give claim with warrant and backing. Non-science students give their argumentation only focus on opinion they made as result of their thinking process. For curriculum development topic, students respond a standpoint based on their experience. Each individual has differences opinion because of their experiential and analytical–rational thinking, it also depends on their cognitive [26]. They generated idea and give respond with various reasoned opinion [27]. The argument that already chose, generated, and evaluate by themselves [28,29]. Non-science student’s argumentation is lack of backing. Many of their arguments didn’t support by solid information. It seems students likely to give persuade opinion that they believe the best for the problem. They strongly depend on their thinking skill even disregard any relevant information. They know well the topic and give whatever in their mind.

When it comes to science students, there are diverse argumentation pattern. Mostly, student gave claim and warrant in their argumentation as 49%. The argument completed with backing is quite high in 9% and 12% when combine with warrant. But, there are some students who didn’t give any argument as 18%. Some students have difficulty to give an argument about science topic, so they remain silence. Science topic such as in human physiology subject has complex criteria for specifying conceptual understanding [30]. Before accepting human physiology concept, they should master some subject such as human anatomy, animal tissue, and biochemistry. So it needs strongly conceptual understanding. It needs a lot of resources. As to solve the standpoint given, students should know any concept related to that topic. It can be seen they whose not give an argument means they don’t master the main concept.

Science topic is also full of data, fact, theory, hypothesis, and experiment [31,32]. All of them acquire complex cognitive skills [33]. The one who talk about science topic aren’t allowed to show only opinion or argument without any data supported that. It requires strong, valid, and reliable information to support those arguments. An argumentation in science topic must be in line with research and methodology [34]. Furthermore, the claim should be consistent with current research frameworks [35]. That’s why the actual scientific argument should complete by backing. Only few students in science class can provide good argument with backing. But this result is better than non-science students who mostly use warrant to support their argument. This condition shows that science students train to think deeply before saying something. They were taught how to analyze every case and solve that with solid explanation. As in
science environment that closed to methodology and research, every case should be done by certain steps, including gathering information to generate hypothesis or opinion. But unfortunately, not all of the students can do that. So, it needs many progresses especially in learning process to promote argumentation quality of students.

When we compare statistically, there is no difference between the quality of argumentation in non-science and science students with significance level as 0.088 (higher than 0.05) (Table 2). Despite that differences in argumentation pattern, both non-science and science student have same potential to generate a good argument. Even though, both of them need to improve the using of backing to complete their argument. There is big gap between science and non-science topic, when science has empirical approach. But non-science usually used emotion, art, and intuition that depend on human’s thought and feeling. If we see deeply that knowledge of science and non-science class has similarities and connection that both need research even in different ways [36]. That mean, every case or problem in science and non-science need to analyze, requiring acquisition of many informations and generating it into opinion and hypothesis. Further it needs to be proven by certain ways, either research or neither method. When it comes to provide an argument they need to give good supporting information with fact or data, to strength the reliability level of their argument.

Table 2. The comparison results of students’ argumentation in non-science and science class.

|                      | Sum of Squares | df | Mean Square | F      | Sig. |
|----------------------|----------------|----|-------------|--------|------|
| Between Groups       | 4.391          | 1  | 4.391       | 3.012  | 0.088|
| Within Groups        | 91.855         | 63 | 1.458       |        |      |
| Total                | 96.246         | 64 |             |        |      |

From the result above, student more easily to express their argument with warrant or the explanation of thinking without providing any supporting relevant data and information. This result shows that student was not accustomed to prepare well their argument. They feel confident with their thinking and experience so it not necessary to search any good data to support their idea. As reflection to this condition, student should improve their critical and analyzing skill when facing some problems that need them to give an argument. So, good environment of learning must be achieved by introducing student best learning model to promote argumentation skills.

4. Conclusion

Non-science and science students has different argumentation pattern. The non-science students tend to give an argument with strong warrant as 85% of them, but few use backings. That condition is quite same with science students when mostly give argument supported by warrants or explanations based on their own thoughts by 49%. But science students show more backing than non-science students. It looks like some of the science students can express their argument with strong supporting data or information as backing. Besides that, their argument is not different statistically, whereas both of them have same potential to show good quality argumentation.

References
[1] Rigotti E and Morasso S G 2009 Argumentation as an Object of Interest and as a Social and Cultural Resource Argumentation and Education (N. Muller Mirza & A.-N. Perret-Clermont) Ed (New York: Springer US)
[2] Inch S E and Warnick B 2006 Critical Thinking and Communication: the Use of Reason in Argument (Boston: Pearson Education)
[3] Bell P and Linn M C 2007 Scientific argument as learning artefact: Designing for learning from the web with KIE International Journal of Science Education 22(8) 797-817
[4] Suppe F 2000 Understanding scientific theories: An assessment of developments 1969-199 Philosophy of Science 67 102–115
[5] Duschl R, Newton P and Osborn J 2002 Supporting and promoting argumentation discourse in Science Education Studies in Science Education 38 39-72
[6] Macagno F 2016 Argument Relevance and Structure: Assessing and Developing Students’ Uses of Evidence International Journal of Educational Research 79 180–194
[7] Driver R 2000 Establishing the Norms of Scientific Argumentation in Classrooms Science Education 85(3), 287- 312
[8] Kuhn D 1992 Thinking as argument Harvard Educational Review 62(2) 155-178
[9] Osborne J 2010 Arguing to Learn in Science, the Role of Collaborative, Critical Discourse Science 328(5977), 463-466
[10] Hayat M S and Minarti I B 2015 Process and Quality Debriefing in Scientific Inquiry of Biology Teacher Prospective Through Argumentation Proc. Int. Conf. Enhancing Education Quality In Facing Asian Community Universitas PGRI Semarang
[11] Zohar A and Nemet F 2002 Fostering Students’ Knowledge and Argumentation Skills Through Dilemmas in Human Genetics Journal of Research in Science Teaching 39 35-62
[12] Erduran S and Maria P J 2008 Argumentation in Science Education (London: Springer)
[13] Sadler T D 2006 Promoting Discourse and Argumentation in Science Teacher Education Journal of Science Teacher Education 323-346
[14] Jonsson A 2016 Student Performance on Argumentation Task in the Swedish National Assessment in Science International Journal of Science Education
[15] Goldey E S 2012 Biological Inquiry: A New Course and Assessment Plan in Response to the Call to Transform Undergraduate Biology CBE-Life Sciences Education 11
[16] Kim S M and Hannafin M J 2016 Synergies: Effects of Source Representation and Goal Instructions on Evidence Quality, Reasoning, and Conceptual Integration during Argumentation-Driven Inquiry International Science Journal
[17] Rapanta C and Walton D 2015 The Use of Argument Maps as An Assessment Tool in Higher Education International Journal of Educational Research
[18] Acar O and Patton B R 2016 Examination of Learning Equity among Prospective Science Teachers Who Are Concrete, Formal and Postformal Reasoners after an Argumentation-Based Inquiry Course Journal of Teacher Education 41(2)
[19] Lou Y, Blanchard P and Kennedy E 2015 Development and Validation of A Science Inquiry Skills Assessment Journal of Geoscience Education 63
[20] Hunt L, Koenders A and Gynnild V 2012 Assessing Practical Laboratory Skills In Undergraduate Molecular Biology Courses Assessment & Evaluation In Higher Education 37(7)
[21] Sen C and Vekli G S 2016 The Impact of Inquiry Based Instruction on Science Process Skills and Self-Efficacy Perceptions of Pre-Service Science Teachers at A University Level Biology Laboratory Universal Journal Of Educational Research 4(3)
[22] Aydeniz M and Ozbek Z 2015 Assessing and Enhancing Pre-Service Science Teachers’ Self-Efficacy to Teach Science through Argumentation: Challenges and Possible Solutions International Journal of Science and Mathematics Education
[23] Roshayanti F, Suneki S, Wahyuni S and Hayat M S 2017 Pengembangan Keterampilan Berargumentasi Mahasiswa UPGRIS melalui Penerapan Model Argumentative Assessment By Scaffolding Standpoint And Coding (AASSC) Laporan Penelitian Hibah Kompetitif PUPIT, Lembaga Penelitian dan Pengabdian Kepada Masyarakat Universitas PGRI Semarang
[24] Toumin S E 1958 The Uses of Argument (Cambridge: Cambridge University Press)
[25] Verheij B 2005 Evaluating arguments based on Toumin’s scheme Argumentation 19(3) 347-371
[26] Epstein S, Pacini R, Denes-Raj V and Heier H 1996 Individual differences in intuitive–experiential and analytical–rational thinking styles Journal of personality and social psychology 71(2) 390
[27] Dori Y J, Tal R T and Tsaushu M 2003 Teaching biotechnology through case studies—can we improve higher order thinking skills of nonscience majors? Science Education 87(6) 767-793
[28] Baron J, Baron J H, Barber J P and Nolen-Hoekseman S 1990 Rational thinking as a goal of therapy Journal of Cognitive Psychotherapy 4(3) 293
[29] Stanovich K E, West R F and Toplak M E 2013 Myside bias, rational thinking, and intelligence Current Directions in Psychological Science 22(4) 259-264
[30] Driver R and Easley J 1978 Pupils and paradigms: A review of literature related to concept development in adolescent science students
[31] Chi M T, Slotta J D and De Leeuw N 1994 From Things to Processes: A Theory of Conceptual Change for Learning Science Concepts Learning and instruction 4(1) 27-43
[32] Zeidler D L, Walker K A, Ackett W A and Simmons M L 2002 Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas Science education 86(3) 343-367
[33] Penner A M 2003 International gender item difficulty interactions in mathematics and science achievement tests Journal of Educational Psychology 95(3) 650
[34] Erduran S 2007 Methodological foundations in the study of argumentation in science classrooms In Argumentation in science education 47-69 (Dordrecht: Springer)
[35] Driver R., Newton P and Osborne J 2000 Establishing the norms of scientific argumentation in classrooms Science education 84(3) 287-312
[36] Longino H E 1990 Science as social knowledge: Values and objectivity in scientific inquiry (Princeton University Press)