DESIGNING INDUSTRIAL ENGINEERING EDUCATION IN A DEVELOPING COUNTRY:
THE CASE OF THE POLYTECHNIC OF NAMIBIA

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ABSTRACT

This paper describes an unfolding task to bring tertiary education in Industrial Engineering (IE) to Namibia. It describes the situation in Namibia and notes the history of IE development at the Polytechnic, and then a decision to start at the level of Master. Following a design approach, the development of such a degree is described including benchmarking of appropriate programmes and evaluations from academics and industrialists. The resulting programme has elements to make it flexible and competitive with degrees elsewhere. Remarks, lessons learned and a conclusion end the paper. As this is a single case, it does not purport to offer general conclusions but rather raises questions for those involved in similar exercises.

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1 PROLOGUE
This describes a still unfolding case. A Master programme has been passed by senate [1] while implementation awaits some approvals. A Bachelor programme is in early stage design and needs to progress through many steps. While this case is written in a relatively logical manner, the situation on the ground was more chaotic as processes unfolded and authors gained knowledge. (Would Operations Researchers call these evolutionary operations?) Some points are still not clear†.

2 THE SITUATION
Namibia, a sparsely populated developing country, has virtually no Industrial Engineers trained, even at Bachelor level. Indigenous people have been influenced, initially as a German colony until the First World War and then by South Africa until independence in 1990. While most people of German and South African extraction are now Namibians and their influence is small, Germany provides assistance in areas like education where many links exist between, e.g. the Polytechnic of Namibia (PoN) and German Universities. South African influence is much larger especially in industrial areas like wholesale and retail, finance and banking etc. Mining and government activity is also large. The Republic of Namibia [3] sees an industrialized nation with service areas like tourism growing strongly in addition to small to medium businesses (SMEs) across many industrial sectors. Such sees Namibia competing on a world stage. While a vision is needed, the issue is how to make Namibia competitive through its people using Industrial Engineering (IE).

3 HISTORY
An early attempt to start IE at the PoN ceased when the consultant died. In 2011, a professor from the University of New Mexico investigated the feasibility for IE in Namibia. From limited case studies, the demand for IE is for the wide spectrum of Namibian industry. A workshop, organized by a consultant partnering with Reutlingen Hochschule, to determine Namibian needs followed. This workshop reflected the perceived needs of participants rather than important sectors of Namibian industry or stated aspirations (e.g. Republic of Namibia, [3, e.g. paragraphs 1.6 and 2.1.2]). From the workshop many prescribed modules, especially at Master level, are needed, but areas found in conventional engineering syllabi, e.g. design, are excluded. The partner is a Business School who, in common with many Hochschule, present courses within the ambit of IE and this German partner naturally aims for business accreditation, e.g. AACSB -the Association to Advance Collegiate Schools of Business. A German engineering based programme in IE would seek ASIIN‡[4] accreditation, this being the German institution presently seeking “Washington Accord” status. At Master level, little research is required, i.e. about nine percent of the allocated time.

To design a suitable IE programme there are at least two courses of action. One is to transplant a solution found elsewhere, the second is to go back to fundamentals and treat this as a design. Transplanting solutions whether from South Africa or elsewhere would not be in the long term interests of Namibia and its people. Such would bring the PoN to a place where other institutions have already reached in countries that differ from Namibia. To

† Although dated, people wanting to get a feeling for such design may read Kidder [2].
‡ Even such degree programmes need to be redesigned to comply with local accreditation and conditions (e.g. in Civil and Mining engineering).
design a programme for Namibia considerations like costs, productivity and flexibility of the programme would have to be addressed.

4 DESIGN APPROACHES AND A MAJOR DECISION

With limited resources the question was whether to start with a Master, or Bachelor, degree. Figure 1 shows some major criteria used to judge the two options. The Master degree was selected mainly to get IE into Namibia more speedily, with lower cost and limited resources.

<table>
<thead>
<tr>
<th>Table 1: Master or Bachelor Degree?</th>
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<tbody>
<tr>
<td><strong>Criterion</strong></td>
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<tr>
<td>Namibia vision 2030</td>
</tr>
<tr>
<td>Size of intake</td>
</tr>
<tr>
<td>Human resources-lecturers</td>
</tr>
<tr>
<td>National constraints</td>
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<tr>
<td>Professional constraints</td>
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Using a design approach means “establishing requirements based on human needs, transforming them into performance specification and functions, which are then mapped and converted (subject to constraints) into design solutions (using creativity, scientific principles and technical knowledge) that can be economically … produced” [5]. The Master degree now becomes an innovative creative design involving opportunistic, incremental, exploratory, research, rational decision-making, iterative and interactive elements and processes. The philosophical approaches are widespread as are the models and techniques on offer. A generally accepted starting point is to establish some bounded specification where clarity is sought. Movement to the solution of the design process is likely to involve synthesis and thinking in a variety of ways. Selected parts in the design follow.

The starting point is called a product requirement specification (PRS), i.e. a clarified statement. Three parts that are important: the requirements, the constraints and the criteria by which solutions may be evaluated (adapted from [6] Ch. 9). This is shown as a PRS formed by the requirements, constraints and criteria for evaluation.

Requirements: People and their innovations are the key to industrialize§ Namibia so IE must fit this. Present examples are mining Uranium for power, gem diamonds for fashion, and transport for large distances. The future vision includes tourism and small and medium enterprises in all types of industries. As prediction of future innovations is likely to be wrong, IE needs to provide general principles and tools to assist graduates to make innovator’s dreams come true and existing firms compete globally.

§Wealth (see producer/consumer surplus from any elementary economics textbook) is enhanced by investing in people’s innovations that generate wealth (or positive Net Present Value).
Constraints: Constraints include legal requirements and bodies that uphold standards. The restrictions of institutions and other National agencies are to be followed. (Here NQA requirements are similar to SAQA). In setting standards there are two schools of thought impacting IE, the AACSB [7] and "Washington Accord" (ECSA [8])††. The foci of Engineering and Business differ. Engineering aims to be ingenious by change where business education aims at administering organizations. Engineers innovate, change, alter, modify, transform or revolutionize while business people manage, direct, run, order, control, oversee, govern, conduct operations or do paperwork.

Criteria for evaluation: Within the requirements and constraints, solutions may be found. Criteria to evaluate solutions include where designs and innovations gain advantage. Advantages may be large (e.g. Schumpeter's creative destruction) or small (e.g. Keizan). Developed ideas or innovations provide competitive advantages, but where are advantages found? Authors differ e.g. between new product and new process development. Slack [9] provides a satisfactory list of advantages as quality, time (speed and dependability), flexibility (including new products and processes) and cost that was used.

5 DEVELOPMENT OF A MASTER DEGREE

Various solutions for the PRS range from having a full coursework programme, a core and electives programme, to a research only programme. After evaluation a half coursework/ half research programme was chosen mainly for the PRS and the small number of suitably qualified industrial engineers in Namibia. The programme was partly developed by looking at other appropriate general programmes from USA, UK and SA. Figure 2 shows some comparisons and figure 3 the proposed programme.

This programme provides declarative IE training in line with Slack's competitive advantages: "IE Tools and Techniques" comprises three courses. "IE methods" stresses cost and speed advantages; "Quality and Reliability" deal with these advantages; and "Work Science" integrates the person and organizational structure as the most flexible factor of production with abilities in "changing what you do" ([9] p.77). Economics/Business shows how Engineering interacts with business theoretically (Applied Economics for Engineers) and practically (Business Analysis) with emphasis on innovation in starting and developing businesses/SMEs. Soft skills like oral and written presentation skills form part of this programme as do industrial projects taking at least half of the students' notional hours in each course. Dickens ([10] Chapters II, VIII and IX) provides an interesting insight into the problem of delivering facts alone. With a course on "Research Methodology and Techniques" introducing the thesis (Individual specialization in Figure 4) students are able to investigate any industry, gain speedy acceptance in the workplace and practice interpersonal skills

** While there are other accrediting agencies (e.g. FIBAA), this uses AACSB [7] as other agencies aspire to this body. AACSB [7] has twenty one standards that allow considerable latitude on the knowledge areas developed. Here a Master degree can emphasize virtually any area of knowledge (including IE).

†† ECSA [8] requirements are followed. They contain ten outcomes and minimum knowledge in at least six areas. While mainly dealing with content, the focus is indirectly addressed, e.g. designs are “procedural, creative or open ended” pointing to engineering making dreams come true. Students are exposed from unseen closed problems with single correct answers (e.g. in mathematics) to open ended problems with multiple solutions (e.g. in design). However some areas, e.g. what does Engineering Science mean for Industrial Engineers is opaque. (Expert opinion sought simply said that “if it (IE) quacks like a duck, it is a duck”. Such shows a lack of knowledge or fosters a desire to stick with IE as a historical code that does not move, denying ingenuity in IE education).
(tacit knowledge). This programme has potential to give graduate Engineers IE expertise effectively and efficiently.

![Diagram of some comparisons between universities]

**Figure 2: Some Comparisons**

- Proposed solution

![Diagram of time allocation]

**Figure 3: The Proposed Programme**

Comments on the Master degree came from academics, industrialists and professionals. The academics were mainly IE specialists and educators from USA, UK, Africa and Europe. Some provided prescriptions of what should be taught and some emphasized advanced courses. Comments were often at variance with one other with the most constructive criticism from highly ranked [11] institutions‡‡. A useful comment here was to check courses, once presented, to ensure that they were of adequate quality. Quality is what is produced, not what is designed. Namibian industrialists and professionals representing finance, consulting, transport, government and the engineering profession also commented. While all endorsed the need for IE, some reservation was expressed about starting at Master level.

**6 REMARKS, LESSONS, NEXT STEPS AND CONCLUSION**

‡‡ A notable exception is Dr B Emwanu’s in-depth critique from Makerere University.
As this is a single case, it does not claim to offer general conclusions. Lessons may be posed as questions when involved in similar exercises and include:-

1. Information received needs to be weighed, e.g. information that purports to cover the market from a few workshops. Alternatively examine assumptions.
2. Start with fundamentals. In designing a programme, important aspects include what words like IE mean.
3. Remember the vision, that resources are limited and designs have requirements and are constrained.
4. Concepts, e.g. design, valid for Engineering may be applicable in other areas.
5. Do not aim for perfection. Quality is not the elegance of plans but what is delivered, ultimately by graduates’ performance in industry. In addition to declarative knowledge (what is in the syllabus) add tacit knowledge and style (or manner of learning). Focus on outcomes, e.g. advantages, rather than detailed syllabi contents.

Next steps in this case include implementing the Master and designing the Bachelor programme. In implementation learning is likely to be high. The PoN needs assistance for setting professional quality levels in courses and research, and mentoring students and staff. When designing an undergraduate programme; should this start this as an elective in, say Mechanical Engineering, a full Bachelor degree, or an enhanced dual degree with Engineering and Business? Assistance here is needed with those with salient experience. Overall the need for partners is high. Many can assist with establishing a sustainable base for IE in Namibia. In turn this increases the footprint of SAIIE in Southern Africa.

7 REFERENCES

[8] ECSA. 2004. Engineering Council of South Africa PE 61/E-02-PE Whole Qualification Standard for Bachelor of Science in Engineering (BSc(Eng))/Bachelors of Engineering

§§ Staff will, more than likely, need to be upgraded to PhD level.

