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Strengthening Theory and Practice Link in Higher Education: An Investigation into Lithography Printing Faults

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ABSTRACT: *This study aimed to assess the effectiveness of a six-week structured pre-press and press activities programme based on integrating theory and practice at the industrial level. The study consisted of twenty-four participants with minimal industrial skills and work experience in lithography printing faults, causes, and remedies. Purposive sampling was used. Qualitative research method and action research design were employed. Data was collected through interviews, observation, focus group discussion and tests. The study was analysed through Thematic and Descriptive analysis. Analysis of the data shows that, at the end of the six-week programme, all 12 participants who took part in the industrial training greatly improved in skill development and work experience in all aspects of the pre-press and press activities. However, the other 12 participants who did not participate in the training did not acquire any skills. This study suggests that integrating theory and practice at the industrial level could enhance graduates' skill and work experience in lithography printing faults, causes and remedies to bridge the gap between theory and practice.*

KEYWORDS: lithography, printing faults, integration, theory, practice.

INTRODUCTION

Technical University Education (TUE) is the engine for economic growth due to the importance it attaches to the development of skills, knowledge, technology and work-related experience critical to meet the middle and high-level human power demand by industry, service, and commercial sectors essential for national development (Kozík 2015). Technical University Education is an essential instrument for producing higher level knowledgeable and skilled technicians who can confidently enter and remain in employment throughout their working lives or create their jobs to promote economic growth (Yorke, 2004).

Lithography printing fault is of great concern in the printing industry due to the impact on the quality of print products (Masod et al., 2015). Print faults are an inherent part of lithographic

printing due to the physical interaction between equipment and the various materials used during the printing process. However, they can be controlled or eliminated before and during the printing process if employees have the skill, experience and knowledge on the characteristics and causes of print faults (Masod et al.,2015; Madhawa, 2017).
Many factors contributing to print faults are well known to printers who have been striving to control them for many years.

As a result of this, the printing industry is always eager to employ graduates with adequate knowledge, skill and work experience in the detection and remedy of lithography printing faults (Chung, 2007; Masod et al. 2015).Students undertake printing technology to prepare graphic design students of the Takoradi Technical University (TTU) for employability in the printing and related industries. In the printing industry, the most widely used printing method is lithography. Its popularity is mainly due to its economic efficiency and persistent quality when printing large quantities such as magazines, newspapers and brochures (Madhawa, 2017). Despite the economic efficiency and persistent quality, lithography printing is prone to printing faults.

For graphic design students to gain employment in the printing industry, excellent knowledge and skills in the detection and remedy of lithography printing faults are crucial, as this printing method produces several faults due to the physical interaction between the various materials and equipment as well as the occasional poor performance of these materials (Madhawa, 2017). The Department of Graphic Design Technology of the TTU pays serious attention to students' industrial attachment, as most practical experience in lithography printing is acquired during industrial attachment (Adjei *et al.,* 2014).

Though printing industries are supposed to provide students with practical skills during industrial attachment, assessment of second-year graphic design students' skill and work experience in lithography printing faults after their first industrial attachment shows a complete lack of skill and work experience in lithography printing, identification of print faults as well as causes and remedy for these faults (Boakye-Amponsah, 2019; Enninful *et al.,* 2021). This has resulted in inadequate theory-practice relations, with many students experiencing a gap between theory and practice that could limit their employment opportunities in the printing industry or ability to set up small-scale industries if not addressed (Yorke, 2004). This study aims to bridge the gap between theory and practice in lithography printing faults, causes and remedy through the integration of theory and practice at the industrial level.

LITERATURE REVIEW

Theoretical Framework

Experiential learning theory is based on the argument that effective learning and acquisition of skills in related practical education, such as Technical University Education, can be achieved through first-hand experience as practical skills and work experience are acquired in an appropriate environment outside the academic classroom setting and may include an internship and industrial attachment (Green *et al.,* 2011). With the central role of skill in work-oriented programmes, the theoretical framework for this study was based on the experiential learning theory of John Dewey and Jean Piaget (Pardjono, 2016). The use of Experiential learning theory for this study puts the study into perspective as it helps to explain possible ways Graphic

Design lecturers can bridge the gap between theory and practice in lithography printing faults to enhance students' skill, work experience, competencies and abilities essential for industrial work and self-employment (McCarthy, 2010).

History of Lithography Printing

Lithography printing was accidentally discovered by Alois Senefelder, a German play writer around 1795 in Germany to help him reduce the cost of printing his play scripts manually (Ives 2004). Through the experiment, Alois Senefelder realised that an image drawn on limestone with greasy ink would repel water, while the surface of the stone itself would hold it (Bryans 2000).

In the second phase, Senefelder's observed through experiments that a drawing or writing on special paper with special ink could be transferred from the paper to the lithographic stone where it became the printing image (Weaver,1964). This allowed drawing of the original reading right instead of backwards as was the case when drawing directly onto the stone. Several identical images were placed on the same stone and increased productivity and popularity of lithography as a copying process (University of Houston).

Lithography printing was giving a boost by the addition of the offset press which was invented by Robert Barclay of England in 1875 to print on tin and further improved by Ira Washington Rubel of the United States in 1904 for printing on paper (Drupa 2018).

In combination with the lithography technique, which is based on the repulsion of oil and water, the offset printing removes the direct contact between plate and substrate by the addition of a rubber blanket surface (Weaver 1964). The offset technique employs a flat (planographic) image carrier, where the inked image is transferred or offset from a plate to a rubber blanket, then to the printing substrate. As there is no direct contact between plate and substrate in offset printing, the plate lasts longer than on direct lithography presses (Kipphan 2006). Besides, as the offset press is rotary rather than flatbed design, it allowed the integration of halftone photography and photolithography. This greatly increased production speeds and made process colour very popular within the lithographic field (Hipphan 2006).

Currently, lithography printing plays a significant role in the world printing industry and for graphic design students to fit into the global printing industry, both theory and practical knowledge, skill and work experience in lithography printing is paramount; especially how to identify printing faults, their causes and how to remove them. The department of graphic design Technology at the Takoradi Technical University understands the importance of quality products in the printing industry and the need for graduates to develop industrial skill and work experience to enhance their job opportunities in the printing industry, hence the need for this study.

Concept of offset Lithography Printing

To understand the challenges relation to lithography printing faults, it is important to understand the basic concept of offset lithography printing.Offset Printing method involves the use different printing plate for each job. It differs from the electronic or digital printing methods as pressure is applied during image formation. Offset, and Lithography are two different terms characterize by two distinctive processes.In lithography printing, the image and the non-image

areas are on the same plane meaning it requires flat printing surface (Leurs 2016). Offset represent the fact that the image is not directly transferred onto the paper from the plate, instead, from the plate, the ink is transferred to a rubber blanket and then to the printing paper or web. This allows the use of a wide range of materials in Offset printing provided they can be placed on a flat surface. In addition, offset printing uses a rotary principle for image transfer, which allows high printing speed favoured in the printing industry (Oittinen 1998).

In offset lithography printing, a printing unit prints one colour on a sheet of paper or web. Therefore, a full-colour printing facility will need four printing units to print full-colour, using cyan, magenta, yellow and black ink. It is important to note that for special finishing effect such as varnish another printing unit can be added (Kipphan 2006).

In relation to this study, the printing curriculum of the graphic design programme require students to understand both the theory and practical aspects of offset lithography printing base on the physical interaction that goes on between the materials that printing issues are eminent. This study therefore provide graphic design students of the TTU a means of understanding especially the practical aspect of lithography printing through the integration of theory and practice at the industrial level.

Lithography Print Faults

Lithography printing involves the use of various parameters which together contribute to the final print quality. These include operator knowledge, information about the original image, paper, ink, printing plates, rubber blanket, dampening solution and human ability to subjectively assess print quality (Lundström 2014). According to Masod et al. (2014) and Madhawa (2017), lithography printing is a physical process prone to defects which arise due to interaction challenges, when there are deficiencies among the paper, ink, press, and press operation factors. They went on to explain that these faults can be related specifically to ink, paper, fountain solution, blanket and press resulting in faults such as banding, colour cast, colour non-uniformity, colour variation, ghosting, graininess, hickeys, misregistration, moiré, mottle, poor line quality, poor trapping and poor text quality. According to Prepressure (2018), these lithography printing faults can lead to a completely different and totally undesired print appearance.

Yangping et al. (2017) are of the view that printing faults may occur due to low precision of printing equipment, a mismatch between equipment and image parameters, and equipment or material fault during image reproduction. Such defects cause an inconsistent visual effect of the printed matter, thereby negatively affecting the quality of the product.From the above discussion, it could be suggested that the importance of consciously equipping graphic design students with relevant industrial skill and work experience in lithography printing faults cannot be underestimated. This is because lithography printing is a complex physical process that makes use of several materials and heavy equipment that need to be carefully coordinated, assessed and monitored throughout the production process to prevent print defects which impact the quality of the final product (Madhawa, 2017).

As printing industries do not take print faults lightly due to the adverse effect, it has on print quality. It is imperative for graphic design students to be abreast with the current range of print faults associated with lithography printing, how to detect them, establish their possible causes

and how they can be prevented in real work situations. Providing students with theoretical knowledge of existing printing faults and assisting them to transfer this knowledge into practice would broaden their knowledge on print faults, equip them with practical skills and work experience and bridge the gap between theory and practice.Some lithography printing faults, are presented below. The identification of these faults will be based on a comparison between printed and original images using visual inspection.

The focus of this study is on lithography printing faults most graphic design students of TTU find it challenging to understand. The designing and development of this handbook will be a perfect resource to help Graphic design students bridge the gap between theory and practice, acquire relevant technical knowledge and practical skills in lithography print faults.

Lithography Print Quality

Printing is a mature industry, and most printers have learned to achieve quality results since customers and businesses expect print products to be of high and constant quality throughout every copy and for different print jobs to either meet requirements and specifications or satisfy customers (Dale, 1999; Mine, 2018). Quality printing depends on the entire activities in the prepress, the actual printing process, press techniques employed, and substrates and ink used (Kipphan, 2006).

Lithography printing is currently the modern standard for high-volume industrial printing of magazines, newspapers, books and many others, therefore for printing industries to develop the businesses they need to ensure the continuous improvement of the printing quality by detecting and removing all printing faults that will affect the quality of products (Madhawa, 2017). More so, the quality of the technology that will be used to produce the printout at the press house is one of the key factors that influence quality output (Enninful *et al*., 2022). Traditionally, the detection and removal of printing faults to ensure print quality was assessed through visual detection assessment by the customer, and the presence or absence of undesired visual print fault such as hickeys, colour cast or misregistration within the final product would lead to the rejection of the work (Lundström and Verikas 2013; Madhawa 2017).

However, due to the current modern standard in high-volume industrial printing and the high-quality expectation from businesses, using manual visual inspection for this kind of technology will be impossible (Yusuf et al. 2015). Though the quality of the final product will depend on visual inspection, visual inspection satisfaction depends to a large extent on the quality and efficiency of the entire printing process. This has resulted in the development of various print fault detection methods, press inbuilt mechanisms and international print standards that help to minimise, detect and prevent print faults (Lundström and Verikas 2013). These include vision-based inspection method that compares an inspected image to a reference image, photo spectrometers used for colour correction by comparing print colour with known colour values to ensure that the quality of the printing ink is up to the standard, automated camera-based tools and forests-based technique for automatic print quality assessment based on objective values of several print quality attributes (Perner 1994; Lundström and Verikas 2013; Yusuf 2015).
In addition to the above, the International Organization for Standardization (ISO) and industry-recognised practices have led to the development of several standards which provides a set of parameters that guarantee print quality and consistency. The ISO is an international organisation for Standardisation that collaborates with a wide range of industries and

businesses like the printing industry by conducting extensive testing to help define standards for the printing industry. It provides printers with a set of standards on how to address conformance of materials before they enter the production process and measures used to prevent defects from enhancing print quality (Chung 2007; 1ink.com 2017; Prepressure 2018).

The role of a lithography printing method in the current global printing industry

Lithography began to gain its popularity as a form of commercial printing in the 19th century, and it is currently one of the most widely used printing methods (Ives 2004). Improvements made in the types of plates, inks, and paper used has strengthened the technology, leading to a more advanced production speed and plate quality (Leurs, 2016). Currently, lithography is the most widely used print method in the printing industry in Ghana and globally due to its high-quality products with clarity of both text and imagery across the whole process and a clear and precise finish. It has a high speed, and high volume, capable of producing more copies faster than most printers, and some web press lithographic machines can print as many as 50,000 sheets per hour (Merriam, 2017). Lithography printing is cost-effective and excellent value as more production comes with reduced cost. This printing method is versatile as it can be used to print smart cards, newspapers, flyers, brochures, and catalogues and aside paper, it can also be used to print on a variety of surfaces such as leather, plastic, fabric, and metal, which are not possible with other printing methods such as flexography (Merriam 2017).

These qualities make lithography printing the favourite to produce most print products in the printing industry and account for more than half of all printing that uses printing plates. (Helmut, 2001). The quality of the prints produced has continued to increase consistently, and the quantity of prints made has shown that lithography is an efficient printing technology for businesses, especially where bulk deliveries are required within a very short period (Helmut, 2001). Helmut (2001) is of the view that, in relation to other printing methods such as flexography, offset printing is cost-effective due to the capacity to produce large volumes of high-quality prints in an economically sound manner that requires little maintenance.

The popularity and qualities of lithography printing make it the best choice of printing method for most industries and the cost-effective choice for most businesses globally (B&B Press (2020). According to Imarc (2018), lithography printing had a global market value of US$ 8.1 Billion in 2017, and it is estimated to exceed US$ 10.5 Billion by 2023. However, lithography printing is associated with several print faults due to the various materials used and the physical interaction nature of the printing process (Madhawa (2017). Therefore, for graphic design students to be employed in the printing industry, they must be abreast with not only the entire printing procedure but also must be able to identify print faults, understand how they occur and how they can be reduced to prevent or preserve print quality, which makes the need for this project crucial.

METHODOLOGY

A qualitative research method was used to obtain comprehensive data to assess the effectiveness of a six-week structured pre-press and press activities programme for the study based on the integration of theory and practice at the industrial level. The action research design was used as the project took place in a real-world setting or printing industry (Dhungana, n.d). Data was collected through a four-stage data collection procedure, which included an

interview, observation, focus group and test. The interview was designed to identify students with limited practical experience in lithography printing and understand their experience and perception of their first industrial attachment. The observation was used to assess each participant's progress in pre-press and press activities to prevent lithography printing faults during the six-week industrial training.

Focus-group discussion with participants was carried out at the end of each session to get feedback on the integration of theory and practice on their practical skills and work experience. Finally, data were obtained using test type of questions to assess the effectiveness of the integrating teaching of theory and practice. Close and open-ended questions allowed participants to explain themselves thoroughly (Creswell & Plano Clark 2011). In all, 24 HND second-year students were purposefully selected for the interview. Twelve participants who took part in the interview and have very limited industrial experience in lithography printing were selected for the industrial practice. These 12 participants also participated in the focus group discussion (FGD). Also, the remaining 12 participants who took part in the interview but not the industrial training joined the 12 participants of the industrial training group to assess the effectiveness of the integrated teaching on the acquisition of practical skills and work experience in lithography printing faults causes and remedy through test questions. The study period was March - September 2020.

Except for the researchers and another lecturer's observation, the remaining data collection procedures were administered and collected by the researchers. Data were analysed using thematic analysis to help capture the complexities of meaning within the documented data. Descriptive analysis was used to summarise the data from the interview, observation and focus group discussion. Data from the test was presented in tables and expressed as percentages to make it meaningful and easy to understand.

FINDINGS AND DISCUSSION

Findings from the analysis of the data from the interview, observation, focus group discussion, and test are presented below.

Interview

To assess the effectiveness of a six-week structured pre-press and press activities programme, based on the integration of theory and practice at the industrial level. It was essential to explore and identify participants' skills and work experience in lithography printing faults through a non-structured interview.Two major findings emerged from the interview: the lack of industry for training and the unwillingness of industry to train students. Many participants found it difficult to get placement in the printing industries due to the limited number of printing industries in Ghana related to the large number of students from Takoradi Technical University, Kwame Nkrumah University of Science and Technology and the University of Education Winneba.

During the interview, it came to light that some graphic design students had a placement in small scale printing industries where only pre-press jobs are carried out. A few graphic design students managed to get placement in the medium-scale press where pre-press and press activities are carried out. However, participants lamented that these students were not allowed

into the room housing the lithography printing machines. During the interview, some participants complained that they did only design work on the computer throughout the three-month industrial attachment period and were not allowed to observe pre-press activities such as preparation of digital files, flats, burning, and washing plates. It came to light that occasionally, a few students end up in large printing industry, but like those in the medium-sized industry, they are not allowed to touch any printing materials, tools or equipment.

All participants unanimously agreed on the importance of industrial attachment concerning industrial skills and work experience development. This, according to participants, will enhance their chances of employment in the printing industry or self-employed. The importance of industrial training in work-related education has already been established. Thus, when students in work-related education are not getting the skill during their University education, it needs to be addressed with all the seriousness it deserves (Yusof et al., 2013; Youssef & Hunter 2014).

Focus Group Discussion (FGD)

The FGD was specifically based on integrating theory and practice at the industrial level. This was to understand participants' perception of this new teaching strategy to develop graphic design students' skills and work experience in lithography printing. Two broad themes emerged from the analysis of the focus group data. These two themes are the significance of integrated theory and practice for skills development and the lack of adequate space, equipment and time for integrated teaching.

On integrating theory and practice at the industrial level, participants were eager for it to continue, as revealed during the FGD, since they could make good progress in acquiring skills and work experience within the six-week study period. From the focus group discussion, some of the participants explained that, though they have a wide range of theoretical knowledge, they need practical industrial experience to help them understand the theory develop practical skills and work experience to keep them abreast with the rapid technological advancement and to help them secure jobs. This is echoed by Gu et al. (2011), who argues that learning industrial skill is not a choice but a must with technical education. Though participants argued that integrated teaching at the University could be the best option, they understand that it will not benefit all the students due to lack of space and resources.

Findings from the FGD revealed that participants believe they will be able to develop industrial skills and work experience if they could spend about two years of their training programme in the industry instead of 6 months; and if only the industries are willing to train them. The importance of allocating more time for industrial practice to assist students to develop adequate and efficient skills in Technical Education has been acknowledged (Amedorme & Fiagbe 2013; Adjei et al., 2014). However, that is not the case in Ghana, where only six months out of the three years for the HND Graphic Design programme is used for industrial training, with theory taking two and a half years. In another development, Datta (2018) share the view of participants on the reluctance of industry to support industrial training of students. According to Datta (2018), the industries that will benefit from the skills of the students after graduation are the very organisations that are refusing to support student's industrial training and advice that the industry needs to support the development of skills for student trainees for a smooth transition from the classroom to the world of work. Also, the lack of commitment on the part of the

industry has been attributed to the ineffective collaboration between Technical University and Industry by numerous studies (Nunfam *et al.* 2015). Surprisingly, very little has been done to improve the University-Industry partnership to facilitate the provision of credible employability skills to students as required by the University curriculum. Latham (2015) suggest that industry and University need to work together as both parties lose out if they do not collaborate.

Observation

The observation was largely based on industrial work by participants and researchers at the TTU press to assess the effectiveness of a six-week structured pre-press and press activities programme, based on the integration of theory and practice at the industrial level. During the study, the following teaching strategy was used:

1. Presentation of theory on each activity.
2. Observation of demonstration.
3. Group and individual participants practice work.
4. Discussion of practice work.
5. Evaluation of group and individual participant's skills development and work experience.

RESULTS AND DISCUSSION

The study observed that by the end of the six-week study period most participants were able to acquire industrial skills and work experience at different rates in the following pre-press and press activities.

Pre-press and Press Activities

Table 1: Industrial skill undertaken by participants

Activity	Skills and Work Experience Acquired
Preparing digital files for printing	Choosing the right style attribute, consistency, white space, alignment, colour and typeface for the Design
Preparation of flat	Accurate alignment of films onto plate. Adequate blackened and sharp edge definition of films, Spread, hakes and white gabs
Burning of printing plate	Adequate blackened of film Sharp edge definition of images Clean films Alignment of the film onto the film
Washing of printing plate	Thorough clean-up of the printing plate (Separation of the images areas from the non- image areas)
Preparation of appropriate medium for impression	Internal strength of the paper. Press room condition appropriateness of medium for the impression
Preparation of colour	Having the right colour and colour consistency.
Preparing the dampening solution	Choosing the right proportion of water and chemicals.

Makeready	Demonstration of excellent adjustment of the inking rollers, dampening rollers, the plate and the blanket cylinder
Identification and characteristics of printing faults	Ability of participants to identify and describe characteristics of different print faults.
Causes of printing faults	Identification of possible causes of printing faults.
Remedy of printing faults	Identification of possible remedy for printing faults

Source: Fieldwork, 2021

Plate 1: Participants undertaking washing of Printing Plate
Source: Fieldwork (2020)

Participants saw the industrial training as a good opportunity to prepare them for industrial work. During the six-week study period, the researcher observed that participants were very excited to have the opportunity to work in a printing industry where they were able not only to observe demonstrations but also, to physically take part in pre-press and press activities through the use of industrial materials, tools and equipment. Participants' reaction on the first day of the industrial training was not surprising as, according to Ochiagha (2014), the only way students can acquire practical skills and work experience in work-related education is to train in an industry related to their field of study using materials, tools and equipment. Agwi (2015) reiterates that, for Technical University students to be gainfully employed in industry, they must be posted to industries related to their field of study to develop industry skills and work experience.

Throughout the study period, it was observed that all participants paid attention to instructions given in the industry and observed demonstrations with 100% focus. Again, the study observed that participants were keen to work in groups to build each other's confidence, and they also enjoyed working on their own to show how well they have been able to master a skill. The researcher also noticed that though few participants must be encouraged to ask questions on things they do not understand during theory presentations and practical demonstrations, most participants were very keen to ask relevant questions about things they do not understand and why certain chemicals or processes are used for further explanation. It was observed that except for a few questions, participants were able to answer most questions they were asked, and they also did very well when asked to explain the demonstration they had observed.

The study noted that all participants did not put up any negative attitude during the study period. They listened attentively to theory presentations, focused on demonstration work and were able to relate theory to practice. There was cooperation between participants, researcher and technicians, and participants during group work. It was also observed that participants were eager to learn from their peers and accepted correction during group and individual work. It was recognised that participants developed industrial skills and work experience at different rates. For example, in the preparation of digital files, participants were expected to develop skills in choosing the right style attribute, consistency, white space, alignment, colour and typeface for the Design. However, at the end of the sixth-week study period, over 20% of participants did excellent work, over 50% of them did good work, and 17% did average work. Since the preparation of digital files is entirely computer work, nearly half of respondents struggled to handle the computers initially as that was the first time some of them had access to computers. Though most of them did well, a few still require further training.

Also, on creating a flat, while about 60% of participants did excellent work, 40% did good work. Similarly, 20% did excellent work on plate burning, 50% of participants did outstanding work, and 30% did good work. This shows that participants developed industrial skills and work experience at different rates. On the washing of printing plates, 67% of participants did excellent work, whiles 33% of them put up a very good performance in thorough clean-up of the printing plate (Separation of the images areas from the non- image areas). This performance suggests that washing of printing plate was one of the easiest skills in lithography printing for participants. On preparing medium for impression, all participants did very well and finally, on the identification of printing faults after the printing, all participants were able to identify the printing faults, they were able to explain the causes of the faults and how to rectify them. Overall, participants' performance concerning skills development and work experience in lithography printing faults, cause and remedy was very good, and some of them performed to industrial standard.

The researchers recognised that participants were proud of their achievement when they could accomplish a task. They also showed interest in self, peer and researcher evaluation of their work. Generally, participants liked the press environment but wished they had more space and equipment to accommodate more students. Findings from the observation advocate that integrated teaching of theory and practice at the industrial level is effective in helping graphic design students to acquire skills and work experience that could bridge the gap between theory and practice in lithography printing.

Presentation, Analysis and Interpretation of Test Data
Group 1 & 2 (All 24 participants)

Table 2: Preparation of Digital Files

Activity - Preparing Digital File	**Group 1**	**Frequency**	**Percentage (%)**	**Group 2**	**Frequency**	**Percentage (%)**
Excellent		5	42		-	-
Very Good		3	25		-	-
Good		2	17		-	-
Average		2	17		4	33
Below Average					8	67
Total		**12**	**100**		**12**	**!00**

Source: Fieldwork (2021)

Evidence from Table 2 shows that in terms of preparation of digital files, 42% of participants in group 1 did exceptionally well, followed by 25% with very good performance and 17% with a good and average score. This suggests that although about 70% of participants in this group have adequate computer skills to understand the preparation of digital files, about 30% of participants struggled with this skill during the industrial training.

Compared to results from group 2, while 33% had an average score, 67% had below average. This suggests that most participants in this group have limited skill and work experience in digital file preparation.

Table 3: Preparation of Flat

Activity – Flat Preparation	Group 1	Frequency	Percentage (%)	Group 2	Frequency	Percentage (%)
Excellent		5	42		-	-
Very Good		4	33		-	-
Good		2	17		-	-
Average		1	8		2	17
Below Average					10	83
Total		**12**	**100**		**12**	**100**

Source Fieldwork (2021)

From Table 3, it could be observed that on the preparation of flat, over 70% of participants in group 1performed very well while a quarter of them did good and average work respectively. This shows the positive impact of industrial training on participants' skills. However, in Group 2, only 17% of participants had an average score, with over 80% scoring below-average marks. These scores show a huge disparity between industrial skill training and adequate theory knowledge as against only theory knowledge without industrial skill.

Table 4: Burning of Printing Plates

Activity - Plate Burning	Group 1	Frequency	Percentage (%)	Group 2	Frequency	Percentage (%)
Excellent		6	50		-	-
Very Good		3	25		-	-
Good		3	25		-	-
Average					2	17
Below Average		-	-		10	83
Total		**12**	**100**		**12**	**100**

Source: Fieldwork (2021)

As seen from Table 4, 50% of participants from group 1 did exceptionally well with the burning of the plate, 25% did very well, and 25% did good work, while in group 2, 17% of participants had average marks with over 80% scoring below average. Results from Table 4 imply that 100% of Group 1 understand the skill of plate burning very well, while over 80% of participants in Group 2 scored below average. The simple interpretation for this is the advantage Group 1 participants had in industrial training against those in Group 2 without any industrial training in the burning of the printing plate.

Table 5: Washing of Printing Plate

Activity - Plate Washing	Group 1	Frequency	Percentage (%)	Group 2	Frequency	Percentage (%)
Excellent		8	67		-	-
Very Good		4	33		-	-
Good		-	-		3	25
Average		-	-		6	50
Below Average					3	25
Total		**12**	**100**		**12**	**100**

Source: Fieldwork (2021)

Findings from Table 5 demonstrate that about 67% of Group 1 were able to wash the printing plates extremely well, while 33% of participants did very good work. Then from group 2, 25% of participants did good work in plate washing, but about 50% had average scores, with 25% scoring below average. The explanation for this could not be different from that of the previous table. However, it must be acknowledged that the performance of group 2 participants in the washing of printing plate is encouraging compared with the first three tables, with about 25% scoring good marks.

Table 6: Preparation of appropriate medium for impression

Activity - Medium Preparation	Group 1	Frequency	Percentage (%)	Group 2	Frequency	Percentage (%)
Excellent		5	42		-	-
Very Good		4	33		-	-
Good		3	25		-	-
Average					4	33
Below Average		-	-		8	67
Total		**12**	**100**		**12**	**100**

Source: Fieldwork (2021)

Regarding the preparation of appropriate medium for impression, Table 6 establishes that over 70% of participants in group 1 did excellent and very good work as against only 33% in group 2 with average work. From Table 6, all participants in group1 performed well in preparing the medium for lithography printing. However, Group 2 suggests inadequate knowledge on skill and work experience medium preparation, which could affect graduates' industrial work opportunities.

Table 7: Preparation of Colour

Activity – Colour Preparation	Group 1	Frequency	Percentage (%)	Group 2	Frequency	Percentage (%)
Excellent		4	33		-	-
Very Good		3	25		-	-
Good		5	42		1	8
Average					5	42
Below Average		-	-		6	50
Total		**12**	**100**		**12**	**100**

Source: Fieldwork (2021)

On the preparation of colour for printing, evidence from Table 7 suggests that almost all participants in group 1 did very well, with 33% doing extremely well, 25% very good and 42% good performance. On the other hand, about 50% of participants in Group 2 had below-average performance, and 8% made a good performance. As evident in Table 7, results from the two groups demonstrate the importance of industrial skill training in relation to Technical University Education to help students meet academic goals and industrial needs.

Table 8: Preparation of Dampening Solution

Activity – Preparing Damp. Solution	Group 1	Frequency	Percentage (%)	Group 2	Frequency	Percentage (%)
Excellent		3	25		-	-
Very Good		5	42		-	-
Good		4	33		1	8
Average					2	17
Below Average		-	-		9	75
Total		**12**	**100**		**12**	**100**

Source: Fieldwork (2021)

Evidence from Table 8 demonstrates that all participants in group 1 acquired the skill of preparing a dampening solution, with only 25% of those in Group 2 having some skill in dampening solution preparation. This suggests that integrating practice and theory at the industrial level could be a beneficial resource in industrial-related programmes to equip graphic design students with industrial skills and work experience.

Table 9: Make ready

Activity – Makeready	Group 1	Frequency	Percentage (%)	Group 2	Frequency	Percentage (%)
Excellent		4	33		-	-
Very Good		3	25		-	-
Good		5	42		-	-
Average					2	17
Below Average		-	-		10	83
Total		**12**	**100**		**12**	**100**

Source: Fieldwork (2021)

Throughout this study, evidence from these tables is very clear on the importance of skills in industrial-related programmes. With the skill of makeready before the actual printing from Table 9, 33% of participants in Group 1 did excellent work, 25% did very good work, and 42% did good work. In relation to Group 2, only 17% of participants did average work, with over 80% of putting up a below-average performance.

Table 10: Identification and characteristics of Printing faults

Activity – Faults Ident. & Charact.	Group 1	Frequency	Percentage (%)	Group 2	Frequency	Percentage (%)
Excellent		8	67		-	-
Very Good		4	33		-	-
Good		-	-		2	17
Average					5	42
Below Average		-	-		5	42
Total		**12**	**100**		**12**	**100**

Source: Fieldwork (2021)

Findings from Table 10 reveal that about 67% of participants from group 1 were able to identify printing faults and their characteristics with accurate precision, while 33% did very good work. Though a few printing faults were challenging to detect, participants could identify and describe their characteristics. This suggests that integrating practice and theory at the industrial level could benefit graphic design students.

On identifying and characteristics of printing faults among participants in group 2, as seen from Table 10, none of the participants in Group 2 did extremely well, and only 17% did good work. However, over 80% of them had average and below-average scores. This suggests that students have very limited knowledge of the identification and characteristics of printing faults and that they urgently need industrial training to acquire skills and work experience in the identification and characteristics of lithography printing faults.

Table 11: Causes of printing faults

Activity – Causes of Faults	Group 1	Frequency	Percentage (%)	Group 2	Frequency	Percentage (%)
Excellent		6	50		-	-
Very Good		3	25		-	-
Good		3	25		-	-
Average					1	25
Below Average		-	-		11	75
Total		**12**	**100**		**12**	**100**

Source: Fieldwork (2021)

Regarding Table 11, all participants in Group 1 did very good work, and it appears participants clearly understand the causes of the printing faults as they could recognise the challenges during the practical. This suggests that extensive industrial practice on lithography printing skills could help graphic design students easily identify the causes of lithography printing faults for correction.

Results from Table 11 show that none of the participants who did not participate in the study practice scored excellent, very good or good marks on the causes of lithography printing faults. However, 25% of them had an average score, while 75% produced below-average work. This shows that these participants have limited knowledge of the causes of lithography printing faults due to a lack of practical skills and work experience.

Table 12: Remedy of Printing faults

Activity - Remedy of Faults	Group 1	Frequency	Percentage (%)	Group 2	Frequency	Percentage (%)
Excellent		7	58		-	-
Very Good		3	25		-	-
Good		2	17		-	-
Average		-	-		-	-
Below Average		-	-		12	12
Total		**12**	**100**		**12**	**100**

Source Fieldwork, (2021)

Results from Table 12 suggest that almost all participants in group 1 did very well, with 58% doing extremely well, 25% very good and 17% good performance. On the other hand, results from Group 2 reveals quite the opposite as all 12 participants put up a below-average performance. These two results from Table 12 reveals that participants in Group 1 understand the various skills employed to resolve lithography printing faults, whiles those in Group 2 lack practice skills in the remedy of printing faults.

DISCUSSION

In the current competitive labour market, industries are interested in employing workers with needed industrial skills to improve production and business development (CIPD, 2022). Therefore, when graphic design students graduate from Technical University without skills for employment, they are set to fail (Enninful et al., 2021). To address this challenge study assesses the effectiveness of a six-week structured pre-press and press activities programme, based on integrating theory and practice at the industrial level to enhance students' skills and work experience.

The significance of Technical University Education on the global economy and national development is enormous (Youssef & Hunter, 2014). For many years, governments worldwide have initiated engagements between technical education providers and industry to build a partnership that could support their economies and promote national development (Hancock 2014; Latham, 2015). This is because Technical University Education plays a vital role in the human resource development of every country by creating a skilled workforce to enhance industrial productivity and quality of life (Yorke 2004; Latham, 2015). To achieve this in Ghana, the Polytechnic Act, 2007, Act 754 was enacted in 2007 to provide career-focused technical tertiary education. Kwami (2001) describes polytechnics as technological institutions with the sole responsibility of contributing actively to national development by providing career-focused education and skills training to the highest level possible and providing opportunities for applied research with close collaboration with industry.

According to Kwami (2001), Polytechnics, which have been currently upgraded to Technical Universities in Ghana, have the unique responsibility to produce highly skilled graduates for industrial development. This is echoed by Hancook (2014), who suggests that, since technical university education deals in work-related programmes such as engineering, textiles, technology and graphic design, they should be rigour and responsive to the needs of these industries; and that for the industry to value Technical University Education, they need to meet industrial standards. However, Latham (2015) believes that without the active involvement of industry in Technical University Education, the universities alone cannot develop an education system that is rigour and responsive to industrial needs.

Evidence from the interview and test results confirm Latham's (2015) views. The unsatisfactory performance of participants in Group 2 on the industrial skills test suggests that, since participants in group 2 did not take part in the industrial training, the theoretical knowledge from the university alone did not help them get good scores. This shows that without industry input in the training of Technical University students, they cannot acquire industrial production skills as the university does not have the technical expertise, environment, tools, equipment, and materials to undertake skill training in lithography printing (Datta 2018).

According to Agwi (2015), close collaboration with industry plays a vital role in Technical University Education as the curriculum comprises theory and practice, which are parts of a whole. Participants understand that while theory takes place in their classroom, practice is carried out in the industry and that the theory is just the fundamentals that need to be further developed in the industry (OECD, 2015). Therefore, to obtain wholeness in Technical

University Education, students must obtain knowledge and skills in theory and practice (McCrone et al., 2015). From the interview, participants bemoaned that they were unable to obtain placement for skill development and those who managed to get placement in printing industries were not trained in the needful skills. During the focus discussion, participants suggested that they have a wide range of theoretical knowledge with very limited skills and work experience, leaving a huge gulf between theory and practice. This could be seen from Table 12 on the remedy of lithography printing faults, where 58% of participants in Group 1 did extremely well, 25% very good and 17% good performance; compared to participants in group 2 where all of them all performed below average. Also, concerning the causes of identified printing faults from Table 11, over 70% of participants in group 1 did exceptionally well, while only 8% of participants in group 2 did good work.

Table 2 revealed that over 80% of Group 1 acquired between good and excellent skills in digital file preparation, while about 33% of those in group 2 had average scores. Then again, concerning the preparation of flat, over 80% of participants in group 1 developed good skills while only 17% of participants in Group 2 developed an average score. These findings attest to the importance of Green et al., (2011) argument that effective learning and acquisition of skills in work-related education, such as Technical University Education, can be achieved through first-hand experience in an appropriate work environment outside the academic classroom setting and may include an internship and industrial attachment.

In a study on how Technical and Vocational Education and Training can support strategic sustainability development for economic growth and national development, Gu Chen et al. (2011) suggested that developing a skilled workforce in knowledge, skills, and attitudes is the key to successful sustainable development. Concerning this, if Technical University graduates do not have the skills needed for employment, they will not be able to support the sustainable development of Ghana. Latham (2015) believes that industry and universities working together is a two-way partnership and that both parties lose out if they do not collaborate. Looking at some of the benefits of this partnership for both University and industry, Russel (2022) states that, while Universities could benefit from the enhanced impact of the research base and enhanced education opportunities for students, similarly, industry partners could benefit from theory knowledge and accessing world-leading innovation and research to growing and developing internal capability. He further suggests that if industry and university collaborate effectively, the nation gets the best of both parties. For example, during the practice session for this study, the researcher and participants gained a lot of industrial skills from press technicians, whiles the press technicians were also equipped with comprehensive theory knowledge on lithography printing faults, causes and remedies. One notable theory knowledge technicians learned from researchers and participants by the end of this study was the use of correct printing terms. Printing industry in Ghana train most of their workers on the job; though they have the skills and work experience, they lack theory knowledge and have coined their lithography printing terms. Include 'shadow' for 'ghosting'; 'bedding' in place of 'offset'; 'socking' for 'strike through' and 'too much ink' instead of the correct term 'show through'. Thus, both industry and students gain from each other by working closely together, as Russel (2022) suggested.

From the interview and focus discussion, participants lamented the challenges in finding placement in the industry for training and the reluctance of the industry to train them. In support of the participant's experience, Datta (2018) suggests that the challenge in skill development

and work experience among the youth for human development to create a strong flow of skilled talent for the industry and national development lacks interest from the industry itself. Evidence from the interview attests to Datta's (2022) suggestion as the industry is not keen to train students. Participants suggested that they were not allowed to observe or participate in pre-press and press activities. However, from the make-up of technical university education, the programme will not be successful if university and industry do not work together as the programme's success depends on the two establishments (OECD, 2015).

As a result of the current increased competition of globalisation and relentless technological advancement, Universities must produce employable graduates by aligning their curriculum with industrial needs to prevent the teaching of irrelevant and outdated content (Datta, 2018). Hancock (2015) also recommends that Educational committees with complex, messy frameworks should not design technical University Education curriculum, but clearly and better standards were written by industry or employers. Evidence from the Graphics department suggests that National Accreditation Board designed the current HND Graphic Design programme without the input of the printing industry. This makes it very challenging for the industry to effectively support student practice, especially where curriculum requirements may differ from industrial practices and needs. According to Agwi (2015), Industrial attachment is the only programme designed to prepare students for industrial work during their technical university education. This suggests that skills training in technical education must not be undervalued as it is the root of human development directly linked with the economic growth of a country and that as a prerequisite for sustainable economic growth, the technical university needs priority attention of government policy and public funding (UNESCO, 2022).

According to CEPTA (2017), as part of their training, students undertaking work-relation programmes must be exposed to effective industrial training in their specialised field of study to provide them with a comprehensive learning platform where they can enhance their employability skills and work exposure to prepare them for the job market. Without relevant industrial training, students are denied the ability to perform effectively in the industry as they will negatively and significantly affect production performance (Russel, 2022). Results from Tables 4 to 12 show significant differences between participants' performance in group 1 and group 2. Participants in Group 1 were able to develop all the skills available to them during the six-week industrial training. However, those in Group 2 did not participate in the industrial training, and their unsatisfactory performance attests to the weakness in the current HND Graphic Design curriculum and the production of unskilled labour.

The incorporation of the principle of Experiential learning theory of the acquisition of skills through first-hand experience in an appropriate environment into this structured programme greatly improved skill development and work experience, especially in plate washing, identification and characteristics of printing faults, causes and remedy of printing faults as evident in Tables 5, 10, 11 and 12. There was a vast disparity between the two groups in the test results showing the importance of industrial training in Technical University Education to prevent the production of unskilled labour. Several studies and reports have stressed the importance of industrial skill training in Technical Education and the need for education providers to put adequate measures to achieve this (Kozík, 2015).

Russel (2022) believes that due to the immense benefit industry derives from this partnership; they should support the development of technical education skills. He suggests that a skilled workforce helps grow income and cut costs in the industry. As skilled workers on a production line will be able to find better ways to do it and will optimise and configure the production line more virtually, they make fewer errors, fix problems and minimise downtime and the more skilled the workforce of industry, the more innovation it will have across every aspect of the business. However, Hussain et al. (2020) suggest that although employing an unskilled workforce may be cheap due to low wages, it comes with a lack of knowledge, skill, and expertise in product development, which may negatively impact industrial performance growth. According to Datta (2018), as Technical Universities have limited access to the latest emerging technologies, support from industry in the form of technical assistance, curriculum development, providing learning resources, helping conduct master training programs and helping the universities be abreast with time. It would be precious as students acquire adequate skill and work experience for industrial work or self-employed.

According to Datta (2018), apart from support from industry, the government also have equal responsibility to provide sustainable employment for the citizen, so government commitment to the success of Technical University Education in Ghana is paramount. In addition to this, Datta (2018) suggest that for graphic design students to have adequate and well-equipped printing industries to train, universities also have the responsibility to influence policymakers to engage industry constructively and financially to provide adequate training places for students. In addition to this, university lecturers require continuous professional development in industrial training from industry in the form of programmes development, delivering guest lectures, providing worksite visits and generally giving them first-hand experience in emerging industrial developments (Mohamad & Kamarul 2011; Datta, 2018). For University lecturers to support students in skills development, they need to realise and understand the extent of the skill gap among students to help them embrace partnership with industrial experts for the benefit of their students (Taylor *et al.*, 2010; Datta 2018). Also, lecturers need to find innovative ways to support students' industrial skills development, as demonstrated by this study. This six-week structured integration of theory and practice programme at the industrial level resulted in the development of various industrial skills in pre-press and press activities. Lithography printing skills developed by second-year Graphic Design students during the study period include preparation of digital files for printing, preparation of flat, burning of a printing plate, washing of printing plate, preparation of medium for impression, preparation of colour, preparation of the dampening solution, makeready, identification and characteristics of printing faults, causes of printing faults, and remedy of printing faults. Evidence of the acquisition of the skills mentioned above could be seen from the observation and focus group discussion analysis and the comparison of the test results between the two groups from Tables 2 - 12.

CONCLUSIONS

This six-week education programme based on integrating theory and practice at the industrial level improved participants' industrial skills in lithography printing faults, causes and remedies. To achieve the objective study, the researcher, industry and participants put up a united front that was key to the success of the industrial training programme.

This study has identified an innovative way of integrating theory and practice at the industrial level to enhance the industrial skills of students for easy employment or self-employed in the current competitive environment after graduation for national development. Conducted in a real working environment at the Takoradi Technical Education Printing Press, this study showed the complexity of the practical aspect of Technical University Education and the importance of the active involvement of industry in Technical University Education if the goals of various departments can be met. In addition, the limited skills in lithography printing of graphic design students in the absence of adequate industrial training were exposed. Participants were trained on lithography printing processes to acquire the needful skill and work experience to address this limitation. This suggests that since industrial attachment is the only way for Technical University students to acquire adequate skills for industrial work to help them achieve their academic goals and make them valuable members of society after graduation, relevant industrial attachment places must be made available to them throughout their course of study. This study's method may be one of the innovative ways lecturers can adapt to bridge the gap between theory and practice in Technical University Education.

Research Implication

The role of Technical University Education in Ghana is to prepare students in every subject area for employability, economic growth and national development. These goals in lithography printing require the development of theory and practical knowledge and skills, such as the preparation of digital files, flats and burning of printing plates, projected in this research.
It is believed that giving equal attention to theory and practice through integrating theory and practice in lithography printing at the industrial level will equip students with the technical knowledge and expertise needed for industrial work in printing technology.

This study will work as a basis for enhancing students' practical knowledge and skills in lithography printing to augment their employment opportunities and contribute to economic growth and national development. The study is projected to contribute to the body of knowledge in graphic design and printing technology education and as a resource for industrial art academics and researchers. As most Technical University lecturers are unaware of the possibility of using available resources on the university campus to enhance students' practical knowledge and skill, this study is anticipated to raise awareness among instructors and lecturers on the need to be innovative with available resources to achieve expected goals.

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