AN INVESTIGATION OF THE PROFILES OF ZIMBABWEAN STEM UNDERGRADUATE FRESHMEN AS INPUT TO ENTREPRENEURSHIP EDUCATION FOR STEM STUDENTS

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1.0 Introduction

Entrepreneurship is the new buzzword in universities across the globe and this has been attributed to fundamental socio-economic forces such as the persistence of unemployment, precarious employment, the emergence of knowledge-driven economies, and the imperative of bringing innovations to market (Karimi, et al., 2011, Valerio, et al., 2014).The shift towards entrepreneurship education is also from the realization that students can and should derive benefit from learning how to create value from their knowledge and skills (Duval-Couetil, 2016).

The educational systems have not, until recently, been geared towards the development of entrepreneurship and self-employment in the STEM (Science Technical Engineering and Mathematics) disciplines (Hynes, 1996). Entrepreneurship has been confined to management and economics disciplines. The general consensus of late is that the provision of entrepreneurship education should not be restricted to certain courses or faculties, as entrepreneurial qualities and skills are needed in every sector of human activity (EC Brussels, 2006, Duval- Couetil, et al., 2011). It has been realised that entrepreneurship education, especially education that provides technological training, is crucial to the enhancement of entrepreneurs' innovation skills in an increasingly challenging environment (Menzies and Paradi, 1999). In fact Hynes (1996) argues that technical and engineering graduates are the originators of product ideas but are usually left out because of their lack of business appreciation to develop the idea further. It is therefore not surprising that entrepreneurship courses are among the fastest growing curricular areas within engineering schools (Duval- Couetil, et al. 2011).

1.1 Problem Statement

The demand for learning entrepreneurship is increasing in Zimbabwe especially with the introduction of STEM programmes at tertiary institutions. However, Universities in Zimbabwe

needs to stimulate the entrepreneurial mindset of all STEM students but the challenge is what to teach, and how to teach students in the STEM field. In addition, the fact that entrepreneurship courses have traditionally been offered in business or management and not engineering schools or faculties has led to entrepreneurship education being perceived as an adapted business management education, (Haase and Lautenschläger, 2011). However according to Hynes (1996), Rideout and Gray (2013) entrepreneurship education is not a "one size fits all" programme. This means entrepreneurship education has to be customized to meet the needs of a particular group i.e. for business and STEM students. Garavan and O'Cinneide (1994), Wilson et al. (2014) in the ASEE 2014 Proceedings, and Udoh- Imeh et al, (2016), cite the appropriateness of curriculum and teaching methods in developing students' entrepreneurial competencies and skills as the major challenge to entrepreneurship education. Hence the research seeks to identify the needs of STEM undergraduates so as to enable preparation of the appropriate curriculum and teaching methods that make entrepreneurship education accessible to STEM students. Katz (1991) suggested that the key to a successful entrepreneurship education is to identify the best match between student needs and teaching techniques.

The current research seeks to explore the profiles and characteristics of Zimbabwean STEM undergraduate freshmen as input to the entrepreneurship curriculum. The research questions are:

1. How much do STEM undergraduate freshmen know about entrepreneurship concepts and topics?
2. What are STEM undergraduate freshmen's perceptions of their entrepreneurial mind-set?
3. How best can entrepreneurship education be delivered to Zimbabwean STEM undergraduates?

1.2 Research objectives

1. To determine the STEM undergraduate freshmen's knowledge levels on Technopreneurship related concepts and topics.
2. To examine the STEM undergraduate freshmen's entrepreneurial mindset.
3. To determine the appropriate teaching techniques that match STEM undergraduate freshmen's needs.

1.3 Significance of Study

The researchers looked at the survey from a marketing point of view, where the educators are the marketers, the courses are the product and the students are the customers and the survey is a market research on the potential customers' motivation, interest and awareness on the entrepreneurship curricular. The study is expected to help the educators in understanding the strength of the characteristics their students already possess, as well as the areas that may require

improvement, in order to enhance their entrepreneurship capabilities and aid in the development of a successful entrepreneurial career.

The findings of the study should assist Zimbabwean policy makers and entrepreneurship educators with information that would enable them to develop curricula that lead to the development or enhancement of entrepreneurial characteristics and entrepreneurial competence among their STEM students.

2.0 Literature review

2.1 Entrepreneurship defined

Hisrich et al., (2005) regard entrepreneurship as a grouping of behaviors such as initiative taking, organizing and reorganizing social and economic mechanisms to turn resources and situation to practical account. Hynes (1996), Fayolle and Gailly (2008) perceive entrepreneurship as just one behavior that results in the creation of business organizations. Kirby and Honeywood (2007) recognize entrepreneurship as more than new venture creation and posit that it involves opportunity recognition, resource harnessing, risk taking and change. For the purpose of this research, entrepreneurship has been defined as the ability to recognize opportunities and use or create resources to improve the social or economic situation through creation of a new business or otherwise.

2.2 Requisites for successful entrepreneurship

Hisrich and Peters, (1998) identify three categories of skills required by entrepreneurs: Technical skills (including written and oral communication, technical management and organizing skills); Business management skills (including planning, decision-making, marketing and accounting skills) and Personal entrepreneurial skills (including inner control, innovation, risk taking and innovation). Timmons et al. (1985) suggest fourteen behaviours that are required by the entrepreneur which are: total commitment, determination and perseverance; drive to achieve and grow; orientation to goals and opportunities; taking initiative and personal responsibility; veridical awareness and a sense of humour; seeking and using feedback; internal locus of control; tolerance of ambiguity, stress and uncertainty; calculated risk taking and risk sharing; low need for status and power; integrity and reliability; decisiveness, urgency and patience; learning from failure; and team builder and hero maker.

To explain the requisites for successful entrepreneurship Karim (2015) first outlines an entrepreneurial cycle which has got the following phases: opportunity identification and

evaluation, resource gathering, start-up and growth. He (ibid) further expounds that creativity and innovativeness are critical during opportunity identification, evaluation and start-up phases while other characteristics, for example leadership, confidence, and ability to manage new resources are very important in latter stages. Importantly, all the authors conclude that these behaviours can be learned, hence by implication entrepreneurship can be taught.

2.3 What is Entrepreneurship education?

According to Hynes (1996) there is formal entrepreneurship education which is about the theory and conceptual frameworks of entrepreneurship. There is also informal entrepreneurship education which is about skills building, attribute development and behavioural change. In a broad definition Hynes (1996), Binks (2005) Fayolle (2009), Samwel, (2010) and Tessema, (2012) note that entrepreneurship education refers to the formalized program to equip students with the needed skills, motivation and knowledge to recognizing business opportunities, searching customer's insights, understanding the needs of the market, creating an idea, developing the business plan, running the business, evaluating environmental, and institutional and political issues.

Matlay and Westhead (2005), and Audretsch (2002) describe entrepreneurship education, as the means of preparing students for the labour market where the emphasis is not only on knowledge acquisition but on skills and competency development. Later researches by Richardson (2007), Yu Cheng et al. (2009), West III et al. (2009) and Jones (2010) pointed out that entrepreneurship education is more than business management or starting a new business. It is about learning to integrate experience, skills and knowledge, to be prepared to start a new venture. Entrepreneurship education thus goes beyond job creation and new venture creation and also encompasses developing individuals who understand entrepreneurial processes and have entrepreneurial skills and ways of thinking (Täks et al, 2016).
It seems all the authors are in agreement with the fact that entrepreneurship education should lead to the development of an entrepreneurial mindset which should enable the learner to define, analyse and solve a broad range of problems. Entrepreneurship education is therefore more than entrepreneurial knowledge but also inspiration, competencies, and readiness to become entrepreneurs in the future (Tessema, 2012). The researchers concur with Fayolle and Gailly (2008), who concluded that entrepreneurship education is to do with the development of entrepreneurial attitudes and skills as well as personal qualities.

2.4 Importance of entrepreneurship education to STEM students

The integration of entrepreneurship in engineering is a relatively new effort (Neck and Green, 2011, Duval-Couetil et al., 2012). This may have been due to the realization that STEM graduates possess discipline specific knowledge that is important for the recognition of business opportunities (Veen and Wakkee , 2004) but are often short of the skill and the business knowledge to develop the idea further (Hynes, 1996). According to Markham et al. (2002) scientists and technologists are usually able to explain the general applications of new technologies, yet they lack the capacity to spot commercial opportunities and develop products that meet specific customer needs. Taks et al. (2015) posit that entrepreneurship education provides graduates with entrepreneurial knowledge, skills and an entrepreneurial mindset which are prerequisites to creativity and innovation and also enablers of entrepreneurial actions that are essential in order to prepare students for a successful professional life. According to Fayolle (2007) the STEM students are likely to end up at positions in innovation and product development and teaching these individuals how to be entrepreneurial is key for innovativeness and growth potential of established organizations. The same skills prepare engineering graduates joining established organisations to become effective team members and managers who can better support their employers as innovators.

NAE (2013) points out that it is inadequate for one to come out of school with a purely technical (STEM) education. They further argue that engineers need to be entrepreneurial in order to understand and contribute in the context of market and business pressures. Entrepreneurship education teaches engineering undergraduates skills such as understanding and designing for end users ("empathy"), working in and managing interdisciplinary teams, communicating effectively, thinking critically, understanding business basics, and solving open-ended problems (NAE 2004). Technological Entrepreneurship Education is also key for facilitating the creation and capture of economic value from technological change (Blanco, 2007). It is believed that engineering populations are more likely to produce technology – driven radical innovations that are most likely to affect wealth and job descriptions (Duval-Couetil et al., 2012; Valerio, et al., 2014). Entrepreneurship education prepares engineering students to commercialize innovations (Mustaar, 2009). For engineers who create new ventures soon after graduation, it gives them experience in product design and development, prototyping, technology trends, and market analysis (Byers and Nelson, 2010).

In trying to outline how entrepreneurship can be taught and learned, Hynes (1996) proffered a Process Model for Entrepreneurship education which has got three elements. These are, Inputs (students' background), Process (program content and teaching approaches) and Outputs (entrepreneurial graduates). The current study draws from the Process Model and focuses on the input aspect and seeks to bring to the fore the profiles and characteristics of Zimbabwean

undergraduate students earmarked for entrepreneurship courses in their universities. The aim of this research is to contribute to the current literature by identifying the profiles and characteristics of prospective entrepreneurship education students from STEM disciplines specifically in Zimbabwean settings.

3. Methodology

The authors developed an assessment instrument to measure entrepreneurial knowledge, attitudes, personality, and intentions. Over a period of two weeks, the questionnaire was administered to students enrolled at entry-level STEM degrees at two state universities with mandatory entrepreneurship courses available to STEM students.

To minimize non-response rate, students received the survey via the faculty members teaching these courses. The instrument was distributed at the beginning of the first lecture(s) in Entrepreneurship and was collected at the end of the same lecture. Contact with faculty members was made through personal contacts at each institution.

The questionnaire was divided into 4 sections: demographic, entrepreneurship knowledge, personality and career intent. Questions on demography focused on the respondent's study discipline, gender and age. On the entrepreneurship knowledge aspect respondents were asked to rank their level of familiarity with entrepreneurship concepts on a Likert Scale of 1 to 5.

The research also sought to investigate the respondents' socio-emotional characteristics such as self-esteem, independence, locus of control, tolerance for ambiguity, risk propensity, innovativeness, interest and attitudes to entrepreneurship. A 5-point Likert scales with endpoints *strongly disagree* (1) *strongly agree* (5) was used.

The research also investigated the respondents' career intent. Multiple choice questions were used. The multiple choice questions were put towards the end of the questionnaire so as not to disrupt the flow of the survey.

Attention was paid to the length of the survey; it had to be comprehensive enough that faculty would recognize its value yet short enough so students would complete it. It was estimated that it would take students approximately 10 minutes to complete. The information obtained will provide baseline data for use in designing more relevant content and delivery methods for entrepreneurship education to STEM undergraduate students.

4. Results

4.1 Demographics

200 questionnaires were equitably distributed at two universities, University A and University B, both located in the capital city of Zimbabwe, Harare. At University A, 75 out of the 100 were collected back in usable form, and at University B, 91 were collected back, giving a total of 166 and an overall response rate of 83%. The collected data was analyzed using Statistical Package for Social Sciences.

The table below shows the distribution of respondents between the two universities.

Table 1. Respondents' distribution by university

University		Frequency	Percent	Valid Percent
Valid	A	75	45.2	45.2
	B	91	54.8	54.8
	Total	166	100.0	100.0

All the respondents were from Science, Technology, Engineering and Mathematics engineering disciplines. Below is a table showing the distribution of respondents by programme of study.

Table 2: Distribution of respondents by program of study

Respondent's program of study	**Frequency**	**Percent**
BSc. Biochemistry	18	10.8
BSc. Biological Sciences	17	10.2
BTech. Biotechnology	14	8.4
BSc. Computer Science	3	1.8
BTech. Chemical and Process Systems Engineering	13	7.8
BTech. Electronic Engineering	14	8.4
BSc. Food Science	3	1.8
BTech Food Processing Technology	13	7.8
BSc. Geology	5	3.0
Industrial and Manufacturing Engineering	13	7.8
BSc. Mathematics	13	7.8
BSc. Nutritional Sciences	5	3.0
BTech Pharmacy	13	7.8
BTech Polymer Technology Engineering	12	7.2
BSc. Statistics	10	6.0
Total	166	100.0

Table 3: Respondents' distribution by gender

Gender		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	80	48.2	48.7	48.8
	Female	85	51.3	51.2	100.0
	Total	166	100.0	100.0	

48 % of the respondents were male while 52% were female. The average age of the students was 20 years.

4.2 Level of knowledge

There are certain topics and concepts that are usually covered in the entrepreneurship curricular for engineers. This research sought to determine the respondents' familiarity with ten of the common topics. The concepts considered in the research are: the role of entrepreneurship in the economy, characteristics of entrepreneurs, legal structures of business, leadership, product development, feasibility study, intellectual property, finance and accounting, target market and Advertising and promotions.

A five point Likert scale was used to obtain the information on the respondents' knowledge levels. The response scale was as outlined below:

1. Poor; never heard of it

2. Below average; heard of it but not sure what it means

3. Average: can explain it partially

4. Above average: can explain it in depth but not sure how it is applied

5. Excellent: can explain it in depth and apply it as well.

The obtained responses are depicted in the table below.

Table 4: Level of knowledge

Entrepreneurship topic/concept	Respondents' level of knowledge				
	POOR	BELOW AVERAGE	AVERAGE	ABOVE AVERAGE	EXCELLENT
Characteristics of entrepreneurs	11.7	6.8	47.5	14.8	19.1
Role of E/ship in the economy	8.6	10.5	34.6	25.9	20.4
Legal structure	44.6	22.3	21.7	5.7	5.7
Leadership	17.3	11.7	22.2	21.6	27.2
Product development	21.5	15.8	27.2	18.4	17.1
Feasibility study	33.8	12.3	27.3	16.2	10.4
intellectual Property	25.8	22	27.7	10.7	13.8
Finance and Accounting	25.8	19	34.4	12.3	8.6
Target Market	25.8	13.2	26.4	20.1	14.5
Advertising and Promotions	17.2	11.7	30.1	14.7	26.4

On the characteristics of entrepreneurs almost one fifth of the respondents had below average to poor knowledge. Slightly less than half (47%) had some knowledge i.e. they could partially explain characteristics of entrepreneurs and more than one third had above average to excellent knowledge.

Most Zimbabwean STEM undergraduate freshmen had some knowledge on the role of entrepreneurship in the economy (80%) had average to excellent knowledge. Only a few, less than one tenth (9%) were unaware of the role entrepreneurship in the world economy.

The leadership concept was fairly known among the respondents, with almost half (48%) indicating above average to excellent knowledge, and 22% having average knowledge, they can partially explain leadership. However, more than a quarter (27.2%) indicated ignorance (below average to poor knowledge). This trend was almost similar on Advertising and promotions, where more than 40% had above average to excellent knowledge, 30% had average knowledge and more than a quarter (28%) had below average to poor knowledge .

The issue of "legal structure of business" was the least known. Almost 90% of the respondents had average to poor knowledge on the aspect; 45% professing total ignorance (POOR), no knowledge at all on the concept.

Feasibility study, finance and accounting, and intellectual property were the other unknown topics; more than 45% of the respondents had poor to below average knowledge on these topics.

Product development and target market were also unfamiliar concepts among STEM undergraduate freshmen. More than a third (37%) of the respondents professed poor to below average knowledge.

A summary of the statistics obtained on knowledge level is illustrated on the chart below: (See Fig. 1 below)

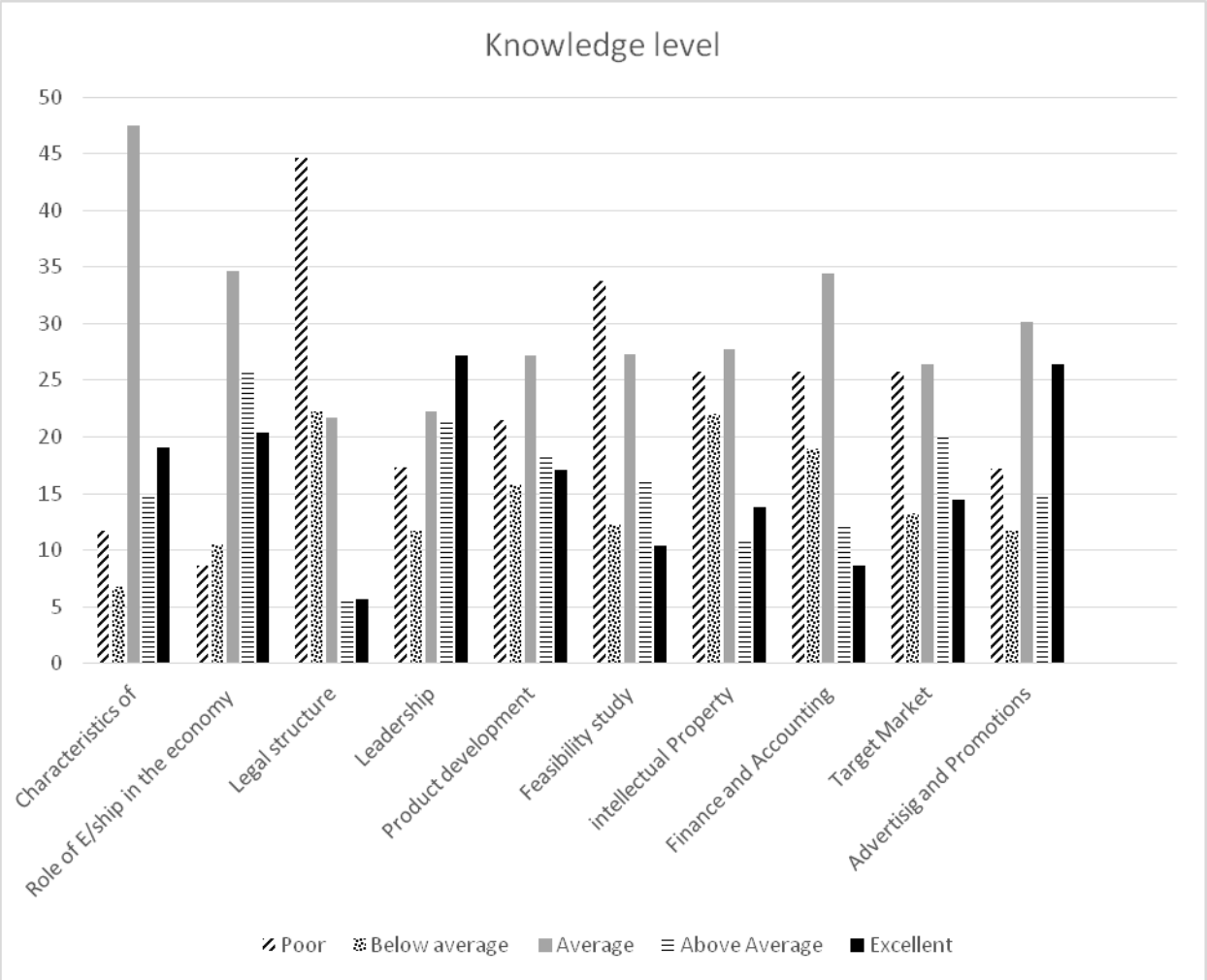

Figure 1: Knowledge level

4.3 Entrepreneurial mind-set

The research also sought to examine the respondents' socio-emotional skills in relation to entrepreneurship skills (entrepreneurial mind-set). A five point Likert scale with 5 responses (Strongly disagree, Disagree , Undecided, Agree, Strongly agree) was used to extract information

pertaining to entrepreneurial mind-set attributes of Self-esteem, Independence, innovation and creativity, internal locus of control, tolerance for ambiguity, risk propensity and lastly attitude and interest in entrepreneurship.

From the results the majority of respondents (90%) had a high level of self-esteem; they agreed and strongly agreed that they were capable of performing tasks that they set for themselves.

Three quarters indicated that they enjoy making decisions affecting their work, thus they have tendencies of high independence.

A huge proportion (88%) said that their success depended on their effort rather than on luck, this is an indication of the presence of internal locus of control among the STEM undergraduate freshmen.

On tolerance for ambiguity most of the respondents (84%) agreed that that "there is a clear difference between right and wrong", showing that they did not tolerate ambiguity. For most of the engineering freshmen there is no room for grey areas, it has got to be either right or wrong, not in between. Engineers do not tolerate ambiguity.

The STEM undergraduate freshmen also have a low risk propensity, 92% said that they are not eager to take risks even if the gains to be obtained are potentially high.

Innovation and creativity was also low amongst STEM undergraduate freshmen, almost half (47%) of the respondents preferred to do things the old way and seldom bothered to think of original ways to perform tasks.

At both institutions Entrepreneurship courses are mandatory, from a marketing perspective the researchers also sought to find out the customers' purchase intent of the courses. When 80% of the respondents indicated a willingness to study the course in their undergraduate studies that was indeed a sure sign of high purchase intent, which was interpreted as high interest in the course. The results also indicate a positive attitude towards the subject, 90% of the respondents admired people who started their own businesses.

4.4 Reliability

Cronbach's alpha was calculated and obtained to be a high of .899 on Knowledge items and .784 on entrepreneurial mindset items implying that the items in the two groupings were consistently measuring the respective aspect.

4.5 Purpose of Entrepreneurship Education

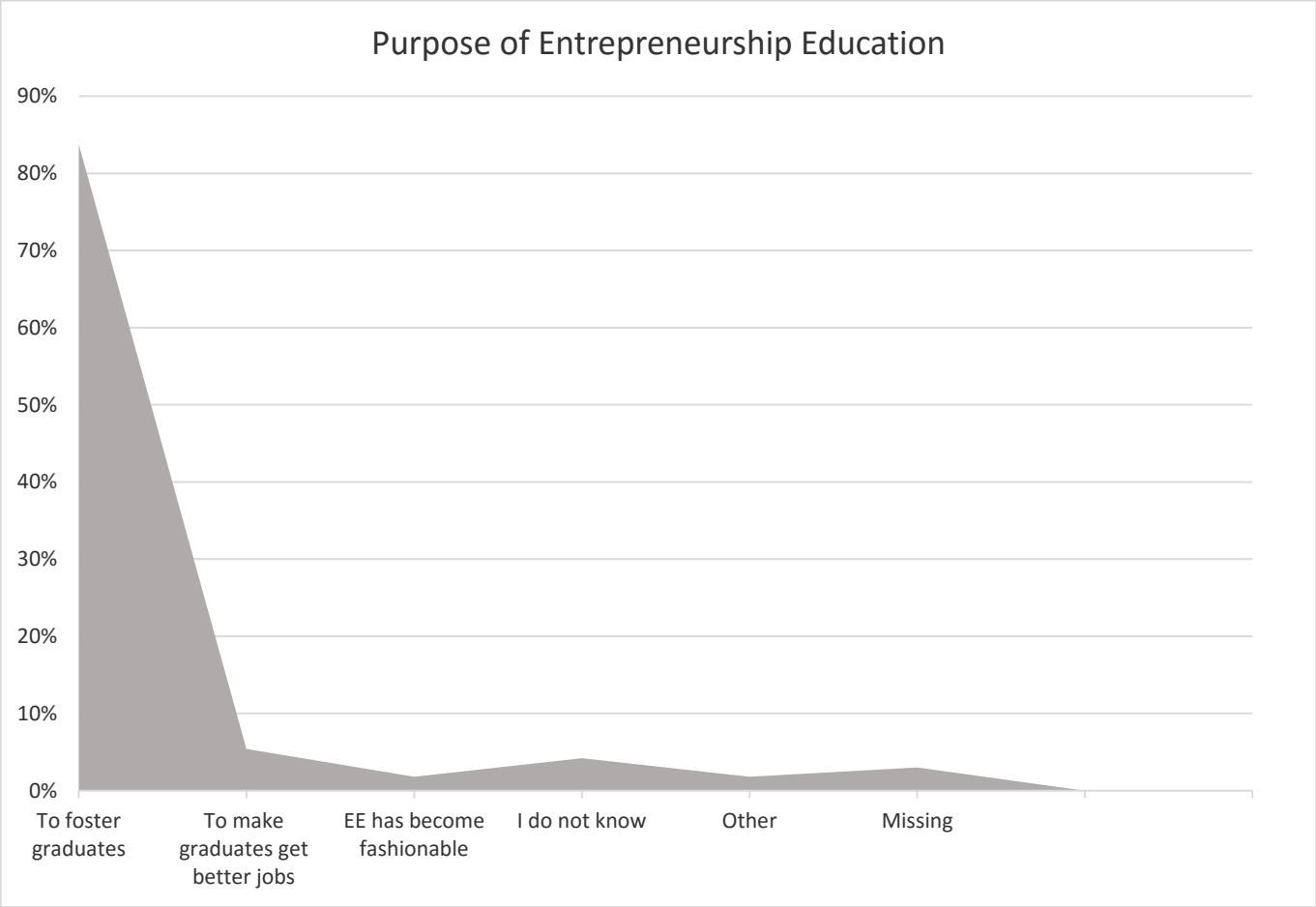

Figure 2: Purpose of Entrepreneurship Education

An overwhelming majority of the freshmen (86%) were of the opinion that the purpose of entrepreneurship education was to foster graduate's ability to spot and act on opportunities (See Fig. 2 above).

4.6 Career intent

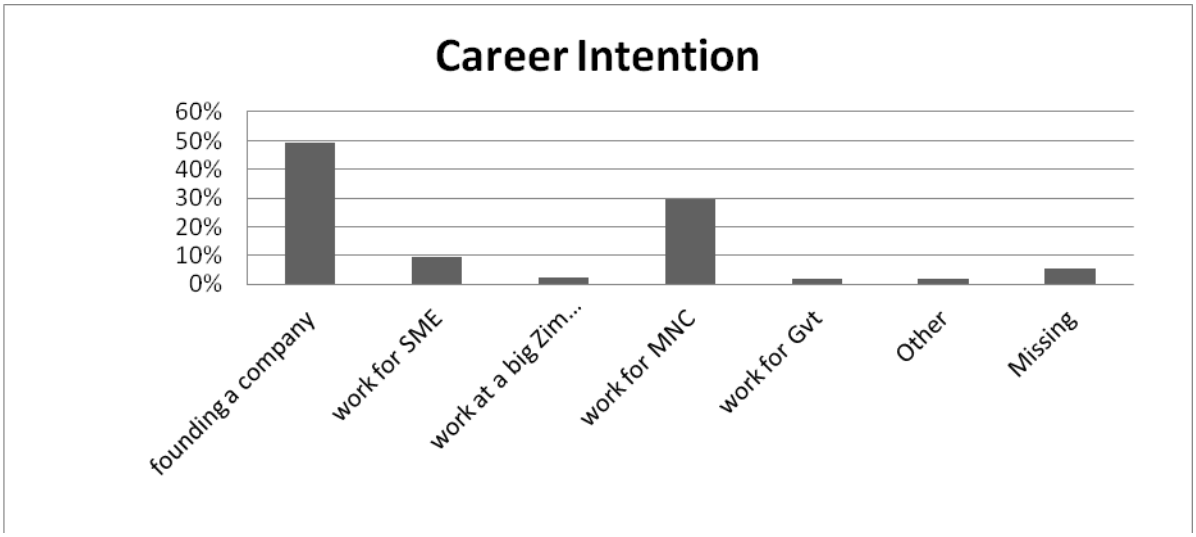

Figure 3: Career intent

The most popular response on the question of career intent was founding a company (49%), followed by working for an MNC (30%). The third choice was working for an SME (10%). The responses founding a company and working for an SME were interpreted as a positive entrepreneurship career intention, so a total of 59% of the interviewed STEM freshmen undergraduate viewed entrepreneurship as a potentially attractive career path. The results for career intent options are shown on Fig. 3 above.

There research also determined the association between where one studied and their career intent. An outstanding observation on the career intent was that most of the respondents (43%) wanting to work in an MNC came from one university (University A) indicating less interest in entrepreneurship as a career.

This prompted the researchers to do some background checks on the universities under study with respect to Entrepreneurship education. A background check on the universities indicated that EE was more recently introduced (about 3 years) at University A whereas it was an old initiative at University B (more than 10 years). It was also observed that entrepreneurship was the branding course for University B.

The research also sought to determine if the characteristics and personality were the same at different institutions. The intention was to be able to conclude if the Entrepreneurship content, delivery and assessment methods could be generalised across the country. Characteristics and personality were similar at both universities.

5. Results Implications, Conclusions and recommendations

The gender distribution of respondents (48:52) in favour of females depicts a departure from tradition where STEM disciplines were dominated by males. This is in line with the global trends were more women are going into these previously male-dominated areas.

The average age of the respondents was 20 years, just the age of high school graduates. So the sample is representative of the target population for this particular research. The researchers wanted input from freshmen (who had not been corrupted by prior exposure to tertiary education or employment) on Entrepreneurship Education.

On the knowledge aspects the average Zimbabwean STEM undergraduate freshman has got some knowledge on some of the common entrepreneurship topics and concepts such as leadership, the role of entrepreneurship in the economy, finance and accounting and advertising and promotions. Knowledge levels were low on legal structure of ventures, product development, feasibility study, intellectual property and target market. Zimbabwean STEM undergraduate freshmen were unfamiliar with these concepts. Generally the majority of respondents had some knowledge on entrepreneurship concepts under consideration, but had challenges in the application of the concepts. If the entrepreneurial capabilities of STEM students are to be enhanced the researchers recommend that entrepreneurship educators be innovative and find/ develop curricula that focus more on application rather than just knowledge creation.

It is more than entrepreneurship concepts that are needed for successful entrepreneurship in an economy. It also encompasses equipping students with entrepreneurial skills and creating entrepreneurial mind-sets. Zimbabwean STEM undergraduate freshmen scored highly on the entrepreneurial mind-set particularly on interest and attitude, self-esteem, internal locus of control, and independence. The researchers recommend that for these behaviours educators have to work on pedagogies that reinforce, nurture, and enhance these attributes; educators have to watch for curriculum aspects that may kill or thwart these entrepreneurial mindsets currently available in students.

However the freshmen indicated high intolerance to ambiguity, low risk propensity and low innovation and creativity. These are also key mindsets for successful entrepreneurship. For these,

the researchers recommend that educators work on designing curricula that starts with developing these attributes and then subsequently nurturing and enhancing.

The researchers concluded that a mixture of approaches to entrepreneurship education is necessary to deliver the experiences and knowledge that lead to innovative and entrepreneurial graduates.

Though it was not part of the research objectives, the results indicated that institutions have got a role in the entrepreneurship education process. The researchers also concluded that learning institutions' culture have a key role to play in terms of creating awareness and raising interest of their incoming students on the value of entrepreneurship education. High interest creates a willingness to learn and instils the motivation to excel in entrepreneurship courses. The recommendation to entrepreneurship educators is that as members of the institutions they have to influence institutional support to entrepreneurship, for entrepreneurship education to work. STEM institutions should work on creating an entrepreneurial culture to raise freshmen's interest rather than leaving entrepreneurship education to designated educators.

The information obtained will provide baseline data on which to design more relevant and more appropriate content, delivery as well as assessment methods for Entrepreneurship education for STEM undergraduate students.

6. Limitations and future research

The limitations of this research most importantly include that the information was based on respondents' self-assessments, which may not be the same as actual entrepreneurial performance. Educators my need to use other means to determine levels of knowledge as well as behaviours in their preparation of entrepreneurship curricula. Consequently they may need to make some minor changes to content, delivery and assessment methods relative to their observation with a particular group. The research did not consider the pedagogical approaches best suited for each of the various knowledge and behavioural areas, in future the researches would want to find out the best pedagogies needed for each knowledge area and for each entrepreneurial attribute.

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ABBREVIATIONS

ASEE	-	American Society for Engineering
B.TECH	-	Bachelor of Technology
EC	-	European Community
MNC	-	Multi-National Corporation
NAE	-	National Academy of Engineering
SME	-	Small to Medium Enterprises
SPSS	-	Statistical Package for Social Sciences
STEM	-	Science Technology Engineering and Mathematics