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Pre-Service Science Teachers' Awareness of their Critical Thinking Abilities

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Abstract
Critical thinking, a core 21st century skill, is needed to effectively explore, analyse, and evaluate problems to be able to find sustainable solutions. Hence, the advocacy for its inclusion in school curricula as part of learning outcomes for students with the universal belief that it fosters academic success. This means teachers should possess the ability to develop critical thinking skills in their students. Thus, teacher education programmes should prepare prospective teachers to acquire the skill to enable them to develop same in their future students. Therefore, this study explored prospective science teachers' awareness of their critical thinking abilities through a survey in a Ghanaian university. The results showed that pre-service science teachers had high levels of awareness of their critical thinking abilities. Although no gender differences were found in the pre-service science teachers' awareness of their critical thinking abilities, the final year students had high levels of awareness as compared to the other students. It was concluded that awareness of critical thinking abilities is ultimately influenced by the university course units earned. Teacher education programmes should consciously develop critical thinking skills among students throughout the programme.

Keywords: Critical thinking; awareness; abilities; pre-service science teachers; academic levels

Introduction

Survival in this generation demands new knowledge, skills and attitudes. This dispensation has come with communication and information tools that have affected how we live (Alayyar, Fisser, & Voogt, 2012; Niess, 2005) leading to rapid acquisition and transformation of knowledge (Yalçın & Çelikler, 2011). The resultant

effect is the demand for a new crop of employees required to successfully survive in the current aggressive work environment. The Partnership for 21st Century Skills (2007), accordingly, has developed a vision for student success in the new global economy. They indicated that students who want to have a competitive edge need to possess learning and innovative skills of which critical thinking is an essential component.

Critical thinking is the ability to undertake "reasonable reflective thinking focussed on deciding what to believe or do" (Ennis, 1993, p.180). Facione (1998) accentuated that experts on the Delphi project on critical thinking agreed that the act of being purposeful and engaging in self-regulatory decision-making that leads to interpretation, analysis, evaluation, and inference is what describes critical thinking. Cottrell (2005) also argued that critical thinking is the ability to identify other people's positions, arguments, and conclusions, evaluate the evidence for alternative points of view, fairly weigh opposing arguments and evidence, read between the lines, see through the surface, and spot false or unfair assumptions.

It is expected that individuals should be able to analyse issues, evaluate options and arrive at informed conclusions based on available information to influence society positively. These activities constitute critical thinking. Cottrell (2005), therefore, underscored that critical thinking enables individuals to make better and more informed decisions about the worthwhileness or the otherwise of information, events and issues. Consequently, it can be argued that individuals who think critically are capable of evaluating evidence to identify whether they are authentic or spurious. Critical thinkers tend to put up strong and better viewpoints or arguments knowing the associated strengths and weaknesses of their arguments. Kurfiss (1988), therefore, highlighted that any healthy democratic society needs individuals who possess critical thinking skills since it is an essential capacity needed for a humane and rational society.

Critical thinking is generally categorised into two broad dimensions: dispositions and abilities. When certain conditions are provided, the propensity to behave in a particular manner is how Ennis (1996) defined critical thinking disposition. He argued that for certain actions to qualify as critical thinking dispositions, they must be applied reflectively. Facione, Facione and Sanchez (1994) dictated that thinking disposition constitutes one's attitudes, intellectual virtues, and

habits of mind. Facione (2000) further argued that human dispositions are the essential distinguishing features of individuals. Perkins, Jay, and Tishman (1993) also argued that thinking dispositions are cognitive behaviour controllers and determinants that are influenced by the affinities of the arrays of intellectual activity. Critical thinking abilities are seen as the ability to think reflectively, act purposefully, critique and analyse issues to decide what to do (Ennis, 1994, Facione, Sanchez, Facione, & Gainen, 1995).

Facione et al. (1995) identified seven dispositions of critical thinking. These are inquisitiveness, open-mindedness, systematicity, analyticity, truth-seeking, critical thinking (CT) Self-confidence and maturity. They explained that the 'inquisitiveness' disposition entails an individual's intellectual curiosity which leads to a person desiring to learn even if the knowledge to be gained and its applications are not for immediate use. This indicates that critical thinkers are curious for knowledge and are always looking for avenues to learn. The ability to be aware of one's own biases and the capacity to accept different and divergent views constitutes open-mindedness. Facione et al. (1994) noted that critical thinkers are diligent, focused, organized and demonstrate orderliness. They noted that such individuals exhibit systematic and methodical approaches when solving problems. These attributes are made possible because the individual possesses the systematicity disposition.

Critical thinkers can use evidence and reason to solve problems as well as identify potential difficulties because they possess the disposition of analyticity. The Truth-seeking disposition entails a quest to pursue the appropriate and best knowledge at any point in time, the penchant to ask questions and being objective even if the available evidence does not favour the individual. Facione et al. (1995) expatiated that when an individual is aware of their reasoning processes then such an individual has the critical thinking self-confidence disposition. They argued that this disposition enables an individual to trust in the appropriateness and soundness of their reasoning and judgments. They noted, however, that this disposition can be underestimated or overestimated by individuals. The last disposition identified by Facione et al. (1995), as far as critical thinking is concerned, is the maturity disposition. They highlighted that this disposition makes an individual thoughtful and cautious when making decisions. This disposition makes an individual aware that some

problems are ill-defined and natured and, therefore, their solution may involve multifaceted approaches.

Aside from the dispositions, the other side of critical thinking is the critical thinking abilities or skills. Facione et al. (1994) observed that individuals engaged in critical thinking do so through the use of analysis, interpretation, inference, explanation, evaluation, and self-regulation. They underscored that these are cognitive skills that critical thinkers use to arrive at an informed and sound judgment. Ennis (1985) identified certain abilities critical thinkers demonstrate and puts these abilities into elementary clarification, basic support, inference, advanced clarification and strategy and tactics. Each category consists of specific abilities that the critical thinker should demonstrate. For elementary clarification, Ennis (1985) reasoned that there should be the ability to focus on attention, analyse arguments, ask and answer clarification and challenge questions. The abilities that constitute basic support include the ability to judge the credibility of the source of information, undertake observations as well as critique observational reports. It was further noted that critical thinkers should be able to make deductions and judge deductions that others have made; induce and judge inductions; infer hypotheses and explanations and make value judgments. Thus, the dispositions and abilities culminate into an individual's critical thinking capabilities.

Since education is the fulcrum through which societal norms, mores and values are shaped, Bailin and Siegel (2003, p.188) argued that "critical thinking is often regarded as a fundamental aim and an overriding ideal of education." Critical thinking is accepted within society as a very powerful tool needed in every educational system and a necessary commodity required for successful personal and civic life (Facione et al., 1995). The education system, therefore, has a huge responsibility to ensure that learners will not just pass their examinations but will and must be able to think critically. Teachers will be doing a great disservice to their students and society at large if they concentrate only on the academic achievement of their students and neglect fostering the ability to think critically among the students. Critical thinking is an enduring ability that should be paramount for colleges and universities to nurture among their students because of its pivotal role in lifelong learning (Jiang, Hu, Zhang, & Yin, 2022; Terenzini Springer, Pascarella, & Nora (1995)

Kurfiss (1988) emphasized that educators are required to foster and develop the capacity to think critically in students and that since critical thinking can be built, developed and nurtured through an individual's learning processes (Duran & Şendağ, 2012), teachers must emphasize critical thinking skills among their students. Teachers are, therefore, anticipated and required to possess critical thinking skills and develop same in their students. This is especially so for science teachers who are required to develop future science professionals. Since science seeks to foster ways of thinking and working to make sense of the natural world, which is achieved through making sense of what we see around us by constructing explanations of them (Newton, 2008), people who have been trained in science are expected to develop a practical problem-solving attitude, rational approach to issues and nurture scientific disposition which are requirements for developing one's capacity to deal with and manage everyday life (Osborne, 2010). These attributes fit into critical thinking skills and, therefore, science teachers must be capable of nurturing them in their students.

The Ghanaian pre-tertiary curriculum has explicitly identified critical thinking and problem solving as a competency expected of learners after going through the educational system (Ministry of Education, 2018). Ghanaian teachers are expected to facilitate the development of their learners' critical thinking abilities. Such expectations become pronounced in science where by default critical thinking and problem solving are requirements needed to be successful in that area (Reffhaug, Andersson-Bakken, & Jegstad, 2024). Science teachers are, therefore, expected to demonstrate critical thinking skills for them to successfully develop that of their students. This implies that the training of science teachers should factor in the development of critical thinking. Thus, the critical thinking skills of pre-service science teachers are important if the nation is to realize its dreams of students developing critical thinking abilities. This is because preservice teachers will eventually become professional teachers who will be expected to nurture critical thinking skills in their students. It is, therefore, important that their critical thinking skills are elicited and necessary remediation and intervention provided if found necessary so that they can ultimately facilitate the development of their students' critical thinking skills. In the absence of such vital information, there could be dire repercussions on the future generation of science students which will ultimately affect society because as noted by Giancarlo and

Facione (2001) students' ability to solve problems through critically examining available avenues are enhanced when their critical thinking dispositions are developed. Thus, this study sought to assess pre-service science teachers' awareness of their critical thinking abilities.

To successfully attain this aim, three research questions guided the study:

1. What is the level of pre-service science teachers' awareness of their critical thinking abilities?

2. What are the differences in awareness among pre-service science teachers' critical thinking abilities across the various academic levels?

3. What difference exists in awareness of critical thinking abilities between male and female pre-service science teachers?

Literature review

It appears, however, that research on critical thinking has sought to identify relationships between critical thinking skills/disposition and academic achievement. For instance, Dehghani, Mirdoraghi, and Pakmehr (2011) investigated the role of graduate students' achievement goals and their disposition towards critical thinking in a university in Iran and realised that there was a significant relationship between students' achievement goals and their critical thinking disposition. The evidence alluded to the fact that students' critical thinking disposition could be predicated on their achievement goals. Although there was no effort to identify causality, the evidence pointed to the fact that there was an association between students' achievement and critical thinking prowess. Similarly, Karagöl and Bekmezci (2015) examined the relationship between academic achievements and critical thinking dispositions of university teacher candidates in terms of school type, the field of study and gender in two universities in Turkey. They found that both critical thinking dispositions and academic achievements of teacher candidates did not differ according to the type of school. Critical thinking dispositions of teacher candidates differed according to the field of study and there was a positive but weak relationship between critical thinking dispositions and academic achievements of

teacher candidates. Their results revealed that the critical thinking dispositions of teacher candidates do not differ in terms of gender.

Wan and Cheng (2019) identified a positive relationship between critical thinking, classroom learning environment and achievement among Hong Kong students. They accentuated that critical thinking skills had a full mediation effect between students' classroom learning environment and their achievement in liberal studies. In a similar vein, Dökmecioğlu, Tas and Yerdelen (2020) found positive relationships among students' perception of their constructivist classroom learning environment, metacognitive self-regulation strategies and critical thinking dispositions.

To identify causality between critical thinking and academic achievement, Chukwuyenum (2013) investigated the impact of critical thinking on the performance in mathematics among 195 senior high school students through a quasi-experimental design where the experimental group received training on critical thinking. The results showed that critical thinking training was effective in improving students' achievement in mathematics. There was, however, no significant difference in performance regarding gender. In similar causality research, Arsal (2015) also found that pre-service teachers' critical thinking dispositions improved after microteaching in a quasi-experimental design and suggested that teacher educators should encourage pre-service teachers to engage in microteaching to improve their critical thinking dispositions. In a similar university setting, Sönmez, Memiş and Yerlikaya (2021) used an argumentation-based enquiry approach to improve preservice science teachers' critical thinking abilities through a chemistry course. They concluded that argumentation-based enquiry has a significant impact on the development of critical thinking among teacher candidates.

The literature on preservice teachers' critical thinking dispositions and skills is not conclusive. While Bakir (2015) found that the critical thinking disposition of pre-service teachers was low, with no significant difference in terms of gender and class level but a weak positive relationship between academic achievement and critical thinking dispositions, Yorganci (2016) indicated that pre-service mathematics teachers had moderate critical thinking dispositions with strong positive relationships among all six subscales (Open-mindedness, inquisitiveness, systematicity, truth-seeking, analyticity, and self-confidence) with significant differences in students' critical

thinking disposition based on gender and grade level. The males performed better than the females on the inquisitive subscale just as the first years outperformed their fourth-year counterparts on the self-confidence scale. Giancarlo and Facione (2001) on the other hand found that females had an overall better score on critical thinking disposition than males. Fikriyati, Agustini, and Suyatno (2022) also identified that both the critical thinking dispositions and critical thinking skills of pre-service science teachers as low. They also observed a significant positive correlation between pre-service science teachers' critical thinking dispositions and critical thinking skills. Welter, Emmerichs-Knapp, and Krell (2023) accentuated that the critical thinking skills of pre-service biology teachers in Germany fell between the low–average range. They further elucidated that students in the master's program demonstrated clearly superior CT skills than those in the bachelor's program. Similarly, Misbah, Hamidah, Sriyati, and Samsudin (2024) noted that pre-service physics teachers demonstrated low proficiency in critical thinking skills across various indicators such as elementary clarification and advanced clarification.

Pilevarzadeh, Shahrokhi and Salari (2015) did not find any significant relationship between critical thinking and the educational progress of students when they investigated the effect of critical thinking on the educational progress of nursing university students. Again, Akgun and Duruk (2016) after investigating pre-service science teachers' critical thinking dispositions in the context of personal and social factors indicated that pre-service science teachers' critical thinking dispositions were low with no significant difference in terms of gender and grade. Although Alper (2010) in a study to explore critical thinking disposition of pre-service freshmen and senior student teachers found that the freshmen and the fourth-year students' disposition scores in all the subscales except for truth-seeking were consistently above 40 indicating a relatively moderate critical thinking disposition, the students did not differ in critical thinking dispositions across the grade level. Yeh and Wu (1992) and Saka (2009), however, reported a positive significant relationship between critical thinking and the educational progress of elementary students, high school students, and university students.

The outcome of no relationship between grade level and critical thinking skills and lower grade levels outperforming their higher grade levels in terms of critical thinking dispositions as seen in Alper (2010)

contradicts Facione et al. (1995) and Giancarlo and Facione (2001) who asserted that as students' progress in educational maturity, their intellectual inquisitiveness and their desire to develop content and pedagogical knowledge continuously increase leading to increased critical thinking abilities.

The evidence from the literature indicates that there is no consensus with regard to the level of critical thinking dispositions among students. Different authors tend to have different results. In some instances, students demonstrate high levels of critical thinking dispositions and skills (Alper, 2010; Arsal, 2015; Dehghani, Mirdoraghi, & Pakmehr, 2011). Unfortunately, there are instances where students' critical thinking abilities were found to be low (Akgun & Duruk, 2016; Bakir, 2015; Fikriyati, Agustini, & Suyatno, 2022; Misbah, Hamidah, Sriyati, & Samsudin, 2024; Welter, Emmerichs-Knapp, & Krell, 2023). Such inconsistent outcomes do not augur well for planning and effective teaching. There ought to be concrete evidence to facilitate and guide teachers to be able to successfully develop and nurture students to the level of competence expected of them in the 21st century.

Similarly, there seem to be varying results and outcomes in critical thinking skills in terms of gender and grade level. Some studies (eg., Yorganci 2016) identified gender differences among students in terms of their critical thinking abilities. Again, grade level inconsistencies regarding critical thinking are a major issue that needs to be dealt with. This is because there seemed to be the argument that students' critical thinking is not affected by the number of courses taken in school as well as maturity levels of students. This creates a gap in research that needs to be filled. Additionally, most of the researches were not explicit on the subjects of the students, especially at the university level. It is pertinent that critical thinking research becomes subject-specific to guide curriculum development and policy implementation.

Methodology

Design and Participants

The major aim of the study was to assess pre-service teachers' awareness of their critical thinking abilities. This was done using the cross-sectional survey design. The study was cross-sectional since a 'snapshot' of pre-service science teachers were surveyed at a particular

point in time (Cohen, Manion, & Morrison, 2007). The cross-sectional design was used to reduce the pressure of time and resources (Gray, 2004). All 592 pre-service science teachers from levels 100 to 400 of the Department of Science Education in the University of Cape Coast, Ghana were used to gain insights into their awareness of their critical thinking abilities. The distribution of the respondents according to levels were 143, 157, 134 and 158 for levels 100 to 400 respectively. There were 460 males and 132 females in the sample. The study was conducted in the second semester of the academic year.

Instrumentation

Information regarding the pre-service science teachers' awareness of their critical thinking abilities was gathered with the 25-item questionnaire constructed by Cottrell (2005) for measuring one's awareness of critical thinking abilities. Each item on the questionnaire was scored on a five-point Likert-type scale format (4-strongly agree, 3-agree, 2-sort of agree, 1-disagree, 0-strongly disagree). The higher the scale score, the more critical thinking abilities are demonstrated. Cottrell (2005) explained that a score over 75 suggests one is very confident about their critical thinking ability while a score under 45 means one is unsure of their ability. Although Cottrell's instrument has been validated, since it was being used in a new context it was deemed appropriate to be validated again. Thus, Cronbach's alpha reliability coefficient was estimated to be 0.88.

The high reliability nonetheless, it should be noted that questionnaires come with inherent weaknesses. As a self-report tool, respondents have been found to either under or overestimate their abilities, skills and perceptions which Creswell (2012) refers to as response bias. There is also the tendency of respondents to exaggerate, lie or provide responses they believe are socially desirable and acceptable (Gray, 2004; Paulhus & Vazire, 2007).

Results

In this study, the level of pre-service science teachers' awareness of their critical thinking abilities was explored using Cottrell's (2005) interpretation where a score of between 0-25 depicts low confidence, 26-50 depicts moderate confidence, 51-75 depicts high confidence and 76-100 depicts very high confidence in their critical

thinking awareness. It was found as shown in Table 1 that generally, pre-service science teachers demonstrated relatively high confidence (72.61) in their awareness of critical thinking abilities. As shown in Table 1, Level 400 students exhibited the highest confidence while Level 200 were the least confident in their awareness of critical thinking abilities.

Table 1: Critical Thinking Awareness Scores of Pre-Service Teachers

Level	Critical Thinking Awareness Score
100	72.85
200	69.61
300	70.87
400	77.10
Grand Score	72.61

The study further examined whether there were statistically significant differences in awareness among pre-service science teachers' critical thinking abilities across the various academic levels. To achieve this objective, a one-way analysis of variance (ANOVA) was used and the results are presented in Table 2. Data in Table 2 shows that there was a statistically significant difference in the awareness of critical thinking abilities among the levels of pre-service science teachers [$F(3,588) = 13.165$, $p < .001$].

Table 2: Results of One-way ANOVA of Pre-Service Science Teachers' Critical Thinking Awareness

Level	Mean	Std Deviation	N	F	df_1	df_2	P
100	2.91	.46	143	13.165	3	588	.001*
200	2.78	.46	157				
300	2.82	.47	134				
400	3.08	.42	158				

Since there was a statistically significant difference in the awareness of critical thinking abilities among the pre-service teachers, a Post Hoc analysis using Tukey HSD was performed to ascertain where the difference lies. Table 3 presents the Post Hoc multiple comparison results.

Table 3: Results of Post Hoc Analysis

(I)Level	(j) Level	p
100	200	.063
	300	.461
	400	.001*
200	300	.780
	400	.001*
300	400	.001*

As shown in Table 3, there was no statistically significant difference in the awareness of critical thinking abilities between Level 100 (M=2.91, SD=.46) and Level 200 (M=2.78, SD=.46, p=.063). There was also no statistically significant difference in the awareness of critical thinking abilities between Level 100 (M=2.91, SD=.46) and Level 300 (M=2.82, SD=.47, p=.461). There was, however, a statistically significant difference in the awareness of critical thinking abilities between Level 100 (M=2.91, SD=.46) and Level 400 (M=3.08, SD=.42, p<.001*) with Level 400 having the highest awareness of critical thinking abilities. Regarding Table 3, there was no statistically significant difference in the awareness of critical thinking abilities between Level 200 (M=2.78, SD=.46) and Level 300 (M=2.82, SD=.47, p=.780). There was a statistically significant difference in the awareness of critical thinking abilities between Level 200 (M=2.78, SD=.46) and Level 400 (M=3.08, SD=.42, p<.001*) with Level 400 having the highest critical thinking ability. There was also a statistically significant difference in the awareness of critical thinking abilities between Level 300 (M=2.82, SD=.47) and Level 400 (M=3.08, SD=.42, p<.001*) with Level 400 having the highest critical thinking ability.

A mean plot of the awareness of critical thinking abilities among the levels of pre-service science teachers was conducted. This was done to provide a pictorial representation of the critical thinking abilities of the various levels of respondents as illustrated in Figure 1.

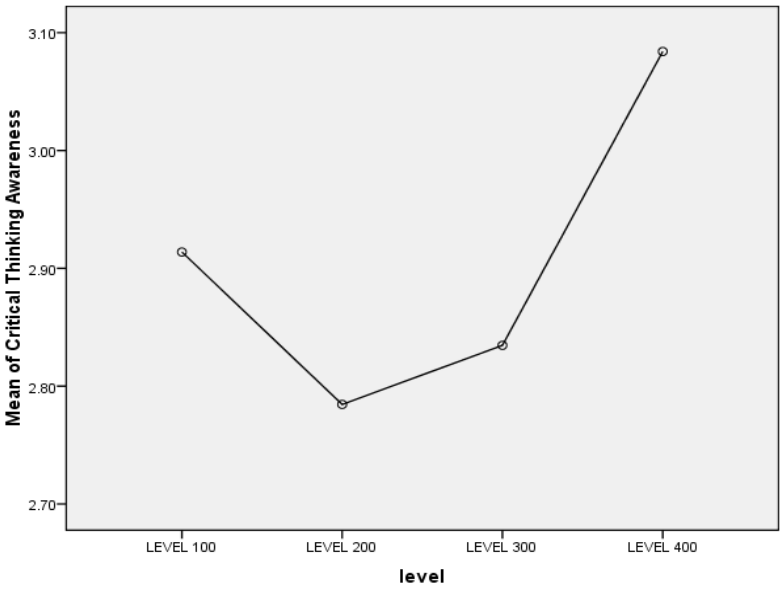

Figure 1. Mean of Critical Thinking Awareness among the Levels

Again, the study explored whether there was any difference in awareness of critical thinking abilities between male and female pre-service science teachers. As indicated in Table 4, the independent samples t-test showed that there was no statistically significant difference in the awareness of critical thinking abilities between male [*M*=2.92, *SD*=.46] and female [*M*=2.83, *SD*=.47] pre-service science teachers [$t(590) = 1.1731$, p=.084]

Table 4: Results of Independent Samples t-test between Male and Female Pre-Service Teachers

Sex	N	Mean	Std. Deviation	t	df	p
Male	460	2.92	.46	1.731	590	.084
Female	132	2.85	.47			

Discussion

Pre-service science teachers in this study exhibited high confidence with regards to their awareness of their critical thinking abilities when their means were viewed in the light of Cottrell's (2005)

interpretation. The outcome of this study seemed to align with Alper (2010), who identified that pre-service freshmen and senior student teachers had high critical thinking disposition scores. On the other hand, Akgun and Duruk (2016) reported low critical thinking dispositions among pre-service science teachers. Evidence from this study points to the fact that pre-service science teachers are capable of making informed decisions due to their awareness of their critical thinking abilities. This is because critical thinking awareness can influence an individual to make appropriate, valid and worthwhile decisions (Bielik, & Krüger, 2022; Facione et al.1995).

The statistical difference obtained in the awareness of pre-service science teachers' critical thinking abilities between Level 400 students and those in the lower levels suggest that ultimately the number of years and courses that are taken in university influence students' critical thinking skills. This outcome emanates from the fact that, fundamentally, as students climb the academic ladder, they would have been introduced to several courses which cumulatively will enhance their critical thinking abilities. However, in this study, no significant difference was seen among Levels 100 to 300 participants in their awareness of their critical thinking abilities. Again, the lack of difference among Levels 100 to 300 could be due to two reasons: the Level 100 students thought too highly of their abilities since they had gained admission into the university and probably thought they were academically good and therefore could think critically. Thus, they may have overestimated their critical thinking abilities (Facione et al., 1995). The level 100 students may have fallen victims to response bias (Creswell, 2012) or provided responses they felt were socially acceptable and desirable (Paulhus & Vazire, 2007). The Level 200 and 300 students had undergone a course in critical thinking and therefore had more knowledge when it comes to critical thinking. This course focuses on developing critical thinking skills by applying logical principles to real-life situations through the use of practical logic. Students learn to make informed judgments about claims, behaviours, and societal practices. This probably could have caused them to underestimate their critical thinking abilities (Facione et al., 1995). Nonetheless, at level 400 the students' critical thinking awareness had increased than all the other lower levels.

Another probable reason for the difference in the awareness of critical thinking abilities of the pre-service teachers is that as they

progress in educational maturity, their intellectual inquisitiveness and their desire to develop content and pedagogical knowledge continuously increase (Facione et al., 1995). This is in agreement with Yeh and Wu (1992) who reported a positive significant relationship between critical thinking and the educational progress of elementary students, high school students, and university students. Saka (2009) also concluded that there is a significant relationship between critical thinking and the scale of educational progress. Generally, the background knowledge of an individual plays a crucial role in their critical thinking abilities (Willingham, 2007). The result of this study, on the other hand, contradicts those of Facione (1990) and Pilevarzadeh et al. (2015) which showed no significant relationship between critical thinking and students' educational progress. Case (2005) and Kennedy et al. (1991) regard background knowledge as a necessary but not sufficient condition for critical thinking.

Furthermore, it was found in this study that there was no difference between males and females pre-service science teachers' awareness of their critical thinking abilities. This finding was similar to that of Karagöl and Bekmezci (2015) who reported no gender differences in pre-service teachers' critical thinking disposition and skills respectively. This finding indicates that there are no gender biases when it comes to the awareness of pre-service science teachers' critical thinking abilities.

Conclusions and Implications

Based on the findings of the research, it can be concluded that pre-service science teachers exhibit a strong awareness of their critical thinking abilities, suggesting a well-developed self-perception in this area. Notably, this awareness is most pronounced among Level 400 students, indicating that as students progress through their training, their recognition of their critical thinking skills becomes more refined. Additionally, the study reveals that there is no significant gender disparity in the awareness of critical thinking abilities, suggesting that both male and female pre-service science teachers possess an equal understanding of their critical thinking capabilities. These findings highlight the effectiveness of the current educational practices in fostering critical thinking awareness among pre-service science teachers, irrespective of gender. The findings from this study could imply that pre-service science teachers might have an initial

overestimation of their awareness of critical thinking abilities and so courses that encourage critical thinking should be introduced right from Level 100 to enable them to avoid the tendency of overestimating their awareness. Also, interventions that seek to promote critical thinking in science teacher preparation should go beyond gender biases. These interventions should be explicitly included in the curriculum and course outlines of courses. Lecturers should therefore ensure that they place emphasis on students' critical thinking abilities in their classes. There should be an attempt to assess students critical thinking along the various dispositions and abilities. Such assessment can provide insights into the nature of students' critical thinking which could lead to the development of specific and targeted interventions.

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