

Application of Mathematics Concepts in Welding and Fabrication Among High School Graduates in Ghana

Acheampong Philip Adjei & Awuah Francis Kwadwo

Department of Teacher Education, Kwame Nkrumah University of Science and Technology, Ghana

Corresponding Author: p.a.acheampong@gmail.com

ORCID iD: <https://orcid.org/0009-0004-7151-0451>

Abstract

Welding and Fabrication (WF) is a professional course taught in Technical and Vocational Education and Training (TVET) second-cycle schools in Ghana that requires certain mathematical competencies. Students' ability to fully apply these mathematics competencies during practical work improve product quality, reduce waste, and maximize profit. However, there is a dearth of knowledge on WF entry level professionals' ability to apply mathematics concepts specifically related to WF during practical work. To address this problem, this study seeks to ascertain how second-cycle graduates in WF apply mathematical concepts during practical work. A case study design was adopted for this study. The researchers purposely selected two entry level professionals from two second-cycle TVET institutions in Ghana. Data were collected through the use of an interview guide and observation guide. Data were analysed using a table and textual analysis. The results indicated that the two students selected found it difficult to identify and apply specific mathematical concepts for particular tasks. Educational implications of the findings were discussed.

Keywords: Mathematical application, Graduate experience, Entry level, welding and fabrication, Vocational education

Introduction

Technical and Vocational educational training (TVET) is gaining more attention in both developed and developing countries due to its economic impacts on countries' development (Mensah, 2023). As a result, countries including Ghana are investing more in TVET education (MOE, 2021). Apart from the sector providing jobs, TVET also equips the youth with entrepreneurial skills to establish their own jobs, thereby reducing the unemployment levels in the country (Afeti, 2018).

One area that is required in TVET education is to help students develop competencies required in specific trade areas (MOE, 2021). One of the subject areas that is required in all TVET trade areas is mathematics (Mutinda, 2023), this is because mathematics equips students with problem-solving and other mathematics competencies required in this trade areas. FitzSimons and Boistrup (2017) indicated that every form of work requires some level of mathematics that is either implicitly or explicitly integrated into it. For example, a lot of mathematical concepts were found in cloth woven among the Australian (Dominikus, Nusantara, Subanji & Muksar, 2017).

Welding and fabrication trade area is one of the courses taught in our second-cycle TVET School that requires such mathematics competencies to help enhance students understanding (MOE, 2010). For example, Jassem and Alyaqout (2018), mathematical calculations play a crucial role in the welding process, ensuring proper welding dimensions, selection of materials, cost-effectiveness, and time management. As a result of this, mathematics is also delivered as part of the TVET program in Ghana. Notwithstanding the mathematics is not integrated into the WF syllabus. Students are, however, required to learn mathematics in general and transfer the knowledge to solve problems in the WF trade area (MOE, 2010).

Vimbelo and Bayaga (2023) in their study have indicated that college students' offering TVET courses find it challenging to apply the concepts they have learned in the workplace. Due to this, TVET students may not be able to meet the mathematical knowledge requirements of the working world after completing their vocational education (Dalby & Noyes, 2015; FitzSimons & Boistrup, 2017). Research has shown how a weak connection between school mathematics

and vocational mathematics often makes it difficult for students to transform their mathematical knowledge from the school context to the working life context, because they have difficulties seeing a connection between them (Frejd & Muhrman, 2022). Despite all these, there is a limited study on whether students are able to apply specific mathematics concepts when performing specific practical tasks in the TVET trade area like WF, thereby creating a gap in the literature.

To address this issue, the current study sought to find out if WF graduates are able to recognize and apply mathematics concepts during practical work. This will help inform instruction on the best way to teach mathematics to WF students and also help to inform policies on how well students have attained the required competencies to meet the demand of the job market. The study was guided by the research question, how do WF entry level professionals recognize and apply mathematical concepts during practical work?

Methodology

A case study design was adopted for this study (Creswell & Creswell, 2018). A case study allows for an in-depth examination of how entry level professionals in WF apply mathematical concepts in real-world setting providing rich, contextual insights into their thought processes and problem-solving strategies (Creswell & Creswell, 2018). The researchers selected two entry level professionals from two second-cycle TVET institutions that have graduated from two second-cycle TVET second cycle schools in Ghana. These two TVET schools are among the pioneers in TVET education who have produced WF students for the past forty years and are among the best TVET institutions in Ghana with advanced equipment and resources. These two students were selected because they had currently completed their programme and are working with master craftsmen so they could give information on the mathematics learnt at school and show they have applied it during practical activities. Data were collected through the use of an interview and observation guide. The trustworthiness of the qualitative data was ensured through triangulation (using interview and observation guide) and member checking to enhance credibility (Ahmed, 2024). The study also followed systematic procedure that ensured dependability and transparent in the data interpretation to minimize researchers' biases for confirmability (Ahmed, 2024). Finally the researchers provided thick descriptions of the entire research process to facilitate transferability (Ahmed, 2024).

Prior to the data collection, ethical clearance was obtained from the "Humanities and Social Sciences Research Ethics Committee at the Kwame Nkrumah University of Science and Technology" (Moriña, 2021). This was to ensure the safety of the participants in terms of confidentiality and anonymity. A letter was also obtained from the department of Teacher Education at KNUST to the master craftsmen to seek their permission prior to the data collection (Moriña, 2021). Before the data collection, the researcher visited the shops of the masters and the students concerned to seek verbal consent, explain the purpose, the time, and the nature of data collection (Shaw, 2016). In addition, the two students were given the participants' information sheets and the consent form to sign. Each of the participants was observed and interviewed within six working days (Moriña, 2021). Pictures and audio recording were taken with participants' consent (Jamshed, 2014). The researchers followed each of the students through every activity and asked specific questions based on the activity carried out. The results were analysed using a table and textual analysis.

Theoretical Framework

The study was guided by situated learning by Lave and Wagner (1991). The situated learning framework, developed by Jean Lave and Etienne Wenger (1991), emphasizes that learning is inherently connected to the context in which it occurs. According to Lave and Wagner (1991), knowledge is shaped by the physical and social environment in which it occurs. The framework highlights the importance of context in learning and applying mathematical concepts, which is particularly relevant in a practical work setting like WF. With the community of practice, this theory helped identified how individuals are able to apply what they have learnt during practical situations (Lave & Wagner, 1991). Situated learning theory guided this study to identify if graduate are able to apply the mathematics concepts they learn in school to solve problems during practical work in their professions (Lave & Wagner, 1991).

Results and Discussion

To answer the research question on how entry level professionals are able to identify and apply specific mathematics concepts during practical work, the researcher observed and interviewed two WF entry level professionals on the mathematics concepts associated with the specific task carried out. Remarks were given on their correct application, incorrect

application and their inability to identify the mathematics content associated with the task. The results are shown in Table 1.

Table 1: Application of Mathematical Concepts in WF among High School Graduates in Ghana

	Pictures /illustration of the practical activities	Description of Practical Activities	What mathematical concepts or competencies are you using in this activity	Remarks
1		Welding a joint of three metal bars	No idea	Unable to identify the mathematics content associated with the task
2		Forming a metal plate in the form of a rectangular tray	Before forming, the original plate had like rectangular shape	Correct application of the concepts
3		Covering a rectangular prism frame with rectangular plates	The whole container is a rectangle	Incorrect application of the concepts
4		Dividing a space into equal sizes	No idea	Unable to identify the mathematics content associated with the task
5		Measuring the distance between two metal bars	Measurement	Correct application of the concepts
6		Marking angle on a metal bar	No idea	Unable to identify the mathematics content associated with the task
7		Cutting a metal bar into different sizes	I don't remember the mathematics for this	Unable to identify the mathematics content associated with the task activity

Table 1 shows some specific activities and the mathematics concepts that students identified during data collection. In total, the researcher collected 68 samples of students' work. Out of the 68 activities recorded, students were able to correctly identify only 9 (13.24%) of the mathematics concepts associated with specific activities they carried out. Examples of mathematical concepts that the students could not identify included fractions, ratios, divisions, angles, area, length, volume and surface area. In activities where students successfully identified the mathematical concept, they typically cited one relevant concept.

This implies that students found it difficult to identify and apply mathematics concepts in a specific task during practical work. This implies that students may not be developing the necessary skills to apply mathematical concepts in WF trade area (Dalby & Noyes, 2015). Alternatively, it could be that mathematical concepts are taught in isolation, without sufficient connection to the specific needs of WF trade area (Dalby & Noyes, 2015). The result contradicts the community of practice assumption under situated learning by Lave and Wagner (1991) that requires individuals to apply what they learn during practical activities.

For example, in activity number 6, the student was cutting part of a metal which could be a fraction, ratio, proportion and angle, but the student could not identify the specific mathematical concept associated with that. In activity two, the student was able to mention that before the formation of the rectangular tray, the plate was rectangular in shape but could not identify that it is a rectangular prism or cuboid with one end open. The reason for students' inability to do this could be as a result of how mathematics was taught to them in school as noted by Vimbelo and Bayaga (2023) that teachers rely heavily on traditional approach of instruction that is devoid of real-life applications in TVET colleges.

When mathematical examples and tasks lack real-life relevance, students find it challenging to apply what they have learned. This could be as a result of lecturers who often do not tie the content to real-life practical education, resulting in considering mathematics as a difficult topic (Vimbelo & Bayaga, 2023). The immediate effect is that it could lead to waste of materials, increase working time, and affect the quality of work. Due to this, students may not be able to meet the mathematical knowledge requirements of the working world after completing their vocational

education (Dalby & Noyes, 2015; FitzSimons & Boistrup, 2017).

The finding from the study is supported by the finding that it is commonly argued that the extent to which students grasp and appreciate the practical relevance of mathematics to various careers and daily activities varies greatly and is often deficient (Commodari & La Rosa, 2021). This finding is also in consonance with the finding that a weak connection between school mathematics and vocational mathematics often makes it difficult for students to transform their mathematical knowledge from the school context to the working life context, because they have difficulties seeing a connection between them (Frejd & Muhrman, 2022). The current study is in consonance with previous studies (Commodari & La Rosa, 2021; Frejd & Muhrman, 2022) because they all highlighted the challenges students face in recognizing and applying mathematical concepts in practical contexts. This creates a gap between what students learn in the classroom and actual requirement in the job area. To bridge this gap, Dalby and Noyes (2015) suggested that classroom mathematics instruction should reflect the unique needs of students' vocations.

Conclusion

The findings of this study indicated that students found it difficult to apply the mathematics they learn in school to practical or work area. This affects the quality of WF education received in Ghana. This problem could be from the syllabus, the textbooks and other teaching resources that teachers use when teaching mathematics. This could also be the results of teachers teaching mathematics not having ideas in WF trade area so as to contextualize these mathematics contents to provide the students with the needed competencies. It is therefore required that the syllabus, the textbooks used to teach mathematics be critically examined to find out if it meets the mathematics competencies required in WF trade area. Also, mathematics teachers should be taking through some workshops, seminars and provide additional training during professional development sections to help them know the content of mathematics required in WF trade area. This work is without limitations, the use of only two students from two TVET schools makes sample size very small. Also, the researcher did not explore how mathematics is taught to WF students in TVET schools in Ghana.

Declaration of Conflict of Interest

We, Philip Adjei Acheampong and Francis Kwadwo Awuah, hereby declare that we have no conflict of interest related to the submission of our manuscript (application of mathematical concepts in WF among high school graduates in Ghana) to the journal (African Journal of Science, Technology and Mathematics Education).

Recommendation

The study examined how second-cycle WF graduates apply mathematical concepts in practical work. The findings indicated that WF students struggle to apply the mathematics they learn in school to practical or work settings. This suggests that there is the need for mathematics instruction that emphasize contextual learning, practical application and explicit connection between mathematical concepts and their application in WF (Dalby & Noyes, 2015). The study therefore recommends that teachers of mathematics should contextualize specific content related to the WF trade area. Again, WF students in Ghana should be assigned more mathematical tasks directly related to WF trade area to help bridge the gap between what they learn in school and the mathematical competencies required in WF trade areas. Furthermore, mathematics teachers with a WF background should be hired to teach mathematics to WF students in accordance with Ghana's teaching syllabus for WF (MOE, 2010). Finally, there is a need to examine the content of mathematics taught to WF students in Ghana's second-cycle institutions and how it aligns with the mathematical competencies required in the WF trade area.

References

- Afeti, G. (2018). Revitalising technical and vocational education and training in Africa: Issues outstanding. *Journal of Vocational, Adult and Continuing Education and Training*, 1(1), xi-xviii.
- Ahmed, S. K. (2024). The pillars of trustworthiness in qualitative research. *Journal of Medicine, Surgery, and Public Health*, 2, 100051.
- Commodari, E., & La Rosa, V. L. (2021). General academic anxiety and math anxiety in primary school. The impact of math anxiety on calculation skills. *Acta psychologica*, 220, 103413.
- Creswell, J. W., & Creswell, J. D. (2018). *Research Design (Qualitative, Quantitative, and Mixed Methods Approaches)* (H. Salmon, C. Neve, M. O'Heffernan, D. C. Felts, & A. Marks (eds.); 7th ed.). SAGE Publications Ltd.
- Dalby, D., & Noyes, A. (2015). Connecting Mathematics Teaching with Vocational Learning. *Adults Learning Mathematics*, 10(1), 40-49.
- Dominikus, W. S., Nusantara, T., Subanji, M. M., & Muksar, M. (2017). Ethnomathematical ideas in the weaving practice of Adonara Society. *Journal of Mathematics and Culture*, 11(4), 83-95.
- FitzSimons, G. E., & Björklund, B. L. (2017). In the workplace mathematics does not announce itself: Towards overcoming the hiatus between mathematics education and work. *Educational Studies in Mathematics*, 95, 329-349.
- Frejd, P., & Muhrman, K. (2022). Is the mathematics classroom a suitable learning space for making workplace mathematics visible? – An analysis of a subject integrated team-teaching approach applied in different learning spaces. *Journal of Vocational Education & Training*, 74(2), 333-351. <https://doi.org/10.1080/13636820.2020.1760337>
- Jamshed, S. (2014). Qualitative research method-interviewing and observation. *Journal of basic and clinical pharmacy*, 5(4), 87.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge university press.
- Minister of Education (MOE) (2010). *Teaching syllabus for welding and fabrication (Technical / Vocational Institutes 1-3)*. Accra: Ghana.
- Ministry of Education, Ghana (2022). Ghana Education Outcomes Project (GEOP). <https://moe.gov.gh/>
- Moriña, A. (2021). When people matter: The ethics of qualitative research in the health and social sciences. *Health & social care in the community*, 29(5), 1559-1565.
- Mutinda, M. M. (2023). Factors Influencing Income Smoothing Practice Among Manufacturing Firms in Kenya. *African Journal of Commercial Studies*, 4(3), 186-193.
- Sawatzki, C., & Sullivan, P. (2018). Shopping for shoes: Teaching students to apply and interpret mathematics in the real world. *International Journal of Science and Mathematics Education*, 16, 1355-1373.
- Shaw, I. F. (2016). Ethics and the practice of qualitative research. In *Practice and Research* (pp. 239-252). Routledge.
- Vimbelo, S., & Bayaga, A. (2023). Current Pedagogical Practices Employed by a Technical Vocational Education and Training College's Mathematics Lecturers. *South African Journal of Higher Education*, 37(4), 305-321.