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Original Article

Examining the Real-life Application Problems in Welding and Fabrication Students' Mathematics Exercise Books

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ABSTRACT

Vocational education has become the focus of many countries including Ghana because of its economic contribution. One trade area under TVET that is gaining much attention is welding and fabrication because it is used in all aspects of life. Also, welding and fabrication require mathematics competencies. As a result of that, mathematics is taught as part of the welding and fabrication programme in Ghana. The mathematics content taught to welding and fabrication students should be contextualized since it is a professional course. The problem is that TVET students including welding and fabrication students have low interest and do not perform well in mathematics. To address this problem, this study sought to look at the extent to which the mathematics real-life problems in Welding and Fabrication students' exercise books address the needs of their trade area. The purpose of this study was to examine the extent to which real-life application problems in welding and fabrication students' mathematics exercise books are related to the trade area. To achieve this, a case study research design under the qualitative research method was employed for the study. Data was collected through the analysis of three welding and fabrication students' mathematics exercise books. These exercise books covered all the exercises from year one to year three. Data were presented using simple frequency and percentages. The results indicated that only 11.27% of the real-life application problems in welding and fabrication students' exercise books were related to the applications in the welding and fabrication trade area. It can be concluded that teachers teaching mathematics in welding and fabrication programs pay little attention to real-life mathematics problems in the welding and fabrication trade area. This can affect students' interest and performance in mathematics thereby equipping them with insufficient mathematics skills required in the welding and fabrication trade area.

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INTRODUCTION

Technical Vocational Education and Training (TVET) is gaining more attention globally due to its importance in the development of nations (Legusov et al., 2022). TVET equip students with the necessary skills needed to gain employment or establish their own firms or companies after completion thereby helping to reduce the unemployment rate in countries (Choy et al., 2018). As a result, both developed and developing countries are giving more attention to TVET education (Choy et al., 2018). One Trade area that most countries including Ghana are giving much attention to is welding and fabrication, this is because it is applied in various spheres of life. For example, welding and fabrication professionals are needed in the construction industries, automobile industries, aerospace and shipbuilding industries. In addition, welders and fabricators are needed in agriculture (for making farm machinery such as harvesters and tractors), health (for making medical equipment like surgical instruments, laboratory equipment and hospital beds), mining (for making mining equipment like drills, conveyor system, excavators), manufacturing (automotive components, assembly lines, consumer electronics) and defence sector of the country's economy (weapons, military vehicles, missile launch pad).

However, like other TVET welding and fabrication professionals require strong mathematics competencies to succeed in their profession (Dalby & Noyes, 2015). It is against this that FitzSimons and Boistrup (2017) indicated that all form of skill work requires some level of mathematics. For example, welding and fabrication professionals require mathematics competencies in geometry, trigonometry, fractions, plane geometry and mensuration to measure accurately, design, layout and fabricate metal structures and components in different industries. Despite this, TVET students including welding and fabrication students have low interest and negative attitudes towards the study of mathematics leading to underachievement in the subject (Vimbelo & Bayaga, 2023a). One of the causes of this low interest and negative attitude towards mathematics is a result of lack of connections between the mathematics concepts taught at school and their trade area (Vimbelo & Bayaga, 2023a). In consonance with this, Vimbelo and Bayaga (2023a) and Vimbelo and Bayaga (2023b) asserted that when students are taught and assessed in the context of their career, it helps to motivate and improve their performance. Students' dislike of mathematics could result in students graduating with inadequate mathematical competencies required in the welding and fabrication trade area. This can result in producing professionals in welding and fabrication that may not meet the requirements of the job market (Fitzsimons & Boistrup, 2017).

To address this problem, previous studies have looked at the causes of TVET students' poor performance in mathematics, TVET students'

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interest and performance in mathematics, the mathematics curriculum for TVET students, the importance of mathematics in the TVET trade area and the effect of teaching mathematics contextually on TVET students' performance. Nevertheless, there has been a scanty study in the literature that looked at how real-life problems in TVET students' exercise books aligned with the competencies and skills required in their respective trade areas. To address this problem, this study sought to look at the extent to which the mathematics real-life problems in Welding and Fabrication students' exercise books address the needs of their trade area. Knowing this will help address the extent to which real-life mathematics problems are related to welding and fabrication competencies. If this is not addressed, students may not see the relevance of the mathematics exercises they do in school in welding and fabrication thereby reducing their interest in the subject and eventually affecting their performance negatively (Vimbelo & Bayaga, 2023b). This study helped to ascertain if the learners are given the necessary skills and competencies required in the welding and fabrication trade area as stipulated in the sustainable development educational goal 4 agenda 2030 documents.

FRAMEWORKS

Theoretical Framework

This study was guided by the situated learning theory propounded by Lave and Wenger (1991) Situated learning theory supports the assertion that students learn better in an authentic environment. That is when the content they are learning is contextualized in real-life situations. The theory indicated that this could be achieved through authentic context, community of practice and cognition (Lave & Wenger, 1991). The authentic content guided this study to determine the extent to which the real-life problems in learners' exercise books with the competencies and skills required in the trade area (Lave & Wenger, 1991).

Conceptual Framework

Fabrication Mathematics I and II by the American Welders' Society (AWS) was adopted as a framework that guided this study. Fabrication Mathematics I and II cater for the mathematics topics that are relevant to the welding and fabrication trade area. This was used as a lens for the study because the American Welders' Society is one of the best welding and fabrication organizations across the globe (Dueck et al., 2021). Also, AWS have expert welding and fabrication professionals from well-known universities and industries across the globe (Harris, 2002). Finally, AWS have standards that are well-accepted worldwide (Hargiyarto et al., 2020). It is therefore certain that fabrication mathematics I and II were developed by experts in the field of welding and fabrication that can provide the necessary mathematics competencies required in the welding and fabrication trade area. As a result, Fabrication Mathematics I and II was used as a lens when looking at the mathematics topics specifically related to the welding and fabrication trade area.

METHODOLOGY

The study adopted a case study research design under a qualitative research approach since a case study can help to get an in-depth understanding of how mathematics problems are related to welding and fabrication competencies in mathematics (Creswell & Creswell, 2018). To collect data for the study, document analysis was employed as a stand-alone method by analysing the real-life application problems in three welding and fabrication mathematics exercise books from three different TVET high schools in Ghana (Bowen, 2009). All the exercises that the students did from year one to year three were used for this study. Ethical clearance was obtained from the Humanities and Social Sciences Research Committee at Kwame Nkrumah University of Science and Technology. To use these documents, the researcher ensured that they contained all exercises covered in the three years. The exercise books were also ensured that

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they bore the learner's name and were marked by the teachers. The researcher showed the exercise books to the various mathematics teachers of the learners in their respective schools to ascertain the validity of the content. The researchers sought the permission of the students and their teachers to take pictures of the exercises in their books. Data were presented using simple frequency and percentages to determine the number of real-life application problems in welding and fabrication. In addition, the researchers employed content analysis to look at some of the real-life problems and how it is aligned with the competencies and skills required in welding and fabrication technology.

RESULTS

The results present real-life mathematics problems found in welding and fabrication students' mathematics exercise books and those specifically related to welding and fabrication trade as depicted in Table 1.

Table 1: Mathematics Problems in Real Life and Welding and Fabrication Technology

Content Areas	Examples of the Concepts	Number of Real-Life Applications	Applications In Welding and Fabrication	
			Frequency	Percentage
Whole numbers and Operation on whole Numbers	None			
Fractions and operations on fractions	1. A man saves $\frac{2}{5}$ of his money and pays $\frac{1}{3}$ of the remainder as rent. Find the fraction of his money left. 2. A metal container 32m by 30m is built on a plot of land measuring 60m by 45m. What fraction of the land is unused?	9	1	11. 1
Basic operations on decimal fractions and conversion between decimal numbers and fractions.	1. Yaw spent 0.5 of his salary on clothing, 0.25 of the remainder on rent and 0.75 of what still remained on entertainment, calculate the fraction of his money left for other things.	1	0	0.0
Measurement (converting units). Unit conversions (metric/u.s. standard characteristics, temperature and time)	None			
Equations	1. A woman is six times as old as her daughter. Three years ago, she was 11 times as old as her daughter, find their present ages.	13	1	7.69

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Content Areas	Examples of the Concepts	Number of Real-Life Applications	Applications In Welding and Fabrication	
	2. Yaw bought 10 plates and 15 drinking cups. A plate cost 50 pesewas more than a drinking cup. If he spent GHC 20.00 altogether, how much was a plate?			
Exponents and scientific notation	None			
Percentages, rates and ratios	1. A boy rode at $3xkm/h$ for 45 munites and walked xkm/h for 15 munites to get to his destination which is $7km$ from his house. What fraction of the journey did the boy ride? 2. The cost of a metal pipe was increased by 25%. If the original price was GHC 150.00. What is the new price of the metal pipe?	16	2	12.5
Lines and angles	None			
Plane Geometry	1. A circular flower bed has a diameter of 1.6m. A metal edging is to be placed around it. Find the length of the metal needed to edge the flower bed. 2. The area of a rectangular floor is the same as a circular floor of diameter 10m. If the length of the rectangular floor is 12.5m. Find its perimeter. $(Take\ \pi = 3.142$.	11	2	18.2
The volume of three-dimensional shapes	1. A fuel tank in the form of a regular pentagonal prism of side 3m long and 15 m high. Calculated a. the total surface area of the tank. B. the quantity of fuel in the tank in litres when it is $\frac{1}{4}$ full. 2. A cylindrical well of a radius of 2 metres is dug out to a depth of 9 metres,	9	2	22.2

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Content Areas	Examples of the Concepts	Number of Real-Life Applications	Applications In Welding and Fabrication	
	calculate the volume of the soil dug out.			
Trigonometry Operations involving trigonometry	1. A ladder 8m long leans against a vertical wall. If the foot of the ladder is 3.5m away from the wall. Find the angle the ladder makes with the wall correct to the nearest whole number. 2. When an aeroplane is 1200m above the ground, its angle of elevation from the point P on the ground is 30^0, How far is the airplane from P by line of sight.	12	0	0.0
Total		**71**	**8**	**11.27**

Adapted from American Welders Society Fabrication Mathematics I and II

Mathematics competencies and skills are essential for a successful career in the welding and fabrication trade area. Also, the type of mathematics problem that students solve in class has a direct link with their interest, engagement, attitude and performance and see the relevance of that exercise especially if it is related to their career. It can be seen from Table 1 that out of the 71 problems identified in the students' exercise books, only 8 problems representing 11.27% of the total problems are related to welding and fabrication. In the specific content areas that are mostly used in welding and fabrication like geometry, trigonometry and volume of solid shapes only little or no attention was given to the learners' trade area.

In addition, only 11.1%, 18.2% and 22.2% of the real-life problems in Fractions and operations on fractions, Plane Geometry and Volume of three-dimensional shapes respectively were linked to application in welding and fabrication. It is so surprising that no real-life problem was set for performing operations involving whole numbers, basic operations on decimal fractions and conversion between decimal numbers and fractions, exponents and scientific notation, Lines and angles. In addition, none of the exercises in the students' mathematics exercise book contains real-life problems involving the application of trigonometry in the welding and fabrication trade area. The highest percentages were recorded by application of real-life problems involving volumes of three-dimensional figures which accounted for only 22.2% and overall only 11.27% of the problems were related to the application of welding and fabrication technology which is not up to one-fourth of the total problems. The question one will ask is how these students can see the relevance of the exercises in their trade area.

DISCUSSION OF THE RESULTS

To determine the extent to which real-life mathematics problems in welding and fabrication students' exercise books, the study found that most of the real-life problems in the students' exercise books (88.73%) do not address the mathematical competencies and skills required in welding and fabrication. This is in line with the finding by Fitzmaurice et al. (2021) that out of 3,145 examples worked in the series of students' textbooks, only

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1.28% have a career focus in mathematics. That is because most of the problems are concerned with other real-life situations in other areas such as ship sailing, sharing of items etc other than the trade area in which the students are being prepared. Examples of real-life problems that are not related to welding and fabrication are shown in Extract 1.

Extract 1

> *"A trader bought m pineapples for GHC 480.00. She found out that 15% of them were rotten. She sold one for GHC 0.50 more than the cost price. Find in terms of m i. the cost price of one pineapple, ii. An expression from the total amount received from the sales.*
>
> *From the top of a cliff* $90m$ *high, the angle of depression of a boat on the sea is* 32.6^0 *.Calculate correct to one decimal place, the distance of the boat from the cliff.*
>
> *A woman went to a market and spent* $\frac{1}{2}$ *of her money on food and* $\frac{1}{4}$ *of what was left on clothes,* $\frac{3}{5}$ *of what was still left on the blender. If she had GHC189.00 left. How much money did she take to the market?*

From the three problems indicated in Extract 1, it could be seen that even though learners are solving application problems, it is not linked to the welding and fabrication trade area. This is not in consonance with the situated learning theory which indicates that lessons must be contextualized in learners' careers. The immediate problem is that the students may find no link between the mathematics they are doing in school and the competencies and skills required in their trade area (Christidis et al., 2024). This could cause the student to see mathematics as irrelevant in their career which can result in the students asking themselves questions like "When Am I (N)ever Going to Use This?" (Istas et al., 2021). This could discourage the students and cause them to dislike the subject (Muhrman, 2022). This is also supported by Walkington and Bernacki (2019) who indicated that connecting mathematics to students' interest areas enhances students' interest in mathematics. When learners do not acquire the needed mathematical competencies required in the welding and fabrication trade area, there will be some deficiency in their professional preparation which has an impact on their work output (FitzSimons, 2014).

As supported by Smith (1999), schools are failing to provide appropriate mathematical competencies to students to prepare them for 'global market competition'. It is against this that Sweden industries asserted that TVET schools do not adequately prepare the students for the job market. However, when the content of the mathematics is directly linked to the welding and fabrication trade areas like examples in extract two, it helps learners to appreciate the mathematics they are learning and find it more relevant to their career (MOE, 2010). The real-life application was related to other fields because mathematics was to prepare the students for daily life and career (MOE, 2010). Examples of real-life problems that are directly linked to welding and fabrication trade areas are illustrated in Extract 2.

Extract 2

> *A metal plate measuring* $18cm$ *by* $12cm$ *is used in making a bread container. A square of 2cm is removed from each corner of the metal and then folded to form an open cuboid, Find i. the total surface area of the container. ii. the volume of the container.*
>
> *How many* $1\frac{1}{2}$ *m lengths of a metal can be cut from a metal that is 35 m long?*

The examples in extract 2 illustrate the application of mathematics in real life that is directly related to the welding and fabrication trade area as supported by situated learning theory (Lave & Wenger, 1991). When students are given problems of this nature, it helps them apply the mathematics they are learning in the classroom to their careers and see the

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relevance of the mathematics they are learning (MOE, 2010; Fitzmaurice, O'Meara, & Johnson, 2021). This can boost their interest and performance in mathematics as the content is contextualized in their career area (Lave &Wagner, 1991). This is in consonance with the study by Leyva, Walkington, Perera & Bernacki (2022), who found that students' perceptions of the application of mathematics in their preferred professional fields were linked to their interest in mathematics and various STEM career paths. The reason that accounted for the low number of welding and fabrication real-life problems may be the lack of support such as textbooks, syllabi and other workshops on how to contextualize mathematics in a given trade area (Fitzmaurice et al., 2021).

One dangerous thing is that the welding and fabrication teaching syllabus requires that students apply the mathematics content they learn from their mathematics class to solve problems in the welding and fabrication trade area (MOE, 2010). So when the content is not contextualized as most of the problems are not linked to welding and fabrication, the aim of the syllabus cannot be achieved and the students will not get the right mathematical competencies and skills required in their trade area (MOE, 2010). One main cause that could lead to this is that the teacher teaching the mathematics content may not have the necessary knowledge in the welding and fabrication trade area as suggested by the teaching syllabus for welding and fabrication that "*qualified persons in these fields will teach mathematics*". If mathematics is handled by mathematicians without adequate knowledge in the welding and fabrication trade area, it will become difficult to contextualize the mathematics they teach in the welding and fabrication trade area in their lessons and assessments (Fitzmaurice et al., 2021). Another cause may be the content of the textbooks and the mathematics syllabus that the teachers use (Fitzmaurice et al., 2021). It is against this that Fitzmaurice et al. (2021) indicated that teachers may lack resources like textbooks that aid them in emphasising practical applications in different vocations. If the examples in the textbooks and the content of the syllabus are also not contextualised, teachers may also follow such examples and that affects the way they teach and assess their students (Hodgen et al., 2018). FitzSimons and Boistrup (2017) concluded in their study that in order to bridge the gap between mathematics and the learners' career and real-life situations, there should be recontextualization of mathematics content.

CONCLUSION AND RECOMMENDATION

Mathematics competencies and skills are very essential in solving problems in welding and fabrication. However, the findings from the current study indicated that less attention is given to real-life mathematics problems in the welding and fabrication trade area. This could cause the learners to develop a negative attitude towards the study of mathematics and consequently lose interest in mathematics. Also, the students may not get the necessary mathematics competencies and skills required in the welding and fabrication trade area. This could result in producing welding and fabrication professionals who are not adequately prepared to meet the demands of the labour market. It is therefore suggested that more real-life application problems in the welding and fabrication trade area be given to the students as assignments, projects and projects. In line with the teaching syllabus for welding and fabrication (MOE, 2010), it is recommended that only qualified mathematics teachers with knowledge of welding and fabrication be employed to teach the mathematics course (Hodgen et al., 2018). Finally, it is recommended that the exercises and the examples in the textbooks and the syllabus be assessed if it is aligned with the competencies and skills required in the welding and fabrication trade area. Despite the findings from this study, the study has limitations. One limitation of this study was that it only concentrated on real-life problems in students' exercise books without looking at the problems in their syllabus and their textbooks. The study did not also interview students' mathematics teachers to find out why

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there is a small number of real-life problems relating to students' chosen careers in students' exercise books.

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