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Students' Integrated Science Process Skills and Argumentation in Basic Natural Science Lecture

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Abstrak

Perkembangan teknologi yang pesat membuat mahasiswa IPS dapat mempraktekkan i-SPS melalui metode praktikum. Penelitian ini bertujuan untuk menganalisis integrated science process skills (i-SPS) dan argumentasi mahasiswa IPS. i-SPS dilatih melalui metode demonstrasi dan metode eksperimen virtual menggunakan simulasi pHET, sedangkan argumentasi dilatih melalui kegiatan debat yang melibatkan kelompok pro (pandangan pseudosains) dan kelompok kontra (pandangan ilmiah). Rancangan penelitian ini adalah metode campuran, aspek kualitatif adalah analisis isi terhadap prestasi belajar i-SPS mahasiswa IPS yang melakukan metode pembelajaran bergilir, sedangkan aspek kuantitatif adalah uji korelasi antara i-SPS dengan pHET dan argumentasi. Rerata skor i-SPS berdasarkan pHET adalah 83,46 dan i-SPS berdasarkan Demonstrasi adalah 55, sedangkan skor rata-rata argumentasi adalah 77,88. Hasil uji korelasi nonparametrik diperoleh r hitung 0,175 lebih kecil dari r tabel 0,404, sehingga disimpulkan tidak ada korelasi antara i-SPS dengan pHET dan argumentasi. Mayoritas mahasiswa IPS sekitar 75% memiliki kategori kombinasi i-SPS yang tidak seimbang menurut pHET dan argumentasi. I-SPS-PHET siswa tidak mempengaruhi argumentasi mereka. Beberapa faktor dapat mempengaruhi argumentasi mahasiswa sosial, seperti pengalaman tentang fenomena, keterbukaan informasi di era digital, dan karakteristik debat melibatkan kelompok pro dan kontra yang memperluas pengetahuan.

Kata kunci: *Keterampilan Proses Sains Terpadu, Argumentasi, Perdebatan, Ilmu Alam Dasar*

Abstract

Rapid technological developments allow social studies students to practice i-SPS through practicum methods. This study aims to analyze the integrated science process skills (i-SPS) and the arguments of social studies students. i-SPS through demonstration methods and virtual experiments using pHET simulations, while arguments through debate activities involving the pro group (pseudoscience view) and the contra group (scientific view). The design of this research is a mixed method. The qualitative aspect analyses the i-SPS learning achievement of social studies students who use the rotating learning method. In contrast, the quantitative aspect is the correlation test between the i-SPS with pHET and argumentation. The mean score of i-SPS based on pHET is 83.46, i-SPS based on the demonstration is 55, and the average argumentation score is 77.88. The results of the nonparametric correlation test obtained that rcount 0.175 is more minor than rtable 0.404. So there is no correlation between i-SPS with pHET and argumentation. About 75% of social studies students have the i-SPS combination category, which is not balanced according to pHET and arguments. I-SPS-PHET students do not affect their arguments. Several factors can influence the argumentation of social students, such as experiences about phenomena, information in the digital era, and the characteristics of debates involving extended groups of pros and cons.

Keywords: Integrated Science Process Skills, Argumentation, Debate, Basic Natural Science

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1. INTRODUCTION

In the society 5.0 era, higher education contributes to training students to think critically in processing digital information to solve various problems in the real world (Brooman & Darwent, 2014; Mason, 2020; Ogunmokun et al., 2020). The roles of education in the society 5.0 era are (i) produce a younger generation whose experts in artificial intelligence (AI) and (ii) to adapt the younger generation to literate information with data support (Bertram et al., 2021; Sharma et al., 2021). This research focused on the second role,

namely training students to solve problems in society using data interpretation. These stages involved integrated science process skills (i-SPS). The goal of the society 5.0 era is the welfare of the wider community, so students need to be trained to communicate the discovery of problem-solving through argumentation. Communication is one of the soft skills needed in social life, so social science students must be trained in argumentation (Aada, 2019; Fukuda, 2020).

The National Oceanic and Atmospheric Administration (NOAA) describes in 1990 to 2019 that there was temperature increased about 1°F every decade. Meanwhile, in 2020 predicted that the temperature will increase by 0.90 degrees from the previous year, and the peak of temperature increase will be in 2030 which can cause the greenhouse effect (L. He et al., 2022; W. He et al., 2022). The greenhouse effect is phenomenon of accumulation danger gas in an environment such as CO_2, methane, and CFC which is produced by human activities in wasteful use of electricity, transportation, beef consumption, and air conditioners/refrigerators and household products containing CFCs (Dong et al., 2021; Hassanien et al., 2022; Xu & Cui, 2021). The greenhouse effect causes temperature increase on the earth which thereby encourages natural phenomena such as droughts, the temperature increases, shifts in rainfall patterns, and floods (Gregory, 2022; Hu et al., 2022). Awareness of protecting the environment is currently needed, especially among the younger generation/ undergraduate students. The environment is ours so we should protect it from damage. Students necessary know what happened in the environment and various strategies for solving several problems of it. Students' awareness on phenomenon of environmental damage can be integrated through Basic Natural Sciences lecture.

The objective of a Basic natural science lecture is to provide a strong foundation for social science students about knowledge of the universe and its contents, so that they can be encouraged to give problem-solving about phenomena in the environment (Ambross et al., 2014; Lo et al., 2021; Maison et al., 2020). This lecture is programmed by social science students, hopefully, they know nature more closely and contribute to solving problems in daily life. The results of the preliminary study explained that the majority of social science students have several habits which can trigger global warming such as using perfume/deodorant containing CFCs, wasting electricity, plastic consumption as food containers, and excessive use of a motorcycle. Based on that finding, social science students should be involved to understand several problems in natural phenomena and solving them through the scientific methods. The scientific method consists of stages to test hypotheses from an empirical phenomenon, through observation or experiment (Castillo, 2013; Subali et al., 2019; Wulandari, 2020). The stages of the scientific method are started by observing phenomena to formulate problems, carrying out experiments, analyzing data, and making conclusions (Anggriani et al., 2020; Subali et al., 2019). The ability of students to apply a series of scientific methods is called integrated science process skills (KPS-t). Integrated science process skills are complex skills that important to be mastered by students (Arantika et al., 2019; Puspita., 2019) including hypothesizing, identifying/ controlling variables, defining operationally, interpreting data, and experimenting. Hypothesizing is a temporary explanation of the formulated problem. Identifying/controlling variables is the identification of response, independent, and dependent variables. Experimenting involves designing procedures, tabulating observations, analyzing data, and drawing conclusions. All of these activities can be trained through experimental learning.

Based on the educational background of undergraduate students, the majority of students took social science in senior high school or vocational school, it was challenging in this research to guide them to practice i-SPS in experiment activities. The preliminary study of 24 undergraduate students stated that only 12.5% of them had carried out experiments in the laboratory because took science in senior high. The majority of social science students

who do not have the experience to experiment in the laboratory causes their i-SPS ability classified as low. This finding is supported by the result of demonstration activities in groups, about 25% of students inappropriate formulating problems, 50% of students gave inaccurate hypotheses and 12.5% of students unable making hypotheses, 12.5% of students unable identifying variables, and 12, 5% of students inaccurate giving conclusions. Social science students' i-SPS need to be trained because through SPS they can apply scientific thinking to solve problems in daily life (Cakir & Sarikaya, 2010), respect other students' ideas (Aktamis & Yenice, 2010), influence creativity (Yildiz & Yildiz, 2021), and make appropriate conclusions (Hodosyová et al., 2015). SPS can train students to think systematically in explaining phenomena from a scientific view so that they can evaluate phenomena that exist in environmental society.

The Phenomena that exist in society can be evaluated from a science and pseudoscience views. The difference between science and pseudoscience is in the aspect of reasoning. Science view is carried out through scientific reasoning or can be proven scientifically, while pseudoscience view through non-scientific reasoning with the main proponent (society trust) so it creates a scientific impression and trusts to be true (O'Neal, 2016; Osborn et al., 2015). The evaluation form of phenomena is packaged in argumentation. A conducive learning environment can encourage the active participation of students in discussions (Abdullah et al., 2012; Ahmad et al., 2015; Amdany et al., 2018). One of which is through debates involving pro and contra groups. The debate process will trigger the emergence of counterarguments between pro and contra groups. Other research stated that inference to a phenomenon is supported by six components of Toulmin's argumentation model, consisting data, warrant, claim, backing, qualifier, and rebuttal (Gabriel et al., 2020). However, in this study, it is limited without a qualifier component, because the qualifier uses the word "perhaps" which implies the possibility that the claim is not entirely true.

Argumentation can encourage students to make decisions based on knowledge (Kim & Oh, 2018; Ozturk & Doganay, 2019; Rahayu et al., 2020). This is important to be trained for social science students, including their contribution providing argumentation about phenomena in the community environment (Humaira & Hurriyah, 2018; Maison et al., 2019). The social science students are not shackled to hoax news that can not be justified. The social science students need to practice giving in-depth argumentation through exploring digital information. The research stated that mastery of technology is an absolute requirement that must be had by students in the society 5.0 era (Cedillo et al., 2019; Prassida & Asfari, 2022). The utilization of technology is humanizing humans, which means that technology is developed based on the community's problems (Bervell & Arkorful, 2020; Wahyuningsih et al., 2020). Social science students must be trained as early as possible to recognize what happened in the community. The education system and society are interrelated, education has a role in making explicit the uniqueness of society so that it should be known by the younger generation (Mason, 2020; Singh, 2019). They can contribute to providing ideas for solving problems that exist in the community. The uniqueness of Indonesian society is very diverse and can not be separated from the phenomenon of belief/myth. Social science students need to criticize each other's myth-based on science and pseudoscience views.

Based on the description of the research background, it is necessary to evaluate the achievement of i-SPS and the argumentation of social science students through the Basic Natural Science lecture. The i-SPS of social science students was thought to affect their argumentation, so it required a correlation test in the statistic. The existence of analysis activities in i-SPS would be expected to affect the social science students' argumentation towards phenomena based on science and pseudoscience views. There were three objectives of this research. The first was analyzing different i-SPS achievements of social science students by using the demonstration method in group activity and the virtual laboratory

method (pHET simulation) in individual activity. The second was analyzing the argumentation achievement of social science students through interactive debate towards science and pseudoscience views. The third was analyzing the correlation between social students' i-SPS in an individual activity and argumentation skills. The social science students' i-SPS and argumentation can support them to face the society's 5.0 era.

2. METHODS

This research applied a mixed method. The quantitative approach was in the form of descriptive analysis which measured the achievement of the i-SPS components (mean and SD) after rotation of the practicum method (from demonstration to virtual lab), while descriptive analysis which measured the achievement of argumentation (mean and SD). It also measured the difference in the number of students in the pro-group and contra-group who reached specific argumentation (levels 1, 2, and 3) after conducting an interactive debate. Then quantitative approach in the form of correlational analysis can be carried out to test the effect of students' i-SPS on their argumentation skills. While the qualitative approach used is in the form of observation and the process of content analysis of students' i-SPS and argumentation, so that they can interpret the data in depth.

The population of this research was 56 social science students of accounting education in the 2019 class of Faculty of Economics, Universitas Negeri Surabaya. The technique used to get the research sample was cluster random sampling. The sample of this research was 24 students, with details of their education background of senior high school/vocational school, about 21 people took social science major and 3 people took science major. This research was conducted on social science students who programmed basic natural science as a compulsory course. Data in this research were i-SPS and Argumentation. Students' i-SPS was collected by experiment report after doing demonstration method and virtual experiment method using pHET. Students designed experiment reports based on students' worksheets, which has categorized into open instruction for demonstration activities and guided instruction for the virtual experiments using pHET. Those worksheets about how to do the transition from open to guided instruction trained components of i-SPS (Arslan, 2014). The i-SPS refers to several components developed by Padilla and Okey (1983) consist of hypothesis, identifying variable, operational defining, designing investigation, and graphing and interpreting. This research only used 3 components of i-SPS which have the potential to be trained for social science students namely hypothesis, identifying variable, and designing investigation. The scoring guide of i-SPS is shown in Table 1.

Table 1. The Scoring Guide of I-SPS Components

Components of Integrated Science Process Skill	Sub-Components of Integrated Science Process Skill	Max Score
Hypothesis	Formulating problems	10
	Making hypothesis	15
Identifying Variable	Identifying independent variable	5
	Identifying dependent variable	5
	Identifying response variable	5
Designing Investigation	Making experiment procedure	10
	Tabulating data	10
	Analyzing	25
	Making conclusion	15

Students' argumentation was collected by the interactive debate, which exists pro group (pseudoscience view) and contra group (science view). Debate forms were developed open opportunities for students to collect information before the debate was held and guide how to argue in the pseudoscience view and scientific view. However, this research used 5 components of Toulmin's argument (data, warrant, claim, backing, and rebuttal) with a scoring guide in Table 2.

Table 2. The Scoring Guide of Components Completeness in Argumentation

Components Completeness in Argumentation	Level/ Score
Claim	1
Claim and Data	2
Claim, Data, and Warrant	3
Rebuttal, Data, and Warrant	

This research used descriptive analysis to get the mean score and standard deviation of i-SPSS and argumentation, so we can interpret its category. This research also used a non-parametric correlation test in statistics namely the spearman rank-order correlation because the data were not distributed normally. It was conducted on SPSS 20.0 for windows. The perquisite test was conducted including normality of i-SPSS Data and Argumentation Data.

3. RESULTS AND DISCUSSION

Result

Basic natural science, which is one of the studies of the nature of science and its development, is able to provide an overview to social science students about scientific method and how the scientists work in developing knowledge. In a series of scientific methods involving i-SPS components, The social science students practiced it through demonstration activities in groups and virtual experiment activities in individuals using pHET. The Mean score of i-SPS by PHET (83.46) was higher than the demonstration (55). Demonstration activities are classified in open instruction which has not maximally trained social science students' i-SPS students. Based on this evaluation, virtual experiment activities in individual using pHET Simulation which has characteristics guided instruction was required to apply in basic natural science lecture. The result showed the percentage number of students who achieved the maximum score of i-SPS when did learning transition from demonstration method to pHET virtual experiment method, in Figure 1.

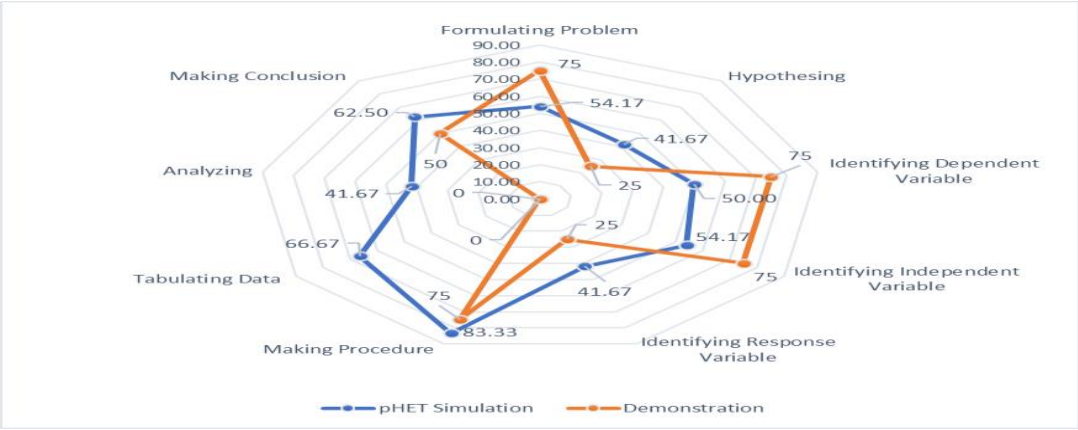

Figure 1. That Percentage Number of Students Who Achieved The Maximumscore of i-SPS When Did Learning Method Transition

Virtual experiment activities using pHET in an individual can prepare the social science students to practice maximally on i-SPS components. This finding was supported by the Figure 1, there was a higher shift in the achievement of the maximum score of i-SPS by demonstration method to virtual experiment method using pHET, such as hypothesize component (25%; 41.67%), identifying response variable (25%; 41.67%), making procedures (75%;83.33%), tabulating data/observation (0%;66.67%), analyzing (0%;41.57%), and making conclusion (40%;62.50%). The social science students' experience in practicing i-SPS component individually has an impact on their self-explanation, thus encouraging them to do meaningful learning.

The learning and teaching can encourage students to reveal argumentation which is through interactive debates between the pro (pseudoscience view) and contra (science view) groups. The phenomena in daily life can be evaluated by science and pseudoscience views. The scientific view evaluates phenomena based on the supported data as empirical evidence, while the pseudoscience view evaluates phenomena based on beliefs held by the community so it is believed to be true. The results of descriptive analysis in statistics and details on argumentation level of the social science students after doing interactive debate of phenomena which to be encountered in the environment in Figure 2.

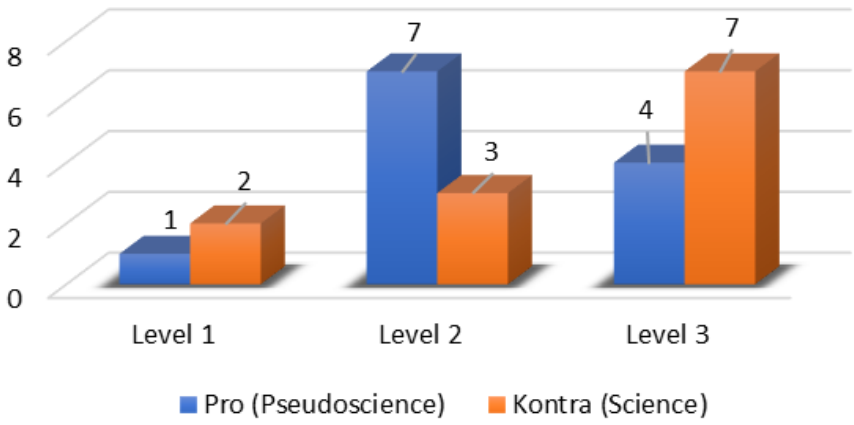

Figure 2. The Number of Students Who Have Argumentation Level Based on Their Contribution as Pro and Contra in Debate

The number of social science students about 11 people were able to reveal argumentation on level 3 involving claims/rebuttals, data, and warrants. The number of social science students about 10 people have argumentation on level 2 involving claims and data, while only 3 students have argumentation involving claims only. It proved that interactive debates that exist between pro/pseudoscience and contra/science groups can encourage social science students to evaluate phenomena in depth. Social science students actively communicated their critical thinking about the myths in society. They argued divided into science and pseudoscience views that can provide insight to them that studying phenomena needs to be balanced with an open-minded. A sampling of the debate on myths in Table 2.

Table 2. Sampling of Students' Argumentation Based on Different Views

Myth	Students' Argumentation	
	Science View	PseudoScience View
Abstinence from	Student NFZ: Catfish contains many benefits, that are low calories, source	Student REA: Residents violate this taboo who will have itchy/white

Myth	Students' Argumentation	
	Science View	**PseudoScience View**
eating catfish for Lamongan residents	of protein and vitamins *(data)*, so it can be consumed *(rebuttal)*	spots on their skin *(claims)*
	Student MSL: Depend on the person who consumes catfish *(claims)*, because allergic reactions (itchy spots) depend on each individual *(data)*	Student NA: This taboo has origins *(warrant)* and is attached to Lamongan residents *(data)*, so they don't eat catfish *(claims)*
	Student RA: Depend on the belief *(claim)*, which has an impact on the body's response when consuming catfish *(warrant)*. Excessive worry response can affect in the occurrence of things to be believed (itchy/white spot allergy) *(data)*	Student EDPS: The origin of the catfish in the ancient period *(warrant)* as an animal was respected by Lamongan residents because the catfish was saving the lives of historical figures *(data)*, so they did not eat catfish *(claim)*

Based on Table 2, it showed that the majority of students use data and/or warrants to support claim/rebuttal (level 2 and 3). The interactive debate presents groups of pros and contra which have proven successfully in directing social science students to provide higher-level arguments about the myths that develop in society as local wisdom. Learning by involving local wisdom provides several advantages, that are (i) fostering students' caring attitudes toward surrounding environment, (ii) enhancing students' literacy skills, and (iii) students' motivation in learning. Based on that study, it can be explained that interactive debate provides an opportunity for social science students to communicate their argumentation which involves inductive thinking processes through the supported data, so they can evaluate phenomena by pseudoscience and scientific view. It is necessary to do a correlation test between i-SPS by pHET and Argumentation. This study used a non-parametric correlation test, namely the spearman rank-order correlation, because the data were not distributed normally. The correlation coefficient r calculated = 0.175 is smaller than r table = 0.3882 (sig 0.05, N = 24), it can be concluded that there is no correlation significantly between i-SPS and argumentation. Based on data analysis, it shows Thet the students' i-SPSS did not affect their argumentation. This finding was contrary to a previous study that concluded that science process skills can be increased significantly through learning, which is explicit argumentation activity (Gultepe & Kilic, 2015; Ping et al., 2020). The opposite finding in this study was caused by the educational background of social science students which could affect the experience of implementing i-SPS. While characteristics of myths phenomena were familiar to social science students so that they developed in-depth argumentation based on science or pseudoscience views.

Dicussion

Demonstration activities are classified in open instruction which has not maximally trained social science students' i-SPS students. it was supported by this research finding that a high percentage number of social science students who did not get the max score of i-SPS. The social science students applied the scientific method for the first time to do experiment in demonstration activities. This is in line with the research that stated science process skills were influenced by how long the i-SPS is applied in classroom learning (Arantika et al., 2019; Aydogdu, 2015). Teaching and learning transition was required, because if open instruction was directly applied, there would be several obstacles such as difficulties in formulating problems, hypotheses, and identifying variables (Arslan, 2014).

The social science students' experience in practicing i-SPS component individually has an impact on their self-explanation, thus encouraged them to do meaningful learning. This is in line with research that concluded self-explanation positively affects the achievement of declarative knowledge through the individual contributions of students to explain steps, apply and solve problems (Fadlelmula et al., 2015; Yang et al., 2020; Zee & Koomen, 2016). The virtual experiment activity using pHET was carried out individually through a guided instruction strategy, and succeeded in directing i-SPS of social science students. Guided instruction has characteristics of problems and ways/meanings to be given by the lecturer, while the answer is open which gives the opportunity for students to explore information by digital literacy (Kuala, 2020; Margunayasa et al., 2019).

In general, i-SPSS trained the social science students to think inductively in evaluating the phenomena of fishermen died because of being electrocuted by electric shock fishing rods in the river. Students had succeeded in analyzing empirical evidence as experimental data, so they concluded that river has the ability to conduct electricity because contains solute particles/ions. Science process skill provides an opportunity for students to construct a strong conceptual framework and apply their knowledge in everyday life (Maison et al., 2019; Servitri & Trisnawaty, 2018; Subali et al., 2019). The role of technology provides virtual laboratory applications has a positive impact on social science students to implement i-SPS. Other research concluded that integrating technology in learning can enhance active interaction, self-confidence, motivation, and hands-on experiences (Clausen et al., 2021; Sadaf & Johnson, 2017). Technological support has provided a solution to the impossibility of individual social science students carrying out wet laboratories (Atkin et al., 2015; Reyes et al., 2017).

Teaching and learning based on argumentation can train the social science students to develop knowledge through evaluating phenomena by pseudoscience and scientific view. It is supported by open-access information in the digital era which encouraged students to understand deeply phenomena, thereby providing insights to be applied in social life (Gürgil, 2018; Hayden et al., 2015). The same finding that knowledge and reasoning are not correlated with argumentation skills (Songsil et al., 2019). So it can be concluded that the majority of social science students do not have education background in science who can explain the phenomena by supporting open-access information through the internet and students' experiences in the environment. Digital literacy skills are a prerequisite for an effective learning process involving information management and critical thinking (Rizaldi et al., 2020; Sánchez-Cruzado et al., 2021).

The social science student who initially did not understand the phenomena by scientific view, but through digital literacy student NAB was able in-depth thinking the effect of Earth's gravity on the fallen lizard because of spatula foot. Using information technology in learning is not only improving academic achievement, but also involves students to analyze problems and solving them so they are classified as successful people's lives in society life (Asad et al., 2020; Kivunja, 2015; Rizaldi et al., 2020). This happened to social science students who have ability to explain phenomena by pseudoscience and scientific view. Group 1 took the myth about "bleeding wounds can heal with our saliva". Student FA gave argumentation by pseudoscience view, on details "the ancients have simple thoughts, so they took initiative to smear their saliva on the wound (data) and miraculously healed (claim)". Meanwhile, student NAF revealed argumentation by scientific view, on details "Not all of the human mouth is clean/ hygienic (data) especially people in the past did not know toothpaste (warrant) so that if they smeared wound with saliva, it large potential to be infected(claim)". Student FA has argumentation on medium category and i-SPS on very low category. NAF has argumentation on high category and i-SPS on medium category. This proved that the existence of pro group and contra group in debating myth phenomena can

encourage both groups to develop in-depth argumentation even though the majority of students have education background of social major. The in-line finding is that teaching arguments to students with low prior knowledge can be done through contradictory conditioning that can lead to rising counterarguments, so constructing knowledge through discovery process and increasing conceptual understanding in science learning (Faize et al., 2018).

4. CONCLUSION

Social science students had better argumentation skills than i-SPS through basic natural science courses, but there were not correlated significantly. Integrated science process skills (i-SPS) were trained to the social science students by virtual laboratory method (pHET) had been higher mean score than demonstration method. Interactive debate existed pro and contra groups which can encourage social science students to actively contribute by providing arguments. The factors that influenced the social science students to successful revealing argumentation which were: experience with phenomena, digital disclosure of information, and the characteristics of debates that present pro and contra groups to expand knowledge. The future study will be expected to be able take natural phenomena as topic of interactive debate for social science students based on science views while still existing pro and contra groups.

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