Lack of Training Opportunities in South African Foundries and the Impact on the Number of Engineering Metallurgy Graduates

Jonathan Mkansi, Hannelie Nel and Annlizé Marnewick
Post-Graduate School of Engineering Management
Faculty of Engineering and the Built Environment
University of Johannesburg
Auckland Park, South Africa
joenno@live.com, hannelien@uj.ac.za, amarnewick@uj.ac.za

Abstract

Lack of in-service training in the field of engineering metallurgy at local foundries has had a negative impact on the number of graduates who are offered an opportunity to complete practical training and to graduate. This leads to shortage of skilled foundrymen and foundry-women who can take the industry forward and help South Africa compete globally. Universities and foundries need partnerships to establish ways in which foundry skills are taught to young technicians. To achieve this, a quantitative study was conducted and data were collected and analysed to investigate the participants' understanding of lack of in-service training and its effect on skills development in foundries. Expert review of the collected data was conducted to complete triangulation. Descriptive analysis was based on actual data collected from all foundries which were randomly selected. Using this information, three types of questions were adopted during interviews and document review. Frequency and percentage distribution graphs were employed to display the results for easy interpretation of trends. Based on the data collected and resultant analysis, three main factors were found to contribute 71% of the problem and recommendations were made based on these findings. These included financial support and budget, lack of government support and lack of training awareness.

Keywords
In-service Training, Work-Integrated Learning, Foundrymen

1. Introduction

Foundries generally melt ferrous and non-ferrous metal charges and / or alloys and reshape them into products through the pouring and solidification of the molten metal or alloy into moulds (Juganan and Paterson, 2012). The foundry industry is a complex and very diverse sector. It consists of a wide range of processes from very simple to complicated practices. Differences that exist within this industry are based on the type of metal melted, with the main distinction being made between ferrous and non-ferrous foundries. Philip (2012) states that, since castings in general are semi-finished products, most foundries are situated not far away from customers, where the products are often machined, assembled and shipped to end users.

Ribeiro (2009) reports that the South African manufacturing industry has been in decline for the past ten years due to job losses. Local foundries are not an exception and have experienced bigger challenges of late; and history indicates that they have declined for more than a decade now. 'Market research conducted by the South African Institute of Foundrymen (SAIF) in 2015 indicated that about 170 foundries melt metals and alloys for a wide variety of applications and about 20 produce the bulk of the output, mostly for the mining sector' (Jardine, 2015). South Africa consisted of about 450 foundries in the 1980s and around 200 in 2003. Between 2007 and 2011 another 13%

closed and employment in the industry declined by 30%. One major challenge facing the foundry industry is the influence of government in assisting university students with in-service training to help improve the industry standard, whilst ensuring that knowledge and skills are transferred to the younger generation (Davies, 2016). Davies (2016) continues to say that the National Foundry Technology Network (NFTN), in partnership with the SAIF, is currently conducting training to reduce skill shortage in the local metal castings sector. These core training programmes include the Gauteng Foundry Training Centre (GFTC), in Kwa-Thema on the East Rand, which was launched in September 2013. The NFTN ensures that apprentices receive training in different foundry skills, including melting, moulding and pattern making (Davies, 2016). The difference is that, in an apprenticeship programme, three to four years is needed for someone to complete the programme in a specific trade such as pattern making whereas the learnership is suited for someone with a high school graduate qualification. This study focused only on the University students and not any trade covered in the apprenticeship programme.

This study was initiated in 2015 and focused purely on students who were studying National Diploma and those who planned to enroll in the same programme at the University of Johannesburg. This study did not look at the effect of the change in curricula from 2017 as announced by the University to gradually phase out most National Diplomas and introduction of the new three-year Bachelor if Engineering Technology.

2. Literature Survey

The Foundry Technology II student's handbook (2008) defines foundry and metal castings as 'the process of melting metals of different specifications and alloys and pouring in cavities or moulds to give desired shape of the final component as per required application'. Ribeiro (2009) suggests that a great amount of research has been conducted in the melting and casting of metal in South Africa and globally. Monroe (2008) adds that the drive for successful castings without defects and ones that are produced timeously, at very competitive prices, has been an ongoing process since metals were poured and cast into useful shapes (Maupa, 2014).

2.1. Structure of Academic Programmes

Technikons (currently known as universities of technology) designed curricula for engineering students to complete mandatory one-year training at any company in line with what the students are studying. This training is completed in one full year after successfully completing two years' course work (Abrahams, 2014). Only after successful completion of the two-year theory and one-year in-service training are students able to graduate with a national diploma. There is, however, constant improvement of syllabi to ensure that universities prepare students for the challenging work life ahead. This was confirmed by the introduction of a new three-year bachelor of engineering technology (BEngTech) qualification at the University of Johannesburg in 2017 as approved by the Department of Higher Education.

2.2. In-Service Training

Smith (1980) states that the need to reduce the gap between course work at universities and workplaces has led to the development of practical training for colleges and universities. In the views of Janneker (2006), practical work experience or in-service training is an essential milestone during studies, provided that the course work is successfully completed. According to a similar study conducted by Van Schoor and Erwee (2000), the marketing department of the University of Free State found that implementation a work-integrated learning approach in the undergraduate programme would be one of the most effective approaches in helping students adapt to the work environment.

A student will apply for training opportunities at different companies as required by the university. The purpose of the practical 1 and 2 (P1 & P2) training programme is to allow individuals to obtain the necessary practical exposure to enable them to complete their qualification. Taymaz (1997) mentions that in-service training is the process that provides students with an opportunity to do practical work for one year to complete the study programme. In-service training imparts knowledge and the necessary skills to perform job descriptions and activities set by universities and companies. These skills are necessary to help students in their future endeavors.

The training programme is conducted in line with university requirements which ensures maximum exposure for the student to learn as much as possible; as well as completion of a training report every six months for the duration of the programme (Mukeredzi and Mandrona, 2013).

A study conducted by Smith (1980) indicates that lack of in-service training and education in foundries is a global challenge, as the United Kingdom is also faced with the same dilemma. Mtombeni (2006) maintains that the most difficult positions for companies to fill are those in the engineering field and skill trade. This could be attributed to various factors such as an economic crisis or the impact of imported products (Janneker, 2006).

2.3. Global Foundry Production Trends

In 2014, the global foundry castings production was higher than 103.6 million metric tons, which is an increase of 2.3% compared to 2013 (Juganan and Paterson, 2012). The authors state that the total foundry casting production in 2014 was at an increase of only 2.38 million metric tons when compared to the previous year of 2013 (*ibid.*). Table 1 indicates the global foundry casting tonnages recorded in 2012.

Table 1. 2012 global production in metric tons (World Foundry Organization, 2013)

	Country	**Number of Foundries**	**Tonnages per annum**
1	China	30,000	42.5 million
2	U. S. A	2,010	11.78 million
3	India	4,500	10.57 million
4	Japan	2,113	5.34 million
5	Germany	605	5.21 million
6	Russia	1,240	4.3 million
7	Brazil	1,277	2.86 million
8	Korea	897	2.44 million
9	Italy	1,111	1.96 million
10	Ukraine	805	1.53 million

2.4. Local Foundries and Training

South Africa has been a major player in the production and global supply of good grade foundry castings. However, the industry has contracted significantly from 2007 (Davies, 2016). There was a 43% reduction in production output from 660 400 tons to 375 240 tons between 2007 and 2013. This decrease could be attributed to foundry closures of 36% since 2007, reducing to 170 foundries in 2015 and to some extent lack of training. Tables 2, 3 and 4 indicate the location of foundries in South Africa, the foundry types and the foundry production tonnages per metal grade respectively.

Table 2. Geographical location of foundries in South Africa (SAIF, 2015)

Province	**No. of foundries 2003**	**No. of foundries 2007**	**No. of foundries 2015**	**% of total foundries in 2015**
Gauteng	143	141	114	66
Kwa-Zulu Natal	26	25	20	12
Western Cape	33	32	14	8
Eastern Cape	20	20	8	5
Free-State	13	13	5	3

Province	**No. of foundries 2003**	**No. of foundries 2007**	**No. of foundries 2015**	**% of total foundries in 2015**
North-West	13	13	4	3
Northern Cape	7	6	3	2
Mpumalanga	15	15	2	1
Total	**270**	**265**	**170**	**100**

Table 3. Industry structure by foundry type in South Africa (SAIF, 2015)

Foundry Type	**No. of foundries 2003**	**No. of foundries 2003**	**No. of foundries 2003**	**% of total foundries in 2015**
Ferrous (Iron and Steel)	110	110	89	-19%
Non-Ferrous (Aluminum, Copper and Zinc) Sand, Gravity, low Pressure	117	119	50	-57%
High Pressure Die-casters	36	32	27	-16%
Investment Casting	7	4	4	0%
Total number of Foundries	**270**	**265**	**170**	**-36%**

Table 4. Estimated annual foundry production by metal type in South Africa (SAIF, 2015)

Metal Type	**Est. annual production 2003 (tons)**	**Est. annual production 2007 (tons)**	**Est. annual production 2012 (tons)**	**Est. annual production 2013 (tons)**
Aluminium	66,000	77,800	21,000	22,000
Brass	9,000	8,200	Copper based 14,300	9,100
Bronze	6,000	7,600		
Zinc	3,000	4,200	1,400	900
Grey Iron	110,000	147,000	161,000	155,000
Ductile Iron	100,000	86,000	59,000	47,000
Other cast iron (white iron)	85,000	145,600	54,000	28,500
Steel	123,000	179,100	118,000	106,000
Stainless Steel	4,000	4,900	5,800	6,500
Total annual production	**506,000**	**660,400**	**416,500**	**375,240**

3. Research Design and Methodology

The research method employed in this study consisted of the gathering of descriptive data through interviews, document review and expert review. Graphs were used to indicate scores, frequencies and rankings. Quantitative research was considered applicable to answer questions using mathematical methods (O'Leary, 2010). Based on the number of foundries in South Africa and the potential of employing students, 52 different foundries within the research setting were selected for the research study.

This research looked at both primary and secondary sources using interviews, document review and expert review to ensure triangulation. Data were collected from senior managers and training departments. The reason for selecting foundry management and training officers, was that they held valuable information on criteria used to recruit as well as the reasons for whenever no training was provided (Sithole, 2009).

Structured interviews were employed as a data collection methodology, where carefully-worded questions were administered (Kothari, 2003). Ten structured interviews were conducted with supervisors, work managers, financial managers and general managers for their views on local foundries and the importance of training students.

At each foundry, training records and training policies were reviewed. It was also important to view training programmes to see how many foundries planned training for workers. Understanding the management of the documents and their training records indicated a clear training plan from top management.

Using a minimum sample size formula below, from a pool of 100 potential foundries to offer in-service training with a confidence level of 90%, a margin of error of 8% and 50% response distribution, 52 different foundries were randomly selected.

4. Results and Analysis

4.1. Importance of In-Service Training

This first question identified whether respondents were aware of compulsory in-service training for students at universities to complete the three-year undergraduate programme. Figure 1 indicates that 76% of respondents were aware of the importance of in-service training. This is a rather large proportion of respondents that are aware of the need to have in-service training available for students than initially anticipated. However, knowing about the importance of in-service training to students did not necessarily mean foundries were offering the training.

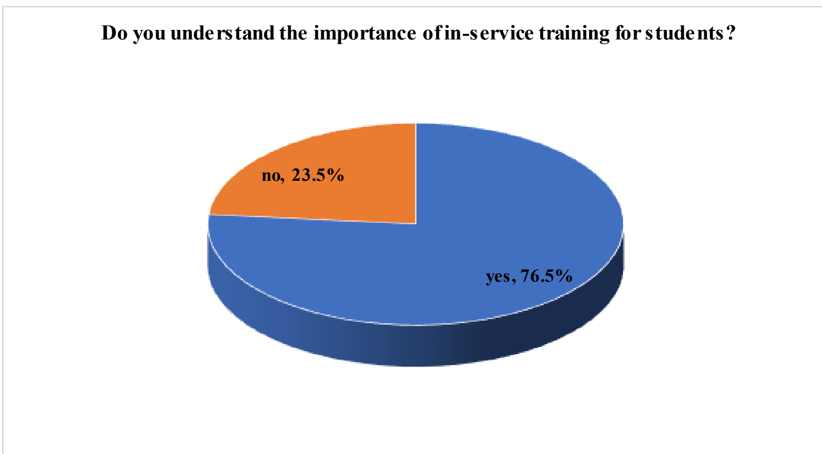

Figure 1. Importance of in-service training as understood by respondents

4.2. Ranking Factors

Respondents were asked to compare a list of different possible contributors to the lack of training in order of importance, and the findings are presented in Figure 2. The figure illustrates Pareto analysis from 52 respondents. The graph reveals that the main contributing factors to a lack of training are budget, lack of government support and lack of training awareness: collectively contributing 71% towards the problem. The graph also indicates that progress can be made, should there be plans in place to address the lack of training. These results confirm the findings by Janneker (2006), namely that budget (or funding) was noted as one of the main contributing factors that needed attention from government and universities.

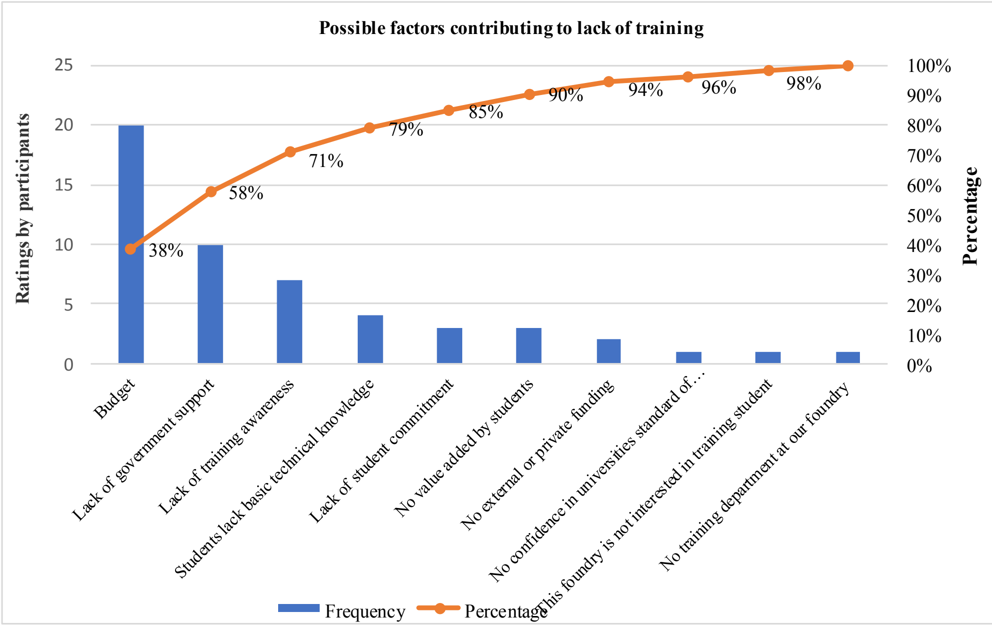

Figure 2. Possible factors ranked against one another from main to least contributing

4.3. Rating Factors

After ranking these possible factors from the most to the least important, it was necessary determine how respondents viewed each individual challenge. A rating technique was introduced where respondents were asked to rate the same factors using a scale from 1 to 10, where 1 was most important and 10 the least important. Answers to these factors were grouped between (1-4) and (5-10); and the total number of each group was established from respondents as displayed in Table 5. The Table reveals some unique findings from respondents, where some factors were rated differently as compared to the first data collected when each factor was rated separately. These differences are highlighted below and the top three factors are explained in detail.

Table 5. Factors grouped from answers by respondents

Factors	**Factors rated between 1-4 (most important) %**	**Factors rated between 5-10 (least important) %**
Budget	83%	17%
Lack of government support	75%	25%
Lack of training awareness	75%	25%
No external or private funding	38%	62%
Lack of student commitment	19%	81%
No value added by students	19%	81%
No confidence in universities standard of learning	15%	85%
No training department at our foundry to monitor training process	13%	87%
Students lack basic technical knowledge	10%	90%
This foundry is not interested in training student	10%	90%

4.4. Budget

Budget was rated first and 83% of respondents rated between (1-4), indicating that a large majority of the respondents believed that budget independently was a highly contributing factor to the lack of in-service training in foundries. The finding confirms the report by Dewhurst and McMurtry (2006) that discusses the economic challenges facing the manufacturing industry. In the report Juganan and Paterson (2012) emphasize the importance of financial and technical support to the industry to improve skills development and training.

4.5. Lack of Government Support

Lack of government support does not necessarily translate to financial support, but rather to broad factors such as operations, process improvement and protection from increasing costs of raw materials and electricity. Most of the respondents also related this factor to the government's failure to introduce a hefty import tax of cast products from China and India which are delivered in South Africa significantly cheaper than the local cost of production per ton. 75% of the respondents strongly believe that this factor was a primary contributor to training challenges. Interestingly, 25% of the respondents believe that the foundries share an equal responsibility of ensuring that they impart skills through in-service training of young students.

4.6. Lack of Training Awareness

Another factor which needed close attention was a "lack of training awareness" to foundries. This included awareness of the role that foundries could play: not only for knowledge improvement but also to assist students to complete training and graduation. Referring to Table 5, 75% of respondents rated *lack of training awareness* high as they believed it was a significant contributing factor. The finding contradicted results with earlier questions answered by respondents in Figure 1, as 76% of respondents indicated that they understood the importance of in-service training. It is valid to deduce that, if 76% of respondents understand the importance of in-service training, awareness of training at foundries should exist. It may also imply that foundries are aware of the importance of in-service training, but they do not have the mechanisms or knowledge to execute training.

4.7. Document Review

Document review of training records was conducted to establish whether foundries were in possession of documents related to in-service training of students. Only 8% of 52 foundries indicated that there were documents regarding training of employees and skills development, thus shedding light on the efforts established by foundries to help students with training.

4.8. Expert Review

Expert review was employed as the final research tool to triangulate and validate the collected data. The findings were discussed with the former Chief Executive Officer of the South African Institute for Foundrymen for insight in the results. The three primary contributors to the lack of in-service training in foundries were confirmed by the foundry expert.

5. Conclusions

A quantitative study was conducted to determine the reasons for South African foundries not taking students for in-service training. The data analysis collected from 52 foundries presented interesting findings and answers to the research questions. The study revealed that there are three primary factors that respondents believe contribute to foundries not giving students opportunities for in-service training, namely budget, lack of government support, and lack of training awareness. Respondents indicated that they believe universities, the government and the foundry industry are disconnected in purpose and support of one another. The respondents indicated that this division influenced and negatively impacted the number of students who are not able to graduate each year due to lack of in-service training.

The following trends were identified from the data collected. Fifty-two (52) foundries were visited but only four (4) indicated that their training documents were up-to-date and made mention of in-service training for undergraduate students. From the four foundries, two were owned fully or partially by the Industrial Development Corporation (IDC). This indicated that the presence of the IDC ensured that the culture of training students was preserved and improvements were made on existing documents.

Large foundries with more than 100 employees and more than 5 000 tons of castings sold per annum, showed that most processes were documented, and that training documents were in place. These foundries indicated that they had employed students in the past for in-service training.

Ninety percent (90%) of foundries visited were family-owned businesses with between 5 to 300 employees. The focus of these foundries is to ensure the survival of the business, thus in-service training was deemed unnecessary and resource-consuming. Most of the respondents representing this category showed dissatisfaction regarding government institutions. These are the foundries that indicated no confidence in the standard of teaching and learning, and were not impressed with students' commitment and technical abilities.

6. Recommendations

Financial support and budget, and government support, were the highest rated factors contributing to the lack of in-service training. It is recommended that the Department of Trade and Industry and the Industrial Development Corporation, together with the assistance of universities, explore the possibility to establish financial mechanisms to assist students to obtain training. Foundries that are proactive in this endeavor should be identified and rewarded for their efforts towards student graduation.

Respondents indicated that they are unaware of the need for the mandatory one-year in-service training in order for students to complete graduation. Each foundry has the potential to help at least one student at a time and all foundries need to understand this process and how they can assist. Universities with the support of relevant departments need to approach foundries and explain the process and encourage them to commit to the project.

Only four foundries were in possession of updated documents related to the training of students. Training processes should be designed with clear training requirements to ensure that students are exposed to different departments; and that they are able to effectively contribute to the goals and business strategy of foundries.

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Biographies

Jonathan Mkansi is currently a fulltime employee as Sales Engineer at Foseco South Africa in the Sales and Marketing department. Mr. Mkansi holds Bachelor of Technology degree in Engineering Metallurgy, Bachelor of Technology degree in Quality Management, Masters of Philosophy in Engineering Management all from the University of Johannesburg. In 2017 he completed an inhouse sales course; Selling by Objectives which focused on combining technical skills to improve processes at customers while helping the local foundry industry. This programme was offered by Mercuri International. Mr. Mkansi has 9 years working experience where he worked as a Metallurgist in the Aluminum rolling company in Pietermaritzburg, a Technical Specialist in the steel tube making company in Alrode and a Sales Engineer for a foundry consumables supplier in Alrode. Mr. Mkansi is a member of the South African institute of Foundrymen where technical presentations and discussions take place every month in an effort to help foundries conduct business differently and compete globally.

Professor Annlize Marnewick is an Associate Professor at the Postgraduate School of Engineering Management, Faculty of Engineering and the Built Environment, University of Johannesburg where she focuses on the supervision of research master's and doctoral students. Before joining the academia she has been involved in the industry with a technical record of 15 years in architecture, design and the implementation of system and software engineering projects with specialisation in requirements engineering. She is a registered professional engineer (Pr Eng) with the Engineering Council of South Africa (ECSA).

Dr Hannelie Nel is a Senior Lecturer at the Postgraduate School of Engineering Management, Faculty of Engineering and the Built Environment, University of Johannesburg. She holds a Doctorate in Engineering Management with twenty years' experience in both industry and academia. Dr Nel is a Fellow of the Southern African Society for Industrial Engineering and currently serves on the Boards of Denel and the Society for Engineering Education. She is an Associate Member of the Institute of Directors in South Africa; and a Member of the International Women's Association.