

# Unlocking the Innovative and Commercialization Potential of the Undergraduate Final Year 'Design and Make' Research Projects

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## Abstract

Innovation and commercialization are viewed as key drivers of any country's economy. Individuals normally start commercial enterprises with an innovative and entrepreneurial mindset. Universities worldwide are regarded as centers of knowledge creation and are expected to play a key role in the industrialization of a country's economy. For undergraduate engineering students, the capstone 'design and make' research module is best placed to unlock their innovative and commercialization potential. Capstone modules are typically about applying what the student has learned during the entire course of studies, thereby presenting a rich setting for innovation and entrepreneurial skills learning. In Zimbabwean universities, the final year capstone project is offered where the student fabricates a product as a possible solution to a problem in industry. However, very few of the ideas from the module have found their way into the real world as goods or services. The study's main question was to establish the extent of the impact of the projects module on agricultural engineering undergraduate students' innovative and commercial-mindedness. Using the case study research design, data were collected on implementing the capstone module at the Chinhoyi University of Technology's Department of Agricultural Engineering. Data were collected on the parameters potentially impacting the student's innovativeness and commercial mindedness. The study findings showed that in its present form, the research project module improves the students' design and innovative skills. All the same, equipping the same scholars with entrepreneurial skills is inadequate.

**Keywords:** education 5.0, curriculum reform, capstone design projects, innovativeness, entrepreneurship, undergraduate agricultural engineering students

## Introduction

Innovation and commercialization are viewed as key drivers of any country's economy. According to Kropp et al. (2006), commercial enterprises and employment creation are started by individuals with an innovative and commercial or entrepreneurial mindset. These individuals' businesses start as small enterprises that morph into big businesses. Universities worldwide are regarded as centers of knowledge creation and are expected to play a key role in the industrialization of a country's economy. The capstone 'design and make' module is best placed to unlock the innovative and commercialization potential of the final undergraduate students. Capstone 'design and make' courses typically apply what the student has learned during the studies. Their experiential nature presents a rich setting for innovation and entrepreneurial skills (Masunda et al., 2022). In developed countries, entrepreneurial capstones have been implemented for more than two decades now, with the accreditation of graduate engineering students referencing the final year capstone 'design and make' project (Shartrand & Weilerstein, 2011). Zimbabwe has redesigned its university

education system with five missions, which is now understood as the Education 5.0 doctrine (Ministry of Higher and Tertiary Education, Science and Technology Development, 2018; Murwira, 2019). The Education 5.0 doctrine has added the pillars of innovation and industrialization to the pillars that formed the then Education 3.0 doctrine: teaching, research, and community service (Murwira, 2019). The research pillar has now assumed an even greater significance because it informs the teaching content and is now the cog in the engine to generate new and innovative goods and services.

In many universities, particularly in developed countries such as the USA and the UK the engineering programs have included a finishing experience for students involving a substantive capstone project, commonly known as the final-year project, that shows a synthesis of learning accrued during the studies. In these universities, a module on business entrepreneurship is taught most effectively using experiential techniques (Matthew et al., 2015). Such an approach has made capstone design courses one popular pedagogy for integrating entrepreneurship into engineering curricula.

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In Zimbabwean universities offering engineering degree programs, the final year capstone project is offered where the student designs and fabricates a gadget as a possible solution to a problem in industry. However, the 'design and make' capstone project has generally not taken a purely entrepreneurial mode. There is great potential to unlock the innovative and commercialization potential of the undergraduate final year 'design and make' research project by providing the requisite support and guidance. The final-year students can build valuable professional skills through engineering design work and increase their value to future employers (Shartrand and Weilerstein, 2011). The student should be able to identify market opportunities, design solutions that can address them, and, more notably, know how to ensure that their ideas become a reality through the industrialization process of the goods and services produced in line with the Education 5.0 doctrine. This is true whether they are starting their enterprise, joining an existing start-up company, patenting their technologies to an already established company, or introducing new products as an employee. This study investigated the potential of the undergraduate final year 'design and make' research project module of agricultural engineering students at Chinhoyi University of Technology (CUT) to incorporate innovation and entrepreneurship into this capstone module.

Like in other engineering degree programs in the UK and the USA, the 'design and make' final year project module at CUT has traditionally been viewed as a zenith of the engineering major that allowed students to apply their technical skills and knowledge to solve an identified problem in industry (Todd et al., 1995). Besides, the module also developed the student's professional skills such as communication, teamwork, project management, and leadership, as shown in the submitted project write-up and the prototype exhibition. However, with the recent redesigning of the university education system that brought the Education 5.0 doctrine, research has been challenged to re-focus and come up with innovative goods and services that have the potential for commercialization (Ministry of Higher and Tertiary Education, Science and Technology Development, 2018; Murwira, 2019). The capstone module presents an ideal setting to learn and apply entrepreneurial skills in the design and process context. In Zimbabwean universities' engineering disciplines, very limited empirical studies have examined engineering capstone modules to identify specific educational instructional practices that can catalyze the innovation of goods and services with the potential for commercialization. Specifically, in the agricultural engineering discipline at CUT, no such studies have been done to date.

The CUT agricultural engineering degree program regulations specify general student assessment guidelines for the capstone 'design and make' module (unpublished regulations). The guideline has several key elements of student assessment, including but not limited to the project proposal, prototype design specifications, prototype functionality, prototype performance evaluation, prototype repair and maintenance plan, and prototype durability and quality of finish. The regulations also specify the project duration. While the assessment guidelines emphasize the technology solution mindset, the prototype and write-up, the entrepreneurial mindset, and the associated customer or client validation are silent. The latter is the important aspect emphasized in the Education 5.0 doctrine as innovative goods and services with potential for commercialization. None of the ideas from the 'design and make' project module from all the agricultural engineering classes since the start of the degree program at CUT in 2004 have found their way into the real world as either goods or services. The outputs of these 'design and make' classes have dismally failed to make an impact in agricultural exhibitions organized by the re-branded Zimbabwe Agricultural Show (ZAS), formerly Harare Agricultural Show, or in the provincial agricultural shows exhibitions organized annually in the provincial capitals of the country. This study aimed to explore the potential of the 'design and make' project module to enhance the students' innovation and entrepreneurial skills to ensure that their ideas become reality through the commercialization process in line with the Education 5.0 doctrine.

## Review of the Related Literature

### *Impact of the Capstone 'Design and Make' Research Project on the Students' Innovativeness and Commercial Mindedness*

Capstone research projects can be purely traditional in that the key objective is to produce a technical product, an engineering solution to an identified problem (Shartrand & Weilerstein, 2011). Another model is the capstone project that can be purely entrepreneurial, aiming to produce a product for commercialization (Odora, 2015). Sometimes, a capstone course can take a hybrid approach and have both traditional and entrepreneurial projects underway simultaneously (Shartrand & Weilerstein, 2011). In all cases, a good capstone project experience provides the engineering undergraduate student with opportunities to apply and integrate what they have experientially learned in their studies, resulting in learning outcomes demonstrating valuable skills and knowledge. However, some important peculiarities exist between the traditional and the entrepreneurial capstone models.

Several studies have demonstrated that engineering undergraduate students who participate in entrepreneurship programs gain insights not available from traditional engineering education. Examples include insights on understanding and designing for end users, effective communication skills, and an understanding of business basics (National Academy of Engineering, 2004). Substantial literature has been written about the benefits of integrating entrepreneurship in higher education curricula Raposo and Do Paço (2011) however, little is known about the effects of such ventures on the commercialization-mindedness of students in the agricultural engineering discipline.

### *Entrepreneurial Mind Set*

A good capstone 'design and make' research project module impacts the student's entrepreneurial mindset and developing a product, service, or technology set for a specific target market/client (Shartrand & Weilerstein, 2011). In this way, students will be taught to recognize opportunities and to apply technology in ways that could potentially create market value. After going through the capstone 'design and make' research project, the students should understand their projects' business and market implications. The prototype gadget or service should address the client's needs; naturally, a commercialization model must be produced. In addition, the capstone product should also incorporate information on market competition, product pricing, product functionality or utility, and product performance standards (Matthew et al., 2015).

### *'Design and Make' Project Idea/Problem*

Several authors are of the opinion that students should generate their own project topic or idea in an entrepreneurial capstone 'design and make' module (Matthew et al., 2015; Maw, 2016; Neck & Greene, 2011; Shartrand & Weilerstein, 2011). This argument is premised on the assertion that by framing their own subject of investigation, the students will become both the "problem finders" and "problem solvers" (Neck & Greene, 2011). In addition, the students cultivate a sense of ownership of the problem and, likely make them apply themselves intensely in the project design work. The practice of originating the research project idea from the industrial attachment (experiential learning) phase is also plausible as another option. During this phase, when students get on-the-job learning and training, they can identify real-life production-related challenges in industry requiring further investigation. Lecturers can also be another source for the project idea or problem. In this case, the project idea could be a component of the 'bigger' project that the researchers could be working on.

Whatever the source of the project idea is, it is important that the students and the supervisory team understand the needs and demands of the market. The identity of who the client is or would be must be clear. In addition, the research team (students and supervisors) must engage the client in the entire design process to ensure that the client's needs and interests are incorporated into the solution.

### **Goods and Services as Deliverables**

A good technopreneurial capstone project is one that goes beyond merely being an educational exercise (Ortiz-Medina et al., 2014). The capstone project must deliver market-driven goods and services. Ortiz-Medina et al. (2014) further assert that the capstone project deliverables must be real products or services that can enter the market and impact people's lives. A good entrepreneurial capstone design project should give students a deeper understanding of the real-world production challenges in industry. Such challenges include product efficacy, product production costs, product safe use, product ease of manufacturability, market characteristics, and profitability. It is important that engineering undergraduates strike a delicate balance between product development as a solution and the bigger picture of enterprise development (Maw, 2016).

### **Experimentation and Iterations**

Experimentation and iteration are other aspects that have been suggested as an element of a good capstone 'design and make' research project. Neck and Greene (2011) have termed it as a 'failing forward.' Iteration is believed to give the engineering undergraduate the opportunity to reflect on the failures that arise and complete a "virtuous cycle." The iteration process equips the students with confidence, perseverance, and knowledge, which they can apply in future design work.

### **Intellectual Property (IP) Rights**

The engineering undergraduates must own the intellectual property of their innovations from the 'design and make' research projects. It is, therefore fundamental that lectures on 'Intellectual Property Rights' are included in the 'design and make' module. This helps to ensure that students understand the details of intellectual property registration and how to apply it to their own work in the future after graduation. Shartrand and Weilerstein (2011) advocated for students to own the intellectual property of their products from the 'design and make' research projects. Hence institutions of higher learning should have IP policies that encourage student innovativeness and creativity.

### **Interdisciplinary Teams**

Ideal capstone projects should involve interdisciplinary teams (Matthew et al., 2015). The teams should go beyond just engineering but include other disciplines such as business planning, art and design, and marketing. Ortiz-Medina et al. (2014) referred to such groups as multidisciplinary teamwork. Such teams are meant to ensure that groups are formed based on areas of expertise. Each team must be comprised of the right set of skills to undertake the project. The multidisciplinary approach offers the highest probability for successful innovations in the capstone 'design and make' projects as it better mimics the team working environment that is common to the industry. The idea of multidisciplinary teams has also not been very convincing to some authors. For example, Handscombe et al. (2008) seem to favor uni-disciplinary teams as opposed to multi-disciplinarity.

### **Industry Engagement**

Another key aspect of a good capstone 'design and make' project is the aspect of industry engagement. Matthews et al. (2011) argue that industry engagement in terms of industry-sponsored problems has been credited for providing real-world problems, technical challenges, and viable projects. Engaging the industry in the 'design and make' projects offers the engineering undergraduate with first-hand information on the needs and expectations of the local industry. Besides, obtaining industry-sponsored projects is one way of bringing academics and industry together. However, Matthews et al. (2015) argue that industry-sponsored projects suppress the student's innovativeness. Such projects are restricted to known problems at the expense of creating innovative solutions or capitalizing on new market

opportunities. Another important addition is to bring in guest speakers from industry and commerce during the proposal development stage of the 'design and make' module. The guest speakers can bring in the industry flair that will help students formulate their research problems.

### **'Design and Make' Project Support**

The need for financial support for materials, consumables, equipment, machinery, and engineering workshops (infrastructure) for the 'design and make' project cannot be over-emphasized. The need for such support is especially important in Zimbabwe's state universities that have recently adopted the Education 5.0 doctrine in their teaching and learning (Murwira, 2019). Shartrand and Weilerstein (2011) suggest that universities should create opportunities for student design and innovation competitions. In Zimbabwe, the Zimbabwe Institution of Engineers (ZIE) administers the National Engineering Students Awards Competition (NESAC) on an annual basis. This is a good initiative to promote creativity and innovation among engineering undergraduates. The competition is, however, lacking adequate funding. However, such extracurricular activities (competitions) in an engineering degree program are hindered by time and space constraints.

Assistance with technology transfer and business incubation is another area that is important in supporting the 'design and make' project module. The Ministry of Higher and Tertiary Education, Science and Technology Development in Zimbabwe has recently made commendable efforts in this regard by constructing innovation hubs in all state universities in the country (Murwira, 2019; Rumbidzai Muzira & Maupa Bondai, 2020). However, adequately equipping these hubs to make them functional and serve their intended purpose remains a challenge.

### **Statement of the Problem**

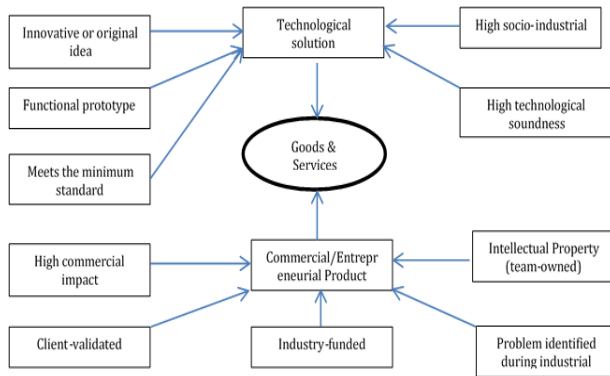
The capstone 'design and make' project module has generally failed to enhance the students' innovation and entrepreneurial skills. However, none of the ideas from the 'design and make' project module from all the Agricultural Engineering degree classes at CUT since 2004 have ever found their way into the real world as either goods or services.

### **Conceptual Framework**

Several elements of a goods and services-oriented capstone 'design and make' project module was suggested and used to explore the impact of the module on the student's innovativeness and commercial mindedness. Figure 1 is a diagrammatic representation of the elements.

Based on the literature on the entrepreneurial engineering capstone, Shartrand and Weilerstein (2011) developed an integrative framework to measure capstone project practices focused on commercialization. They distinguished what they termed an entrepreneurial capstone from a traditional capstone. According to Shartrand and Weilerstein (2011), an entrepreneurial capstone aims to produce engineering graduates who are able to recognize, create, and act on entrepreneurial opportunities that are related to engineering products and solutions. The traditional capstone, on the other hand, focuses on the technical aspects of the prototype and is silent on the commercialization potential. This particular framework was also adopted by Matthews (2015). Together, the authors identified and emphasized a number of elements of an entrepreneurial capstone, which include the mindset, course, and project funding practices, criteria for project success and course requirements, project duration and extended support, the importance of educational outcomes, intellectual property and entrepreneurial support (Matthews et al., 2015; Shartrand & Weilerstein, 2011;). The conceptual framework for the product-oriented 'design & make' research project in Figure 1 was developed from the evidence gathered in the case study and also by borrowing the ideas from Matthews et al. (2015) and Shartrand and Weilerstein (2011) frameworks on entrepreneurial focused capstone projects.

**Figure 1**  
Conceptual Framework for Product-Oriented 'Design & Make' Research Project



**Objectives**

1. Determine the impact of the capstone 'design and make' research project module on the CUT agricultural engineering undergraduate student's innovativeness.
2. Determine the impact of the capstone 'design and make' research project module on the CUT agricultural engineering undergraduate student's commercial mindset or beliefs.

**Methodology**

This supervised capstone 'design and make' research employed the case study research design to collect quantitative data on unlocking the innovative and commercialization potential of the undergraduate final year 'design and make' research projects of the Agricultural Engineering students at Chinhoyi University of Technology in Zimbabwe. Data were collected using a Google form survey link questionnaire from a census sample of thirty (30) final year Bachelor of Science Honors degree in Agricultural Engineering, of whom five (5) majored in mechanization while the other 25 specialized in irrigation. To collect data, two surveys using the same questionnaire were conducted on the students soon after completion of the initiation or commencement lectures on the 'design and make' module and at the end of the module just before submission of the project write-up. Data pertaining to the variables with the potential to impact student innovativeness and commercial-mindedness were coded on a scale of 1 to 4 that described the student's level of knowledge or skill acquisition. Level 1 represented elementary (or basic) knowledge or skill, 2 = intermediate (average), 3 = innovative (cutting edge), and 4 = skillful (proficient). The concerned student population was considered small in number. Hence, no sampling was done as the entire class of 30 final-year students was included as respondents in the study. The results obtained were tabulated. Using these parameters, one table showed the mean differences in student

innovativeness between the pre-proposal implementation stage and the post-proposal implementation stage. Another table summarized the mean differences in the student's commercial mindedness between the pre-proposal implementation stage and the post-proposal implementation stage. This table used the following parameters: ability to conduct market research, product development as a potential business, product costing and pricing, working as a team of research engineers, and ability to conduct a SWOT analysis. The arithmetic means and the standard deviation was used as the inferential statistics to understand this class of students' change in innovativeness and commercial mindedness after following the one-year 'design and make' research project module.

**Results and Discussion**

**Demographic Information of Respondents**

The study population was the CUT students' final year 'Design and Make' Research Project class of 2022 doing the degree in Agricultural Engineering. The survey questionnaire was carried out in two stages. The first stage was conducted at the pre-proposal implementation stage when the students had completed the initiation lectures that covered all aspects of the engineering design process. The same questionnaire was administered to the students soon after the post-proposal implementation stage. At this stage, the students were exhibiting their completed gadgets and submitting their research project write-ups. The results obtained were tabulated. The study population was the final-year undergraduate Agricultural Engineering students of the 2022 class. The class had 30 candidates, comprising eight female (27%) and 22 male students (73%). This suggests that there is a gender imbalance in the undergraduate agricultural engineering degree program at the university. The agricultural engineering degree program at CUT offers two specializations, namely irrigation and mechanization, to choose from. The specializations begin in the third year. Eighty-three (83) percent of the candidates opted for the irrigation engineering specialization, clearly indicating its popularity with the students.

**Impact of the Capstone 'Design and Make' Research Project Module on the Cut Agricultural Engineering Undergraduate Student's Innovativeness**

From the first stage, a total of 23 questionnaire responses were received from the students, translating to a 77% response rate, while in the second stage, 21 out of the expected 30 questionnaires were returned. Table 1 summarizes the mean difference between the student innovativeness at the pre-proposal implementation stage (after the introductory engineering design process lectures) and the post-proposal implementation stage (after the completion of the design project). The first semester in the final year focuses on the research proposal write-up that is implemented in the second semester when the candidates exhibit their fabricated prototype and submit the project write-up report for assessment.

**Table 1**  
Mean Difference between Pre-Proposal Implementation Stage and Post-Proposal Implementation Stage for Student Innovativeness Growth Assessment

Capstone element	Pre-proposal stage		Post-proposal stage		MD
	M	SD	M	SD	
Problem identification	1.34	.66	2.40	.62	1.06
Target user identification	1.41	.77	2.10	.68	.69
Utility of the gadget to the target user group	1.60	.55	2.69	.67	1.09
Ability to generate innovative ideas	1.32	.87	2.39	.81	1.07
Design specifications	1.50	.66	2.71	.69	1.21
Gadget functionality	1.22	.88	2.77	.83	1.55
Performance standards setting	1.31	.81	2.40	.57	1.09
Repair and maintenance plans	1.26	.71	2.55	.79	1.29
Gadget durability and quality of finish	1.24	.69	2.65	.91	1.41

Notes: MD = mean difference

As can be seen in Table 1, there was a general increase in all the capstone elements impacting the design skills and innovativeness of the students after the completion of the design project. The greatest increase in the level of knowledge and skills acquisition was observed in the ability to design functional gadgets with a focus on gadget durability and quality of finish ( $M = 1.55$  and  $1.41$ , respectively). This could possibly be the case because of the support the students receive from the technical staff in the engineering workshop and the availability of workshop equipment such as milling, drilling, and lathe machines. Guiding the students in the fabrication of their prototypes are the Engineering Workshop Technician and two General Workshop Assistants.

Table 1 shows that the least increase in the level of knowledge and skills acquisition was observed in the students' target user identification capabilities ( $M = .69$ ). The identification of the target users of any innovation is important as it is the first step toward commercialization of the product. This suggested that probably commercialization aptitude is the weakest skill the 'design and make' research project is failing to impart to the students.

### Impact of the Capstone 'Design and Make' Research Project Module on the Cut Agricultural Engineering Undergraduate Student's Commercial Mindedness or Attitude

Table 2 summarizes the mean difference between the student's commercial mindedness or attitude at the pre-proposal implementation stage (after the introductory engineering design process lectures) and the post-proposal implementation stage (after completion of the design project). As can be observed in

Table 2, there was generally a modest mean increase in all the commercial-mindedness attributes of the students. This is an indication that the 'design and make' research project module had some positive effects on students' entrepreneurial skills, though modest compared to student's innovativeness. The highest mean difference ( $M = 1.27$ ) was observed for teamwork, suggesting the value of working as a team. Probably, there was more brainstorming and sharing of ideas in teams, thereby benefiting the students more in their entrepreneurial skills. However, marginal mean increases in the level of entrepreneurial skills were observed in the capability to carry out a SWOT analysis (.19), the ability to develop a product as a potential business ( $M = .23$ ), and the know-how to conduct market research ( $M = .42$ ). All these capstone elements are critical for the commercialization of research products from the 'design and make' module.

For the successful implementation of the Education 5.0 doctrine in Zimbabwean universities, the potential contribution of the 'design and make' research project to the production of innovative goods and services cannot be ignored. Hence the engineering student must evolve from a problem solver to an opportunity and business creator. This agrees with the observations by Ochs et al. (2006), who suggested and recommended a comprehensive model for integrating entrepreneurship education and capstone projects.

Besides graduating with technical skills and knowledge acquisition, the undergraduate agricultural engineering student needs to be commercially minded as well. This will help the student to understand the needs of the agricultural industry and accordingly contribute to agricultural production and agro-processing.

**Table 2**

*Mean Difference between Pre-Proposal Implementation Stage and Post-Proposal Implementation Stage for Student Commercial Mindedness Growth Assessment*

Capstone element	Pre-proposal stage		Post-proposal stage		MD
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Ability to conduct market research	1.43	.67	1.85	.76	.42
Product developed as a potential business	1.55	.98	1.78	.87	.23
Product costing and pricing	1.79	.83	2.82	.64	1.03
Working as a team of research engineers	1.66	.77	2.93	.79	1.27
Ability to conduct a SWOT analysis	1.83	.66	2.02	.63	.19

Notes: MD = mean difference

In its present form, the agricultural engineering 'design and make' research project module at CUT is inadequate to equip students to start their own businesses soon after graduation. The module needs review to include commercial or entrepreneurship pedagogy. This approach will give the student solid experience in product design and development as a business, market research and analysis, technology trends, and the know-how to carry out a SWOT analysis. While these skills are relevant for success in established businesses, they are equally instrumental in start-ups. One of the key attributes of the Education 5.0 policy in Zimbabwe is to produce graduates who are job creators rather than job seekers at graduation (Murwira, 2019). In several African countries, many higher education institutions have incorporated entrepreneurship education into the 'design and make' research project curriculum after realizing that it enhances the innovative and enterprising spirit of the students (Nwekeaku, 2013).

Several studies have demonstrated that engineering students who are taught entrepreneurship as undergraduates gain insights not available from traditional engineering education (Lans et al., 2014; Odora, 2015; Raposo et al., 2011). Such additional insights gained include understanding and designing for end users, working in and managing interdisciplinary teams, communicating effectively, thinking critically, understanding business basics, and solving open-ended problems (Lans et al., 2014; Odora, 2015).

Several authors have written about the benefits of integrating entrepreneurship into higher education curricula (Lans et al., 2014; Odora, 2015; Raposo et al., 2011). However, little is known about the effects of entrepreneurship education on the innovativeness and commercial-mindedness of engineering students in general, let alone those in the agricultural engineering

discipline. This study used pre and post-proposal stage surveys to determine the effects of the 'design and make' research project module on the students' innovativeness and commercial mindedness. Analyses of statistical data revealed a generally positive change in the students' innovativeness and commercial mindedness as a result of following the 'design and make' research project module, as already alluded to earlier on. The findings of this study is largely consistent with earlier work done in India (Viswanathan & Sridharan, 2012) and in South Africa (Odora, 2015), which indicated that using the 'design and make' project was enormously motivating the students the opportunity to develop and accomplish their design and business plans. In general terms, the thinking is that entrepreneurship education must be incorporated in the 'design and make' research project module in which engineering problem-solving takes place in the setting of a business opportunity.

### Conclusion

The study concludes that the 'design and make' research project module positively impacted the design and innovative skills of the agricultural engineering undergraduate students. Secondly, the same module only had a marginally positive effect on the students' entrepreneurial skills compared to student's design skills and innovativeness. This implies that in its present form, the agricultural engineering 'design and make' research project module at CUT improves the design and innovative skills of the students while, at the same time, it is inadequate to equip the same students to start their own businesses soon after graduation.

### Recommendations

The study recommends that:

1. Entrepreneurship education must be incorporated in the CUT 'design and make' research project module in which agricultural engineering problem-solving takes place in the setting of a business opportunity.
2. In its present form, the agricultural engineering 'design and make' research project module at CUT is inadequate to equip students to start their own businesses soon after graduation; hence, the module needs review to include commercial or entrepreneurship pedagogy.
3. The 'design and make' research project must deliberately be incorporated and recognized in the Education 5.0 policy for resource mobilization purposes, as its potential for the production of innovative goods and services cannot be ignored.
4. Further instruction specifically focused on the students' target user identification capabilities is needed. The identification of the target user of any innovation is important as the first step toward the potential commercialization of the product.
5. Further studies will be carried out on the potential role of the agricultural industry in financing the capstone 'design and make' research project module and also on Intellectual Property Rights (IPR) modalities on products from the capstone 'design and make' research project module.

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