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# Explicit scientific argument on science teaching as an inquiry: designing activity on online schema using fuzzy delphi method

Z R Hendrastuti<sup>1</sup>, S Siswanto<sup>2</sup>, A Muhlisin<sup>2</sup>, F Firmadani<sup>3</sup>, H Hartono<sup>4</sup>, B.Subali<sup>4</sup> and E Elianawati<sup>4</sup>

<sup>1</sup>Mathematic Education Department, Universitas Tidar, Magelang, Indonesia

<sup>2</sup>Natural Science Education Department, Universitas Tidar, Magelang, Indonesia

<sup>3</sup>Faculty of Teacher Training and Education, Universitas Tidar, Magelang, Indonesia

<sup>4</sup>Physics Department, Universitas Negeri Semarang, Indonesia a

\*Corresponding author: siswanto@untidar.ac.id

**Abstract.** In science learning, inquiry and argumentation activities can make science teaching and learning meaningful by maintaining the science as a process and a product. In addition, both of them were able to train higher order thinking skills. This study aims to design an online science learning process using the stages of inquiry learning that includes argumentation activities. The Fuzzy Delphi Method (FDM) is employed to design the stages of learning activities involving 10 experts, including researchers in the field of science learning design, learning psychology, and also practitioners (science educators). Based on the FDM method, learning stages are arranged consisting of three online sessions where each session is carried out in one online learning meeting. The first session was in the form of identifying problems, conducting literature studies, formulating hypotheses by proposing scientific arguments. The second session is in the form of activities to prove the truth of the proposed hypothesis (collecting data), analyzing data, and evaluating the proposed hypothesis along with the scientific arguments that are prepared. The third session communicated the findings of the investigation. Based on the results, the stages of learning activities are very suitable for application in science learning which is carried out online.

## 1. Introduction

Along with the times, technology continues to develop rapidly and it has been influential in the field of education. Currently, learning activities that combine with technology often encountered, one example is the online learning process, both synchronously and asynchronously. With this technology, the learning process makes it possible to be no face-to-face learning in the classroom. This also applies to learning science.

Online learning, including science learning, is very important to develop because it can facilitate access in learning [1,2], and makes the learning process unhindered by distance and time [3]. With this easy access, students can easily receive material even though there is no face-to-face interaction in the classroom by the lecturer.

One of the obstacles in learning science online is the difficulty of practicing higher order thinking skills to students. In essence, one of the important achievements of the learning process in higher



education is practicing higher order thinking skills or HOTs [4]. According to Zohar [5] and Karim [6], high-order thinking skills are very important to be trained in the learning process so that students are able to face challenges or problems in every daily life.

In science learning, higher order thinking skills (HOTs) can be built through a process of inquiry. In essence, science is built on the basis of scientific processes, scientific products, and scientific attitudes, so that the science learning process is not just transferring knowledge to students, but training students to build this knowledge through a scientific process [7].

There are several benefits in the science learning process which emphasizes the inquiry stage. The process of inquiry can help students learn how to think and act like scientists [7,8]. In addition, according to Kai Wu [9] inquiry learning can build students' knowledge from a low level of cognition to a high level of cognition. Therefore, the use of inquiry in science learning is able to train students' intellectual skills. The stages of inquiry include: (1) identifying problems, (2) formulating hypotheses, (3) conducting experiments, (4) conducting data analysis, (5) communicate the analysis results [7].

In other to inquiry activities, argumentation activities are also important in the science learning process. The science learning process that involves argumentation activities can strengthen the students' understanding of the concept as a whole [10,11]. In addition, argumentation activities also make it easier for students to comprehend the dimensions of higher-order thinking achievement [12].

Therefore, this research was conducted to develop a science learning process that was packaged online using phases of inquiry which involved arguing. Based on the literature conducted, there is still a small amount of science learning carried out online process that integrates argumentation activities [13-16]. The argumentation activities carried out refer to the Toulmin Argumentation Pattern (TAP) which includes activities to submit claims, evidence, justification, and support.

## 2. Methods

This study used the Fuzzy Delphy method [17]. Based on literature studies, this method is effectively used to make decisions on the feasibility of a learning stage [18]. The Fuzzy Delphy method is used to obtain a group agreement (in this case an expert) [19]. According to Kuo [20], the Fuzzy Delphy method can be used to design the stages of learning activities involving 10 experts.

In this study, the 10 experts involved included researchers in the field of science learning design as well as educators in the field of science with at least 10 years of teaching experience. In this study, the experts evaluated the stages of learning designed with a questionnaire guide.

Based on the Fuzzy Delphy method, learning stages are arranged of three online sessions where each session is carried out in one online learning meeting. In the first and second sessions there are three learning activities (P), while in the third session there is one learning activity. The three sessions must be carried out sequentially. The stages of activities in the first session were (1) identifying problems, (2) conducting literature studies, (3) formulating hypotheses by proposing scientific arguments. The stages in the second session are (1) proving the truth of the proposed hypothesis (collecting data), (2) analyzing the data, (3) evaluating the proposed hypothesis accompanied by scientific arguments. The activity stage in the third session is communicating the results of the investigation.

This questionnaire consist 7 question items, which combined the Likert scale with fuzzy numbers. The seven question items are adjusted to the stages in the learning being developed.

Data analysis was carried out in four steps, i.e.: 1) Determining the linguistic scale (can be seen in Table 1). The linguistic scale uses a Likert scale by adding three fuzzy numbers / FN ( $m_1, m_2, m_3$ ) with a scale of 0 to 1. Fuzzy numbers are used as a triangulation model in this study. 2) Calculating the average score of fuzzy numbers ( $(FN)^{\bar{}}$ ). 3) Calculating the threshold value ( $d$ ) using equation (1) so that the level of agreement between experts is known. If the value ( $d$ )  $\leq 0.2$  and the percentage  $\geq 75\%$ , it can be said that the experts are in the same agreement, then it can be stated that the status of the planned learning stage (S) is Acceptable (A) and the rest is Unacceptable (UA). 4) Perform ranking (R) at the

designed learning stage. Ranking needs to be done to consider the priority of the stages that must be carried out. The ranking is based on the Defuzzification Process (DV) value using equation (2).

$$d = \sqrt{\frac{1}{3}(\bar{m}_1 - m_1)^2 + (\bar{m}_2 - m_2)^2 + (\bar{m}_3 - m_3)^2} \tag{1}$$

$$DV = \frac{1}{3} * (\bar{m}_1 + \bar{m}_2 + \bar{m}_3) \tag{2}$$

**Table 1.** Scale of Linguistic

Scale of Linguistic	Fuzzy number		
	m <sub>1</sub>	m <sub>2</sub>	m <sub>3</sub>
Strongly Agree	0,6	0,8	1
Agree	0,4	0,6	0,8
Moderately Agree	0,2	0,4	0,6
Not Agree	0	0,2	0,4
Strongly not Agree	0	0	0,2

**3. Results and Discussion**

The results of data analysis can be seen in Table 2. Based on this table, in general all experts agree that learning activities are carried out in three sessions, where each session is carried out in one meeting. This is indicated by the value of  $d \leq 0.2$  and the percentage of acceptance  $\geq 75\%$ . All learning activities designed in this study are packaged in the form of online learning. Learning activities also involve virtual laboratories as a unit in learning, especially in the second session.

In the first session, all activities need to be carried out in learning activities in order of priority that must be carried out, namely the 1st phase (identifying problems), 3rd phase (formulating hypotheses by proposing scientific arguments), and 2nd phase (doing study of literature). Based on the results of the expert consensus, the second phase is the last priority in session 1, but nevertheless this phase is important to do. Based on the results of the questionnaire, session 1 was conducted in order to prepare student concepts before carrying out investigative activities.

In the second session, all activities are also must be done. Phase 1 (proving the truth of the proposed hypothesis (collecting data) is in the order of first priority, while phases 2 (analyzing data) and 3 (evaluating the proposed hypothesis accompanied by scientific arguments) get the same priority order. It means that the learning activities in the 2nd and 3rd phases have the same priority level to be carried out. Based on the questionnaire filled out by experts, the second session is carried out in order to construct knowledge. Meanwhile, in the third session, all experts agree that the activities mandatory to do. At this third session, students report the results of their investigations.

The inquiry process is not just a transfer of knowledge to students, but also trains students to build that knowledge through a scientific process [13,14]. Inquiry-based learning process has several benefits including being able to build students' knowledge from a low level of cognition to a high level of cognition [14,15]. In addition, through the process of inquiry students are trained their intellectual skills [9].

The argumentation activities that are integrated into inquiry learning have a role to further improve student learning outcomes. All experts agree that the set up stages of learning can improve learning outcomes in the higher order thinking dimension. Based on the research findings, the better students' skills in constructing arguments, so the ability to construct their knowledge will be better [12,21]. It is because students need argumentation skills to strengthen their understanding [22,23]. In this study, the argumentation activity carried out refers to the Toulmin Argumentation Pattern (TAP) which includes the activities of filing claims, evidence, justification, and support [21].

**Table 2.** Results of the Questionnaire Analysis Filled by Experts

P	FN	Expert										FN	d/%	S	DV	R	
		1	2	3	4	5	6	7	8	9	10						
Sesi 1																	
1	m1	0.6	0.6	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.58	0.036 96.4	A	0.78	1
	m2	0.8	0.8	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.78				
	m3	1	1	0.8	1	1	1	1	1	1	1	1	0.98				
2	m1	0.6	0.4	0.4	0.6	0.4	0.6	0.6	0.4	0.6	0.6	0.52	0.096 90.4	A	0.72	3	
	m2	0.8	0.6	0.6	0.8	0.6	0.8	0.8	0.6	0.8	0.8	0.72					
	m3	1	0.8	0.8	1	0.8	1	1	0.8	1	1	0.92					
3	m1	0.6	0.6	0.4	0.6	0.6	0.6	0.6	0.4	0.6	0.6	0.56	0.064 93.6	A	0.76	2	
	m2	0.8	0.8	0.6	0.8	0.8	0.8	0.8	0.6	0.8	0.8	0.76					
	m3	1	1	0.8	1	1	1	1	0.8	1	1	0.96					
Sesi 2																	
1	m1	0.6	0.6	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.56	0.064 93.6	A	0.76	2	
	m2	0.8	0.8	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.76					
	m3	1	1	0.8	0.8	1	1	1	1	1	1	0.96					
2	m1	0.6	0.6	0.6	0.6	0.4	0.6	0.6	0.4	0.6	0.6	0.56	0.064 93.6	A	0.76	2	
	m2	0.8	0.8	0.8	0.8	0.6	0.8	0.8	0.6	0.8	0.8	0.76					
	m3	1	1	1	1	0.8	1	1	0.8	1	1	0.96					
3	m1	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0	A	0.8	1	
	m2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8					
	m3	1	1	1	1	1	1	1	1	1	1	1					
Sesi 3																	
1	m1	0.4	0.6	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.52	0.096 90.4	A	0.72	1	
	m2	0.6	0.8	0.6	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.72					
	m3	0.8	1	0.8	0.8	0.8	1	1	1	1	1	0.92					

**4. Conclusion**

Based on the research results, it can be concluded that the inquiry learning stage has been designed by inserting an online argumentation activity. Learning is carried out in three sessions, where each session is carried out in one lesson. In session one, there were three stages of learning, namely (1) identifying problems, (2) conducting literature studies, (3) formulating hypotheses by proposing scientific arguments. In the second session, there were three stages of learning, namely (1) proving the truth of the proposed hypothesis (collecting data), (2) analyzing data, (3) evaluating the proposed hypothesis

accompanied by scientific arguments. Meanwhile, in the third session there is one learning stage, namely communicating the results of the investigation. All experts agree that packaged learning activities are able to train students in order to think at higher levels.

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