Industry Skills Need and Skills Level Met by Polytechnic Engineering Graduates in Ghana and Sierra Leone

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ABSTRACT

Deficits in skills of engineering graduates from the Polytechnics in Ghana and Sierra Leone have been of great concern to both industry and the training institutions because they threaten the very survival of the training institutions and the student body. The key objectives of this study are to determine (1) the specific skills and attributes industries emphasised for new engineering graduates of polytechnics, and (2) the level of the skills and attributes that was met by the new engineering graduates at the various companies. Data was collected through the use of open-ended structured questionnaires and interviews. Findings revealed that (1) skills need of the industries comprised both technical and non-technical, (2) the industries attached equal importance to both the technical and non-technical skills and attributes, and (3) the industry's estimate of the skills Polytechnic Engineering graduates met at the point of entry was 50 to 60% depth of knowledge, 40 to 45% of technical skills for those without industry experience and 50 to 55% technical skills for those who had industrial attachment. This study provides industry specific information on skills and attributes expected from Polytechnic Engineering graduates and also guides trainers in developing appropriate curricula and training modules.

Keywords:

Ghana, industry skills, Polytechnic, Polytechnic Engineering graduates, Sierra Leone.

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INTRODUCTION

Industry skills needs have garnered significant attention in popular discourse, research work and policies across the world (Curtis and McKenzie, 2001; Hwang *et al.*, 2014; Kassim and Ali, 2010; Lee *et al.*, 1995; Melguizo and Perea, 2016; Royle and Laing, 2014; Runciman, 2014) probably because of employers' growing concern that new recruits do not meet their skills expectations (Alaimo *et al.*, 2015; Cappelli, 2015; Cyphert and Lyle, 2016; Osterman and Weaver, 2014; Perkins and Nigel, 2015). This contributes to the increasing rate of unemployment globally (Acheboune and Driouchi, 2014; Bhaduri *et al.*, 2015; Constantinescu, 2015). This suggests that the requisite skills required by industries are probably not being transferred effectively to the trainees at the educational institutions.

The available literature shows that there are gaps in the skills expectation of employers as a result of weak linkages between training institutions and local industries for hands-on-experience for both instructors and trainees (Dasmani, 2011). For instance, Giffi *et al.* (2015) showed that many industries in the United States of America reported that high school students have demonstrated a lack of proficiency in Mathematics and Science required on the job. The Minerals Council of Australia (2005) also showed that many graduates in the mining sector of Australia exhibited poor understanding of how their theoretical knowledge can be applied in practice. In the Middle East and North Africa regions, the managers of companies indicated that, what the graduates needed most was improvement in communication, time management and continuous learning (Ramadi *et al.*, 2016). In the sub-Saharan region, a study by Arai *et al.* (2010) on multinational mining companies in Sierra Leone identified the skills needs as literacy, experience in operating and repairing heavy machinery; experience in designing, planning, and constructing mine sites for the civil and electrical engineering; and experience in determining terrestrial or three-dimensional space position of points and the distances and angles between them on the earth's surface for mining surveyors. Additionally, the skills needed in the Agriculture sector relates to operating and maintaining heavy duty farm equipment such as bulldozers, tractors, hydraulic operated ploughs and harrows, boom sprayers, combine harvesters, planters and manure spreaders. According to GISDC (2005), the shortage of skills associated to processing operations in Ghana are related to installation, commissioning, maintenance and repair of modern automated electro-mechanical plants, working on pneumatic and hydraulic equipment, welding and material joining, fitting, machining, working as a member of a team, and communicating effectively with colleagues.

Often times the newly trained graduates in developing countries such as Sierra Leone and Ghana have to be retrained by their employers before they could perform competently on their new jobs. Because of the lack of suitably skilled staff, some companies are unable to acquire new technologies or update their equipment. However, those that did, often have to bring in expertise from outside the company (most often outside the country) to solve critical problems related to equipment breakdown (Mbroh, Personal Communication, 12 March, 2009). Most of such companies in Ghana which use expertise from outside were found to be using automated processing machinery regulated by Programmable Logic Control (PLC) and in some cases, the advanced Supervisory Control and Data Acquisition (SCADA)

systems (GISDC, 2005). Governments and other organisations have however made several attempts through some donor supported interventions and projects to narrow the skills gap (Dias and Escoval, 2014). For example, in Sierra Leone, the Youth Employment and Support Programme (YESP) was pursued by the government (Dumbuya, 2017), while in Ghana, interventions such as the Skill Training and Employment Placement (STEP) Programme, the National Youth Employment Programme (NYEP) [[now Ghana Youth Employment and Entrepreneurial Development Agency (GYEEDA)], were also pursued (Baah-Boateng and Baffour-Awuah, 2015). Attempts have also been made in some cases to implement Competency Based Training (CBT) programmes in some educational institutions to improve the hands-on skills training.

Regardless of all these concerted efforts of governments and industries, there is still employers' growing concern that new recruits are not meeting their skills expectations. In fact, research by Holzer (2015) and World Economic Forum (2014) show that industries still complain that it is becoming difficult to get the right calibre of people to fill vacancies. It is even more worrying to know from Perkins and Nigel (2015) that the skills gap seems to be widening year by year. The problem currently faced by the engineering industry, which tends to be the drive for this study is that, the Polytechnic institutions in Sierra Leone and Ghana are not supplying the right calibre of skills to the labour market. Jackson (2015) suggests a combination of traditional and academic study with student exposure to the world-of-work in their chosen profession as a way of addressing such problems. However, this study on Sierra Leone and Ghana goes further to find the exact skills and attributes industries expect from polytechnic engineering graduates to facilitate the bridging of skills gap.

The study had two primary objectives which sought to determine: (1) The specific skills and attributes industries emphasised for new engineering graduates of polytechnics; and (2) the level of the skills and attributes that were met by the new engineering graduates at the various companies.

The findings of the study will inform policy makers of the attributes and skills to be emphasised in the engineering training curriculum. The study will also add to the limited empirical studies on the skills needs of engineering industries and the level of skills exhibited in industry by polytechnic engineering graduates in Sierra Leone and Ghana.

LITERATURE REVIEW

The acquisition of technologies and equipment to improve productivity often requires skilled people as a source of competitive advantage. Spinks *et al*. (2007) put skills required by industries into three broad categories: technical, personal and business skills. The technical skills seem to be the most emphasised in engineering companies probably because they form the core requirement for an engineer and also the substance for mastering new technologies. A study by Zaharim *et al*. (2009), identified some of these technical skills and attributes as the ability to acquire and apply knowledge of engineering fundamentals; having the competence in theoretical and research engineering; having the know-how in application and practical oriented engineering; having in-depth technical competence in a specific engineering discipline; the ability to utilise a systems approach to design and evaluate operational performance; and the ability to design and conduct experiments as

well as to analyse and interpret data. Apart from being skilled in the sense of having the required knowledge in a specific discipline and having the necessary technical skills required in a profession, engineering graduates are also expected to have generic skills such as communication skills and interpersonal skills (Smith and Kruger, 2008).

The engineering work is very complex because technical and social skills are inextricably intertwined and as such, theoretical knowledge; technical skills; management skills; and engineering principles are skills needed for technology-based engineering (Motsoeneng *et al*., 2013). All these add to the notion that engineers need to acquire a large number of technical skills, generic skills, and profound technical knowledge, of which very little is learned at university (Trevelyan, 2008) as well as polytechnics. The narrow training technical specialist receive is a thing of the past (Spinks *et al*., 2007) and most employers allude to this assertion. Currently, employers look out for people with multi-technical skills and so, an ideal engineering graduate is expected to be the best in the field, be highly competent in at least one technical skill, and also have an understanding of the other engineering and technical disciplines. At least 73% of employers attached great importance to all the technical competencies identified by Zaharim *et al*. (2009) while 85.5% expects engineering graduates to be competent in both application and practical oriented engineering.

Personal skills and attributes concerning communication were also seen as important in every engineering role today and have been linked to the ability to work with others such as customers, suppliers, and other business partners outside the company's boundary (Spinks *et al*., 2007). Other personal attributes emphasised include creativity and innovation, and drive and enthusiasm. Employers increasingly cite deficiencies not only in up-to-date technical skills training of job applicants but also in the "employability skills", creativity, problem-solving, teamwork, leadership, self-esteem and integrity that are indispensable to productivity in today's workplace (Frimpong, 2011). Business leaders have often reported deficiencies in both hard and soft skills in four key areas: basic skills (which include communications and basic business acumen skills); technical and professionals skills (technology skills); management and leadership skills (covering areas such as supervision, team building, planning, decision-making and ethical judgment); and emotional intelligence skills (such as self-awareness, self-discipline, persistence and empathy) (ASTD Public Policy Council, 2012).

Again, business leaders are looking for people with a far wider range of skills than ever before (Tiernan, 2014). A high percentage of employers (86.7%) put much emphasis on the ability to communicate effectively with engineers and non-engineers and almost the same number (85.1%) emphasised the ability to function effectively as an individual and in a group with the capacity to be a leader or manager as well as an effective team member (Zaharim *et al*., 2009). In this regard, business and commercial skills have been found to be an essential requirement for engineers. However, Spinks *et al*. (2007) indicate that though important, it is not something that engineering graduates were expected to be adept in when they were recruited. Rather, the potential to develop (including developing appropriate management skills) is of immense relevance (Spinks *et al*., 2007). This was supported by Cai

(2013) and Bui and Porter (2010) who indicated that in addition to knowledge, employers also demanded good personality attributes from the graduates and among which the important factors considered are the ability to adapt to the culture of the firm and the desire to learn continuously.

Basic entrepreneurial skills were considered by a moderate number of employers (57.6%) as important (Zaharim *et al.*, 2009). "The days of lifetime careers are gone; chameleon-like employees who apply their skills whenever and wherever they are needed are now in high demand" (Tiernan, 2014). In recent years, it is not sufficient for graduate applicants to simply list skills they have developed but employers want graduates who can help them deal with change (Markes, 2006). A study carried out by Martin *et al*. (2005) indicated that Chemical Engineering graduates identified their weaknesses to be related to working in multi-disciplinary teams, leadership, practical preparation and managerial skills. In the current knowledge era, Horn (2006) views proficiency in mathematics, computation, reading, writing, the effective use of resources and information, interpersonal skills, an understanding of systems, and mastering of technology and flexibility in coping with change in the workplace as the new competencies required by Engineers. As the world is moving with an unprecedented speed into a high-tech future, Science, Technology, Engineering, and Mathematics (STEM) education and the ability to have a skilled and educated manpower are very paramount for business development (Ahmed, 2016).

In emerging economies such as Ghana and Sierra Leone, where technology acquisition for industrialisation is necessary to reduce the productivity gap between developed and developing countries (Athreye and Kapur, 2015) and also to contribute significantly to GDP, it is critical for companies to have access to a skillful, knowledgeable, and disciplined workforce (Kodzi, 2008).

Methods

Study Area and Data Collection

The study focused on thirteen (13) active engineering companies purposively sampled from four (4) industry sectors (Manufacturing and Processing, Oil and Gas, Mining, and Agricultural Engineering) in Ghana and Sierra Leone. The data for the study was completely primary data gathered through a survey by the use of an open-ended structured questionnaire aided by in-depth face-to-face formal and informal interviews. The questionnaire was designed to collect a range of data on: types of skills and attributes (both technical and non-technical) the company looks for when employing new engineering graduates, and level of theoretical knowledge and technical skills exhibited by the new engineering graduates. The questionnaires were self-administered by any two or more employees in their capacity as Training Officer, Maintenance Manager, Managing Director, Operation Manager, Chief Inspector of Mines, Works Manager, Human Resource Manager, Division Training and Development Manager, Supervisor, Production Manager or Chief Engineer, while the interview was administered by the researcher on any two or more of those respondents as mentioned above.

Data Analysis

The data gathered was categorised into both technical and non-technical skills and attributes, and they were compared with the

following listed skills and attributes compiled from Zaharim *et al*. (2009), Bui and Porter (2010), Frimpong (2011), Horn (2006), Spinks *et al*. (2007), and Zaharim *et al*. (2009).

a. Ability to acquire and apply knowledge of engineering fundamentals
b. Having the competence in theoretical and research engineering
c. Having know-how in application and practical oriented engineering
d. Having in-depth technical competence in a specific engineering discipline
e. Ability to utilise a systems approach to design and evaluate operational performance
f. Ability to design and conduct experiments, as well as to analyse and interpret data
g. Ability to work and communicate effectively, not only with engineers but also with others such as customers, suppliers, and other business partners outside the company's boundary and the community at large
h. Ability to undertake problem identification, formulation and solution
i. Ability to function effectively as an individual and in a group with the capacity to be a leader or manager as well as an effective team member
j. Having the understanding of the social, cultural, global and environmental responsibilities and ethics of a professional engineer and the need for sustainable development
k. Recognising the need to undertake lifelong learning, and possessing/ acquiring the capacity to do so.
l. Having the knowledge of contemporary issues and the flexibility in coping with change in the workplace
m. Having the basic entrepreneurial skills
n. Having the creativity and innovation skills
o. Having the drive and enthusiasm
p. Having the self-esteem and integrity
q. Ability to adapt to the culture of the firm
r. Having the proficiency in mathematics, computation, information technology, reading, and writing
s. The effective use of resources and information
t. Having interpersonal skills
u. Understanding of systems and mastering of technology

The technical skills and attributes are from A to F, while the non-technical skills and attributes are from G to U. Descriptive statistics was employed to discuss the similarities and differences in the skills and attributes across the industries and Microsoft Excel Version 2010 was used to process the data. An independent-sample t-test was conducted to validate the findings.

RESULTS AND DISCUSSION

Figure 1 represents the percentage of technical and non-technical skills and attributes of the twenty-one (21) listed skills (A to U inclusive) that industries emphasised as required of the new engineering graduates from Polytechnics.

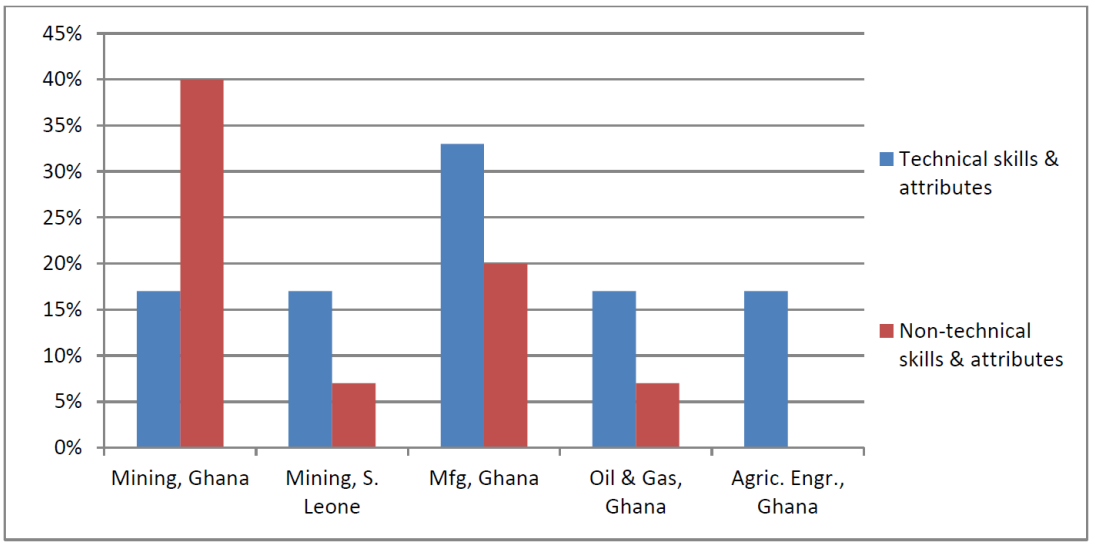

Figure 1: Level of technical and non-technical skills and attributes emphasised by the industries for Polytechnic Engineering graduates.

Source: Field Survey (2009 and 2010).

As Figure 1 shows, all the industries except one (Agricultural Engineering) emphasised the need for both technical and non-technical skills and attributes for new engineering graduates. This suggests that technical skills are core skills required for an engineer or technician in the engineering profession and industry (see Spinks *et al.*, 2007; Zaharim *et al.*, 2009).

The mining industry in Ghana seems to lay much emphasis (40%) on the non-technical skills as against 17% technical skills and attributes. This may be an indication that in Ghana, new engineering graduates have little or none of the expected non-technical skills and attributes which are now very important for the improvement in business performance. A study by Bhamra et al. (2015) indicated that combined technical and non-technical skills create a powerful workforce that is able to respond to continuously changing technology, as against those with technical skills only.

Figure 2 shows the percentage of industries that emphasised the specific skills and attributes new engineering graduates from polytechnics should exhibit.

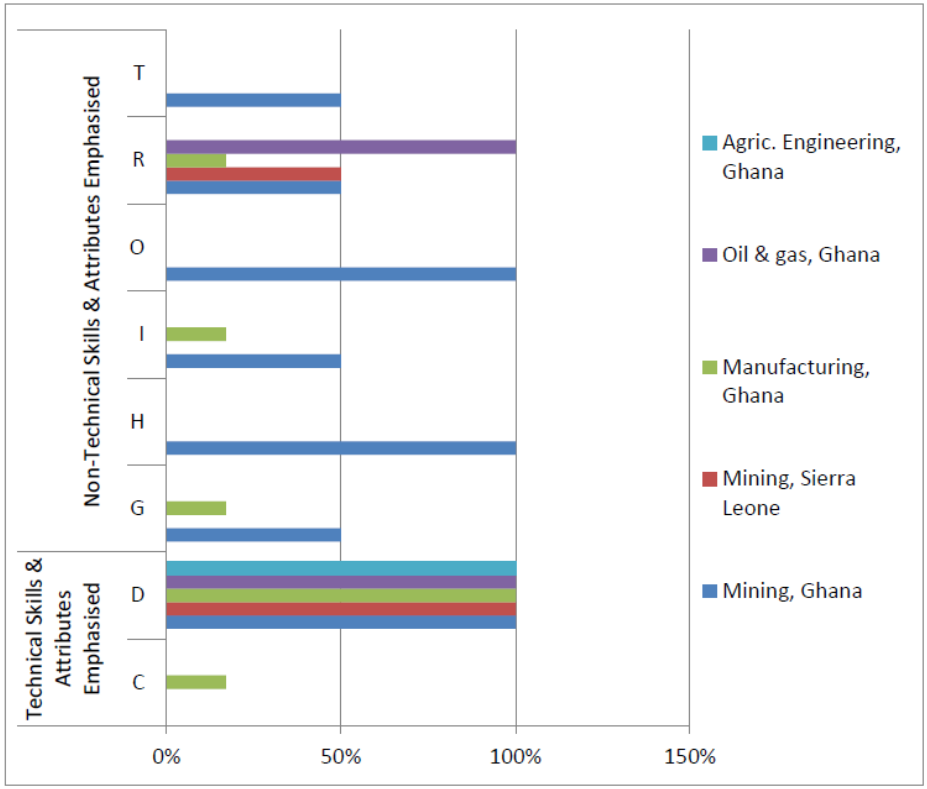

Figure 2: Percentage of the industry that emphasised the needed skills and attributes (C-T defined in the Research Methodology) of new engineering graduates of polytechnics.

Source: Field Survey (2009 and 2010).

Exactly 100% of the mining industry in Ghana emphasised D, H, and O while 50% emphasised G, I, R, and T. However, in the case of Sierra Leone's mining industry, all the companies emphasised D and 50% emphasised R. The whole manufacturing and processing industry emphasised D (a technical skill) while only 17% emphasised the technical skill C and non-technical skills G, I, R, and T. The study on the Oil and Gas industry covered an Oil Well servicing company and a mechanical engineering company that provides machining, welding and fabrication services in addition to other non-engineering Oil and Gas services. Both companies fully emphasised D and R. The Agricultural Engineering Services Directorate (AESD) only emphasised D for the new Engineering graduates.

Table 1 presents the responses of the employers and industry experts on the industry skills needs of the company (categorised as technical and non-technical skills and attributes) and also the skills level met by the new employed Engineering graduates from the Polytechnic.

Table 1: Industry Skills Need and Skills Level Met by New Engineering Graduates

Industry	Company	Technical skills and attributes	Non-Technical skills and attributes	Skills level met in percentage
Solid Mineral Mining	AngloGold Ashanti, Ghana.*	Boiler making skills, fitting and machining skills, and electrical skills (which include working on electronics and Programmable Logic Control (PLC)).	Problem-solving skills, drive and interpersonal skills.	The new HND graduates exhibited up to 45% of the technical skills of what the job requires at the point of entry, and about 70% within 3 months of training on the job.
	Ghana Bauxite Company Limited.	A multi technical skilled workforce with skill in plumbing, carpentry, masonry, vehicle repair and maintenance, and some other mechanical and electrical areas.	Communicate effectively, read and write well, work with other people, solve problems, show initiative, plan and manage workload with minimum supervision.	Not available
	Sierra Rutile Limited, Sierra Leone.	Skills in instrumentation and control for the engineering and maintenance department.	Not available	Not available
	London Mining Plc,Sierra Leone.	Middle-level skills such as heavy duty equipment fitting, boiler making, crane operating, plumbing and electricals.	Information technology (IT) skills.	Not available

Manufacturing and Processing	Coca-Cola Bottling Company of Ghana Limited	Production and machine maintenance (involving fault diagnosing, machine component identification, dismantling and assembling) and instrumentation and controls (including working on PLC equipment) skills. Workforce with multi-technical skills.	Not available	The new engineering employees exhibited less than 40% of the company's skills requirement at the point of entry.
	Fan..Milk Limited, Ghana.	Mechanical (including fitting) skills, electrical and refrigeration skills, and engineering drawing skills.	Not available	About 50% depth of knowledge of the trade was exhibited at interview and about 40% level of the practical skills required of the company was exhibited on the job.
	Ghacem Limited, Ghana.	Multi-technical skilled person with two or more skills related to fabrication, machining, electric motor rewinding and maintenance.	Strong general education background in the basics of writing, reading and simple mathematics. Skills of report writing, communication and working under minimum supervision.	Not available

	Volta Aluminium Company (VALCO), Ghana.	Multi-technical skilled workforce was much desired. Machining, welding and fabrication, instrumentation, and electric motor rewinding skills are needed.	Not available	The new engineering employees only met about 20% of the skills required by the company.
	Tex Styles Ghana Limited	Skills related to precision measuring, engineering drawing, manufacturing of machine components, the use and understanding of technical manuals and diagrams.	Not available	The depth of theoretical knowledge was about 50 to 60%. About 40 to 45% of the practical skills required by the company were met by the graduates at the point of entry. Exceptional cases of 50 to 55% skills level were found with those who had some level of industrial attachment.
	Accra Brewery Limited, Ghana.	Mechanical skills related to machining of parts, welding and fabrication, dismantling and assembling of machine parts, and electrical skills.	Not available	The depth of knowledge and level of skill of most applicants has been below 50% of the company's requirement.

Upstream Oil and Gas	Baker Hughes (Ghana) Limited	Skills in directional drilling, formation evaluation, completion and production practices and techniques, and Well intervention and remediation. Additionally, warehouse activities, machining, non-destructive testing and inspection.	Fundamental skills in mathematics, basic sciences such as chemistry and physics, mechanical aptitude, ICT, transportation and logistics will also be needed.	Not available
	Seaweld Engineering Limited, Ghana.	Mechanical skills such as machining, measuring, welding and fabrication, and safety.	Skills in information and communication technology (ICT), basic science and mathematics.	Not available
Agriculture	Agricultural Engineering Services Directorate (AESD), Ghana.	Skills required for manufacturing agricultural equipment, diagnosing and solving of problems that relates to the hydraulic, electronic and sensor systems on agricultural machinery and implements.	Not available	The engineering graduates' knowledge in the trade was about 40% and the level of practical competence acquired was from 50 to 55% of what the work requires.

Source: Field survey, *2009, 2010.

Apparently, almost all the four industries stressed the need for basic skills and attributes of machining, welding and fitting. However, for the electrical engineering or trade skills, the emphasis was on instrumentation, electric motor servicing or rewinding, and working on electronic and PLC equipment (Table 1). These are basic skills required at where machines are operated and maintained. The soft skills and attributes stressed by the Ghanaian companies are problem-solving, effective communication, and teamwork (Table 1). The skills level met by the new engineering graduates engaged by AngloGold Ashanti was 45% of the technical skills required of the company. However, this level shot up to about 70% after a 3 month when an in-house skills upgrading training was organised for the new recruited engineering graduates.

The technical skills emphasised mostly were general plant maintenance (mechanical and electrical) and process engineering. The non-technical skills emphasised were report writing, communication and working under minimum supervision. Surprisingly, only one manufacturing and processing company emphasised this probably because the other companies expect such skills to be picked on the job as indicated by Spinks et al. (2007). Generally, all the manufacturing and processing companies placed much emphasis on the technical skills of which less than 45% was exhibited by the new engineering graduates from the Polytechnics. VALCO estimated the level of skills exhibited by these graduates to be about 20% of what the company required, and this represented the least amongst what was recorded for all the other companies probably because of the high standard of engineering practice and professionalism associated with the company. The level of theoretical knowledge met for all the companies was less than 60%.

Most of the mining and manufacturing companies indicated that they preferred people with multi-technical skills and who are prepared to continue to learn (Table 1). In some of the informal discussions with the employers, it came up that having a multi-technical skilled workforce helped greatly in situations of reassigning workers to temporal roles during emergencies. There was also the flexibility of moving the skilled workforce around and that cuts down on operational cost since one multi-technical skilled person could handle a task that will require more than one person. This confirms the findings of Spinks *et al*. (2007) and Tiernan (2014) that employers no more want narrow technical specialists but multi-technical skilled employees who apply their skills whenever and wherever they are needed. Most of the companies especially VALCO and AngloGold Ashanti provided such comprehensive basic skills training to the new engineering graduate employees before putting them on the job. In almost all the companies, the soft skills formed part of the in-house training lined out for the new employees; hence little or no emphasis was laid on it during recruitment of new graduates.

The upstream Oil and Gas industry is quite new in Ghana and it was yet to have graduate engineers with specialised oil and gas skills from the Polytechnics. However, skills related to metal machining, welding and fabrication, repair and maintenance that are acquired from the traditional engineering courses are quite very relevant and could fill gaps in the business line of services in the industry, as found with the activities of Seaweld Engineering Limited, a provider of flexible and well-resourced inspection, repair and maintenance services to the oil, gas and petrochemical industries.

The AESD realised that the newly employed Polytechnic engineering graduates exhibited only 40% of the trade knowledge and 50 to 55% of the level of practical competence of what the company required. From earlier informal discussions, it was understood that most of the new engineering graduates were found to have difficulty in doing analysis that entails calculations, using working drawings to manufacture and in some cases deducing the mechanisms behind the operations of some agricultural equipment such as the rice mill, irrigation pump and some other field machinery. The soft skills such as ICT and effective communication were also found to be weak. This confirms the assertion of the Mineral Council of Australia (2005) that graduates often have a poor understanding of how to apply theoretical knowledge in practice.

The non-technical skills identified and required of the new engineering graduates relate to problem-solving ability, effective communication ability, the ability to interact with others well, showing drive and initiative, effective planning and managing workload, and good report writing ability (Table 1). This confirms the findings of ASTD Public Policy Council (2006), Smith and Kruger (2008), and Tiernan (2014). Strong general education background with grounding in basic writing, reading and mathematics were recommended to enable those with good technical skills but minimum schooling to fit well and function properly in the engineering industry. This is consistent with the findings of Horn (2006) which also identified the skills mentioned above as being amongst the new competencies required of engineers.

Outcomes of an independent-sample non-directional two-tailed t-test conducted to compare the industry's mean response on technical skills and non-technical skills and attributes show that there was not a significant difference in the mean scores for technical skills and attributes (M=2.333, SD=1.862) and non-technical skills and attributes (M=1.273, SD=0.467) conditions; t (5) =1.372, p = 0.228. These results suggest that the industries place equal emphasis on the technical and non-technical skills and attributes. This finding concurs with that of Smith and Kruger (2008), Motsoeneng et al. (2013) and Trevelyan (2008).

CONCLUSION

There is a huge gap between the skills needs of industry (which comprised both technical and non-technical skills and attributes) and the skills acquired by the engineering graduates from the Polytechnics in Ghana and Sierra Leone. Therefore, the Polytechnics have to give equal importance to both technical and non-technical skills and attributes in a well-ordered teaching methodology that emphasises hands-on training and industrial attachment for the engineering students. Industry should take the initiative to introduce new technologies to both lecturers and students and also play a key role in facilitating training in the institutions. Periodic upgrade of the curricula to reflect the skills needs of industry is critical because inaction could threaten the survival of the engineering departments and the faculty. It is therefore imperative that industrial attachment for students should as a matter of policy, be made a requirement for the award of certificates. Tertiary institutions (Polytechnics) should consult industry in the development of their teaching curricula and skills training activities in order to respond adequately to industry skills needs and also enhance the employability of their trainees.

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