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Availability and Utilisation of Science Laboratory Facilities on Science Teacher-Trainees' Pedagogical Content Knowledge in Science

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Abstract

This study assessed final-year science teacher-trainee perceptions of the impact of the availability and utilization of laboratory facilities on science students' pedagogical content knowledge (PCK) in science at Accra and Ada Colleges of Education. This research was motivated by an initial study that stated that the majority of junior high school science teachers were unable to teach science effectively so it was easier for students to understand. This research used a quantitative approach with a cross-sectional descriptive survey design involving 62 intern teachers, 15 science tutors, and two school principals. The research instrument (tutor and teacher questionnaire) was declared suitable for use after a slight revision with the Validity and Reliability scores of 0.84 and 0.86. The research revealed that final-year science teacher candidates at the Accra College of Education were of the opinion that the availability and utilization of laboratory facilities had a moderate but neutral impact on PCK in science, in contrast to the results of research by science teachers at Ada College which stated that the availability and use of Laboratory facilities have a high and positive impact on PCK Science. It is recommended that science tutors engage science trainee teachers in efficient hands-on activities, and also focus on on-campus and off-campus practicums to develop the training of PCK science trainee teachers.

Keywords: Laboratory Facilities, Science Teacher-Trainees, Pedagogical Content Knowledge (PCK) in Science

Ketersediaan dan Pemanfaatan Fasilitas Laboratorium IPA pada Pengetahuan Muatan Pedagogik Guru-Pelatih IPA dalam IPA

Abstrak

Studi ini menilai persepsi guru-peserta pelatihan sains tahun terakhir tentang dampak ketersediaan dan pemanfaatan fasilitas laboratorium terhadap pengetahuan konten pedagogis siswa sains (PCK) dalam sains di Accra dan Ada Colleges of Education. Penelitian ini dilatarbelakangi oleh penelitian awal yang menyatakan bahwa sebagian besar guru IPA SMP belum mampu mengajarkan IPA secara

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efektif sehingga lebih mudah dipahami oleh siswa. Penelitian ini menggunakan pendekatan kuantitatif dengan desain survei deskriptif cross-sectional yang melibatkan 62 orang guru magang, 15 orang tutor IPA, dan dua orang kepala sekolah. Instrumen penelitian (angket tutor dan guru) dinyatakan layak digunakan setelah dilakukan sedikit revisi dengan skor Validitas dan Reliabilitas sebesar 0,84 dan 0,86. Hasil penelitian mengungkapkan bahwa calon guru IPA tingkat akhir di Accra College of Education berpendapat bahwa ketersediaan dan pemanfaatan fasilitas laboratorium berdampak sedang namun netral terhadap PCK bidang IPA, berbeda dengan hasil penelitian guru IPA di Ada College yang menyatakan bahwa ketersediaan dan pemanfaatan fasilitas Laboratorium memberikan dampak yang tinggi dan positif terhadap PCK Sains. Disarankan agar tutor sains melibatkan guru peserta pelatihan sains dalam kegiatan praktik langsung yang efisien, dan juga fokus pada praktik di dalam kampus dan di luar kampus untuk mengembangkan pelatihan guru peserta pelatihan sains PCK.

Kata kunci : Fasilitas Laboratorium, Guru-Pelatih Sains, Pengetahuan Konten Pedagogis (PCK) dalam Sains,

INTRODUCTION

Learning studies on Pedagogical Content Knowledge (PCK) in science learning is something that is important for a prospective science teacher student to have, as the basic preparation to become a teacher who is able to teach science material professionally and effectively. In accordance with the opinion of several experts who state that teaching requires in-depth special knowledge/PCK about what material will be taught and knowledge of how students learn that material. (Ball, Thames, and Phelps, 2008; Shulman, 1987; Ball, Hill, and Bass, 2005). Pedagogical Content Knowledge (PCK) is closely related to the study of learning aimed at improving student learning and teacher professional development (Nilsson, 2014; Mårtensson, 2019). Pedagogical Content Knowledge (PCK) can help focus prospective teachers' attention in directing the topic being taught and can help them realize what needs to be done in teaching so that students can learn the intended content (Royea dan Nicol, 2019; Pang dan Runesson Kempe, 2019).

A teacher's Pedagogical Content Knowledge (PCK) is influenced by several factors including collaboration/cooperation between fellow teachers, availability of infrastructure at school, etc. In accordance with the research several researchers state that working in a collaborative process with colleagues in teaching and learning investigations can help prospective teachers develop their teaching skills during the teacher education process

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(Hiebert et al., 2007; Cheng, 2014; Royea dan Nicol, 2019). Participation in Lesson Study (Lewis, Perry, dan Friedkin, 2009) has been proven to develop prospective teachers' pedagogical competencies (PCK), such as observing, reviewing, and planning lessons (Leavy and Hourigan, 2016; Lee, 2019), and leads to development in their learning. pedagogical content knowledge (PCK) (Leavy dan Hourigan, 2018). The information obtained in learning PCK cannot be applied optimally due to the availability of the required infrastructure (Kibirige & Tsamago, 2013). Research has reported the lack of availability of science laboratory facilities as a major challenge affecting the effectiveness of science learning delivery at the primary school level (Adu-Gyamfi, 2014). Science laboratory facilities have a positive influence on the development of PCK because laboratory facilities are all the resources such as laboratory space, equipment, materials, specimens, and chemicals, among others, that are needed by science students and teachers to promote or improve the effective instructional delivery of science content to students (Enderle & Leeanne, 2016)

Research in the last decade in several countries regarding pedagogical content knowledge (PCK) states that PCK is one of the preparations that is considered important for prospective teachers to become professional teachers. As per research, Learning studies have been included in initial teacher education in various places in the world, e.g. Hong Kong, Sweden, and Canada. Cheng (2014) and Ko (2012) proposed instructional learning as a model to help prospective teachers develop instructional design skills and teaching competencies in initial teacher education. Pang and Runesson Kempe (2019) suggest that introducing instructional learning to prospective teachers will also give them a deeper understanding of instructional learning approaches, and enable them to introduce and practice them in their schools in the future. However, there is debate about whether prospective teachers are prepared to focus intensely on student learning during teacher education (Davies and Dunhill, 2008). Challenges faced by Prospective Teachers in the learning process include the limited teaching experience that Prospective Teachers have, the time required to study learning, and difficulties in understanding and using various learning models (Davies and Dunhill, 2008; Holmqvist, 2011; Royea and Nikol, 2019). Research showed that poor teacher quality is a major contributory factor to the poor

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performance of Ghanaian students in recent times, as far as standardized assessment with their counterparts on the African continent is concerned (Buabeng et. al., 2014).

Several studies show that prospective teachers benefit from experience when participating in learning has a positive impact on the development of their teaching skills (Lamb and Ko, 2016; Cheng, 2014; Lai and Lo-Fu, 2013). A study conducted by Olufuke (2012) on the impact of frequent use of science laboratory facilities revealed that, in schools that frequently used laboratory facilities, students obtained significantly higher average grades compared to their peers found in schools that used the facilities. science laboratory. Tan (2018) stated that prospective teachers can learn from the evaluation process they carried out in the previous learning process. It would be in vain if a science teacher taught a concept in science, for example balancing chemical equations in chemistry if the teacher himself did not have a comprehensive understanding and knowledge of the underlying scientific theories, laws, and principles (PCK) (Enderle & Leeanne, 2016). Based on previous research analysis, there are not many studies that reveal the relationship between PCK achievement and the availability of facilities in a laboratory. So the aim of this research is to explore the perceptions of science teacher-trainers on the extent to which the availability and utilization of science laboratory facilities impact their pedagogical content knowledge (PCK) in science in public tertiary institutions in the Greater Accra Metropolis in Ghana, namely the Ada and Accra Colleges of Education.

METHODOLOGY

The study adopted the quantitative approach because it enabled the researchers to use descriptive and inferential statistics to analyze the numerical data gathered from the respondents (Farenga & Joyce, 2010). The descriptive cross-sectional survey design was adopted for the study because it enabled the researchers to gather one-shot data from several people such as science tutors and science teacher trainees from two different colleges of education to give a succinct description of their views/opinions/perceptions on the topic. This was done to enhance the validity and reliability of the results. The total population of the study was 79, consisting of 62 science teacher-trainees, 15 science tutors, and two college principals at Ada and Accra Colleges of Education. This category of students was chosen because they are believed to have undergone all the requisite theoretical and

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practical professional training to become competent science teachers that qualifies them to be able to effectively teach science at the JHS level, where their pedagogical content knowledge (PCK) in science teaching would be brought to bear. Also, the science tutors were selected for the study because of their direct involvement in the professional training of the prospective science teachers.

The purposive sampling technique was adopted by the researchers to select the sample for the study because it enabled the researchers to select the participants whose characteristics were of direct interest to researchers and the research topic. Purposive sampling has been defined as the procedure where the researcher intentionally selects a group of individuals with certain characteristics that of direct interest to the researcher (Farenga & Joyce, 2010). This technique was used to select 15 science tutors from the two colleges, two college principals, and a total of 62 final-year science trainee-teachers at the two colleges for the study. The science tutors were selected because of their direct role those charged with the responsibility of engaging the science trainee teachers in the requisite professional theoretical and hands-on laboratory experiences aimed at boosting their pedagogical content knowledge (PCK) in science. Convenience sampling technique was adopted to select Accra and Ada Colleges of Education because the two institutions are located within the region and catchment area of the national capital of Ghana and the national headquarters of the Ministry of Education, and therefore, it is believed that these two teacher training institutions may be privileged to receive greater attention when it comes to provision of adequate funding and resources or facilities aimed at promoting quality science education delivery. This would lead to production of competent science teachers with the requisite pedagogical content knowledge to effectively teach science at the basic school level. The convenience sampling technique was also adopted to select Accra and Ada Colleges of Education because of the advantage it offered to the researchers, in terms of time and budgetary constraints, due to their close proximity and easy accessibility to the respondents (Farenga & Joyce, 2010).

The main research instrument was the questionnaire. To crosscheck the credibility of the responses provided by the respondents, two separate close-ended questionnaires were administered; one for science tutors and another for the science teacher-trainees, to gather data on the research topic (Farenga & Joyce, 2010). A Cronbach's Alpha Coefficient was

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adopted by the researcher to ascertain the internal consistency reliability of the 5-point Agree (A)-Disagree (D) Likert Scale questionnaire items. Reliability coefficients of 0.84 and 0.86 were established for tutors' and teacher-trainees' questionnaires respectively. Observation checklist was adopted to personally observe, rate and record the extent of availability of the laboratory facilities available at the two colleges. This was done to crosscheck the credibility of the results. Due to the advantages of triangulation, two separate structured interview guide/schedule-one for science tutors and another for the teacher-trainees, were adopted for the study to enhance the credibility of the findings (Farenga & Joyce, 2010).

The study was carried out at the two public colleges of education in the Greater Accra Metropolis of Ghana. The colleges were purposely selected for the study because the two institutions are located within the catchment area of the national capital of Ghana and the national headquarters of the Ministry of Education, and therefore, it is believed that they may be privileged to receive greater attention when it comes to provision of adequate funding and facilities or resources, aimed at promoting quality science education delivery, thereby leading to production of competent science teachers who can effectively teach science at the basic school level. The study areas were selected for the study because of their close proximity to the researchers and easy accessibility to the respondents. Hence, time and budgetary constraints were minimized.

i. Ada College of Education

Ada College of Education is in Ada-Foah within the Accra Metropolis in Greater Accra Region of Ghana. It was established in 1965. Geographically, the college is located within Ada-Foah, Ada East, GY0249, Ghana 5.78044◦N 0.62001◦E. Ada College of Education currently runs bachelor's degree programmes in Early Grade, Upper Primary and Junior High School (JHS) education.

ii. *Accra College of Education*

Accra College of Education is located within the Greater Accra Metropolis of Ghana. It was established in 1909. Geographically, the institution is located within Accra, Accra Metro, GA516, Ghana 5.65719◦N 0.16094◦W. The college currently runs bachelor's degree programmes in Early Grade, Upper Primary and Junior High School (JHS) education.

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RESULTS AND DISCUSSION

The purpose of the study was to investigate the perceived impact of availability and utilization of science laboratory facilities on science teacher-trainees' pedagogical content knowledge (PCK) competencies at the two public Colleges of Education within the Greater Accra Metropolis of Ghana. Specifically, the present study sought to achieve the following objectives; (1) explore science teacher-trainees' perception of the extent to which availability and utilization of science laboratory facilities has impacted on their PCK competencies in science at the Ada College of Education. (2) explore science teacher-trainees' perception of the extent to which availability and utilization of science laboratory facilities has impacted on their PCK competencies in science at the Ada College of Education. *Impact of Availability and Utilisation of Laboratory Facilities on Teacher-Trainees' Pedagogical Content Knowledge in Science at Accra and Ada Colleges of Education*

Table 1.0: *Rating of the Impact of Availability and Utilisation of Laboratory Facilities on Trainee-Teachers' Pedagogical Content Knowledge in Science*

S/N	*College*	*SA (5)*	*A (4)*	*N (3)*	*D (2)*	*SD (1)*	*Mean*	*Std Dev.*
1	*Ada College*	*12 (30.8%)*	*13 (33.3%)*	*8 (20.5%)*	*4 (10.3%)*	*2 (5.1%)*	*3.74*	*1.163*
2	*Accra College*	*3 (13.0%)*	*8 (34.8%)*	*5 (21.7%)*	*7 (30.4%)*	*0 (0.0%)*	*3.30*	*1.063*

SA: Strongly Agree, A: Agree, N: Neutral, D: Disagree, SD: Strongly Disagree; Source: Field Data, 2022

Following Tables 1.0 a mean of 3.74 and standard deviation of 1.16 implies that the science teacher-trainees at the Ada College of Education held the opinion that availability and utilization of science laboratory facilities has had a high and positive impact on their pedagogical content knowledge (PCK) competencies in science. However, a mean of 3.30 and standard deviation of 1.06 implies that the science teacher-trainees at the Acca College of Education opined that availability and utilization of science laboratory facilities has had a moderate and neutral impact on their pedagogical content knowledge (PCK) competencies in science.

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Table 1.1: *Reference for Rating of the Impact of Availability and Utilisation of Laboratory Facilities on Trainee-Teachers' Pedagogical Content Knowledge in Science*

Scale	*Agreement*	*Range*	*Interpretation*	*Classification*
5	*Strongly Agree*	*4.21 - 5.00*	*Very High Impact*	*Positive*
4	*Agree*	*3.41 - 4.20*	*High Impact*	
3	*Neutral*	*2.61 - 3.40*	*Moderate Impact*	*Neutral*
2	*Disagree*	*1.81 - 2.60*	*Low Impact*	*Negative*
1	*Strongly Disagree*	*1.00- 1.80*	*Very Low Impact*	

Source: Field Data, 2022

The Table 1.1, is a reference or guide showing the extent to which availability and utilization of science laboratory facilities has impacted science teacher-trainees' PCK competencies in science, and the classification of the impact as either positive, negative or neutral. Impact of Availability and Utilisation of Science Laboratory Facilities on Science Teacher-Trainees' Pedagogical Content Knowledge in Science at Accra and Ada Colleges of Education. On the impact of the availability and utilisation of science laboratory facilities at the Ada College of Education, 33.3 % (13) of the science teacher-trainees who responded to the questionnaire agreed that it has had an impact on their PCK in science, 30.8% (12) strongly agreed, 20.5% (8) remained neutral, 10.3% (4) disagreed, whiles 5.1% (2) strongly disagreed (Table **1.0).** At the Accra College of Education, 34.8% (8) of the science teacher-trainees held the opinion that the availability and utilisation of science laboratory facilities has had an impact on science trainee teachers' competencies in terms of PCK in science, 13% (3) strongly agreed, 30.4% (7) disagreed, whiles 21.7% (5) remained neutral (Table 1.0). Again, it can be observed that a mean response of 3.74 with a standard deviation of 1.163, and a mean response of 3.30 with a standard deviation of 1.063, indicates that availability and utilisation of science laboratory facilities have had a high and positive impact on science teacher-trainees' PCK competencies in science. Research results are in line with Olufuke (2012) who opined that adequate availability and frequent utilization of science laboratory facilities has had a positive effect on students' performance in science. Results are also in line with findings from a study conducted by Nwagbo & Uzoma (2014) who opined that majority of physics teachers had positive perception of their PCK

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competencies in organizing hands-on practical activities with their students using science laboratory facilities.

The implication of this is that, with adequate availability and efficient utilization of the science laboratory facilities the science teacher-trainees at the Ada College of Education would develop the requisite process skills and practical competencies that would enable them to carry out hands-on practical activities with the students when they pass out from the colleges. Again, a mean of 3.30 and standard deviation of 1.06 indicates that science teacher-trainees who participated in the study at the Accra College of Education opined that availability and utilisation of science laboratory facilities has had a moderate but neutral impact on their pedagogical content knowledge in science (Tables 1.0, 1.1). This means the students had poor and negative perception of their PCK competencies in science. Research results are in accordance with related study conducted by Anyanwu and Alafiatayo (2015) which reported that Chemistry teachers had poor and negative perception of their PCK competencies in improvisation of instructional materials to teach science.

The implication of the science teacher-trainees largely holding a neutral position regarding the impact of the availability and utilisation of science laboratory facilities on their Pedagogical Content Knowledge (PCK) competencies at Accra College of Education is that majority of them do not believe that the availability and use of science laboratory facilities at their college has had any positive impact on their pedagogical content knowledge (PCK) in science. This viewpoint could partly be attributed to the fact that the availability of science laboratory facilities was to a low extent and rarely utilised for hands-on practical activities in science at the Accra College of Education. Consequently, these science teacher-trainees might not be able to engage their prospective students in practical activities in science in the classroom. In order words, these crop of science teacher-trainees might not be able to effectively teach science in the most comprehensible and practical way to students when they graduate from the college. To improve upon the perception of these students toward their PCK competencies there is the urgent need for their tutors and laboratory assistants to engage them in frequent and efficient hands-on laboratory practical activities. This would enable the students to develop the requisite science process skills and competencies. Inconsistent with research which reveals that teaching methods that involve practical activities with students are more effective in encouraging the acquisition of

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science process skills in students, thereby leading to improved student academic performance in science (Nwagbo and Uzoma, 2014). In another study, Oluwasegun, Ohwofosirai and Emabetere (2014) in their research revealed that there was a significant influence between physics practice on students' academic performance results in Nigeria. The issue of whether these science teachers would be up to the task or not, would, among other factors, depend on how well their science tutors engaged them in laboratory practical activities during their period of training at the colleges (Buabeng et. al., 2014). In accordance with one of the teacher classifications presented by Bailey (Bailey et al., 2011), teachers view science education as a means of acquiring scientific literacy. As a result, these teachers view science as merely the possession and transmission of scientific knowledge.

CONCLUSION

It can be concluded that availability and utilization of science laboratory facilities has had at has had a high and positive impact on the PCK competencies of science teacher-trainees at the Ada College of Education. However, availability and utilization of science laboratory facilities has had a moderate but neutral impact on science teacher-trainees' PCK competencies in science at the Accra College of Education. It is recommended that the government of Ghana and other stakeholders in science education provide adequate science laboratory facilities to the colleges to promote the study of science. Science tutors and laboratory assistants must ensure that the science teacher-trainees are engaged in frequent and efficient hands-on laboratory practical activities to boost their PCK competencies in science. Principals of Accra and Ada Colleges of Education must put measures in place to ensure that the science trainee-teachers are sent to their affiliated universities on regular basis to have hands-on practical sessions to boost their practical competencies when the facilities needed to engage them in laboratory activities are unavailable or woefully inadequate.

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