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Effectiveness of Epistemic Beliefs and Scientific Argument to Improve Learning Process Quality

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The formation of scientific arguments by involving constructivist epistemic beliefs will produce deeper knowledge. This study uses a quasi-experimental research method involving 200 students from the science study program, namely biology, chemistry, physics, and mathematics at a public university in Bandung. In the experimental group, students were divided into several groups based on the results of demographic analysis, including absolutists, relativists, and evaluativist. Furthermore, intervention was given to explain the criteria for scientific argumentation and instructions for scientific argumentation. The control group did not experience the division of roles and was not given intervention. The results showed that students in the experimental group produced scientific arguments and carried out the learning process better than the control class. The increase in the quality of the argumentation is marked by the number of alternative ideas and thought experiments used in the argument. In detail, of the three groups of students, the evaluative group was more critical and could generate more new ideas when discussing learning topics. In addition, evaluative groups are also more reliable in solving problems correctly. The relativist group shows a less critical and less confident attitude when interacting with others. The implication of this research is that scientific argumentation instruction can be used as an alternative in understanding conceptual and increasing students' epistemic beliefs.

Keywords: epistemic belief, scientific argumentation, learning process quality, learning

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INTRODUCTION

Scientific argumentation is a statement used to convince or strengthen an idea by including various elements, namely claims, data, evidence, guarantees to strengthen the hypothesis and reinforced with alternative opinions to strengthen the initial claim (Jin & Kim, 2021). Arguments can be used to strengthen new concepts, findings, or theories through critical discussion with various considerations from several people. The result will produce a concept that is stronger, more complete, or even vice versa (Jones, 2014; Lee et al., 2016; Lin & Tsai, 2017). Scientific argumentation should become a general activity that must exist in the learning process. The learning process is a knowledge construction process that actively involves students, so that scientific argumentation becomes an important component in the learning process (Noroozi & Hatami, 2019; Shemwell & Furtak, 2010).. So, the scientific argument must meet scientific standards, i.e. an argument can be said to be a scientific argument if it has scientific components including claims, evidence, guarantees, theories, hypotheses, and counter explanations that strengthen the claims (Erduran & Kaya, 2016; Jönsson, 2016).. Scientific arguments are used to understand more deeply about a concept or test concepts, as well as strengthen existing concepts (Bathgate et al., 2015; Hadianto et al., 2021b).

Argumentation has several benefits in the learning process, one of which is strengthening students' understanding of the concept or material being studied. (Ford, 2012; Shemwell & Furtak, 2010) However, in practice, not all students are actively involved in scientific argumentation in the classroom. Assertive students tend not to be too active to involve themselves in presenting their arguments during the learning process (Clayton & Gautier, 2006; Hadianto et al., 2022). This is a challenge for teachers so that all students with different characters can take a role in the construction of knowledge, one of which is by presenting arguments. Therefore, various methods are used by the teacher to actively encourage students to want to argue. However, it should be noted that if this is done in a coercive manner, it will make students uncomfortable during the learning process (Ballenger, 1997; Bathgate et al., 2015). So, we need another alternative that divides students to stay involved in expressing their ideas, but still according to their interests. One of them is by dividing the proportion of roles in carrying out the scientific argumentation process so that students understand the concept or material in depth.

In presenting an argument, some students may reject an understanding that is contrary to their understanding. This happens because students already have strong prior knowledge so they do not want to change the concepts they already understand. In fact, differences in beliefs or points of view are indispensable in forming strong conceptual knowledge. Beliefs about a concept are called epistemic beliefs. Epistemic belief is a student's belief in a knowledge, concept or material. This knowledge belief can also be influenced by other individual differences variables that cause differences in views between students (Casas-Quiroga & Crujeiras-Pérez, 2020; Ferguson, 2015). Researchers refer to the term epistemic from epistemological because epistemic refers to students' beliefs about a knowledge (Clayton & Gautier, 2006; Ford, 2012).. This epistemological belief has a very important role in the learning process because through epistemic belief students can be actively involved in expressing their ideas according to their beliefs. This process can facilitate students to solve problems as well as strengthen or refute their current understanding. Thus, epistemic beliefs are useful for problem solving, understanding debatable information, and conceptual change (Gibson, 2008; Loper et al., 2017).

The students' epistemic beliefs have a strong correlation with the students' involvement during the argumentation. Students who have the belief that knowledge is certain and unchanging tend to avoid scientific arguments because arguments will raise concerns about their beliefs about a concept (Gilles & Buck, 2020; Heng et al., 2015).. However, students who view knowledge as dynamic and continue to develop have better epistemic beliefs or are also referred to as constructivist epistemics. Students who have constructivist epistemic beliefs can produce more complex arguments because they use the development of their epistemic beliefs, in contrast to students who only have epistemic beliefs (Duschl & Osborne, 2002). Epistemic belief assessment is carried out based on the levels, namely absolutist, relativist, and evaluative. The belief of students who have constructivist epistemics can provide alternative theories or other evidence to strengthen their arguments (J. Osborne, 2005; Yang et al., 2016).. These types of students can face the claims of others with strong reasons and evidence.

Epistemic beliefs are related to conceptual change. Students who have the view that knowledge is something that is dynamic, flexible, and changing will make it possible to change students' understanding of concepts based on scientific findings (Ferguson, 2015; Lin & Tsai, 2017). This indicates that students who have constructivist level beliefs can be more receptive to scientific explanations. This epistemic ability improvement can be done by the teacher by involving students in scientific argumentation debates. One of them can be done by designing scientific argumentation instructions. Based on previous research, instruction can effectively organize scientific argumentation activities in the learning process (Ballenger, 1997; Bathgate et al., 2015). Students often have difficulty in making scientific arguments, but students' argumentation skills increase through scaffolding or instructions. Instructions can be a guide for students in positioning themselves when the argumentation process is carried out. For example, by dividing the roles of the pros and cons of a concept or material in a scientific debate.

Previous research has proven that scaffolding can improve students' argumentation skills. A conditioned learning environment will encourage students to argue in the learning process. One component of scientific argumentation instruction that is considered effective in improving the quality of students' arguments is an explanation of the criteria for scientific argumentation. Students through scientific argumentation instruction can evaluate their own arguments with logical, economical, coherent, and comprehensive criteria. So, instruction on making scientific arguments can improve the quality of students' arguments while at the same time promoting the material or theory being studied. Learning conditions that support students in building scientific arguments are learning environments that provide opportunities for students to engage in scientific dialogue to understand concepts or theories, use evidence or facts when arguing, and are given the opportunity to predict, analyze, conclude, and consider evidence.

Based on this explanation, this study aims to study the effect of epistemic level and the quality of argumentation on learning process quality. This study used an experimental design which was divided into two groups. The experimental group received an explanation of the criteria for scientific argumentation and the control group did not receive an explanation of the criteria for scientific arguments. The difference between previous research and current research is that the current research focuses on the effect of epistememic beliefs and instruction on scientific argumentation on the quality of arguments and the quality of the learning process. In addition, based on the theory that scientific argumentation is a social process, the researchers also studied whether this instructional intervention could encourage students' involvement in making arguments and could promote learning of conceptual material or make a shift towards conceptual understanding. Conceptual shift is the renewal of previous knowledge. So, although this study focuses on the intervention of argument criteria and epistemic beliefs on the quality of arguments and the learning process, the researcher also studies student learning outcomes. So, it can be concluded that, whether epistemic beliefs and criteria for scientific argumentation can facilitate students to be better able to use alternative points of view so as to create opportunities for students to modify students' initial conceptions.

METHOD

Participants and Design

This study used a quasi-experimental research method with the division of the experimental group and the control group. This study involved 200 students from several science study programs at a private university in Bandung. The students involved were students in the first semester (50%), semester 2-5 (30%), and final semester (20%). Participants consisted of women (70%) and men (30%). Participants in the experimental group were divided into three roles, namely absolutist, relativist, and evaluative. GPA between two group is not far different (M exp = 3.40, M manage = 3.35, t (82) = -0.76, p = 0.48). The experimental group was given an explanation on how to make quality scientific arguments, while the control group did not accept it. Both groups learn in the online system through the campus online learning portal.

Materials and Procedures

This research went through several procedures, first of which students were asked to fill out an online survey. Students fill out the survey takes about 30-50 minutes. The survey consists of several questions that are classified into four groups, namely questions about the demographics of students, the tendency to argue, epistemic perceptions to see the desire and expertise in debating. This survey is used as a basis for grouping students into epistemic groups according to their desires and expertise in debating (Gibson, 2008; Heng et al., 2015). Students are divided into 3 roles when carrying out debate arguments during the learning process. The three roles include absolutist, relativist, and evaluative (J. F. Osborne, 2010),. The division of roles is not all based on desire, but also based on the characteristics of students in the learning process. Absolutists see knowledge as something constant and absolute certainty. The relativist sees knowledge as something simple by accepting it from various theories. Thus, the relativist views that a particular theory and the opposite theory can both be true. Evaluativist see knowledge as something dynamic. The idea of authentic knowledge is little recognized because it is based entirely on the evaluation of facts, evidence, warrants, and other alternative theories that support the concept (J. F. Osborne et al., 2016). Of the three types of epistemic beliefs, evaluativist are the group with the highest knowledge compared to absolutists and relativist.

Measurement of epistemic beliefs is based on an assessment of 5 domains including taste, aesthetics, values, scientific physical world, scientific social world. The instrument used to assess each domain consists of 15 items. Responses are used as the basis for grouping students into 3 types of epistemic beliefs (Shemwell & Furtak, 2010; Stark et al., 2009). The following are examples of items on the epistemic scale of measurement: John believes in one theory about the basics of atoms, Dean believes in another theory about the basics of atoms. Students are asked to choose one option, among a) only one is correct, b) both can be true, but one can be true, and c) both can be true but one cannot be truer than the other. The validity of the instrument is carried out empirically by comparing the results of the questionnaire and direct interviews, obtained 80% are considered to have similarities, and 94% have adjacent levels. So, this instrument meets the criteria of validity. To see the tendency of students in debating, the researcher used a questionnaire with 26 items using a linkert scale. 13 statement items like arguments and 13 statement items avoid arguments. The argument preference component describes the interest and pleasure in arguing and the avoidance component describes the anxiety to argue. Internal consistency on this scale shows a preference component of 0.93 and an avoidance component of 0.90, and reliability test (0,91-0,98). So, it can be judged that this instrument meets the criteria for use.

Online training and discussion

The survey was conducted online. Training and discussions to hone students' argumentation skills are guided by scientific argumentation instructions by asking students questions. Example: Instructions for discussing two objects with different weights being dropped on the ground. Chicken feathers and a table tennis ball are dropped in a plastic tube 2 meters long and filled with air. Which object hits the ground first? Would the result be the same if done in a vacuum and provide your arguments. Online discussion is used to discuss the given problem and students take notes to make their arguments. Students are made in pairs and each pair makes notes to complete each separately first then comments on their partner's notes (agree or disagree) and give reasons and arguments. Next, each pair discusses to formulate the best argument in solving the problem. Students who are in the experimental group are given an explanation of the criteria for scientific argumentation a) linking variables, explaining causality, making claims that are strengthened by facts, explaining facts and counter examples, and providing alternative theories. After being given the intervention, each group was given the same question to see the strength of the arguments of each experimental and control group.

Scientific Argument Assessment

To assess the students' argument notes, the researcher used an assessment rubric to measure its suitability with the criteria for scientific argumentation (Mercan, 2012; Muis, 2007).. The criteria used are that there are two variables, using conceptual theory, there are efficient reasons, and causal mechanisms. Arguments are scored using the 5-point Linkert scale. Starting from not mentioning variables to describing causal mechanisms. Point 4: students consider, integrate, elaborate ideas. Point 3: Inadequate integration due to inconsistency, Point 2: some ideas are not elaborated, Point 1: one or two ideas are not elaborated, Point 0: students' arguments cannot be identified by their components. In addition, researchers also see the results of learning. Is there a conceptual shift, is there an increase or decrease in misconceptions after the learning process is implemented?

FINDINGS

In the research results, the researcher presents quantitative analysis in the form of statistical processing results and qualitative analysis to reveal more research findings

Quantitative Analysis

Researchers present the effects of the intervention through the results of statistical processing first and then supported by the results of qualitative analysis. Overall, from 188 note discussion arguments resulted in M = 8.20 per group, SD = 4.45. There are 21 records generated from the intervention process. Argument notes were scored by two raters each. Variations on the results of the arguments on the discussion notes were resolved through joint discussion. From the results of the assessment, there is a correlation between the 2 raters who are between .87 to .97. The processing results are considered for the lower limit reliability level. Different analyzes of the two raters produced differences that affected the level of data reliability. Based on the measurement results, the level of reliability on the epistemic belief also meets the criteria (percentage agreement = 0.80).

In table 1, the average and standard deviation of the results of student discussions are presented. Based on the sample as a whole, it was found that on average students used research quotes which were still few, but students were more dominant in using their own exploration of thinking (M = 0.50). So, in general, students strengthen their arguments with research or previous studies with a percentage of more than half (M = 0.58). Almost the same value is shown in the ability of students to consider alternative ideas (0.55), and contradictory theories (M=0.52). Students get an average value of the ability to develop arguments (M = 1.80). Students from the intervention were able to come up with many ideas, but they did not elaborate on them. The students showed the interaction score between students (M=2,30).

Table 1
Means (standard deviation) of variable results

Result	Total	Experimental	Control
Argument features			
Expounds causal mechanism	2.50	3.02	2.41
	(0.87)	(0.84)	(0.87)
Experiments	0.15	0.15	0.20
	(0.52)	(0.40)	(0.65)
Supposed experiments	0.50	0.71	0.33
	(0.89)	(1.21)	(0.50)
Alternative ideas	0.55	0.70	0.39
Argument growth	1.80	2.07	1.05
	(0.91)	(0.90)	(0.74)
Communication			
Disputes	0.52	0.58	0.52
	(0.67)	(0.65)	(0.70)
Collaboration score[a]	2.30	2.41	2.14
	(0.92)	(1.02)	(0.80)
Change in fallacies[b]	−0.07	−0.04	−0.12
	(0.45)	(0.50)	(0.40)

Note: Based on person ratings (Listwise n = 200). aScore is the identical for each individuals of every institution. b A poor rating shows a lower in fallacies (variable coded 1 for lower, +1 for improvement, and zero for no change).

Furthermore, the researchers compared it with the experimental and control groups. Table 1 shows some of the variation between the two groups in each individual. Researchers process data using SPSS to see the level of significance, calculate probability values and test statistical hypotheses. Statistical processing needs to be done using a multilevel model because the student scores are not independent (note that the dialogue arguments are affected by each other). The stratified model aims to control the results of the effect test at one dyad. In statistical processing, the result scores for each epistemic belief (absolute, relativist, and evaluative are involved in processing the stratified model at the individual level. Based on the results of statistical processing, the results of the intervention test in the experimental group are presented below. Interventions explain the criteria for scientific argumentation and distribution). the role in presenting scientific arguments has been proven to have a positive impact, the following specifically include:

a) Students who accept the explanation of the criteria for scientific arguments become more dominant in using their thought experiments in arguing t (75) = 2.12, $p < .05$. The intervention in the experimental group was able to increase the ability to argue about 88% from an average of 0.33 increased to 0.70
b) Students in the experimental group considered more alternative ideas t (75) = 1.97, p .05. This means that students who get the intervention are able to involve more ideas (0.70 versus 0.39).
c) The arguments of students in the experimental group are more qualified t (75) = 2.50, p = 0.01. The average result of the students' argument development was 1.05 in the control group and 2.08 in the experimental group out of a total of 5 scales.

This improvement in quality indicates that students who receive an explanation of the criteria for a quality scientific argumentation are better able to consider many ideas and are able to describe it in detail.

Based on the results of data analysis, no significant difference was found between the causal mechanism group and the interaction group. To find out whether there was a shift in conceptual understanding, the researcher looked at the coding data to determine the level of misconception, decreased, increased or remained (Erduran & Kaya, 2016). Based on the results of statistical processing, there was no decrease in the level of students' misconceptions t (75) = 1.0, p = 0.33. Researchers set the criteria for conceptual shift quite strictly, it was found that only 13% of all samples experienced misconceptions. The experimental group was more significant in adopting the answers. On average they were able to answer one problem out of two problems about dropped objects, t(75) = 2.70, p < 0.

Based on the results of the analysis, overall, the interventions carried out were able to make students use more complete scientific argumentation criteria in their discussion notes and arguments. The intervention is also able to improve the ability of conceptual understanding (Yang et al., 2016). During the intervention period, students also conducted experiments at home to answer a given problem with a score (M = 0.15). Experiments conducted by students at home found no significant difference between conditions t(75) = -0.70, p > 0.05. The researcher uses a scientific truth rating scale to see the effect of epistemic beliefs. Table 2 with sample proportions for each role of epistemic belief 50% evaluative, 30% relativist, and 18% absolutist. Based on these data, there was no significant difference between the experimental and control groups at the epistemic confidence level = 0.15, p = 0.32.)

Table 2
Composition of epistemic beliefs in each group

Positioning	Entire sample		Group			
			Experimental		Control	
	n	%	*n*	%	*n*	%
Absolutist	28	18	14	15.0	9	10
Relativists	60	30	34	35.0	23	24.0
Evaluativis	100	50	53	54.2	58	60.0
None	2	2	2	2	5	5.1

Notes: Of the a hundred contributors, did now no longer entire the survey (n = 198). a No modal cost throughout items.

Based on the results of the analysis, it was found that there were several effects of the students' epithemic beliefs on the ability of scientific argumentation and the learning process. Here are some research findings regarding the influence of epistemic beliefs.

a) The group of evaluative students displayed different ideas from their partner t(75) = 2,20, p < .05, compared to the group of absolutist students. The average ability to present ideas in the absolutist group is 0, while the evaluative group is 0.45. The ability of the relativist group was in the range between the two groups (M=0.36) but not very significant.

b) The value of the interaction ability of the relativists group is lower than the other two groups. The relativist score is in the range of 0.5-0.8. This value indicates that this group is not too involved in the debate, they tend to issue a statement agreeing or not

c) From the results of the study, the relativist group did not seem comfortable in debating. This is in accordance with the theory which states that students who do not have constructivist beliefs tend to avoid debate because they do not have a strong-schemata.

Based on these findings, the researcher conducted an analysis on the relativist group. The relativist group has lower argument ability than the other two groups. These findings are based on the results of one-way analysis of variance (2.91) = 3.75, $p < 0.05$. In the aspect of misconceptions, the evaluative group experienced a decrease in the level of misconceptions $t(72) = 1.50$, $p = 0.14$. The evaluative group resulted in a decrease in misconceptions because this group got exposure to scientific arguments that involved many alternative ideas, so that they were better able to construct their knowledge. The evaluative group had significantly better scientific argumentation skills than the absolutist group 2(1) = 8.80, $p = .004$ based on the results of regression analysis. From the results of the intervention, this evaluative group has a 5 times higher chance of solving problems correctly.

Table 3
Means of epistemic perception orientation for unique thoughts and interplay scores

Positioning	The number of ideas submitted differs from the pair	Contact score
Absolutist	0.00	2.60
Relativists	0.40	1.64**
Evaluativeists	0.45*	2.31

Note: The document desk approach derived from the regression coefficient (n = 200). *Means differed considerably from absolutist ($p < .05$). **Means differed considerably from each absolutist ($p < .01$) and evaluative ($p < .01$).

Based on the results of quantitative analysis, it can be concluded that epistemic beliefs have an effect on interactions between partners or other students. This interaction affects the quality of the learning process because it presents quality interactions in the classroom. In addition, instructional intervention in the form of scientific argumentation criteria has an effect on improving the quality of students' scientific arguments. The increase in argument ability can be seen from the increase in the number of alternative ideas in the use of arguments.

Qualitative analysis

The researcher presented a sample of scientific arguments made by students to find out more clearly about the effect of the intervention in explaining the criteria for scientific argumentation. The researcher analyzed the alternative aspects of theory or idea and paragraph development for students who were in the experimental group. Based on the results of the analysis, the experimental group displayed more consideration of ideas in answering the problem. However, in the aspect of argument development, students describe ideas but only one idea occurs. The ability to interact in the experimental group showed a significant increase, especially in the evaluative group (interaction score = 4 out of a scale of 5).

Table 4
Scientific argument sample

Ryan	In my opinion, a feather and a tennis ball will hit the ground at the same time because the force of gravity acts on the object with the same force even though the weight is different. This happens because the two objects are dropped on a vacuum tube. Even though heavier objects are hit by a strong gravitational force, they will fall to the ground at the same time because they are the same distance. This can happen to other objects, such as baseballs and golf balls that have different weights. Both objects will fall at the same speed so that they hit the ground at the same time. There is another factor that makes heavier objects hit the ground faster, namely air resistance. So, if a feather and a rock are dropped, the rock has more velocity because the air resistance is less than the feather. The theory of air resistance can strengthen the theory of gravity to answer the problem of falling objects. So if an object is dropped into a vacuum, it will hit the ground at the same time. This occurs in chicken feathers and tennis balls dropped in a vacuum because they have no air resistance.
Comment	Ryan's argument is correct, but he hasn't been able to combine the gravitational force on different objects in his arguemn. He seeks to strengthen his argument with another example
Eric	Both objects will be pulled at the same speed downward by the force of gravity, so they will touch the bottom position at the same time. Air and water have the same density, gravity will have the same effect on heavy and light objects in a vacuum, so they will have the same speed when they fall. Both objects are not affected by the density of air which affects the velocity of the object.
Comment	Eric's argument explains the effect of air resistance on the velocity of an object. He is more focused on the density of the air not on objects. However, both are still compatible with regards to air resistance.
Ryan	What is your answer about these two things? In your opinion, which object hits the ground first between a feather and a tennis ball?
Eric	Which do you think is denser? Density information is not shared so I still can't determine which one hits the ground first. In my opinion, if an object is dropped in a vacuum the density of the object is no longer considered, so the density and surface area of the object are not variables that must be considered
Comment	Eric's question is excellent. Most students assume that one object has more density without paying attention to or evaluating other variables.
Eric	I agree with your opinion, but if you do it on a rock and feather object will it reach the ground at the same time if it is dropped with the same density of air?
Comment	Eric's argument shifted focus on air density. This shows that he takes into account the importance of the object and the density of the air
Ryan	Object density information is not explained, but this problem is to test our reasoning ability to solve this problem. I'm not sure the density of an object has anything to do with gravity because the force of gravity will pull the object at the same speed even though the weight of the two objects is different. What do you mean by air resistance factor? I think the larger the surface area of the object the slower the object's speed when it falls because of the surface area it holds. For example, feathers and stones, stones will touch the bottom faster because of the amount of air resistance they receive. However, if done in a vacuum both objects will have the same speed as they fall.
Comment	Ryan tries to form an argument by giving examples but not directly. He considered the relevant factors and not even though his argument was wrong which stated that the density of matter was irrelevant.
Eric	I thought that when it was less crowded. If the chicken feathers are given air, the gravitational force that pulls the feathers is no stronger than a rock so the feathers will fall more slowly. I think that inside the tube there is a constant air temperature. The denser the object the less air exerts a force on the object regardless of the size of the object.
Comment	Ryan's misunderstanding tried to be corrected by Eric. Ryan's misunderstanding was to state the density of the object as unimportant and relate it to air resistance. Eric also tried to relate it to temperature.

Eric	The density factor is very important in this problem. Pebbles will have more speed than feathers when dropped because feathers have a wider surface than rocks. The density of the object is very important because it affects the density of the air. Feathers have more density despite their larger surface area. If it is dropped in water and see which object reaches the bottom first. Feathers will be slower because they are denser than air.
Comment	Eric strengthens the statement in his argument by including an experiment of his idea. He also includes density in his arguments.
Ryan	Okay, so what kind of argument would you give in answering this question?
Eric	We both argue almost alike. Feathers are less dense than tennis balls, so they'll be much slower to hit the bottom. If the object has more density than air, the force exerted by the air is less. However, if done in a vacuum, no air exerts a force on the object, but gravity still exerts a force. So, density of objects is not a problem. In this context, the only force acting on an object is gravity. An example of water and air is the density of the fluid which collides with the density and gravity of the object.
Ryan	We conclude by mutual agreement that the object that will hit the bottom first is the tennis ball and then the feathers, because tennis balls have a higher density. Although gravity will attract both objects with the same force because in a vacuum, air resistance has a role. The denser an object is, the less air resistance it has, so the object will go faster as it falls. However, if done in a vacuum, no matter how heavy the two objects will touch the ground at the same time because there is no air to block it.
Comment	Finally, Ryan considers that density is one of the appropriate factors in the context of the problem.

Based on the argument sample, the intervention given to the experimental group greatly affected the quality of the argument. The intervention group considered various factors in answering the problem, resulting in an expansion of the concept, and several conceptual shifts. The two students were having a discussion that was able to make the scientific arguments they made more qualified. Students build scientific arguments by giving different thought experiments, but still relevant to the problem. In some other cases, students strengthen their arguments by including different variables and alternative theories (such as air resistance, density of objects) in the above case. So, it can be concluded that intervention makes students able to make broader arguments.

The researcher also analyzed the effect of students' epistemic beliefs on the quality of arguments and the quality of the learning process. Based on the results of the analysis, it was found that the attitudes of students who were evaluative were able to encourage other students to be more critical of each other, as Eric and Ryan argued above. The two pairs in the sample argument above are able to argue by giving different ideas so that they can have a good influence on other students. From the case of other pairs, relativist students tend to be more accepting of partners from evaluativist who are considered more experienced and have more schemata.

From the results of the analysis, both groups, it was found that students who belonged to the relativist group tended to be less critical, compared to the evaluative group. Table 4 shows that the evaluativist are the most critical of the two other groups. The relativist group (35%) showed less critical argumentation skills. From half of the dialogue cases (50%) analyzed, relativist groups tend to make arguments inconsistently, especially in including reasoning in their arguments. Examples of cases found, namely:

a) Relativists argue that a table tennis ball will hit the ground faster because it is heavier than a feather (a misunderstanding). However, if in a vacuum a tennis ball will fall along with a feather because there is no gravitational force in a vacuum, however, the two objects still have a weight that causes the two objects to fall at the same time. (This argument shows the inconsistency of stating the weight factor of objects in air, but is not discussed in the context of a vacuum)

b) Relativists also argue that a table tennis ball will fall faster in a vacuum because it is heavier than a feather. However, he refuted his own argument by saying that tennis balls will fall more slowly because heavier tennis balls require more force to move.

Based on the observations, even though they showed inconsistencies, they were not bothered by their thinking. The relativist group experiences more misconceptions, is incoherent, and is not integrated when uniting one thought with another. This indicates that relativists tend to tolerate contradictory ideas or thoughts.

Table 5
Proportion of dyads and suggest interplay score, through epistemic notion orientation

Orientation	Percentage of dyads	*M*	*SD*
Evaluativeists – Evaluativeists	41.2	3.02	0.89
Evaluativeists – Relativists	34.3	1.78	0.60
Relativis –absolutist	5.8	3.30	0.40
Relativis – Relativists	12.5	3.00	0.00
Relativis –absolutist	5.8	2.60	0.55
Absolutist–absolutist	3.1	3.55	−a

The researcher also analyzed the evaluative group. Based on the results of the study, the evaluative group showed little inconsistency. The evaluative group tends to be more critical and is found to often contradict the relativist group by positioning a different point of view, including contradicting facts. Based on the data in table 5, the average score of relativist and evaluative pairs is lower than other couples. The combined mean score of this group was 1.78 versus 2.60 for the other groups $t(22) = 2.89$, $p < .01$. Researchers conducted a non-parametric significance test ($W = 130$, $p < .05$). From the results of the study, the evaluative group was more intensive in providing a different point of view and trying to convince the relativist group more. However, the relativist group tends to only agree with the evaluative group's argument without correcting the inconsistency in their argument. Thus, the interaction scores in the relativist group overall appear low (3 combinations involving relativists in table 4). The combination of relativists with evaluatives is very strict.

Regarding the study of the absolutist group, the absolutist group showed a better intensity of interaction than the relativist group, but the absolutist group tended to only believe in one correct answer. Their epistemic belief is very strong in one answer that they think is correct. Their goal in interacting with each other is simply to find one correct answer. The disadvantage of the absolutist group is that they tend to be less able to distinguish concepts and less able to integrate alternative ideas offered. This absolutist group seems unable to clear up misunderstandings in their discussions. Of the three groups, the evaluative group only showed a decrease in misconceptions. This group division can improve the quality of the learning process.

DISCUSSION

This study aims to examine the role of students' epistemic beliefs and explanations of scientific argumentation criteria in improving the quality of the learning process and the quality of students' scientific arguments through online learning. This study was designed by promoting critical discussion between the different epistemic beliefs of the students. Based on this research, epistemic beliefs in constructivist groups and scientific argumentation instruction designed by researchers can improve students' ability to consider alternative evidence and points of view, so that this has the potential to develop concepts (Duschl & Osborne, 2002; Erduran & Kaya, 2016).. Interventions to explain scientific argumentation criteria make students more able to increase their argument skills, this can be seen from the more argument criteria they use, for example they use thought experiments more often, involving more alternative ideas in their arguments (Mercan, 2012; Noroozi & Hatami, 2019; Hadianto et al., 2021a). The intervention of criteria and instructions in this study was able to encourage students to be more open in solving problems, so that the arguments they made were also more complex and reasonable. This result is in accordance with previous research which proved that when students were given the opportunity to argue about the concept of the law of science, students' arguments were better able to involve other relevant variables (Lin & Tsai, 2017).

This study strengthens previous research using software. Software is able to help students to make scientific arguments by involving theories and facts that are more complex and relevant (Christenson & Chang Rundgren, 2015; Koffman et al., 2017). Through this research, software scaffolding is able to facilitate students to involve more variations of argumentation reinforcement. In contrast to the research, the intervention in this study did not use software, but students were able to improve the quality of their arguments by presenting more variations of argument reinforcement (theories, thought experiments, ideas, facts). The explanation of the criteria for scientific argumentation is able to direct students to be involved in discussions and deeper cognitive construction processes. This happened because many students from various groups gave varied and complementary arguments. This process makes students' understanding of a problem more comprehensive and deeper (González-Howard et al., 2017; Zhu et al., 2017).. This is in accordance with the theory of the conceptual change model. Based on this theory, superficial differences in understanding and cognitive can be corrected by involving students in critical discussions and various arguments (pro and contra arguments).

Students who are able to develop quality arguments tend to have more conceptual shifts in the learning process. This happens because critical discussion can lead to a significant increase in conceptual mastery. This finding is reinforced by evidence that conceptual changes for the better occurred in the evaluative group because this group was able to provide alternative ideas and theories that were able to open up the views of relativist and absolutist groups that made both groups able to accept their arguments logically (Infante & Licona, 2021; Jönsson, 2016).. So, the instruction and criteria of scientific argumentation contribute to the birth of a new understanding of the concept in students. With the development of scientific argumentation skills, there is a greater chance for conceptual changes in students to occur. The role of epistemic belief in argumentation and conceptual shift is seen in the evaluative and relativist groups (Gibson, 2008) and Gilles & Buck, 2020; Hadianto et al., 2021c). The evaluative group tends to be more varied in raising problems and the relativist group shows little interaction but is still able to accept the evaluative opinion even though it still shows inconsistencies. In contrast to the absolute group, researchers did not find a better conceptual change because they only recognized one correct answer. The absolutist group is critical and active in arguing, but arguments from other groups are only used to strengthen the answers they claim to be correct (Erduran & Kaya, 2016; Koffman et al., 2017).. So, the nature of the student's argument is strongly influenced by the level of epistemic belief of his opponent. The students in the other groups were four times more likely to adopt the arguments of the epistemic group. This finding supports previous research, namely epistemic beliefs are strongly related to conceptual change and the quality of the learning process (Jones, 2014; Mao et al., 2018).

The findings of this study have implications that the level of epistemic confidence itself can be used by teachers as a scaffold in encouraging students' critical attitudes towards problems or materials that can result in a conceptual shift towards a more comprehensive direction (Ford, 2012; Stark et al., 2009). The criteria for scientific argumentation (claims, evidence, theories, alternative ideas, etc.) may not be sufficient to improve the quality of learning (Clayton & Gautier, 2006; McNeill et al., 2018). It takes students' epistemic beliefs that are able to improve the quality of the learning process to be more alive and critical. Epistemic beliefs and conceptual changes experienced by students can open up opportunities to better understand theories or concepts more broadly. The theory is in accordance with the findings of the researcher. An interesting finding in this study is that the relativist group looks uncritical and interactive. This is because this group has not looked at a problem comprehensively and has not been able to integrate the alternative ideas given (Hadianto et al., 2022; Lee-Hammond & McConney, 2017).. Therefore, further research is needed to find out the causes of relativist and absolutist groups that tend not to develop their argumentative abilities, unlike evaluative groups.

CONCLUSION

Epistemic beliefs of students play a very important role in improving the quality of arguments and the quality of the learning process. This active and interactive learning process makes students more critical in responding to problems. This is what makes students' understanding of a problem more comprehensive. The division of the role of epistemic beliefs based on the characteristics of students makes students' argumentation skills better, especially the evaluative group which makes the absolutist and relativist argumentation abilities more extensive and complex. So, the intervention of scientific argumentation criteria and scientific argumentation instruction can improve scientific argumentation skills and improve the quality of the learning process which directly also makes students' understanding of a problem more comprehensive. This study has several limitations including this research does not pay attention to gender variables, the sample is still limited, and not optimal in improving the argumentation ability of students who are in the absolutist and relativist groups. Future research should focus on students who have absolutes and absolutist beliefs so that they are able to argue more critically and be open to input from evaluative groups. In addition, future research should pay attention to conceptual shifts that are evenly distributed in various epistemic beliefs held by students. In addition, future research should also take a wider sample specifically applied to students in the social field.

REFERENCES

Ballenger, C. (1997). Social identities, moral narratives, scientific argumentation: Science talk in a bilingual classroom. *Language and Education*, *11*(1), 1–14. https://doi.org/10.1080/09500789708666715

Bathgate, M., Crowell, A., Schunn, C., Cannady, M., & Dorph, R. (2015). The Learning Benefits of Being Willing and Able to Engage in Scientific Argumentation. *International Journal of Science Education*, *37*(10), 1590–1612. https://doi.org/10.1080/09500693.2015.1045958

Casas-Quiroga, L., & Crujeiras-Pérez, B. (2020). Epistemic operations performed by high school students in an argumentation and decision-making context: Setrocia's alimentary emergency. *International Journal of Science Education*, *42*(16), 2653–2673. https://doi.org/10.1080/09500693.2020.1824300

Christenson, N., & Chang Rundgren, S. N. (2015). A framework for teachers assessment of socio-scientific argumentation: An example using the GMO issue. *Journal of Biological Education*, *49*(2), 204–212. https://doi.org/10.1080/00219266.2014.923486

Clayton, D. S., & Gautier, C. (2006). Scientific Argumentation in Earth System Science Education. *Journal of Geoscience Education*, *54*(3), 374–382. https://doi.org/10.5408/1089-9995-54.3.374

Duschl, R. A., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education*, *38*(1), 39–72. https://doi.org/10.1080/03057260208560187

Erduran, S., & Kaya, E. (2016). Scientific Argumentation and Deliberative Democracy: An Incompatible Mix in School Science? *Theory into Practice*, *55*(4), 302–310. https://doi.org/10.1080/00405841.2016.1208067

Ferguson, L. E. (2015). Epistemic Beliefs and Their Relation to Multiple-Text Comprehension: A Norwegian Program of Research. *Scandinavian Journal of Educational Research*, *59*(6), 731–752. https://doi.org/10.1080/00313831.2014.971863

Ford, M. J. (2012). A Dialogic Account of Sense-Making in Scientific Argumentation and Reasoning. *Cognition and Instruction*, *30*(3), 207–245. https://doi.org/10.1080/07370008.2012.689383

Gibson, K. (2008). Analogy in scientific argumentation. *Technical Communication Quarterly*, *17*(2), 202–219. https://doi.org/10.1080/10572250701878868

Gilles, B., & Buck, G. (2020). Preservice Teachers' use of Discourse to Shape the Construction of Scientific Arguments. *Journal of Science Teacher Education*, *31*(3), 291–310. https://doi.org/10.1080/1046560X.2019.1696005

González-Howard, M., McNeill, K. L., Marco-Bujosa, L. M., & Proctor, C. P. (2017). 'Does it answer the question or is it French fries?': an exploration of language supports for scientific argumentation. *International Journal of Science Education*, *39*(5), 528–547. https://doi.org/10.1080/09500693.2017.1294785

Hadianto, D., Damaianti, V. S., Mulyati, Y., & Sastromiharjo, A. (2021a). Does reading comprehension competence determine level of solving mathematical word problems competence? *Journal of Physics: Conference Series*, *1806*(1). https://doi.org/10.1088/1742-6596/1806/1/012049

Hadianto, D., Damaianti, V. S., Mulyati, Y., & Sastromiharjo, A. (2021b). Enhancing scientific argumentation skill through partnership comprehensive literacy. *Journal of Physics: Conference Series*, *2098*(1). https://doi.org/10.1088/1742-6596/2098/1/012015

Hadianto, D., Damaianti, V. S., Mulyati, Y., & Sastromiharjo, A. (2021c). The role of multimodal text to develop literacy and change social behaviour foreign learner. *International Journal of Instruction*, *14*(4), 85–102. https://doi.org/10.29333/iji.2021.1446a

Hadianto, D., S. Damaianti, V., Mulyati, Y., & Sastromiharjo, A. (2022). Effectiveness of Literacy Teaching Design Integrating Local Culture Discourse and Activities to Enhance Reading Skills. *Cogent Education*, *9*(1), 0–13. https://doi.org/10.1080/2331186X.2021.2016040

Heng, L. L., Surif, J., & Seng, C. H. (2015). Malaysian Students' Scientific Argumentation: Do groups perform better than individuals? *International Journal of Science Education*, *37*(3), 505–528. https://doi.org/10.1080/09500693.2014.995147

Infante, P., & Licona, P. R. (2021). Translanguaging as pedagogy: developing learner scientific discursive practices in a bilingual middle school science classroom. *International Journal of Bilingual Education and Bilingualism*, *24*(7), 913–926. https://doi.org/10.1080/13670050.2018.1526885

Jin, Q., & Kim, M. (2021). Supporting elementary students' scientific argumentation with argument-focused metacognitive scaffolds (AMS). *International Journal of Science Education*, *43*(12), 1984–2006. https://doi.org/10.1080/09500693.2021.1947542

Jones, L. (2014). Developing deaf children's conceptual understanding and scientific argumentation skills: A literature review. *Deafness and Education International*, *16*(3), 146–160. https://doi.org/10.1179/1557069X13Y.0000000032

Jönsson, A. (2016). Student performance on argumentation task in the Swedish National Assessment in science. *International Journal of Science Education*, *38*(11), 1825–1840. https://doi.org/10.1080/09500693.2016.1218567

Koffman, B. G., Kreutz, K. J., & Trenbath, K. (2017). Integrating scientific argumentation to improve undergraduate writing and learning in a global environmental change course. *Journal of Geoscience Education*, *65*(3), 231–239. https://doi.org/10.5408/16-232.1

Lee-Hammond, L., & McConney, A. (2017). The impact of village-based kindergarten on early literacy, numeracy, and school attendance in Solomon Islands. *European Early Childhood Education Research Journal*, *25*(4), 541–560. https://doi.org/10.1080/1350293X.2016.1155256

Lee, S. W. Y., Liang, J. C., & Tsai, C. C. (2016). Do sophisticated epistemic beliefs predict meaningful learning? Findings from a structural equation model of undergraduate biology learning. *International Journal of Science Education*, *38*(15), 2327–2345. https://doi.org/10.1080/09500693.2016.1240384

Lin, T. J., & Tsai, C. C. (2017). Developing instruments concerning scientific epistemic beliefs and goal orientations in learning science: a validation study. *International Journal of Science Education*, *39*(17), 2382–2401. https://doi.org/10.1080/09500693.2017.1384593

Loper, S., McNeill, K. L., & González-Howard, M. (2017). Multimedia educative curriculum materials (MECMs): Teachers' choices in using mecms designed to support scientific argumentation. *Journal of Science Teacher Education*, *28*(1), 36–56. https://doi.org/10.1080/1046560X.2016.1277600

Mao, L., Liu, O. L., Roohr, K., Belur, V., Mulholland, M., Lee, H. S., & Pallant, A. (2018). Validation of Automated Scoring for a Formative Assessment that Employs Scientific Argumentation. *Educational Assessment*, *23*(2), 121–138. https://doi.org/10.1080/10627197.2018.1427570

McNeill, K. L., Marco-Bujosa, L. M., González-Howard, M., & Loper, S. (2018). Teachers' enactments of curriculum: Fidelity to Procedure versus Fidelity to Goal for scientific argumentation. *International Journal of Science Education*, *40*(12), 1455–1475. https://doi.org/10.1080/09500693.2018.1482508

Mercan, F. Ç. (2012). Epistemic Beliefs about Justification Employed by Physics Students and Faculty in Two Different Problem Contexts. *International Journal of Science Education*, *34*(9), 1411–1441. https://doi.org/10.1080/09500693.2012.664794

Muis, K. R. (2007). The role of epistemic beliefs in self-regulated learning. *Educational Psychologist*, *42*(3), 173–190. https://doi.org/10.1080/00461520701416306

Noroozi, O., & Hatami, J. (2019). The effects of online peer feedback and epistemic beliefs on students' argumentation-based learning. *Innovations in Education and Teaching International*, *56*(5), 548–557. https://doi.org/10.1080/14703297.2018.1431143

Osborne, J. (2005). The role of argument in science education. *Research and the Quality of Science Education*, 367–380. https://doi.org/10.1007/1-4020-3673-6_29

Osborne, J. F. (2010). R & D: An argument for arguments in science classes. *Phi Delta Kappan*, *91*(4), 62–65. https://doi.org/10.1177/003172171009100413

Osborne, J. F., Henderson, J. B., MacPherson, A., Szu, E., Wild, A., & Yao, S. Y. (2016). The development and validation of a learning progression for argumentation in science. *Journal of Research in Science Teaching*, *53*(6), 821–846. https://doi.org/10.1002/tea.21316

Shemwell, J. T., & Furtak, E. M. (2010). Science classroom discussion as scientific argumentation: A study of conceptually rich (and poor) student talk. *Educational Assessment*, *15*(3), 222–250. https://doi.org/10.1080/10627197.2010.530563

Stark, R., Puhl, T., & Krause, U. M. (2009). Improving scientific argumentation skills by a problem-based learning environment: Effects of an elaboration tool and relevance of student characteristics. *Evaluation and Research in Education*, *22*(1), 51–68. https://doi.org/10.1080/09500790903082362

Yang, F. Y., Chang, C. C., Chen, L. L., & Chen, Y. C. (2016). Exploring learners' beliefs about science reading and scientific epistemic beliefs, and their relations with science text understanding. *International Journal of Science Education*, *38*(10), 1591–1606. https://doi.org/10.1080/09500693.2016.1200763

Zhu, M., Lee, H. S., Wang, T., Liu, O. L., Belur, V., & Pallant, A. (2017). Investigating the impact of automated feedback on students' scientific argumentation. *International Journal of Science Education*, *39*(12), 1648–1668. https://doi.org/10.1080/09500693.2017.1347303