Mechanical engineering academics' attitude towards graduate attributes: antecedents and a conceptual model

Tiyamike Ngonda

Cape Peninsula University of Technology
Bellville, South Africa

ABSTRACT: This study explored the relationship between mechanical engineering lecturers' attitudes towards graduate attributes and their antecedents and roles in engineering education. It used a qualitative case study approach and collected data from four mechanical engineering lecturers at a university in South Africa using audio-recorded semi-structured interviews for thematic analysis. The study found that mechanical engineering lecturers' attitudes towards graduate attributes were influenced by their perceived ease of implementation, perceived usefulness and shared understanding of graduate attributes. It was further found that the perceived usefulness of graduate attributes is related to the perceived ease of implementation and shared understanding of graduate attributes. However, no association was found between the shared understanding of graduate attributes and the perceived ease of implementation. Finally, it was found that the university-driven implementation of graduate attributes influenced the perceived ease of implementation. This study uncovered in-depth issues pertaining to academic staff's attitudes towards graduate attributes that would form the foundation of future studies. The most significant implication of this study is the need for consultation and training before adopting or when changing, learning

INTRODUCTION

Graduate attributes are the responses of universities and professional bodies to government and employers' demands for employable engineering graduates. They are individually assessable outcomes representing the qualities, skills, knowledge and attitudes students are expected to attain when they graduate from their degree programmes [1][2]. They are directly related to the professional competencies required in engineering. Therefore, although there is a distinction between the two, the development of graduate attributes is intended to prepare students for the professional competencies required in engineering. Professional competencies refer to the skills and knowledge essential for competently carrying out tasks and responsibilities associated with a specific profession or occupation according to the expected standards of independent employment or practice [2].

Graduate attributes are essential for preparing students for the professional competencies required in the workplace. The development of graduate attributes in engineering education is crucial to ensure the employability of engineering graduates. Engineering lecturers' understanding of graduate attributes is essential to their ability to instil these attributes in their students. If engineering lecturers do not clearly understand graduate attributes or their relevance to the engineering profession, they may overlook or undervalue them in their teaching. These limitations in understanding would result in graduates lacking the essential skills and attributes required for success in their future careers, thereby compromising their employability. This study explored the relationship between mechanical engineering lecturers' attitudes towards graduate attributes and their antecedents and roles in engineering education. This study was guided by two research questions.

1. What is mechanical engineering lecturers' understanding of professional body-mandated graduate attributes?

2. How does engineering lecturers' understanding of graduate attributes influence how they lecture and assess their students?

This study focuses on professional body-mandated graduate attributes instead of university graduate attributes. In South Africa, graduate attributes are mandated by the Engineering Council of South Africa (ECSA). They signal the ECSA's understanding of the competencies that engineering students need to meet and the educational requirements to register as a candidate professional in various registration categories.

South Africa has two broad categories of engineering qualifications: engineering science and engineering technology. With two exceptions, universities of technology offer engineering technology programmes. In contrast, universities offer engineering science programmes. Engineering technology programmes used to be content based. They included the National Diploma and Bachelor of Technology degrees. Since 2017, universities have recurriculated new outcomes-based engineering programmes and phased out old content-based qualifications. However, they shifted to competency-based engineering qualifications later than traditional universities and faced implementation issues. Their current programme and qualification mix (PQM) for undergraduate engineering studies includes a Diploma in Engineering Technology, a Diploma in Engineering, an Advanced Diploma and a Bachelor of Engineering Technology. A vital component of new competency-based engineering qualifications is the graduate attribute.

THEORETICAL FRAMEWORK

This study utilised the social learning theory (SLT) to investigate the influence of engineering lecturers' understanding of graduate attributes. The SLT suggests that people learn behaviour, attitudes and values through imitation, direct instruction and reinforcement [3][4]. This further suggests that individuals are more likely to emulate the behaviour of role models that are perceived as competent, prestigious and like themselves. The theory posits a triadic reciprocal interplay between behaviour, the environment and personal factors that influence an individual's learning and behaviour [3]. Thus, students learn not only from formal instruction but also from observing the behaviour of their lecturers and peers. If engineering lecturers perceive graduate attributes as valued by employers and the engineering profession, they might model those attributes in their behaviour, influencing their students' behaviour and attitudes. Students are more likely to perceive these attributes as essential and develop them accordingly. By contrast, if engineering lecturers lack a clear understanding of graduate attributes or their relevance to the engineering profession, they may inadvertently overlook or undervalue these attributes in their teaching. As a result, students may perceive these graduate attributes as less critical and may not develop them to the same extent.

RESEARCH METHODS

This study used a qualitative case study approach because of its suitability for a study focusing on complex issues in real-life settings [5]. This study chose one instrumental case to gain a broader appreciation of graduate attributes in engineering education.

Background and Context

This study focuses on the perceptions of mechanical engineering lecturers from a South African university of technology. The participants were positioned in the historical context of a content-based to competency-based curriculum shift. In addition, most participants were trained in a content-based education era. Now, they teach in competency-based curricula.

Sampling

The author conveniently and purposively selected four academic staff members from a mechanical engineering department. Two participants had taught for a long time, and their experience covered old and new engineering qualifications. The other two participants only lectured on the new programmes.

Data Collection and Analysis

The study collected qualitative data from participants using audio-recorded semi-structured interviews. The author transcribed and imported audio recordings into NVivo for further analysis, and conducted a thematic analysis following the guidelines outlined by Bryman [6].

FINDINGS

This section describes the themes that emerged from this analysis. These five themes are:

1) attitude towards graduate attributes;
2) perceived ease of implementation;
3) perceived usefulness of graduate attributes;
4) shared understanding of graduate attributes;
5) university-driven implementation of graduate attributes.

Attitude Towards Graduate Attributes

All but one respondent felt a lack of ownership, apathy and resentment towards graduate attributes. They argued that the graduate attribute contributed nothing positively to engineering education; they were a tool to police how they teach and were a bad idea from the start. Lecturer 2 summarised the lecturers' negative attitude towards graduate attributes as follows:

Academics' problems with graduate attributes were multi-layered. The number one issue is that staff do not feel included. Secondly, the administration of these graduate attributes is time-consuming. Some think this is a bad idea from the beginning. These issues result in resentment and resistance from the staff. (Lecturer 2)

Lecturer 2 added:

Staff feel insulted by the introduction of the graduate attributes because it tells us they think we are not doing what we should be. Now, they want to police us. I feel that some staff feel like that. (Lecturer 2)

When considered at face value, respondents' attitudes appear to be extreme. However, the attitudes reflect a lack of ownership. This is reflected in statements, *staff do not feel included* and *they want to police us*. This notion of *them* versus *staff* was prevalent in all the interviews. Lecturer 3 referred to *them* as *the people above*. Who was *them* changed depending on what was being articulated. In some instances, it was management; in others, it was ECSA.

Perceived Ease of Implementation

The second theme that emerged was the perceived ease of implementation of graduate attributes. There was consensus among the respondents that the introduction of graduate attributes, particularly the individualised assessment reporting that was needed, significantly increased their workload. The large classes had limited options to individualise graduate attribute assessment. For example, Lecturer 1 explained how having a large class limited his assessment of individual student's contributions to group projects:

I would have improved my assessment of the project by adding an oral presentation. But this is my dilemma. You know, I have over 100 students. The number is a problem. (Lecturer 1)

The other respondents concur with Lecturer 1, adding that this implementation of graduate attributes increased the administrative tasks load. They had to complete forms to track each student's progress and ensure that they had performed the functions that assessed the designated graduate attributes. Additionally, they had to conduct reassessments related to failed graduate attribute achievement.

In addition, the respondents found it challenging to create assessments that accurately assessed graduate attributes without compromising on other learning and teaching activities. Lecturer 4 highlighted the challenges of integrating graduate attribute assessments into existing assessment routines:

We had to figure out how to integrate graduate attributes into our assessment procedures. We had to figure out how to incorporate this without breaking what worked. (Lecturer 4)

It seems that academics have found the implementation of graduate attributes challenging and time-consuming. Large class sizes compounded this problem.

Perceived Usefulness of Graduate Attributes

Despite the implementation challenges, the respondents were generally optimistic about the usefulness of graduate attributes. First, they indicate that graduate attributes assist in closing the gap between the industry's expectations and the skills of new graduates. Second, there is the systematic inculcation of desired graduate characteristics, introduced by the concept of graduate attributes, as articulated by Lecturer 3:

The difference between the exit outcomes for the old diploma and the graduate attribute of the new curriculum is the explicitness. Graduate attributes allow use to inculcate desired characteristics win out students systematically and explicitly. (Lecturer 3)

Third, they stated that graduate attributes contributed to curriculum responsiveness. Lecturer 3 noted that the presence of a graduate attribute dealing with engineering management led to the introduction of a module on the subject. This would not have happened if it were not for the graduate attribute. Finally, they indicated that graduate attributes create awareness of the qualities, skills and behaviours that graduating students were expected to have.

Shared Understanding of Graduate Attributes

The concept of graduate attributes seems to be well understood by the participants. Lecturer 1 said that they are outcomes reflecting what a student should be able to produce upon graduating. Lecturer 2 added that they define the characteristics of a competent engineering graduate. Lecturer 3 said the students must internalise graduate attributes before they exit the university. In all explanations of graduate attributes, the respondents emphasised their relationship with competency and employability. Lecturer 2 summarised the link between graduate attributes and employability:

Graduate attributes are the characteristics that a student should have when they finish the qualification. They represent the concept that one's degree must be written back. I think you could consider graduate attributes like a competency checklist. If students do not tick all twelve graduate attributes, they will not be competent engineering graduates. (Lecturer 2)

While there was consensus on what the graduate attribute concept represents, there were differences in how the respondents thought they should be implemented, assessed, and the general value of the curriculum. Lecturer 1 believed that the best way to evaluate the attainment of a graduate attribute is to measure performance, as represented by a percentage:

There is debate on whether you indicate passing a graduate attribute as Yes or No or with a mark. In my view, it is the same. When you say Yes or No, are you right or wrong? To me, a mark is the proportion of Right or Wrong. So, if I give a student 51%, I am saying he leans more towards Right; 49% leans more towards Wrong. So, it is a balance. This Yes or No thing is superficial because everybody inherently uses a mark. (Lecturer 1)

Lecturer 2 had a contrary view:

I am aware of the debate regarding actual GA assessments. I support the staff who say that we should use Yes or No measures. You are either competent or not. It should be implemented in the same way that we are now doing the subminimum. The question is, how do you decide if it is a Yes or No? However, this requires clarification. (Lecturer 2)

On the other hand, Lecturer 4 suggested that there should not be an independent assessment of graduate attributes, as they are embedded in traditional evaluations.

University-driven Implementation of Graduate Attributes

The respondents attributed these challenges to the limitations of the introduction of graduate attributes. Lecturer 1 and Lecturer 2 concur that inadequate training constrains their ability to design appropriate assessments for graduate attributes:

The graduate attributes were not properly explained. They simply said that you must have graduate attributes. Remember, we had this thing of learning outcomes. (Lecturer 1)

Staff members were not provided with a platform to make meaningful contributions. Now, there is resentment from the staff that you forced this on us. Now, you want to hold us accountable for something we did not initially agree with. Now, we are doing it to comply, not to feel beneficial. I do not know how the process was followed, but I do not think that staff members were included in the decision-making process. The people at the top decided. It was a top-down management style, and it was not bottom-up. (Lecturer 2)

The responses suggested forced implementation with limited consultations or training. Lecturer 2 in the quotation above linked the challenges in the introduction to how lecturers perceive the usefulness of graduate attributes.

Consolidation of the Themes and the Conceptual Model

Table 1 presents the results of a matrix coding query for the themes uncovered in the study. Matrix coding shows the associations between various themes. The results suggest that attitudes towards graduate attributes are influenced by the perceived ease of implementation, perceived usefulness of graduate attributes and shared understanding of graduate attributes. The results further suggest associations between the three antecedents of attitudes towards graduate attributes, except that there is no association between the shared understanding of graduate attributes and the perceived ease of implementation. Finally, university-driven implementation of graduate attributes seems to influence the perceived ease of implementation.

Table 1: Results from a matrix coding query of the themes.

	ATGA	PEI	PUGA	SUGA	UDIGA
Attitude towards graduate attributes (ATGA)		Yes	Yes	Yes	No
Perceived ease of implementation (PEI)	Yes		Yes	No	Yes
Perceived usefulness of graduate attributes (PUGA)	Yes	Yes		Yes	No
Shared understanding of graduate attributes (SUGA)	Yes	No	Yes		No
University-driven implementation of graduate attributes (UDIGA)	No	Yes	No	No	

Figure 1 presents the associations outlined in Table 1, as a conceptual model.
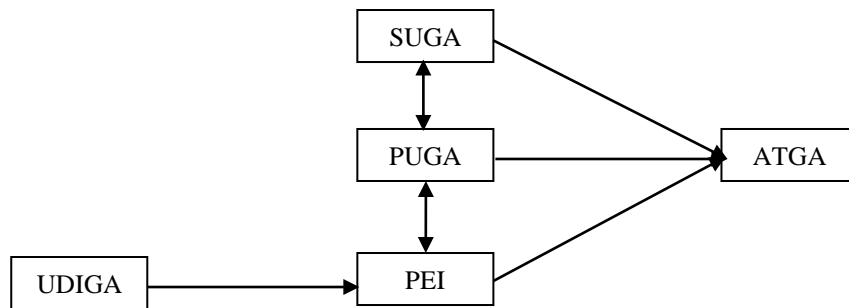
Figure 1: Conceptual model showing relationships among attitudes towards graduate attributes, perceived ease of implementation, perceived usefulness of graduate attributes, shared understanding of graduate attributes and university-driven implementation of graduate attributes.

DISCUSSION

The findings of this study suggest that academic staffs' attitudes towards graduate attributes are influenced by perceived usefulness, ease of implementation and a shared understanding of the concept. The findings of this study are consistent with the literature on the adoption of innovative behaviour. One such study was by Mo et al, who examined the factors associated with the intention to receive the Covid-19 vaccine [7]. They found that vaccine uptake was influenced by the vaccine's perceived efficacy, similar to the perceived usefulness in the present study.

Another study by Goh and Sigala on the adoption of ICT interventions in education, found similar results [8]. They found that perceived difficulty in changing behaviour influenced lecturers' attitudes towards adopted ICT innovations. It is evident from this that the implementation of graduate attributes should follow the tenets of introducing innovative behaviours. There should be an appreciation of socio-cultural contextual issues, such as dealing with the fear of change, pre-conceived notions of what engineering education is, and the pedagogical competencies needed to implement the changes.

Implications

The most significant implication of this study is the need for consultation and training before adopting or when changing, learning and teaching strategies to accommodate graduate attributes.

Limitations and Further Work

The findings of this study are indicative, rather than conclusive, because of its limitations. The sample was not representative because the participants were conveniently selected from the university department. There are limitations that apply to all qualitative studies relating to the transferability and generalisability of the findings. Despite these limitations, this study uncovered in-depth issues pertaining to academic staff's attitudes towards graduate attributes, which would form the foundation for future studies. Further studies should consider developing instruments to measure the concepts uncovered in this study. They can focus on quantitative studies to validate the conceptual model developed in this study.

CONCLUSIONS

This study explored the relationship between mechanical engineering lecturers' attitudes towards graduate attributes and their antecedents and roles in engineering education. This study used a qualitative case study approach. Mechanical engineering lecturers' attitudes towards graduate attributes were influenced by their perceived ease of implementation, perceived usefulness and shared understanding of graduate attributes. It was further found that the perceived usefulness of graduate attributes is related to the perceived ease of implementation and the shared understanding of graduate attributes. However, no association was found between the shared understanding of graduate attributes and the perceived ease of implementation. Finally, it was found that the university-driven implementation of graduate attributes influenced the perceived ease of implementation. These findings are indicative rather than conclusive because of the limitations of this study. The relationships found in this study were not definitive, as the study was limited by the lack of a representative sample. However, these findings form a foundation for future studies.

REFERENCES

1. Chalmers, D. and Partridge, L., *Teaching Graduate Attributes and Academic Skills*. In: Hunt, L, and Chalmers, D. (Eds), University Teaching in Focus: a Learning-centred Approach. Camberwell: ACER Press, 56-73 (2012).
2. IEA. Graduate Attributes and Professional Competencies (2021), 11 May 2023, https://www.ieagreements.org/assets/Uploads/IEA-Graduate-Attributes-and-Professional-Competencies-2021.1-Sept-2021.pdf

3. Bandura, A., *Model of Causality in Social Learning Theory*. In: Freeman, A., Mahoney, M., Devito, P. and Martin, D. (Eds), Cognition and Psychotherapy. New York: Springer (2004).
4. Bandura, A., *Social Foundations of Thought and Action*. Englewood Cliffs: Prentice Hall (1986).
5. Yin, R.K., *Case Study Research and Applications: Design and Methods*. Thousand Oaks: SAGE (2018).
6. Bryman, A., *Social Research Methods*. Oxford: Oxford University Press (2016).
7. Mo, P.H., Luo, S., Wang, S., Zhao, J., Zhang, G., Li, L., Li, L., Xie, L. and Lau, J.T.F., Intention to receive the Covid-19 vaccination in China: application of the diffusion of innovations theory and the moderating role of openness to experience. Vaccines, 9, **2**, 127 (2021).
8. Goh, E. and Sigala, M., Integrating information & communication technologies (ICT) into classroom instruction: teaching tips for hospitality educators from a diffusion of innovation approach. *J. of Teaching in Travel & Tourism*, 20, **2**, 156-165 (2020).

BIOGRAPHY

Tiyamike Ngonda graduated with a Bachelor of Science in mechanical engineering (with distinction) from the University of Malawi in 2001, Master of Engineering (with distinction) from the University of the Witwatersrand in 2004 and Doctor of Philosophy from the University of Cape Town in 2020. Dr Ngonda is a professional mechanical engineer registered with the Engineering Council of South Africa. He has worked as a lecturer at several universities in Southern Africa. He is currently a senior lecturer in mechanical engineering at Cape Peninsula University of Technology, South Africa. Dr Ngonda has published in peer-reviewed journals and conference proceedings. His research focuses on engineering education, thermodynamics, renewable energy and materials science.