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Development of Graduate Attributes in Civil Engineering in DIT - Provisional Methodology

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Development of Graduate Attributes in Civil Engineering in DIT

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1 Introduction

As a primary research area, I am interested in how the structure and content of DIT Civil and Structural Engineering programmes, along with their delivery and development, results in nurturing graduate attributes such as self-management, effective communication, interpersonal and teamwork competence, problem-solving, innovation, adaptability, and integration of skills (technical and soft skills). Delivery methods must reflect modern teaching practice and engage students. Effective pedagogical practices suggest that a learning environment conducive to promoting engagement and learning has characteristics such as autonomous activities, stimulation and challenge, discovery and error facilitation, critical thinking and responsiveness to individual need (Swann, 2012).

The intended contribution to be made by this body of research is in relation to graduate attributes in Civil and Structural Engineering in Ireland and offers to add to literature on operationalising graduate attribute development. Specifically, I am interested in the identification of attributes or skills sought by industry/employers, how these skills are delivered to students, and how the level of success of delivery might be measured. As argued by Wang (2015, p. 1551), higher education “has a responsibility to help students develop positive attitudes and dispositions to prepare them for the unpredictability of life” and to “introduce the student to a space of strangeness, and create learning opportunities that facilitate accepting strangeness.” Input from industry/employers is key to understanding the attributes required in our graduates. Examples of skills which are included in some of my current modules are project management, financial management, and integration of various technical areas (e.g. concrete design, environmental considerations etc.).

My role as 3rd year Level 8 Civil Engineering tutor gives me unique access and responsibility for development of graduate attributes of our Civil Engineering students. Upon entering Third year, these students are in year which can afford the time to practice news integration of skills gained in other modules, without the pressures of final year. The ‘learning curve’ for skills integration (i.e. Project management, financial management, application of technical skill) can be lengthy and I believe in order for students to gain the most from their final year, and so graduate with these skills firmly embedded, integration must begin in third year. This, however, is only one example of where this type of integration could be introduced.

Subsequent to delivery, to be considered effective, it is essential to have a methodology to measure if students can demonstrate the attributes which the programmes are designed to deliver. While learning outcomes are assessed, graduate attributes are not typically measured or recorded during studies. One example cited in Fallows and Steven (2000, p. 191) suggests that in addition to learning outcomes, including a matrix of key transferable skills, their practice and assessment would help in making graduate attribute development explicit for students, teaching staff and employers.

2 Research Questions – Conceptualisation and Context

2.1 The Questions

Question 1: What is the student experience as they participate in knowledge during the Design Project, particularly in relation to development of Graduate Attributes?

The intent behind this question is to examine the module and its effectiveness from the perspective of those taking the module, the students. It is postulated that the transformative experience will result in development of relevant graduate attributes.

Question 2: To what extent do delivery and assessment within this module contribute to the development of Graduate Attributes?

The intent behind this again is to more closely examine how the module's current design, content, delivery and assessment contribute to development of Graduate Attributes. The intended research approach to be applied here is evaluation. This part of the study is also intended to identify areas which might require revision in order to optimise development of Graduate Attributes. This revised version of the module would then be re-evaluated in a second run in the academic year 2019/2020.

2.2 Conceptualisation

2.2.1 Literature

Simon Barrie has written extensively on the subject of graduate attributes. In his 2012 paper regarding a research-based approach to generic graduate attributes, he discusses the issues with the lack of cohesive definitions of what constitutes graduate attributes. Research conducted in Australia has shown that there is also a lack of knowledge amongst teaching staff as to what teaching and learning practices might facilitate the development of graduate attributes. It is intended that this study would contribute to the dearth of knowledge in this area by investigating the views of the students along with how delivery and assessment contribute with the module under study. Ahern et al (2012) have also studied this in an Irish context with similar findings. That study investigated attitudes towards the concept of Critical thinking across a range of faculties e.g. engineering & social sciences, with a variety of responses received. Interestingly, that study noted that while all faculties valued the concept, the “technical” faculties such as engineering were less well able to define what they considered actually defined critical thinking. In contrast, the social sciences, perhaps more used navigating more nebulous concepts, were better able to give a definition of the concept.

2.2.2 Defined Graduate Attributes

2.2.2.1 Institute-Linked

Dublin Institute of Technology has developed an agreed set of graduate attributes to be developed throughout all programmes in the Institute. They are as follows:

Engaged	Effective	Enterprising	Enquiry-Based	Expert
Global Citizen	Emotionally Intelligent	Innovator	Critical Thinker	Disciplinary Knowledge
Ethical	Active team player	Collaborative worker	Problem Solver	Work based / work related learner
Motivated self-starter	Strategic thinker	Entrepreneur	Creator of New Knowledge	Reflective Practitioner
Excellent Communicator	Resilient	Leader	Decision Maker	Digitally literate

Table 1: DIT Graduate Attributes, headings and subheadings (<http://www.dit.ie/teaching/graduateattributes/overview/>)

2.2.2.2 Accreditation-Linked

The International Engineering Alliance, the global organisation which coordinates agreements between national engineering accreditation bodies (IEA, 2018), has defined graduate attributes as they should be reflected in the programme outcomes of the varying national accreditation bodies. As these programme outcomes in turn shape the learning outcomes of the varying accredited engineering programmes, the definitions of the various graduate attributes stem from the IEA. Excerpted below are the definition of some of the graduate attributes required by IEA.

Graduate Attribute Profile	
Differentiating Characteristic	Interpretation for Engineering graduates (Level 8, BEng)
Problem Analysis: Complexity of analysis	<i>"Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions..."</i>
Design/ development of solutions: Breadth and uniqueness of engineering problems i.e. the extent to which problems are original and to which solutions have previously been identified or codified	<i>"Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations"</i>
Investigation: Breadth and depth of investigation and experimentation	<i>"Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions".</i>
Modern Tool Usage: Level of understanding of the appropriateness of the tool	<i>"Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations"</i>
The Engineer and Society: Level of knowledge and responsibility	<i>"Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems"</i>
Environment and Sustainability: Type of solutions.	<i>"Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts."</i>

Table 2 Grade Attribute definitions, adapted from IEA, 2013, pp 10-11

Engineers Ireland are the national accreditation body and their accreditation requirements map to those of the IEA. There is a cyclical process of accreditation on all engineering degrees in the Dept. of Civil and Structural Engineering in DIT and as such, the need to adequately demonstrate that they are being delivered as part of our programmes is ever present. It should be noted here that an engineering programme which is not accredited by Engineers Ireland is unlikely to attract students, as graduate options for employment would be hampered; so achieving accreditation is of crucial importance. The purpose of this study is not only to aid in achieving the requirements of accreditation however, but to better equip our graduates for professional life, and to better demonstrate that it is being achieved in Design Project.

It will be integral to this research as to how graduate attributes are defined. The starting point from this will be the above two sources of information. However, it is also intended to survey industry/employers as how they understand or define the attributes listed above so as to better determine if what is being developed in the classroom is what is sought by industry/employers.

3 Research Design

3.1 Overview – The “Layer Cake”

The research design process requires not only that a research question (or questions) be identified but also that deeper questions are addressed, such as what methods will be used and how these methods are chosen, justified and explained (Crotty, 1998). Referred to as the research methods “Layer Cake” (Loxley, 2017), the layers aim to explain the author's biases and justification for the design of the research, the methods chosen and how data might be interpreted. The layers of the “cake” address differing levels of detail from the very nature of existence all the way to the data collection instruments and data analysis. A broad idea of the relationship between layers is presented in Figure 1. The “what” of this study will be discussed in later sections, while the “how” (and “why”) will now be considered.

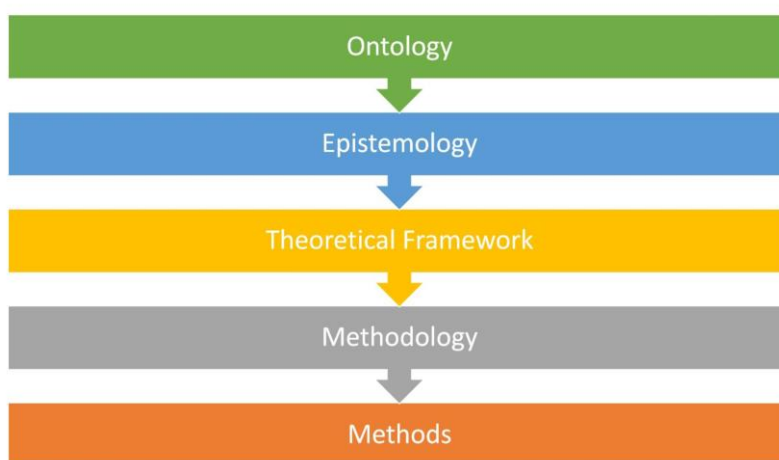


Figure 1 The Methodological Layer Cake (adapted from Crotty, 1998)

Design of research at this level requires consideration of aspects such as ontology and epistemology. Ontology is the question of what knowledge is, while Epistemology is the question of how knowledge is created.

The researcher’s perspective is interpretivist in that the nature of reality of knowledge is constructed contextually and subjectively. So, knowledge is not absolute, but is instead created during the process of learning, an epistemological viewpoint known as constructionism. In the case of this study, the author considers that this knowledge creation occurs when learners participate in the creation of knowledge with others, either peers, teaching staff or others, a version of constructionism known as social constructionism (Cohen et al, 2018). Cohen et al, (2018) goes on to on to on discuss this concept, saying that as social constructionism focuses on the social nature of learning, certain learning only occurs through social interaction. The module to be investigated in this study is one in which students work together in groups with guidance and input from teaching staff, to achieve learning outcomes, aligning with the concept of social constructionism. This In the case of this doctoral study, knowledge will be created by interpretation of the qualitative data collected from the participants in the study i.e. students, teaching staff, employers etc.

In addition, biases and viewpoints of the researcher must be elucidated so as to understand how they may impact on the design process and interpretation of data later during the research process. This can be termed the paradigm (Cohen, 2018), theoretical framework/perspective/lens (Crotty, 1998) or sometimes worldview (Creswell, 2009). As Crotty (1998) mentions, assumptions about reality and

knowledge go to the heart of how a researcher designs their research process. These assumptions should be clear, not hidden, so as to highlight potential bias and influence in the research work and findings (Duffy, 2016)

As discussed by Cohen et al (2018, p9), the use of the paradigms within educational research are not without their controversy in their application and use. Cohen discusses the idea that the various paradigms identified by various researchers e.g. interpretive, critical and so on, need not be the main drivers in educational research. Indeed, in her paper on the use of theory in Action Research, Zambo, (2014), discusses whether theory is even used by certain educational researchers. While this paper discusses a research method rather than a paradigm or theoretical framework, it helps to illustrate the point that, for practitioner-researchers, theory can seem abstract and unintuitive, unrelated to the resolution of issues and problems facing them in their classrooms. However, Cohen (2018) goes on to discuss the point further, commenting that these paradigms can be used to clarify or give structure instead of being considered absolute or discrete from one another.

3.2 Causation

Following on from the points made in the preceding section, it would now be appropriate to discuss the concept of causation. Cohen et al (2018) states that the concept of causation as being something that is “hard-wired” into humans’ brains, but that is difficult for those working in education research to apply in their research. Indeed from this researcher’s ontological and epistemological stance, causation is demoted by the agency of students as they shape the development of graduate attributes through their interaction with context and others as they engage in their learning activities. Education in practice occurs in the ‘real world’ and as such, is influenced by a multitude of factors and variable, unlike the controlled environments of many research constructs. Later, Cohen et al (2018, p. 94) discusses the fact that causes are rarely, if ever, single in nature as are effects. Instead, multiple causes result in multiple effects. This has relevance in the section of this document regarding evaluation and the difficulties in determining a straightforward policy recommendation from a study as each educational environment, e.g. a module, a classroom, a university department, is different.

Cohen et al (2018) lists some questions of use for the novice researcher to consider when designing research. As the goal of the doctoral study is eventually to determine changes required (if any) to the Design Project module, it would be prudent to review these questions posed by Cohen et al (2018).

They are as follows (adapted from Cohen, 2018, p. 87 & 99):

- Does research seek to establish causation? Why?
- What constitutes a cause and what constitutes an effect?
- What constitutes evidence of the cause and evidence the effect?
- What methodology will be used to investigate causes of effects?
- What data would be needed to show causation?

These issues and how they might be addressed is of relevance to this doctoral study, as mentioned above, as I intend to use to findings to support the need for change within the Design Project module. The correct identification of causation, if any, as in what ‘causes’ the students to develop relevant Graduate Attributes, is at the heart of this study. The investigation into the transformative learning journey of the students is likely to demonstrate that there a multitude of variables inputs in outside of the research sphere of this study (the Design Project classroom) that influence the extent to which students develop these attributes. It will be one of the challenges of the study to tease out those within the classroom and outside it.

3.3 A note on Quantitative vs Qualitative

It is intended that this study will be qualitative, which Hammersley (2013, as cited in Cohen, 2018 p287) defines as:

“a form of social inquiry that tends to adopt a flexible and data-driven research design, to use relatively unstructured data, to emphasize the essential role of subjectivity in the research process, to study a number of naturally occurring cases in detail and to use verbal rather than statistical forms of approach.”

This definition highlights the aspects of this research that then align my perspectives within the ‘methodological layer cake’, that I will interpret the data to create knowledge regarding the experience of the students in their development of Graduate Attributes as part of the Design Project module. Additionally, data collection techniques will be verbal (e.g. interviews) or written (journals, surveys etc.) as opposed to numerical or statistical as would be expected in a quantitative study.

Taking a qualitative rather than a quantitative approach to data collection allows deep insights into the lived experiences of student participants as they progress on their learning journeys. In contrast a quantitative approach tends to hide those lived experiences to provide only objective data. Rather, the anti-positivist qualitative perspective assumes the subjective accounts of participants as constructing knowledge from interview narratives. The inductive logic of an interpretivist perspective furthermore favours a qualitative approach that allows faithful interpretation of meaning as related by participants. Contrastingly a positivist quantitative paradigm lends itself to uncovering causal relationships and hypothesis testing that may make invisible the lived experiences of participants.

4 Research Methodologies

Research methodologies help to define the research methods chosen, including data collection instruments (Crotty, 1998). Two research methodologies are presented in this document, each of which will be used in different parts of this doctoral study.

4.1 Data Collection

4.2 Data Analysis Framework

Analysing the collected data involves interrogating and coding interview narratives. From an interpretivist perspective and in line with the researcher’s ontological stance, data analysis is an iterative and recursive process that codes, categorises and compares the data throughout the research. Interpretation is inductive rather than deductive to make the respondents’ voice visible throughout the research. Approaches such as grounded theory analysis or thematic analysis promise to provide insights and understandings as to how and why student participants develop graduate attributes as they participate in their studies. Analytical approaches adopt systematic yet flexible techniques to on the one hand, maintain authenticity in abstracting data and on the other hand to assure robustness of process.

4.3 Data Interpretation Conceptual Framework

4.3.1 Research Question 1 – Transformative Learning

With regard to research question 1, a Transformative Learning perspective is proposed to interpret the narrated experiences of students as they engage in the programme module. It is an aspect of transformative learning that learners reflect on experience within a construct and create a new way of defining their world. Mezirow (2009, p. 92) defines transformative learning as

the process by which we transform problematic frames of reference (mindsets, habits of mind, meaning perspectives) – sets of assumption and expectation – to make them more inclusive, discriminating, open, reflective and emotionally able to change. Such frames are better because they are more likely to generate beliefs and opinions that will prove more true or justified to guide action.

Frames of reference encompass two broad dimensions – habits of mind and resulting points of view. Habits of mind is an abstract, habitual and orienting way of thinking, feeling and acting that is influenced by social, cultural, linguistic, moral and educational codes. The resulting and evolving points of view are guided by beliefs, feelings, attitudes, judgements and expectations arising from changing habits of mind and articulated in particular perspectives (Mezirow, 2009).

Within educational practices, transformative learning is seen as “teaching for change” (Mezirow and Taylor, 2009, p. 3). Such an approach is premised on the idea that as students are challenged to assess their expectations and assumptions as they engage in educational activities, their habits of mind and perspectives are changed by the experience. In seeking insights into how individual students experience their educational engagement, interpreting their narrative accounts through a transformative lens offers to provide understanding of how students critically reflect on their learning activities, how they experience the transformative journey and how interaction with others (peers, lecturers and others) shape developing habits of mind and perspectives

4.3.2 Research Question 2 - Evaluation

With regard to research question 2, on the design, content, delivery and assessment contribution to development of Graduate Attributes, it is intended that a evaluative methodology will be employed.

Qualitative evaluation of programmes has increased in importance of late due to increased accountability, desire for transparency in funding, and application of evidence-based practice (Patton, 2015). Patton states that in such charged environments as educational funding, qualitative evaluation provides the evidence required to validate evidence-based practice.

Programme evaluation is separate from routine programme management; in the case of this study, routine programme management would involve tracking student numbers, absenteeism, participation submission of assessments and pass/fail rates. Instead programme evaluation considers why a particular result has occurred.

Evaluation research is linked with policy making (Cohen et al, 2018). However, the identification of what works, in terms of intervention in programmes or policies, requires examination of a large number of variables and interactions, which may interact in unforeseen ways. As Cohen et al (2018) discuss, this can frustrate policy makers (and decision-makers) as linkage between what works in programmes and what policy conclusions can be drawn from ‘what works’ may not always apply to every programme.

Key questions for evaluation concern the following (adapted from Pawson, 2013 as cited in Cohen, 2018):

- What parts of a programme are working?
- Why do these parts work?
- For whom, i.e. from whose perspective, are they working?
- Under what conditions and circumstances do they work?
- What is the time period considered?

Key to appropriate methodological choice in programme evaluation is the extent to which the findings can be used for programme improvement. With this in mind, a pragmatic approach to qualitative enquiry could be suitable for this evaluation. Patton (2015) states that pragmatism can help in the practical understanding about real-world issues. In fact the information gleaned using the approach can inform further action and as such, this approach is closely linked to the use of action research.

4.4 Data Collection Instruments

A wide selection of data collection methods are available for qualitative research, each with pros and cons in relation to what they convey and how their use might influence the information collected.

Below is a selection based on Creswell, 2009. This table is not meant to be comprehensive. Further consideration will be needed before final selection, based on the needs of the research questions.

Data Collection Type	Variations	Advantages	Disadvantages
Interview	One-on-one, Focus groups	Immediate information researcher is present (first hand record) Researcher can exercise control over questioning	Difficulty in getting participants, Researcher is present (influences information)
Observation	In the field, in focus groups	non-verbal information can be noted, Researcher can observe in field setting, while class is underway	Researchers presence may lead to bias.
Documents	Surveys, Journals, blogs	Researcher has a record in the words of the subject, (not filtered through researcher's note-taking) Written evidence	Poor response rate, Subjects may not take time to respond comprehensively, leading to sparse data, Evidence gathered in hard copy only.

Table 3 Data Collection types in Qualitative Research, selection based on Creswell (2009), and chosen in relation to what could be used in this doctoral study.

5 Reflexivity and Ethics

Bryman, (2008) defines reflexivity as being the term used when referring to the process by which social researchers reflect on the implications of the biases, methodological choices, values, and 'mere presence' they carry with them into their research and the knowledge generated from this research. Creswell (2009) states that qualitative research is interpretive research, so from this is easy to see how the aspects mentioned by Bryman (2018) would impact on research and the knowledge and conclusions generated. This is especially pertinent in relation to the discussion upon causation in Section 3.2 above.

As with the idea of the theoretical framework, which can give insight into the researchers own worldview, the reflexive process, when carried out effectively, will help the researcher elucidate these influential aspects. In the case of this doctoral study, this is of particular importance as the subjects in the research process are my own students.

It is appropriate therefore to give a clear account of the context of any past experience that I have with would be relevant to the study. Multiple strategies of validity (Creswell, 2009) can be used to

ensure that research is accurate. Ethical processes and clearances should be clearly explained, including the process of any ethical approvals required. The researchers role in and out of the research should be carefully explained and any conflicts highlighted.

Creswell (2009) discusses the following steps suggested by Bogdan and Biklen (1992, as cited in Creswell, 2009) as topics to consider for inclusion in the preparation for the research. I have addressed these concerns with regard to this doctoral study, after each question.

Questions (Bogdan and Biklen, (1992)as cited in Creswell, (2009))	Responses in regard to this doctoral study
Why was this site chosen?	Site: Design Project Module; Why: the purpose of this module is to emulate professional practice and help students develop Graduate Attributes required for their work as professional engineers. In addition, I am personally involved in the class and want to make sure it is achieving this goal in a verifiable manner.
What activities will occur?	The research will involve querying the students as they progress through the module, to determine how they are developing Graduate Attributes. This querying process will involve observations, reflection, interview and focus groups intermittently throughout the module.
How will the study be disruptive?	It is my aim that the study is of minimum disruption to the normal practice of the class. Participating students will complete their class assignments as non-participating students do. However, there will be additional input required from participating students by way of participation in interviews and focus groups.
How will the results be reported?	At this stage of the research, it is intended that results would be reported back into teaching staff to enable improvement of the module.
What will the gatekeeper* gain from the study?	Gatekeepers will gain improvement in validity and justification for a module which is already highly regarded by the accreditation body, Engineers Ireland. In addition, the module will, ideally, better prepare students for a similar module in 4 th year, Scheme Design, and subsequent to graduation, employment. This reflects well on the Dept. and ideally increases attractiveness to future students.

*Table 4 Reflexive Aspects to be considered in this doctoral study. *In relation the concept of the gatekeeper, in this reference it refers to those at the research site who allow the research to be done and control the site (Creswell, 2009). With regard to this doctoral study, this would refer to the ethical approvals committee of DIT and the management personal of the Dept. of Civil and Structural Engineering.*

Lastly, ethical issues which may arise will need to be addressed, again giving transparency to the process. As previously mentioned, in this study, the practitioner-researcher (the author) is also the lecturer in charge of the module under study. This gives flexibility, but it also presents an ethical conflict as I am responsible for assessing the student's work and allocating marks. The ethical issues here are two-fold (at least!). Firstly, my role as assessor may prevent the students who are participating in the study from feeling they are free to answer questions or interviews in an honest fashion. They may feel that negative responses will impact on their final mark or that over-positive

answers may improve marks. One way to circumvent this issue would be to conduct interviews after the grading process has been completed. An alternative would be to request oversight of the grading process by another member of staff. As this module is co-delivered between myself and another lecturer, this may be a practical option. Or both options may be employed. Alternately, anonymous surveys could be used to gather feedback before the end of the grading process, with interviews then conducted afterwards.

The second potential ethical consideration relates to research question 2, how does delivery of the module contribute to development of Graduate Attributes in the students. This obviously relates directly to my own work as the deliverer of the module. If feedback from the students on the topic is negative, there could be the inclination to downplay these findings, as it could be seen as a reflection on my own work or even jeopardise my position on the module. It will be important to be transparent during this data collection phase, again possibly enlisting other staff members in data collection so as to avoid bias. Further consideration is required here to find a solution that does not add unduly onto other staff members' workloads, while still providing transparency and accountability.

6 Conclusion

The intention of this doctoral study is to investigate the development of graduate attributes in the Design Project module in third year of the Level 8 Civil Engineering programme in DIT. Two research questions are proposed, one concerned with the content, delivery and assessment of the module and one concerned with the student's perspective on their development during the module. As such two research approaches are proposed, an evaluation through pragmatism which addresses the content, delivery and assessment question and a transformative learning approach which will address the student experience question.

This is a qualitative study in which the researcher states an interpretivist stance in which knowledge will be created through the interpretation of data collected from participants.

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