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Constructing the Bourdieusian field of engineering education: Engineering education transformation as a field phenomena

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Abstract: *We propose to express engineering education as a Bourdieusian field. For engineering education to be considered a field distinct from higher education, specific capital and specific logic for pursuing and gaining that capital needs identifying. Bourdieu suggests that information on capital and specific logic of a field can be obtained through observing the trajectory of that field. In this research, the trajectory was the recent historical transformation of engineering education. Drawing from documentation of engineering education changes over the period 1980-present, we give evidence that engineering education is a field with specific capital, informed by and responding to industry, with implicit rules. We argue that viewing engineering education as field allows for exposure of the positions of engineering education participants related to their capital or power. This exposure facilitates analysis of issues of practice in engineering education.*

Keywords: Bourdieu, field, transformation

Introduction

Engineering education research quality- the role of theory

Qualitative approaches in educational research include established methods of data collection and analysis selected on the basis of articulated theoretical and epistemological positing of research design. Engineering education research (EER) has emerged and rapidly evolved as a discipline only relatively recently (Jesiek, Newswander, & Borrego, 2009; Lohman, 2008) with global capacity in EER fostered through initiatives supporting development of a collaborative, internationally connected EER community (Williams & Wankat, 2016). Unlike well-established educational research, which had clear foundations in relevant theory, theoretical perspectives (learning, social, psychological and pedagogical theory) and linkages to research design were often found to be missing in early EER (Streveler & Smith, 2006). The maturation of EER has also seen researchers grapple with the scientific authority of quantitative and statistical methods "which can provide an aura of trustworthiness" (Koro ljungberg & Douglas, 2008, p. 172). Geographically aligned methodological differences in educational research approaches can both compound and inform the definition of EER quality (Borrego and Bernhard, 2011). In the US, the method driven research tradition is evidenced by a paucity of qualitative research, and the trend for publishing empirically evidenced research (Borrego & Bernhard, 2011; Koro ljungberg & Douglas, 2008). It maybe supposed that this early 2000's paucity is now reversed; yet as recently as 2014, despite an increasing number of qualitative research papers submitted to JEE, a high number were rejected (Baillie & Douglas, 2014). Baillie & Douglas (2014) suggested the juxtaposition of engineering and social sciences research cultures contribute to confusion over how to assess quality of engineering education research and, in the case

of JEE, leads to the rejection of research which conform to an engineering culture of positivism.

In order to enhance the quality of qualitative research Baillie and Douglas (2014, p. 6) exhort researchers to move beyond a thematic analysis and "include the epistemological stance taken, the methodology and methods used, the role of theory, and the relationships among all of these". In a similar vein, EE researchers call for explicit and consistent application and articulation of the theoretical perspective for quality in EER (Borrego & Bernhard, 2011; Borrego, Douglas, & Amelink, 2009; Case & Light, 2011). The well-argued need for a theoretical positon to inform EER design and practice led the first author to an exploration of relevant theoretical perspectives in their doctoral research.

Bourdieu's social theory of practice

One such relevant social theoretical perspective, the 'theory of practice', by French sociologist Pierre Bourdieu (Bourdieu, 1977) has been used and continues to be useful in education research (Grenfell & James, 2003; Murphy & Costa, 2016). In addition, Bourdieu himself undertook research in education (Bourdieu, 1988; Bourdieu & Passeron, 1990). The theory of practice has three core concepts; field, capital and habitus that are introduced briefly here, before proceeding to focus on field for this discussion. Explaining the theory of practice, Bourdieu refers to a field as a social arena of practice characterised by specific capital (that thing of value) and specific logic (rules) to obtain that capital, where agents try to acquire capital by playing by the rules of the field, bringing to the field their own habitus (learned behaviour) (Bourdieu, 1990). Bourdieu also refers to field "[a]s a space of potential and active forces" and as a site of conflict or struggle; where agents compete to transform or preserve the configuration of these forces (Bourdieu & Wacquant, 1992, p. 101). The other concepts of capital and habitus can be understood through the following authors' interpretations:

Anything may count as capital that is afforded, however tacitly, an exchange value in a given field, and thereby serves both as a resource for action and as a "good" to be sought after and accumulated. The implication of this is that forms of capital are multiple; each field defines its own species of capital. (Crossley, 2001, p. 87)

Simply put, habitus focuses on our ways of acting, feeling, thinking and being. It captures how we carry within us our history, how we bring this history into our present circumstances, and how we then make choices to act in certain ways and not others. (Grenfell, 2008, p. 52)

What is of interest in this paper is Bourdieu's demonstration of the composition of the field (the structure of the field) which is defined by the objective positions that agents (actors, participants) can take in the field (Bourdieu, 1993). The positions depend on different kinds of capital that are active and recognised by the field (Grenfell, 2008).

Mendoza, Kuntz, and Berger (2012) succinctly explain Bourdieu's (sometimes inconsistent) positioning of education as a field, a competitive arena with varying, relative positions of participants, including academics, determined by academic, scientific and intellectual capital. Academics' shared understanding of norms, or habitus, is informed by socialisation and habitus is in turn shaped by access to capital and shapes capital: "Capital and habitus come into play within a specific field, because that field and its specific logic dictates in what ways different amounts and types of capital can be used for competitive advantage."(Mendoza et al., 2012, p. 560)

Bourdieu's theory of practice and engineering education research

The three concepts of field, capital and habitus, have been used sparingly in engineering education research, for example, Devine (2012) used the notion of habitus to understand students' behaviour whilst Kloot and Rouvrais (2017) used field and capital to help explain the South African context of engineering education. Mendoza et al. (2012) argued against Delanty's (2001) criticism that Bourdieu's theoretical framework was inadequate to deal with

complexities of contemporary academic capitalism (evidenced by commercialisation, industry-academia collaborations and funding, spin offs and patents) by applying concepts of strategy and habitus. Very few others have used all three concepts of field, capital and habitus, and the secondary concepts that developed from them such as conflict or competition and strategy (Jolly, 2016; Kloot, 2011).

Proposing engineering education as a field

While previous studies have applied Bourdieu's concepts in EER and some (Jolly, 2016; Kloot, 2011) have tried to establish the field of engineering education, a challenge seems to be differentiating the capital and specific logic (implicit rules) that are unique to the field from its influencing fields of higher education and industry. This paper proposes to construct engineering education as a field with specific capital and specific logic.

Research questions

In order to construct engineering education as field distinct from higher education, two research questions are therefore posed:

- What is the specific capital of engineering education?
- What is the specific logic around pursuing that capital?

The capital and logic of the field can be understood by observing occurrences in the field, which is, what the main actors within it are doing, and how they are doing what they do. These occurrences can be obtained from the trajectory of that field, which is best observed through the changes or transformations that have occurred in a field (Grenfell, 2008; Kloot, 2011). The aim is to establish the existence of specific capital and the specific logic associated with engineering education, opening up the prospect for using Bourdieusian concepts of field, capital, and habitus to provide a theoretically grounded interpretation of issues of engineering education that are related to socio-political contexts such as the current doctoral research study of the first author.

The doctoral study explores the argument that the existing discourse on developing global engineers is founded on the Global North perspective of what engineering education is. The abundant literature available on globalisation of engineers does not speak from the reality of engineering education that exists in most Africa countries, although it contains a few contributions from Africa. Using Tanzania as a case of Africa, the doctoral study seeks to contribute an African perspective of engineering education, analysing challenges and opportunities of adapting the existing discourse to the context. A critical review of literature, undertaken for the doctoral research, found that intertwined issues of globalisation and accreditation embedded in engineering education are subject to power inequities and struggle in the African context in relation to the Global North where the discourse originates (Matemba & Lloyd, 2017). This highlighted the need to expose the structure of engineering education and an exploration of Bourdieu's theory for sense-making of the doctoral research data and context.

Bourdieusian notion of field

It is useful to consider a field as a hierarchical system that recognises some objective positions that agents and institutions can take up according to the amount and type of capital they possess (Naidoo, 2004; Webb, Schirato, & Danaher, 2002). For example the higher education field recognises, establishes and maintains hierarchies of academic positions; professors, senior lecturer, assistant lecturer and tutor. Each of those positions in the university is defined and attained by the amount of capital; such as contribution to and profile in the profession and discipline (intellectual capital), record of research and publications (scientific capital), and the generation and control of teaching, research and financial resources (academic capital). The university and departmental organizational fields also reward those positions in different ways and academics strategize to attain those positions

by following rules of the field or its specific logic, such as by acquiring a PhD and research grants, publishing in particular journals and increasing citations. Those positions however, are not equal across intuitions although intuitions may have the same descriptors or titles of positions; as Bourdieu and Wacquant (1992) explain- the positions are objective but also relative:

In analytic terms, a field may be defined as a network, or a configuration, of objective relations between positions. And these positions are objectively defined, in their existence and in the determinations they impose upon their occupants, agents or institutions, by their present and potential situation (situs) in the structure of the distribution of species of power (or capital) whose possession commands access to that specific profits that are at stake in the field, as well as by their objective relation to other positions (domination, subordination, homology, etc.). (Bourdieu & Wacquant, 1992, p. 97)

For example, a professorial position at a small regional institution is not the same as one at a large state university, or similarly, position differentials occur between research-intensive and applied-research institutions of technology. This network of objective relations between positions that Bourdieu and Wacquant (1992) talk about here, is what is significant in the field notion. These positions are defined by what individuals need to do to access those positions, and what tenants in those positions are expected to do. Also within a field there are dominant capital (capital that is active in the field) and those who possess this play a leading role in the functioning and transformation of the field:

The principle of the dynamics of a field lies in the form of its structure and, in particular, in the distance, the gaps, and the asymmetries between the various specific forces that confront one another. The forces that are active in the field - and thus selected by the analyst as pertinent because they produce the most relevant differences- are those which define the specific capital. (Bourdieu & Wacquant, 1992, p. 101)

Methodology

To address the research questions, the authors conducted desk research to seek the occurrences in engineering education, which is, what the main actors within engineering education are doing, and how they are doing it. These occurrences were obtained from the trajectory (changes or transformations) of EE from the 1980s to the early 2000s, a period of transformation in engineering education with significance to the Global North discourse of engineering education and accreditation, and the emergence and evolution of EER.

Occurrences were obtained through a comprehensive exploration of literature on the transformation, history, evolution, or development of engineering education. The literature searched included journal and conference articles, discussion papers and editorials, and documents from: EE specific journals including the Journal of Engineering Education, European Journal of Engineering Education, International Journal of Engineering Education and the Australasian Journal of Engineering Education; conference proceedings including IEEE Frontiers conference and the Australasian Association of EE conferences; and organisations' documents including reports, accreditation criteria and guidelines (Engineers Australia, American Society of Engineering Education, etc).

The literature was selected from the search if it informed or interpreted the trajectory of the field, this included previous reviews of engineering education trends. Relevant references found in the selected literature were also searched for and added to the data if they provided additional information on trajectory phenomena. The literature was curated in the qualitative research tool Nvivo11 and coded starting with concept-driven coding (Richards, 2009) where data was coded into pre-set main categories of 'capital' and 'logic', and then moved to data-driven coding where data in the main categories was coded iteratively to create sub-themes. In the process two new categories 'agents' and 'influence' developed and were included in explaining the field's distinction. The data collection is currently ongoing until saturation is reached, but the following are the developing findings.

The distinction of engineering education as a field

Engineering education agents

Engineering education under scrutiny in this research is higher education that focuses on training of engineers. In this area of practice we see people (individuals, organisations or institutions) such as academia, industry and professional community, involved because of their interest and stakeholder vestment in developing engineers - in particular, engineers who demonstrate the knowledge and attributes for entry to the profession (Sheppard, Colby, Macatangay, & Sullivan, 2006). In Bourdieu's terms, engineers, professional bodies, accreditors and academics, may be defined as agents who participate in the field of engineering education.

The transformation literature shows that agents have debated about what should be taught, who should be taught and how it should be taught- curriculum and methods of teaching- and these debates have been significant in the trajectory of the field (Froyd, Wankat, & Smith, 2012; Seely, 1999).The debates in Bourdieu's terms can explain that the field of engineering education contains agents who are contending to define what is capital and how to obtain that capital as they try to improve their own position. They also appear to be playing by some implicit rules or following a certain logic that the field is made up of, for example, adhering to accreditation, transforming to outcome–based education and engaging in EER.

Influence of higher education and industry on field

The training of engineers, through history, has come to a place where it sits within the academy (the university or polytechnic) but operates according to its own set of rules that are related to the acquisition of professional competencies. The acquisition of these professional competencies is variously defined as the purpose of engineering education: for instance, the Washington Accord, which is a multi-lateral agreement between bodies responsible for accreditation or recognition of tertiary-level engineering qualifications states:

…the purpose of engineering education is to build a knowledge base and attributes to continue learning and to proceed to formative development that will develop the competencies required for independent practice (Froyd et al., 2012)

And the international initiative and community or practice in engineering education Conceive, Design Implement and Operate (CDIO) organisation state:

The purpose of engineering education is to provide the learning required by students to become successful engineers –technical expertise, social awareness, and a bias towards innovation (Crawley, Malmqvist, Östlund, Brodeur, & Edström, 2014, p. 1)

Engineers Australia describe engineering education as the process of developing competencies that

…represent the profession's expression of the knowledge and skill base, engineering application abilities, and professional skills, values and attitudes that must be demonstrated at the point of entry to practice. (Engineers Australia, 2013, p. 4)

These definitions of purpose indicate that the engineering education field is influenced heavily by the profession, or industry. However, it can't be fully free of the higher education field in which it operates (unless it reverts to the apprentice system akin to England in the 1880s) nor can it just submit to the rules and forms of capital operating within higher education either. This means in Bourdieu's terms that the engineering education field has relative autonomy (Maton, 2005), that is, it has independence but also that independence is at times influenced by other powers as illustrated by professional body accreditation. The level of autonomy differs between contexts.

What is the specific capital of engineering education?

The literature on transformation of engineering education shows that since the1980s there was a greater focus on graduate professional skills or competencies, starting with realisation of the lack of generic skills for graduate engineers (Dodrige, 1999). The EE generic competency discussions between the 1980s and the 1990s were motivated in part by engineers' increasing mobility brought about by the opportunities of the global job market for engineers due to globalisation and technological revolutions (Ibrahim & Cockrum, 1993; Lucena, Downer, Jesiek, & Elber, 2008), and the predictions of their increase in the 21st century. This brought about an urgency for nations (mostly the Global North) to assure transferable skills for graduate engineers in a bid to retain their competitiveness in the global arena (Dodrige, 1999; Engineers Australia, 1996; Ibrahim & Cockrum, 1993; Lucena et al., 2008; Wulf, 1998). This also meant that they needed to identify those competencies which at the time were not clearly defined as they were not the focus of engineering education.

In the mid to the end of the 1990s there was increase in national debates about graduate competencies coupled with initiatives to transform engineering education and in 1995 the American accreditation organisation Accreditation Board for Engineering and Technology, ABET, introduced a set of competencies known as Engineering Criteria 2000 (EC-2000). Introduction of EC-2000 marked a milestone in engineering education as it resulted in the shift to competencies-based accreditation and later to outcomes-based engineering education, it also saw ABET transforming into a powerful stakeholder in the engineering education arena. ABET criteria, EC-2000, very quickly became international (Lucena et al., 2008; Prados, Peterson, & Lattuca, 2005) with American proponents trying to promote it in conferences, with other countries including it in their discussions as seen in the report by the Australian engineering professional body, 'Engineers Australia – Changing the Culture' (Engineers Australia, 1996). This drove transformation in engineering education curriculum to outcome-focused from content –focused.

Discussion progressed during the early 2000s as engineering education actors sought to define how competencies such as the ABET 2000 criteria could be taught and assessed (Besterfield-Sacre et al., 2000; Shauman & al, 2005). There were debates about the difficulty for engineering education to achieve the required competencies in their graduates accelerated by industry complaining that they were not receiving graduates that were ready to practice (work-ready) which led to more efforts in defining engineering competencies (Lohmann, Rollins, & Joseph Hoey, 2006). Also around this time some practitioners' work reflected an effort to define generic competencies for graduates relative to their countries (King, 2008) while others tried to create a more global perspective (Allan & Chisholm, 2009); referring to the competencies as global skills or competencies for the 21st century or generic competencies (Male, Bush, & Chapman, 2011). These efforts were also well supported by the then developing engineering education research area (Jesiek et al., 2009; Lucena et al., 2008). This also led to reforms in accreditation systems including the Washington Accord which started using graduate attributes as an educational requirements in their accreditation standards from 2013 (IEA, n.d.) with accreditation bodies defining their standards in more detail as seen in Australia, when Engineers Australia produced more detailed sets of requirements in 2005 for entry to profession.

The focus of the debate has since developed into the current decade with industry transformations leading to increased discussions and efforts to re-define graduate competencies with a new focus on what contemporary engineers do, and how engineering education can build that expertise (Litzinger, Lattuca, Hadgraft, & Newstetter, 2011; Walther, Kellam, Sochacka, & Radcliffe, 2011). Engineering education researchers have been participating in these efforts by researching the role of engineers in the industry and society - how engineers practice their profession- and this focus on relevance to industry practice has allowed for the competencies capital to be more distinct.

Engineering education transformation phenomena shows that there is a developing shift in capital in engineering education catalysed by industry and their demand for engineering education to produce engineers that are relevant to industry – hence more push for the competencies capital. The focus on competencies of graduate engineers in relation to what engineers actually do (Trevelyan, 2010b) became more dynamic about a decade ago with concentration on the environment that engineers had to work which is now not only multidisciplinary but also multicultural due to globalisation. For example the issue of understanding the community and turning the importance of competencies such as intercultural teamwork and communication and knowledge of social issues became central (Chan & Fishbein, 2009). This focus, globalisation, seems to still be the current debate in engineering education either explicitly or implicitly (Jesiek, Zhu, Woo, Thompson, & Mazzurco, 2014; Male et al., 2011) reflecting the current job market. Hence the debate on competencies continues up to the most recent with the issues being closing the gap between graduate attributes and professional skills (Trevelyan, 2010a; J. Walther & Radcliffe, 2007).

What are the specific logic around pursuing that capital?

The observation of transformation activities also reveal a certain pattern to which changes are taking place in engineering education; for instance the collaboration among different actors such as engineering educators, professional bodies and higher education stakeholders in advocating changes. Also there were always activities such as debates, workshops, and some forms of working parties prior to every major transformation and a new agenda in transformation; for instance ABET criteria were promoted in national and international forums (Lucena et al., 2008). At all times since the introduction of competence-based accreditation in the 1990s professional and regulatory bodies described the standards – hence defining the capital and rules of the field through accreditation which then mobilised changes towards changing education, for instance, changing the curricula or teaching and learning. This pattern of accreditation can be interpreted as the specific logic of the field. These specific logic of the described field seem to be according to the context- geographical, economic or social- from which the trajectory belongs. The trajectory in discussion is across the Unites States, Australia, and sometimes Europe. For example, literature shows how important accreditation is to engineering institutions in signifying competencies and the efforts by the institution in those contexts strive to achieve accreditation of their programs.

The main logic of the field identified from the transformation literature apart from program accreditation is outcome-based education, and collaboration (involvement) of stakeholders (Engineers Australia, 1996). These seemed to be the assumed procedures in the field especially with regards to acquiring competencies capital. Program accreditation run by a professional body or an independent agency seemed to be an important rule, as the competencies were defined through accreditation for example ABET criteria 2000 (Lucena et al., 2008). The discussion also shows signs that the field favours international accreditation as the engineering role required more global working (Patil, Nair, & Codner, 2008). Outcome-based curriculum – based on competencies defined by accreditation -is another specific logic that seems to be supported by the field as engineering education. It is seen to be constantly trying to conform to industry demands in exchange for employability of their students by the global market as well as their keenness to establish a relationship with industry partners for research funding. Collaboration of important stakeholders such as industry, academia, and professional bodies seem to be important in acquiring competencies capital. In a smaller scale learner centred methods and programs such as those using problem based learning and work integrated learning (Beanland & Hadgraft, 2013; Cook, Mann, & Daniel, 2017) and other methods of teaching and learning are beginning to emerge as rules reliant on collaboration.

Conclusion

This paper gives evidence that engineering education is a field with specific capital related to industry practice, competencies capital, and highlights part of the specific logic of the field as drawn from the transformation phenomena. We argue that by viewing engineering education as field, one is able provide a more critical analysis of issues of practice in engineering education because of the ability to understand different agents' viewpoints because their position is determined by capital and conforming to the specific logic. The available literature, although reflecting the transformation occurrences in a wide part of the world and oftentimes assuming that it has represented transformation of the field of engineering education, only represents what is happening in some countries- hence gives the Global North perspective of that field. There are parts of the world that have yet to adopt such procedures like program accreditation or outcome based education (Matemba & Lloyd, 2017), which seem to be the implicit rules of the engineering education field. When considering the capital valued by the field (competencies), it is obvious that the global and technological trends have made it crucial for engineering education in any country to constantly strive to acquire that capital to ensure competitiveness in the global job market. What are the implications of having a set of rules for obtaining the field's capital that is not conversant to the other part of the world such as most countries in Africa, the area that the wider doctoral research is focused on? In terms of field this may implicate issues with regards to the specific logic, which are important in participating in engineering education field. Hence theoretically we will be able to clearly expose some inequalities in acquiring capital in the field – the dominant agent and the dominated parties.

The significance of this paper is its use of the engineering education trajectory to construct engineering education as a Bourdieusian field. We thus provide an opportunity or possibility for researchers to engage in reflection, discussion and research of engineering education from a social theoretical view point. Given engineering education is influenced by national and global socio-economic and political contexts, the application of a Bourdieu's social 'theory of practice' to define engineering education as an explicit field is of significance to researchers and educators.

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