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Exploring curiosity and critical thinking skills for prospective biology teacher

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ABSTRACT

Curiosity and critical thinking as one of the characteristics and skills developed in the goals of Indonesian education and 21st-century learning. Curiosity is a driving force for intrinsic motivation to explore behavior and gain new understanding and knowledge through observation. Curiosity and critical thinking skills are the needs of every individual to explore sciences such as biology. This study's aim is to explore the curiosity and critical thinking skills of prospective biology teacher students. This research is a qualitative descriptive study with a survey method. The sample of this study amounted to 150 students who were taken using purposive random sampling. Curiosity data was collected using science curiosity in learning environments (SCILE) and critical thinking skills were collected using the developed instrument. The data obtained were analyzed using the partial least square program to determine the contribution of gender to scientific curiosity (SC) and critical thinking skills. The results of the analysis show that gender contributes directly to critical thinking skills through SC on the stretching indicator. In general, SC needs to do research to find out the contribution of each critical thinking.

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1. INTRODUCTION

Curiosity and critical thinking skills are competencies that must be considered in learning in the era of industrial revolution 4.0 as in the learning framework developed by the partnership for 21st-century learning [1]–[3]. 21st-century learning emphasizes innovative learning that develops thinking skills such as critical thinking skills [4]–[6]. Development of critical thinking as the basis of education in the modern era [7]–[9]. Critical thinking skills are very important to be integrated into learning because they are related to everyday life that can affect a person's learning and career success [10], [11]. Critical thinking is a basis and an important part of learning that can hone analytical and reasoning skills in innovation [12], [13] as well as determinants in student performance success.

Some researchers define critical thinking as logical and reflective thinking to make the right decisions based on beliefs [14]–[18]. Critical thinking is an intellectual discipline that involves elements of thinking such as gathering information, identifying problems, clarifying concepts, discovering, assuming, and reflecting critically [19]. Conceptualized as; cognitive dimension (logical reasoning); metacognitive

dimensions (self-reflection, self-evaluation, higher-order thinking); and the ethical and moral dimensions [20], [21]. Critical thinking is a cognitive process that includes the ability to interpret, analyze, evaluate, conclude, explain, and self-regulation [22]. Meanwhile, according to several researchers [1], [23], critical thinking is an intellectual process that conceptualizes, applies, analyzes, synthesizes, and evaluates information collected through observation, reflection, and consideration as a reference in making decisions.

Empowerment of thinking skills in learning can facilitate students to focus, and conduct comprehensive analysis in solving problems and making conclusions [24]. Previous researchers [25] stated that critical thinking is a process of analyzing and evaluating thinking with the aim of improving it, and has several roles, namely: i) questioning the problem (questioning the problem); ii) goals; ii) information (sourced from data, facts, observations, and experiences); iv) interpretation and inference (conclusions and solutions); v) a concept in the form of a mindset that becomes a framework for thinking and acting (theories, definitions, axioms, laws, principles, and models); vi) assumptions; vii) point of view (frame of reference, perspective, orientation); and viii) implications and consequences.

In biology learning, not only aspects of critical thinking skills are needed, but aspects of curiosity are also needed to support academic abilities and [26] cognitive development. So, it is important to be integrated with learning [27]–[29]. Curiosity becomes a component of learning to increase motivation and academic performance [30], [31]. In learning, curiosity is needed which represents a way of thinking and attitude. Curiosity is an intrinsic motivation to investigate and observe what is seen, heard, and learned [32]. Critical thinking has a correlation with curiosity because curiosity is the initial stage used to investigate and discover [33]. Critical thinking skills, character, and curiosity become an important basis that students must have to face changes that must be developed simultaneously in education [29].

Curiosity as an attitude and critical thinking is the ability to solve problems in everyday life through the thinking process. These two competencies are demands in 21st-century learning that must be possessed by students. Teaching students how to learn and how to develop curiosity is the goal of education in general and science in particular [34], [35]. The 21st-century learning emphasizes the formation of an attitude of curiosity and innovative thinking skills such as critical thinking [1]. Curiosity is one of the characteristics that must be possessed by students in 21st-century learning [36]. Curiosity is important to be taught in the classroom because it can be a spirit and motivation to think and solve problems and can develop scientific literacy [37]–[40].

Everyone has a curiosity that characterizes intelligence to seek information that is considered new through scientific discoveries [41], [42]. In addition, the curiosity can help explore and understand scientific disciplines [43]. Curiosity includes perceptual curiosity (certain interests and stimuli), diverse curiosity (novelty or sensation seeking), epistemic curiosity (interest in specific topics), perceptual curiosity (accommodating experience through the senses), specific curiosity (exploratory motivation), and diverse curiosity (multiple curiosities) [44]–[49].

Curiosity becomes an intrinsic motivation in the learning process to achieve the planned learning objectives [31], [50] and can have a positive effect on improving learning outcomes [51]. The existence of curiosity as self-motivation helps focus attention on obtaining specific information from observation or investigation activities [34], [52], [53]. In addition, curiosity can be a driving force for individuals or groups to gain new insights and innovations in the learning process [54].

Students' curiosity about events or phenomena in the surrounding environment through the process of asking questions, observing, and conducting scientific investigations, characterizes students' curiosity [55], strong curiosity drives student success [56], and curiosity motivates people to act and think in new ways and to investigate, imagine and learn about the things that interest them [57], [58]. Curiosity makes students more sensitive in observing various phenomena or events around them and can also be used to show interest in something [59]. Arousing curiosity can be through internal stimuli such as complexity, novelty, uncertainty, and conflict [44]. Meanwhile, Borowske [60] stated that arouses curiosity by: i) Indicating gaps in the knowledge possessed; ii) Providing sufficient information to resolve curiosity; and iii) Providing sufficient time to complete curiosity.

The results of previous studies [32], [61] stated that students who had low curiosity had lower critical thinking skills than students who had high curiosity. High curiosity is shown enthusiastically in seeking answers to questions, focusing on the object being observed, and being enthusiastic about the scientific process [62]. Curiosity positively contributes to the level of attention, concentration, exploration, questioning skills, understanding, and skills in learning [28], [63]–[65]. Meanwhile, research conducted by showed contradictory results. Naturalist intelligence has no significant effect on students' critical thinking skills and curiosity [29]. Abakpa *et al.* [66] showed that scientific curiosity and academic performance were negatively correlated.

Research conducted by Dubey and Griffiths [41] shows that students' curiosity is not only sensitive to the nature of stimuli but is also influenced by the nature of the environment. This illustrates that to develop students' curiosity, a learning environment or learning scenario is needed which leads to the formation of

curiosity. It is also important to take action by educators in the form of encouragement to increase student curiosity [67]. Both in terms of learning strategies, learning methods, the use of learning media used in the process of teaching and learning activities in the classroom, as well as actions that can motivate these students to be more enthusiastic and focused in learning.

In terms of gender Raharja *et al*. [68] characterizes curiosity based on gender which states that there is no difference between male and female students. Referring to the concept of incongruity theories states that curiosity is an attempt to understand the world with the constant and interrelated nature of the consequences it receives [69]. There are several behavioral biases in the learning process in the classroom based on differences between male and female adolescents: a female are obedient, quiet, and more patient than boys who tend to be noisy and like to seek attention; and unwittingly teachers pay more attention to a male who often ask for clear explanations and instructions than female [70].

Different studies show that the average curiosity of male adolescents is 36.40 higher than female adolescents with an average curiosity value of only 33.76. This shows that male's curiosity is higher than female's [71]. Female and male have different performances in their involvement in interpreting something new they know [72]. On the other hand, according to King and Shari [73], male are less likely to be curious than female.

The research results that have been described show that students' curiosity and critical thinking are very important in determining students' motivation, interests, thinking skills, and academic results. This study aims to identify the curiosity and critical thinking skills of prospective biology teacher students. Student curiosity is important to analyze in order to provide learning to students according to their needs [74]. Curiosity is viewed from three components, namely science practices, stretching (looking for new information and experiences), and embracing (new experiences from everyday life) [75]. While critical thinking skills use four indicators, namely analysis (anl), inference (inf), evaluation (evl), and decision making (dsc). These four critical thinking indicators were used in previous studies [12], [76]–[79].

2. RESEARCH METHOD

This research is a quantitative descriptive study with a survey method to explore the scientific curiosity and critical thinking skills of prospective biology teachers. The research subjects were 150 prospective biology teacher students. Samples were taken using a purposive random sampling technique [80]. The instrument used is the science curiosity in learning environments questionnaire. SCILE is a tool to measure scientific curiosity attitude which consists of 12 statement items and is divided into three indicators, namely science practices (sp) (4 items), stretching (s) (6 items), and embracing (e) (2 items) indicators with a level of reliability based on the scale Cronbach of 0.91 [81]. Students' critical thinking skills (CTS) were collected using an instrument developed according to four indicators, namely: analysis, inference, evaluation, and decision making [76]. The instrument that has been developed is then assessed for validity by two people who are categorized in Table 1.

Table 1. The instrument validity category is based on the average value of the validator [82]

Interval score	Category
> 3.6	Very valid
2.8-3.6	valid
1.9-2.7	Invalid
1.0-1.8	Totally invalid

The instrument is said to be reliable if the reliable value is 75%. Instrument test results are presented in Table 2. The scientific data of curiosity and critical thinking skills obtained were analyzed using the partial least square program. Instrument reliability was analyzed using (1) [83]:

$$\text{Percentage of agreement} = 100\ [1 - \frac{(\text{AB})}{(\text{A+B})}] \quad (1)$$

Table 2. Content and construct validity and reliability of the instrument

Content validity	Reliability	Construct validity	Reliability
3.9	0.97	3.7	0.97

3. RESULTS AND DISCUSSION

Curiosity and critical thinking skills are two components in learning that must be developed because curiosity is the driving force for intrinsic motivation to learn while critical thinking skills are power in solving problems. Based on the results of curiosity analysis and critical thinking skills still need to be developed further. In addition, in terms of the contribution of gender to scientific curiosity and critical thinking, there are differences in contributions. The results of the analysis are presented in Figure 1.

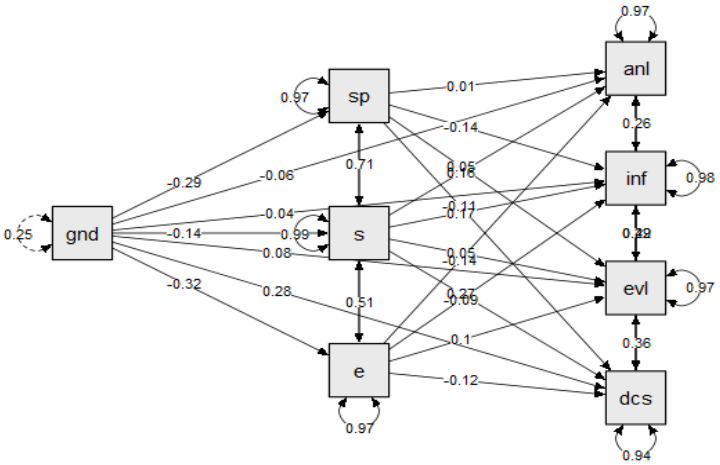

Figure 1. Gender contribution model to scientific curiosity and critical thinking skills

The model shows that gender does not have a direct contribution to the three scientific curiosity indicators, namely the science practices (sp), stretching (s), and embracing (e) indicators, while judging from gender (gnd) the four critical thinking skills indicators show that. There is a direct difference in the contribution, namely the analytical indicator (anl) does not contribute, while the three indicators of critical thinking skills have a direct contribution, namely the inference indicator (inf) 0.04, the evaluation indicator (evl) 0.08, and the decision-making indicator (dcs) of 0.28. If viewed from the indirect contribution between gender and SC and CTS, it was found that gender contributed to CTS in the analysis indicators (0.01), and evaluation (0.05) while the two namely decision making and inference did not contribute.

The indirect gender contribution to CTS through stretching indicators shows that the analysis indicator is 0.16, the inference is 0.17, the evaluation is 0.05, and the decision-making indicator is 0.27. The contribution of gender indirectly through stretching indicators as a whole contributes. Judging from the indirect gender contribution through SC on the embracing indicator, it was found that only the indirect gender evaluation indicator had a contribution of 0.1.

The indirect gender contribution through the SC stretching indicator shows that it contributes to all critical thinking indicators. Stretching is the desire to seek information and new experiences illustrating that it can contribute to critical thinking skills on the four critical thinking indicators. In general, SC is a motivator for students to observe and think critically. Previous studies [28], [63]–[65] find that curiosity positively contributed to the level of attention, concentration, exploration, questioning skills, understanding, and skills in learning. Curiosity plays a role in learning [73]. Curiosity is very important to be developed in learning as a driving force and driver of motivation, interest, and desire of students to make observations, and investigate new things related to the material being studied.

4. CONCLUSION

In general, gender has a direct or indirect contribution to critical thinking skills. The indirect gender contribution to critical thinking skills through stretching indicators shows that the analysis indicator is 0.16, the inference is 0.17, the evaluation is 0.05, and the decision-making indicator is 0.27. the contribution of gender indirectly through stretching indicators as a whole contributes. In general, scientific curiosity is needed by students as a motivator in learning.

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