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Assessment of pre-service physics teachers' conceptual understanding in electricity and magnetism

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Abstract: This study focused on an assessment of pre-service physics teachers' conceptual understanding of physics in the domain of electricity and magnetism concepts. The study employed a descriptive survey method of research. The study sample consisted of 100 pre-service physics teachers from five teacher education colleges during the academic year 2021/21. The study used preliminary data from a PhD dissertation that was gathered by administering a conceptual understanding test on electricity and magnetism, which contained 32 items adapted from standardized tests. The data were analyzed using descriptive statistics, one sample t-tests, independent samples t-tests, and one-way ANOVA. The results of the one sample t-test showed that the conceptual understanding test scores for electricity and magnetism were considerably below 50 and 70 which are the national standard pass mark points and the baseline for certification of competency to the teaching profession, respectively. ANOVA analysis revealed that there was a statistically significant mean difference among the pre-service physics teachers in the colleges. The post hoc test analysis showed that there was a statistically significant mean difference between pre-service teachers from two colleges. The independent samples t-test revealed that there was statistically significant mean difference between test scores of males and females in favor of male pre-service physics teachers. In addition, the participation of female candidates was too low compared to their male counterparts. In conclusion, the achievement of pre-service physics teachers was below the expected values; differences among colleges were detected; and there was an achievement and participation imbalance in relation to gender, though consecutive measures were taken. Based on the conclusions, recommendations are given that could be applicable.

Keywords: conceptual understanding; electricity and magnetism; Pre-service physics teacher

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Introduction

It is no longer arguable whether science education is important and necessary. What is perhaps still questioned and investigated is how to provide high-quality science education at various stages of education. The economic, social, cultural and political development a society and a nation at large is very difficult to be achieved without well-educated and skilled manpower (Zolfaghari, 2015; Mc Eneaney, 2003). That is why science education has received special attention by individuals, institutions and countries in the globe at large. The goals of science education should therefore meet the demands of the changing world as education is primarily focused to prepare its future generation workforce. Empirically validated teaching strategies which stem out of constructivist view of learning emphasizes

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active-engagement and inquiry style teaching-learning methods, in which the learners can effectively construct their understanding under the guidance of instruction (Bao & Koenig, 2019).

Despite underachievement and low percentage of excellent performance, there is great concern and emphasis regarding science and mathematics education in several countries. A much more serious problem of the education system in low-income countries is low attainment (Alemu et al., 2019). Despite quality problems, science subjects are also emphasized in the Ethiopian education system being aware of their contributions in all-round development of the country (MOE, 2015;2009; MoE, 1994). However, researchers have highlighted a number of issues, including lecture-dominated instruction, an overemphasis on content, and a lack of facilities and resources, all of which are ascribed to the system-wide problem of science education (Alemu, 2015; Ayalew et al., 2009; Semela, 2010;Bekalo & Welford, 2000). The Ethiopian government has made important improvements in response to challenges and problems of science and mathematics education identified in research. Therefore, recurrent reviewing of changes in students' learning after the implementation of improvements will help us not to rely on past findings and provide quick amendments, if there exists.

Physics is essential to ensuring future demands for scientific and technical competence Physics is essential to ensuring future demands for scientific and technical competence (Angell et al., 2004). However, the Organization for Economic Co-operation and Development OCED (2018) study revealed that many nations are seeing declines in both rates of enrollment in undergraduate scientific programs and in students' international test scores. Science and mathematics education should get the proper focus beginning in the primary grades, and the school curriculum should be developed to enhance students' problem-solving skills. Physics is one of the prioritized subjects of science and mathematics education in Ethiopia. It is given as an independent subject starting from grade 7 (MoE, 2009). Offering physics as a separate subject starting from 7^{th} grade allows students to prepare mentally, academically, and psychologically for the next grade and gain basic knowledge of physics for further study in engineering, medicine, space science, and other technical fields (MoE, 2009; Redish & Redish, 2004). This is due to the fact that a good physics education is crucial for educating the next generation for a world with more advanced technologies in the future (Bigozzi et al., 2018; Masood, 2014). For this purpose, we need to develop qualified and trained physics teachers who can properly teach the new generation and guide the future direction of technology development (Masood, 2014). Despite its substantial role in diverse spheres, the number of students enrolled in physics is declining globally including in the United States, England, Germany and Netherlands (Semela, 2010). According to existing studies, a decline in interest in physics was already apparent as early as lower secondary education (Hoffmann, 2002), which later led to worsening college admission (Semela, 2010; Hoffmann, 2002).

Science education researches in general and physics education researches in particular have demonstrated that quality physics instruction is a challenge both in the developed and developing nations (Mbonyiryivuze et al., 2019). One of the most prominent contributions of physics education researches was its finding that shed light on the failure of traditional instruction focused on rote learning, mere memorization, and naïve quantitative problem solving in teaching introductory physics courses which do not bring conceptual understanding of physics concepts, principles and laws (Fan, 2015; Gerace & Beatty, 2005). Many students completed their study of physics with severe gaps in their conceptual understanding of concepts in many physics topics in a traditional instruction regardless of physics teachers' efforts (Eshetu & Alemu, 2018; Cahyadi, 2007). That is, in one hand, traditional teaching approaches lead to problems of misconceptions and inadequate conceptual understanding in physics concepts, on the other hand; many of the students remain with inadequate explanation of physics concepts after completing traditional instruction. This is because students learn very little from traditional lecture type instruction and it does not encourage them to think by themselves in constructing their own meaning and learning (Fan, 2015; Lasry et al., 2014). The question of quality physics education is still a concern which is continued to the present time.

Conceptual understanding is an essential goal in learning in science education because it is required to make meaning of phenomena (Phanphech et al., 2019). Conceptual understanding is one of the most frequently assessed outcome variables in empirical studies because of its significant importance and role as a part of scientific literacy (Wörner & Scheiter, 2022). It was further elaborated by Anderson et al., 2001 that understanding entails being ability to deduce, interpret, and explain information which entails a grasp of *the principles that govern a domain, as well as the interrelationships between domain units of knowledge*. Cognizant of its importance in learning physics, conceptual understanding is among the important topical areas and most studied issue in PER. For example, Docktor & Mestre (2014), classified the focus areas of PER into six topical parts based on previous physics education researches: conceptual understanding, problem solving, curriculum and instruction, assessment, cognitive psychology, and attitudes and beliefs about learning and teaching. Because of their impact on students' learning, studies of physics students' conceptual understanding and misconceptions have become a significant subject in physics. Students who perform well in quantitative problem solving are challenged by conceptual questions (Muise, 2015; Wieman & Perkins, 2006) and those with high scores have been reported lacking deep conceptual understanding of some basic concepts in physics topics (Wieman & Perkins, 2006).

Because of their abstract nature, electricity and magnetism concepts are considered as one of the most difficult topics in physics. As a result, several researches on students' conceptual understanding of electricity and magnetism have been undertaken, as well as several instructional strategies have been suggested for conceptual change in this topic (Mbonyiryivuze et al., 2019). Conceptual understanding difficulties among learners were identified at various levels of schooling. For instance, poor achievement of results was recorded among pre-service physics teachers (Kola & Langenhoven, 2021; Alemu et al., 2019) and undergraduate students (Mbonyiryivuze et al., 2019; Hussain et al., 2012).

The goal of science, in accordance with Babalola et al. (2020) and (Millar, 2010), is to deepen our understanding of the natural world, its components, and its functioning. The authors continue by stating that either physically exhibiting certain concepts to students, such as objects, processes, and occurrences, or putting them in situations where they may directly see these concepts is required for teaching science. As a consequence, including effective practical work and laboratory experiments in physics teaching and learning would promote conceptual understanding in addition to practical activities in physics (Antwi et al., 2021; Twahirwa & Twizeyimana, 2020). Because of this, laboratory experiments and activities in physics are one of the ways to improve conceptual understanding since they have long had a central role as a means of making sense of the natural world (Hofstein & Lunetta, 2004). According to Lunetta et al. (2007), laboratory activities demand as a way of allowing students to learn with understanding and help students engage in the process of learning by doing via constructing their own knowledge. Experiments in physics classrooms can help in promoting deep conceptual understanding of physics concepts (Omosewo, 2006) develop skills to infer and interrelate multiple concepts (Okono et al., 2015), encourage participation and serve to develop critical thinking, catching and holding learners' interest and motivation (Babalola et al., 2020), and enhance students' scientific skills (Ndihokubwayo, 2017).

However, the recipe-based, confirmatory-style and cookbook labs and experiments were found to be insufficient to enhance students' learning because of an expository type instruction in order to arrive at a pre-determined answer to a problem under investigation (Babalola, 2017). Effective laboratory experiments and activities are recommended to be facilitated using reformed instructional strategies such as physics by inquiry and computer-based focusing on developing scientific abilities exhibited higher gains in physics (Riaz et al., 2020; Docktor & Mestre, 2014). The advancement of information and communication technologies has led to the usage of technology-enhanced physics laboratories in physics instruction. In fact, there are ongoing discussions in the literature on the efficacy of various types of physics laboratory experiments, such as real, virtual, and blended (Wörner et al., 2022; Brinson, 2015). The difference in related research findings and the arguments regarding effectiveness of different modes of physics experimentations; however, focus on whether one mode of experimentation can replace the other. In a review of over 133 empirical researches focused on learning outcome achievement of traditional and non-traditional laboratories, Brinson (2015) concluded that no consensus exists yet regarding best practices of modes of lab experimentations.

It is obvious that foundations are laid at lower levels of education so that efforts should be made to train qualified teachers, as teachers are an important element of quality education, among other factors. In line with this, educational institutions (Teferra et al., 2018) and scholars (Ahmad, 2014) suggested that promoting the quality of teachers is the most important factor in improving the education system at all levels. In addition, UNESCO (2018) stated the following in relation to the quality of pre-service teachers and quality of students' learning:

Teachers are expected to ensure that their students master the academic content in order to be able to apply what they have learned, think critically and solve problems, and keep pace with rapidly changing learning environments and new technologies. Teachers are also expected to oversee the cognitive and social-emotional development of their students (p.135).

Based on the above points, educating and training of pre-service physics teachers is very important to curve the decline of physics achievement of students though there are other challenges identified by scholars. In the literature, a lot of challenges to quality physics education were identified including shortage and absence of qualified and innovative physics teachers, inadequate teaching resources and facilities, shortage of laboratory equipment for experimentation and hands-on activities, limited job opportunities, irrelevance of some contents which are unrelated to every day experience of students, a high difficulty perception of the subject, and others (Adolphus, 2019; Keller et al., 2017; Semela, 2010).

Statement of the Problem

Though there were many importance of physics, there are challenges to quality physics education. Because of this reason, a number of researches have been conducted to improve the teaching learning process of physics education in different parts of the world ranging from lower to higher levels of the education system. The findings revealed that traditional instruction followed by cook-book style of lab work failed to benefit students learning of physics (Singh, 2014; Hofstein & Lunetta, 2004). This type of approach do not engage students in thinking for their own learning.

In the Ethiopian context, deterioration in the quality of physics instruction was reported via different researches despite the efforts made to curve the problem. For example, the composite mean score of physics for grade 8 students were 35.32%, 32.2% and 34.47% in the national learning assessments conducted in years 2004, 2008 and 2012, respectively (Belay et al., 2016; Woldetsadik, 2013). When considering grade 10 and 12, the composite mean score in physics were 31.2 % and 36.6%, respectively as revealed by the fourth national learning assessment. Furthermore, Education Sector Development Program V (ESDP V) disclosed that in study conducted by Ministry of Education 2014, grade 10 students achieved 50% and 75% were only 14% and 2%, respectively (MoE, 2015). It is well known that this low level of academic achievement at the school level will have an impact on their future academic career. This low achievement at school level also affects the achievement of pre-service teachers in colleges.

In addition to upper primary and secondary school levels, the quality of physics education is also facing problems in College of Teacher Educations (CTEs). For example, the Amhara National Regional State Education Bureau (ANRSEB) releases annual report regarding COC, result of pre-service teachers of College of Teacher Educations (CTEs). When the recent three years (2017 to 2019) report was analyzed, students who achieved above 70% in integrated natural science were found to be below 50%. In addition, no student scored above 70% in physics in 2017 and there was only one student who scored above 70% in 2019 (ANRSEB, 2019). The results can demonstrate the low achievement scores in the subject. The report of the bureau can provide important evidence of problem of conceptual understanding preservice physics teachers (PSPTs') as it is one of the learning outcome of physics.

To improve the quality of physics education, conceptual understanding is one of the learning goals for both theoretical concepts and laboratory work in physics. In order to use their knowledge in daily life, students must be able to grasp the concept clearly (Wörner et al., 2022; National Research Council, 2006). Technology integration in physics instruction as a whole is one strategy being used to enhance students' conceptual understanding of the subject (Gunawan et al., 2018; Banda & Nzabahimana, 2022). Teachers should have a deep conceptual understanding of physics concepts being taught in order to be able to teach their students well. If teachers do not fully understand the concept of physics, the quality of physics lessons in the classroom can deteriorate, resulting in a negative impact on the student`s conceptual understanding of physics (Aviyanti, 2020; Phanphech et al., 2019; Dervić et al., 2018). Concepts related to electricity and magnetism, are mainly problematic because of their abstract and complex nature making it challenging to students to understand (Miokovic et al., 2012). It is reported that teachers and students have misconceptions which are difficult to give up, especially when they have held such a belief for a long time (Gunstone et al., 2009).

Gender issue is debatably one of the most important debates we have in physics education. The literature regarding gender issues in physics education is diverse and debatable. Some authors say that physics education is independent of gender issues and should not be considered in PER (Heron & Meltzer, 2005); other authors reported that women are underachievement and underrepresentation in physics education and need to be studied (Danielsson, 2009). For example, in OECD countries the number of women who received degrees in STEM accounts only 30% (Montecinos & Anguita, 2015). Research findings in Ethiopia have also shown that there are gender differences among physics students at universities and other levels of education. For example, in a study focused on who joins physics and factors influencing the choice of physics students at Ethiopian Universities, in 2006/2007, only 7.9% of the students enrolled in a bachelor's degree in physics were females. In addition, of the 507 physics teachers who graduated in 2008, only 29 (5.7%) were females (Semela, 2010). The government has recognized gender imbalance in favor of men so that planned alleviate the problem with 50% share of women teacher trainees in CTEs (MoE, 2015).

Based on this evidence and our day-to-day experience, it can be said that gender inequality in enrollment in physics subjects has not improved significantly. Despite the fact that low female enrolment in physics has been reported repeatedly, various activities have been carried out, but it is important to study the current situation and to get the latest information. One of the purposes of this article is to investigate the current state of women's participation in CTEs. Hence, it is important to investigate pre-service teachers' conceptual understanding of physics, as they will be the physics teachers of tomorrow who will have the responsibility of teaching physics to their students in the future (Aviyanti, 2020). To sum up, the decline in the achievement of students at different levels of schooling as well as the decrease in the number of students enrolled in studying the subject and the gender inequality is a problem encountered in many parts of the world. Based on the above-mentioned evidences and scholarly recommendations and in agreement with the paramount importance of conceptual understanding to physics teachers, the essence of this article was intended to assess pre-service physics teachers' conceptual understanding on electricity and magnetism concepts. This study would give practitioners and academics the most recent evidence, even if the learning outcome variable, conceptual understanding, was frequently measured by various authors in different countries. Concomitantly, an attempt was made to look at gender participation of pre-service physics teacher' and its dependence on achievement.

The general objective of this study was to examine the status of pre-service physics teachers' conceptual understanding in electricity and magnetism topics. The following research questions were addressed in this study as a result of the concerns indicated above:

1. Is there any significance difference between the mean of pre-service physics teachers' conceptual understanding test scores and national standard pass mark and baseline for certification of competency?
2. Is there any significance difference among CTEs in relation to conceptual understanding scores?
3. What is the extent in the enrolment of male and female students into physics education program in CTEs in 2020/2021 academic year?
4. Is there any significant difference in conceptual understanding test scores of male and female pre-service physics teachers?

Materials and Methods

This study used a quantitative descriptive survey design. The focus of this study was second-year preservice physics teachers who were enrolled in CTEs in Ethiopia's Amhara Regional State. When this study was conducted in the academic year 2020–2021, there were ten CTEs available, and five of them had second-year pre-service physics teachers enrolled in a linear physics diploma program. A total of 100 second-year PSPTs enrolled in these five CTEs were sampled using the available sampling techniques. The data were gathered using the Electricity and Magnetism Conceptual Understanding Test (EMCUT), which was adapted with permission from standardized tests. The independent variables of the study were CTEs and gender, while conceptual understanding serving as the dependent variable.

The tests were selected to correspond with the topics covered in the electricity and magnetism course. There are 32 items on the conceptual understanding test that are connected to concepts in electricity and magnetism. The test item scores have been reset to 100%. To ensure that the elements on the test were indicative of the course material on electricity and magnetism, a test blueprint was created. Face validity and content validity were verified by the author and other two colleagues to check for clarity and free of ambiguity and to assure representativeness of the topics, respectively. The Cronbach's alpha reliability of the items was calculated and found to be .79 which was in the accepted range of Cronbach's alpha interpretation.

The data analysis methods employed in this study were descriptive statistics, one sample t-test, independent samples t-test, effect sizes, and ANOVA. The one sample t-test was used to analyze PSPTs' conceptual understanding test scores against the test values (50 pass mark points and 70 baseline score). The independent sample t-test was used to compare gender differences in conceptual understanding. One-way ANOVA was employed to see whether there was statistically significance mean difference of PSPTs' conceptual understanding scores among CTEs. The assumptions of normality and homogeneity of variances of the scores were checked before deciding the type of inferential statistics.

Results and Discussion

In this quantitative descriptive survey study, preservice physics teachers' conceptual understanding of the topics of electricity and magnetism was assessed. The first step in the data analysis process was to test the EMCUT's assumptions. To verify for outliers and the distribution of the test results, histograms, normal Q-Q plots, and boxplots were visually inspected. The test results were approximately normally distributed, as these graphical techniques demonstrated. Additionally, skewness, kurtosis, the corresponding z-scores, and the Shapiro-Wilk test were used to conduct descriptive and statistical testing of normality. These results were shown in Table 1.

Table 1. Descriptive statistics, skewness, kurtosis and z-scores of dependent variable

				Skewness			Kurtosis		
Dependent Variable	N	M	SD	Statistic	SE	Z_S	Statistic	SE	Z_K
EMCU	100	32.63	9.97	-.153	.241	-.635	-.189	.478	-.395

As it is displayed in Table 1, the mean and standard deviations of EMCUT scores for PSPTs were (M=32.63; SD=9.97). The skewness and kurtosis of the scores were -.153 and -.189, respectively. Furthermore, the Z-scores for skewness and kurtosis were -.635 and -.395, respectively. The skewness and kurtosis values lie in between ± 1 and the respective Z-score values in between ± 1.96. Thus, it can be concluded that the data were approximately normally distributed. In addition to graphical evaluation, a statistical test of normality is revealed in Table 2.

Table 2. Statistical test of normality

Dependent Variable	Group	Shapiro-Wilk		
		Statistic	df	Sig.
Conceptual Understanding	CTE1	.937	21	.193
	CTE2	.912	16	.124
	CTE3	.940	26	.136
	CTE4	.950	21	.341
	CTE5	.887	16	.050
Gender	Female	.895	16	.066
	Male	.968	84	.053

As detailed in Table 2, statistical test of normality using Shapiro-Wilk test was not statistically significant when computed across colleges and gender, W(21)=.94, *p*=.19,for CTE1; W(16)=.91, *p*=.12, for CTE2; W(26)=.94, *p*=.14, for CTE3; W(21)=.95, *p*=.34, for CTE4; W(16)=.89, *p*=.05, for CTE5; W(16)=.90, *p*=.07 for Female, and W(84)=.97, *p*=.05 for male. The Shapiro-Wilk test indicated that there was no significant departure from normality.

Research Question 1: Do pre-service physics teachers' conceptual understanding test scores deviate from standard pass mark of 50 points and the baseline for certification of competency to teaching profession?

Table 3. Result of one-sample t-test statistics

	N	Mean	Std. Deviation	Std. Error Mean
Conceptual Understanding	100	32.63	9.97	.997

As shown in Table 3, the one-sample statistics revealed number, mean, standard deviation and standard error of conceptual understanding test scores (*N*=100, *M*=32.63, *SD*=9.97, *SE*=.997). Mean score of conceptual understanding of pre-service physics teachers (32.63 ± .997) was lower than the pass mark of 50 points.

Table 4. One sample t-test with a test value of 50

Dependent Variable	Test Value = 50					
					95% CI	
	t	df	Sig. (2-tailed)	MD	LB	UB
Conceptual Understanding	-17.42	99	.000	-17.38	-19.35	-15.40

As it is shown in Table 4, the mean score of EMCUT for PSPTs was significantly deviated from pass mark value of 50, *t* (99) =-17.42, *p*<.000. Furthermore, it was significantly lower by 17.38, 95% CI [15.40, 19.35] than the pass mark taken as a test value of 50, *t*(99)=-17.42, *p*=.000, with very large effect size (Cohen's *d*=1.74).

Table 5. One sample t-test with a test value of 70

	Test Value = 70					
					95% CI	
	t	df	Sig. (2-tailed)	MD	LB	UB
Conceptual Understanding	-37.47	99	.000	-37.38	-39.35	-35.40

As it is depicted in Table 5, the mean difference of EMCUT for PSPTs was statistically significantly lower than the 70% cutoff value for the COC, *t*(99)=-37.47, *p*=.000, with very large effect size (Cohen's *d*=3.75).

Research Question 2: Is there any significance difference among CTEs in relation to conceptual understanding test scores?

Because there were five CTEs, the one-way ANOVA analysis was performed to answer the second research questions of the study.

Table 6. Test of homogeneity of variances

		Levene's Statistic	df1	df2	Sig.
Conceptual Understanding	Based on Mean	.264	4	95	.900

As it is displayed in Table 6, the Levene's test of homogeneity of variances showed that the variances of EMCUT scores were not statistically significant, $F(4,95)=.264$, $p=.90$. To say it in the words, the null hypothesis of equal variances was not rejected implying that homogeneity of variance assumption needed for a One-Way ANOVA was obeyed.

Table 7. Descriptive of ANOVA analysis

DV	College	N	M	SD	SE	95% CI LB	95% CI UB
CU	CTE1	21	28.72	9.36	2.04	24.46	32.98
	CTE2	16	30.08	9.26	2.32	25.14	35.01
	CTE3	26	36.54	11.28	2.21	31.98	41.09
	CTE4	21	35.12	8.32	1.82	31.33	38.91
	CTE5	16	30.66	9.07	2.27	25.83	35.50
	Total	100	32.63	9.97	.997	30.65	34.60

As it is depicted in Table 7, descriptive statistics of the ANOVA analysis showed that mean score of EMCUT for PSPTs across colleges ranges from 28.72 (CTE1) to 36.54 (CTE3). In addition, the standard deviations range from 11.28 (CTE3) to 8.32 (CTE5), the minimum values range from 15.63 (CTE1) to 21.88 (CTE4); the maximum values range from 46.88 (CTE2) to 68.75(CTE3). In CTE2, there was no a single pre-service physics teacher scored above 50 and the maximum score was recorded in CTE3. Despite the descriptive differences mentioned, no pre-service physics teacher scored more than 70.

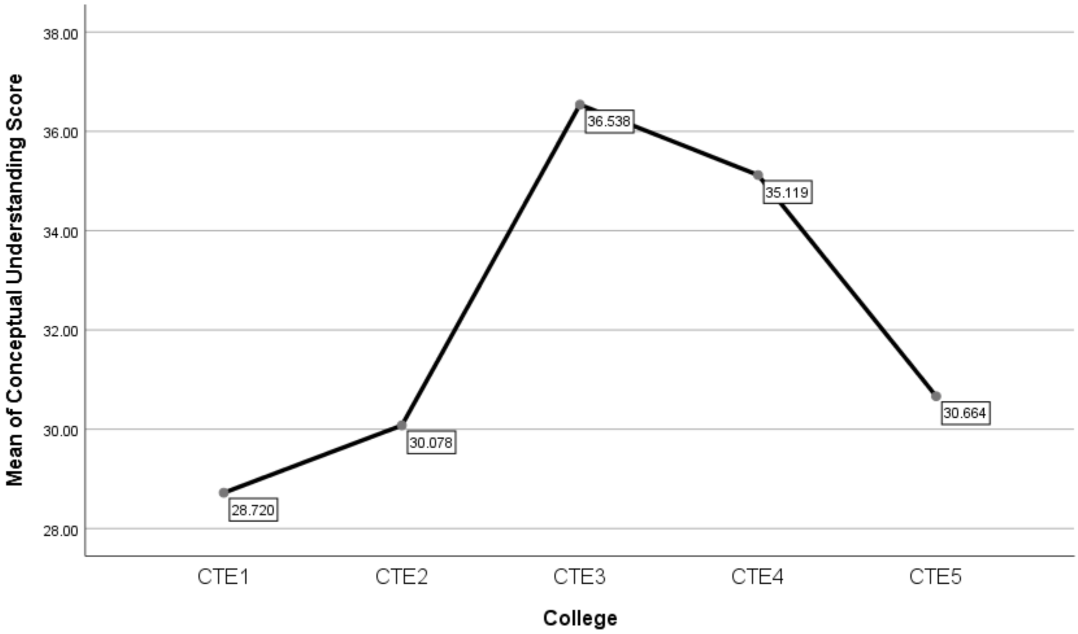

Figure 1. Means plot of conceptual understanding scores across CTEs

The mean plot of EMCUT mean score depicts mean comparison across colleges clearly. As it is shown in Figure 1, the mean plot revealed that CTE3 was at the highest mean followed by CTE5 and CTE1 was with the lowest mean.

The one-way ANOVA was carried out to examine whether there was mean difference in EMCUT scores on PSPT across colleges.

Table 8. ANOVA analysis of EMCUT scores across CTEs

Conceptual Understanding	*SS*	*df*	*MS*	*F*	*p*
Between Groups	1014.32	4	253.58	2.73	.034
Within Groups	8835.68	95	93.01		
Total	9850.00	99			

As it is indicated in Table 8. ANOVA analysis of EMCUT scores across CTEs, there was statistically significant difference among CTEs in the mean scores of conceptual understanding of pre-service physics teachers, $F(4,95)=2.73$, $p<.05$, with medium to large effect size ($\eta^2=.103$).

Research Question 3**:** What is the extent in the enrolment of male and female students into physics education program in CTEs in 2020/2021 academic year?

The participation of male and female PSPT in the CTEs was analyzed using descriptive statistics, and the results are shown in table 9 below. The table revealed the number of male and female second year pre-service physics teachers enrolled in linear physics diploma program in five CTEs of Amhara regional state, Ethiopia in 2020/21 academic year.

Table 9. Second year Pre-service physics teachers enrollment in five CTEs

			Teacher Education College					
			CTE1	CTE2	CTE3	CTE4	CTE5	Total
Sex	Female	N	3	4	2	4	3	16
		%	14.3%	25.0%	7.7%	19.0%	18.8%	16.0%
	Male	N	18	12	24	17	13	84
		%	85.7%	75.0%	92.3%	81.0%	81.3%	84.0%
	Total	N	21	16	26	21	16	100
		%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

As shown in Table 9 above, the number of female PSPT enrolled in the program in the five CTEs in 2020/21 academic year was found to be very low. That is, in each college, there were fewer than five female PSPT. Overall, 84 of the 100 second -year PSPT enrolled in the program during the study period were male and 16 were female. This equates to 84% male and 16% female.

Research question 4: Is there any significant difference in conceptual understanding test scores of male and female pre-service physics teachers?

Table 10. Descriptive statistics of independent samples t-test

	Sex	N	M	SD	SE
Conceptual Understanding	Female	16	28.51	5.34	1.33
	Male	84	33.41	10.47	1.14

As it is portrayed in Table 10 above, the mean score of males was greater than females in EMCUT, ($N=16$, $M=28.51$, $SD=5.34$, $SE=1.33$) for females and ($N=84$, $M=33.41$, $SD=10.47$, $SE=1.14$). The independent samples t-test was computed to investigate whether this mean difference was statistically significant.

Table 11. Levene's test of equality of variances

		Levene's Test		t-test for Equality of Means						
									95% CI	
		F	*p*	*t*	*df*	Sig.(2-tailed)	*MD*	*SE*	LB	UB
Conceptual Understanding	Equal variances not assumed	5.79	.018	-2.78	41.07	.008	-4.89	1.76	-8.44	-1.34

As it is presented in table 11 above, the significance value of Levene's test of equality of variances for independent samples t-test was found to be significant, $F(41.07)=5.79$, $p<.05$. That is why the *equal variances not assumed* row was selected. The result showed that conceptual understanding scores of female pre-service physics teachers was found to be lower than that of males, ($MD=4.89$; $SE=1.76$). This mean difference was statistically significant, $t(41.07)=2.78$, p<.05. Saying it the other way, males outperformed than females in EMCUT administered.

This study attempted to assess pre-service physics teachers' conceptual understanding and, along the way, gender issues. Many authors have stated that conceptual understanding of physics is one of the fundamental goals of physics education, which is especially important for teachers in order to help their students learn best. Gender issues, such as disparities in participation and achievement, are also major considerations.

Conceptual understanding test scores of pre-service physics teachers on electricity and magnetism concepts were significantly lower by mean differences of 17.42 and 37.47 when compared with the 50 and 70 percent test values, respectively. It signifies how the achievement result was deviated from the expected values. The findings of this study are in line with other results in that students tend to hold multiple misconceptions in these concepts (Aviyanti, 2020; Engelhardt & Beichner, 2004). In addition, a recent study by Saputra et al. (2020) reported that pre-service science teachers had misconceptions about simple electric circuits in series and parallel. There are again studies that reported students' difficulty of electricity and magnetism concepts than other courses because of the concepts complex and abstract nature (Mbonyiryivuze et al., 2019; Gunstone et al., 2009).

In the Ethiopian context, Eshetu & Alemu (2018) identified levels of conception of voltage and resistance on first year university undergraduate students after taking electricity and magnetism course. The authors reported that the conception of students formed about voltage and resistance were not much affected after taking the same concepts in advanced levels. Similarly, majority of undergraduate physic students showed improper and counterproductive responses in abstract concepts of electricity and magnetism (Dega et al., 2013). The decline in subject knowledge and achievement of pre-service physics teachers leads to incompetence in teaching effectively which further affects generations of Ethiopian students under-achieve (Alemu et al., 2019) and thrown the education system in vicious circle of poor quality of education (Teferra et al., 2018).

The ANOVA analysis revealed that there was significant difference in achievement of pre-service physics teachers across colleges. Further multiple comparison test analysis showed that the significance difference was observed in only two CTEs. This shows that, with the exception of the significant differences between the two colleges, all the colleges were closely scored low results in conceptual understanding tests. Beyond that, it indicates that pre-service physics teachers' in all of the colleges have shown a decline in conceptual understanding tests. Although there were significant differences between the two colleges, in terms of baseline values, all results registered in all of the colleges were far very small. The significance difference among the colleges signifies a sort of problem which need to be investigated. For example, (Teferra et al., 2018) disclosed that there was lack of uniform admission of candidates, lack of potential candidates, socioeconomic problems, quota systems and others in CTEs.

The finding related to gender participation revealed that it was found thoughtful gender gap in favor of male pre-service physics teachers' enrolled in linear diploma physics teacher education program. The result was in agreement with other studies conducted in Ethiopia (Semela, 2010), Africa (Adolphus, 2019; Alkali & Musa, 2015) and elsewhere in the globe (McCullough, 2007) at secondary schools, colleges and universities. On the contrary, other authors did not take into account gender issues in physics education. For example, Heron & Meltzer (2005) in their study of current and future directions of PER ommited gender issues believing that gender is not a challenge. In this study, geneder inequality was identified and actions should be taken as Ethiopia is striving to increase gender balance in aspect of its move.

This huge gap needs immediate intervention to alleviate the problem. For example, (Ethiopian Science and Agency Technology (ESTA), 2006) suggested that establishing a system to encourage women and youth in science, technology and innovation (STI) activities is one approach to promote participation. It attracts children and young girls and creates inspiration, especially for studying physics and other natural sciences in general. In favor of this argument, other scholars also suggested on how to adjust the observed gender inequity in favor of the underprivileged group (Alkali & Musa, 2015). Ethiopian ESDP V (MoE, 2015) stated the following in order to improve gender participation in CTEs:

> *In particular, the current gender imbalance among teacher trainees will be addressed with the objective of achieving, as soon as possible, a 50% share of women teacher trainees in new annual intakes to CTEs; and in ensuring retention of all teacher trainees (p.56).*

Moreover, Ethiopian Education Road Map (2018-2030) pointed out that though there are improvements, there is still gender gap in higher education institutions (Teferra et al., 2018). So the gender inequality detected in CTEs is one example of the issue which needs an intervention. Males and females also showed significance difference in their conceptual understanding scores in favor of males. That means, males outscored than females with regard to the test administered. There was no equal chance of scoring on the test prepared. The finding was in agreement with other researches (Omar, 2017). The problem become a twofold as there was underrepresentation of females and low score of conceptual understanding tests in linear pre-service physics teacher education program. The achievement gap is also a severe issue which need to be addressed in agreement with participation because the quota system has its own impact on quality (Teferra et al., 2018).

Conclusion and Recommendations

The current study aimed to assess the conceptual understanding of second-year pre-service physics teachers enrolled in five CTEs' linear physics diploma programs in the topics of electricity and magnetism. According to the results of the study, pre-service physics teachers' conceptual understanding exam results on electricity and magnetism were significantly below the 50-point threshold for passing and the 70-point minimum required for certification of competency (COC) in the teaching profession. It suggests that physics education is still characterized by a deterioration in physics achievement despite significant efforts being made. Compared to their male counterparts, the involvement of female pre-service physics teachers was quite low. Additionally, males performed better than girls on tests of conceptual understanding of electricity and magnetism, which may indicate that gender concerns are important in physics education. Although the study only comprised topics from a single course and limited data gathering methods, it could still be seen as a reflection of the situation as it is in the ground. The results of this study provide an up-to-date evaluation of how well physics is performing right now.

Students with these subpar grades were enrolled in order to receive an education and training to become teachers at the elementary and upper primary levels, where children and youth are expected to build the foundation for their future study. The decline in science performance in general and in physics in particular was not resolved, according to other publications that followed. We might imagine that during a crisis or COVID-19 epidemic, the issue may become considerably worse. As a result, it is crucial and only natural to inquire about and examine the current level of progress in science generally and physics specifically since doing so will help us escape the vicious cycle.

Based on the findings of the study, the following recommendations were forwarded:-

1. To improve the quality of physics education, attention needs to be paid to physics teacher education, in particular, efforts to support physics courses with practical works and laboratory experiments. Practical works and experimentation in physics education need to be developed in teacher education programs in order to improve the knowledge, skills and interest of the

children and young people they teach, especially as teachers are important to lay the foundation in the primary and upper primary school levels. For this reason, it is important to focus on laboratory and experimentation methods that can be an alternative and a solution even in times of crisis. To do this, examining the philosophy, views and the way to respond to new ways of laboratory and experimentation modes need to be conducted for further improvement and adjustment of the new approaches.

2. The number of new pre-service physics candidates in general and female candidates in particular is low compared to other disciplines and males, respectively. Teacher education colleges should rethink their enrolment advertisement apart from the quality of the teaching learning process. Though it is a general problem in all subjects, an attempt should be made to attract competent students to study physics. Establish a system of encouragement to attract females in physics education programs.
3. Identify mechanisms on how to assist females to learn physics best

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