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Engineering Education and Bourdieu: using Field, Capital and Habitus to Enhance Responsiveness.

Kehdinga George Fomunyam

Abstract: ***This paper takes a close look at the relevance of Bourdieu's concepts of habitus, field and capital in enhancing learning in engineering education andproposes that effective engineering education can be achieved through the adoption of appropriate measures related to Bourdieu's theories.it further shows the link between the concepts of field, capital and habitus and explores how engineering institutions can restructureteaching methods and curriculum content in a way that students can relate and respond to. This paper also highlights environmental and foundational changes that need to be imbibed from the elementary stages of education to help mould a potential teacher to be effective in the field and build capital that further impacts his effectiveness as a teacher. Again, through the review of related literature, this study explores how academia's habitus affects their teaching methods within the field and the effect of institutional systems and environment on the pedagogy of engineering educators. The study further outlines some of the challenges limiting the field of engineering education stemming from deficiencies from an individuals past and current environment, followed by a description of key initiatives and recommendations aimed at better pedagogy and learning techniques for productive ngineering education.***

Keywords: ***The study further outlines some of the challenges limiting the field of engineering education stemming from deficiencies from an individuals***

I. INTRODUCTION

Educational systems all over the world face different challenges sometimes stemming from how the political, economic and social systems of a country are structured. Other times, these systems face challenges that are often common to educational systems across the world. Some of these problems include; low enrolment numbers, underqualified staff, obsolete curriculum, inadequate learning facilities, poor teaching and learning methods, under-skilled teachers and students and engineering graduate shortage. Engineering education is also plagued by problems in higher institutions across the world as well. Australia is presently facing an engineering skills shortage and has added chemical, mining and mechanical engineering among its migrant occupation on demand list as less than 5% of 24 year olds have engineering degrees and only 6 in 1000 females have engineering degrees. South Africa is also facing a similar problem, as are other countries. In 2018, 1.9 million students graduated with bachelor's degrees in the US with only 121, 956 of these degree being bachelors degree in engineering, while *51,721 earned masters degrees.*

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*****Correspondence Author
Dr. Kehdinga George Fomunyam, Mangosuthu University of Technology, Durban, South Africa

Bourdieu has put forth a series of theories and concepts and this study highlights the theories of field, capital and habitus and relates them to engineering education, focusing on their impact on pedagogy and learning, and how they can enhance responsiveness to learning.

Individuals from a particular socio-economic group will have many aspects of their habitus in common. Habitus is shaped by the social structures within which it is formed and also regulates the action of an individual within those social structures. In other words, pedagogy adopted by engineering academia is to an extent influenced and determined by the environment in which they learnt and their socio- economic interactions. Field refers to all organisations and individuals involved in a particular social or cultural arena and the interaction between them. The objective of participants in each field is to optimize their accumulation or retention of capital (Beanland, 2013). In the context of engineering education this encompasses higher institutions of engineering and academia, comprised of teachers and students and their learning environment. The purposes, decisions and actions of engineering educators, their strategies (which depend on and respond to the structures within the field) can be explained within Bourdieu's habitus. This study examines the applicability of the theories to engineering education in terms of improving responsiveness and highlights how the concepts of field, capital and habitus can be exploited and applied to improve teachers and institutional pedagogy along with students learning methods and assimilation level in engineering education across countries. Learning is a moderately permanent behavioural change stemming from experience with various factors responsible for encouraging or inhibiting learning. In examining responsive regulation types of responsiveness considered are; pyramidal responsiveness, micro-responsiveness, networked responsiveness and meta-regulatory and socialist responsiveness. A teachers responsiveness to his environment impacts how he teaches students which in turn affects or even dictates their learning responsiveness and future teaching pattern, this chain of cause and effect is captured by Bourdieu under his theory of habitus. Repeated exposure to an environment and process in the case of engineering education can result in an individual becoming habituated by displaying increased or decreased responsiveness to his environment (Cliffs notes).

II. STATUS QUO AND CHALLENGES IN ENGINEERING EDUCATION

Engineering is a fairly popular course of study and should be even more so considering its essential contribution to society and mankind.Upon an examination of the world's student population enrolled to study different courses across higher institutions, it has been observed that engineering enrollment and graduation numbers are far from commensurate with the demand for well qualified engineers and a variety of reasons have

led to an even higher scarcity of prospective engineering students, thereby slowing or even limiting societal development in numerous countries. In 2018, 393 institutions in the US awarded a total of 622,502 bachelors degree in engineering 93,559 masters and 12, 156 PhD degrees (Roy, 2019). Asian universities accounted for over 4 million of the world's science and engineering bachelors degrees in 2014, with over50% of being engineering degrees. Students across Europe (including Eastern Europe and Russia) earned more than 1.5 million S&E bachelors degrees (about 40% of them in engineering), and students in North America earned nearly 1 million S&E first degrees in 2014 (24% in engineering). India and China awarded the largest numbers of first degrees in S&E (1.9 and 1.7 million, respectively), followed by the United States (742,000), Russia (429,000), and Japan (316,000). An enquiry by the professional engineering academies and organisations in many countries have revealed similar findings with the Carnegie report; in addition to a shortfall in engineering graduate numbers, the engineering graduates being churned out are very under skilled for engineering practice. Sheppard, Macatangay, Colby and Sullivan (2009) argue that the problem lies in the emphasis on the development of technical knowledge above professional skills. "*Although engineering education is strong on imparting some kinds of knowledge, it is not very effective in preparing student to integrate their knowledge, skills and identity as developing professionals*" (Sheppard et al, 2009, p. 6). Sheppard et al (2009) argue that it is, "i*n essence a [curriculum] design problem"*. A UNESCO report authored by professor Roger Hadgraft (2013), similarly highlighted several issues with engineering education; Engineering graduates do not meet the expectation of most employers who find them to be grossly under skilled. Many students view engineering education as uninteresting and difficult and often avoid pursuing an engineering degree. Again, the field fails to attract students keen on contributing to societal growth. The field is not well understood within most communities. The curriculum often contains predominantly specialised technical knowledge. Related course work experience is also at a negligible degree. Most program curriculum and content do not equip students with essential skills for practicing engineering. There is very little emphasis on mathematics and science in primary and secondary schools, and students after graduating secondary schools are unlikely to enrol for courses with subjects like science and mathematics that they are unfamiliar with and these subjects feature widely in engineering. Governments should create incentives to encourage students to embrace STEM subjects from an early age. Cameron, Reidsema and Hadgraft (2011) express concerns over the capacity of engineering teaching staff to develop vital expertise. There is a limited number of engineering academics with professional experience above 4 years. Again, there is the issue of outdated experience, gained long ago and not updated prior to joining academia. The teachers should possess skills that "*enable them define and navigate the complexities of curricula problem solving, engineering application and practice, with themes of design, the engineering life-cycle, complex systems, and multi-disciplinarity". (*Cameron et al, 2011, p. 109-110). Some engineering educators may only possess informal training and often have a lot of autonomy in what and how they teach (Turns et al, 2007, p. 297).Issues related to evaluation, creativity, identifying relevant issues, learning as necessary and efficient application of what is learnt are hardly addressed in engineering education presently. Opportunities for practical application of knowledge is also limited. The key elements required from all graduate engineers have been identified in the Washington Accord (WA) and these attributes are inadequately addressed by universities and Accrediting Authorities in numerous countries. The Washington Accord Graduate Attributes addresses engineering knowledge, problem analysis, investigation, design/development of solutions, modern tool usage, the engineer and society, environment and society, ethics, leadership and team work, communications, project management and finance, and life-long learning). Added to this, the structure of University programs have not evolved or progressed with the changing times for over 4 decades. Higher institutions have also not utilised the opportunities of digital learning provided by the Information Technology revolution. The majority of these problems need to be tackled from the foundations of education, especially pedagogical and learning techniques.

III. LITERATURE REVIEW

Bourdieu (1992, pp.72-73) posits that a field is a configuration of relations between clear positions and the medium of these relations is capital, which can be social, economic or cultural. All capital is symbolic and its configuration shapes or determines social practice. These mediums impose determinations upon their products and processes, and in the case of engineering education which is the relevant field of this study, patterns common to engineering education will have an effect on the teaching methods of educators and the processes adopted by these educators in order to build capital will throw more light on the processes and pattern within the field and perhaps, define and influence engineering education itself. To understand the learning culture in engineering education, it is essential that the field of higher education be thoroughly examined as field dynamics vary from site to site. Difference in practices impacts how a learners identity is moulded, researchers would have to examine each practice to the learning methods and content – what is being learned as every learning practice allows or rejects certain kinds of learning.

Colleges, learning sites, decisions and actions of engineering teachers are also explained by Bourdieu's concept of habitus who opines that the habitus as a system of dispositions to a certain practice serves as an objective basis to a consistent pattern of behaviour and thus the frequency or regularity of behaviour can be predicted or predetermined because where habitus is present its agents will follow a certain pattern of behaviour under particular circumstances (Bourdieu, 1990, p. 77). Reay elaborates on the definition of habitus thus; *based on conditions ascribed to Bourdieu's objective condition, (Bourdieu, 1990a, p. 54) the most unlikely practices are cast aside as unthinkable, but at the same time, only a limited range of practices are possible .*

(Reay, 2004, p. 433).The concept of habitus accounts for common, existing knowledge about what influences teaching methods adopted by teachers like the role of pre-existing ideas about teaching and learning, the epistemological basis of a discipline which is being taught, and the effects of the contextual and institutional conditions in which teaching occurs. The theories of habitus and field allow us understand teaching practice within the context of thought and action in which it occurs. There is a need to understand how engineering teachers' belief about teaching in their discipline affects how they teach,this discovery will facilitate the required change in teaching practice.Acquiring pedagogical content knowledge and teaching techniques different from what is currently obtainable requires revolutionary and innovative learning strategies more advanced than just reading and discussions about new pedagogical ideas (Ball & Cohen, 1996). Teachers learn through studying, by doing and reflecting, by collaborating with other teachers, by looking closely at students and their work, and by sharing what they see. (Major & Palmer, 2006, p. 621). Each participant in a learning culture contributes to the reconstruction of that culture. This is emphasized by Bourdieu, who provides us with several conceptual tools for understanding the complexity of this interrelationship. The impact of an individual on a learning culture depends upon a combination of their position within that culture, their dispositions towards that culture and the various types of capital (social, cultural and economic) that they possess (Bourdieu 1986). Participants can influence the nature of the learning culture within which they participate consciously, through working to change and/or preserve certain attributes or practices. However, majority of the impact of individuals in a learning culture is due to their presence and actions within it, whether they set out to influence that culture or not. In an on site engineering class, the diverse nature of the students, their desire to learn in class and the ways in which they and the tutors interact face-to- face are an integral parts of a distinctive set of practices that make up the learning culture. Expressed differently, a field operates at the scale of individual interactions, as well as the more macro-scales with which Bourdieu was primarily concerned. It is therefore obvious that a field operates both at the scale of individual interactions and macro-scales, which is majorly examined by Bourdieu. Individual behaviour are important and significant because such behaviour and actions collectively make up a distinctive set of practices that constitute the learning culture. Dewey and Mead (1931) opine that the learning of the individual is also social and this social trait is inherent through communication, interaction and participation and not at all external to the individual (Biesta, 1999). Bourdieu's belief that people are always socially positioned is captured under the concept of habitus, which comprises of subconscious dispositions to all areas of life. According to Bourdieu (1977) the habitus is a battery of durable, transposable but also mutable dispositions to all aspects of life that are often sub-conscious or tacit. It can also be viewed as social structures occurring or functioning within and through a person. They grow from our social positions and for the duration of our lives. An individual's learning is also social and Mead reinforces the opinion that the social is not outside but exists within and through an individual through interaction, participation and communication (Biesta, 1999). Bourdieu's habitus examines the social aspects of an individual and suggests that people with similar social positions and experiences will share similar characteristics but habitus is not totalising as people have partly unique and evolving experiences. A learner's environment sets the limit to what learning is possible and enables learning within these limits, just as differing learning cultures offer different learning opportunities to participants. This is also the case for the dispositions that constitute an individual's habitus. According to Hodkinson et al. (1996) a person's horizon for learning is entrenched or ingrained through current and changing interrelationship between their disposition and the learning culture they are a part of. The concept of habitus explains the degree to which cultural practices determine or influence learning. It expantiates on the relationship between learning and cultural practice, whereby learning culture is influenced by our level of engagement in cultural practices. Learning is built not only by action but also by reflecting on, and consciously monitoring our actions. Understanding engineering teachers' bodies of pedagogical knowledge and how they are comprised and developed is a vital step in this process. until we understand how engineering teachers' beliefs about teaching in their discipline (among other variables) affect how they teach, we cannot address how to successfully undertake wide scale and effective change in teaching practice. Research…shows that acquired pedagogical content knowledge and developing methods different from what teachers themselves experienced as students requires learning opportunities for teachers that are more powerful than simply reading and talking about new pedagogical ideas (Ball & Cohen, 1996). Teachers learn through studying, by doing and reflecting, by collaborating with other teachers, by looking closely at students and their work, and by sharing what they see. (Major & Palmer, 2006, p. 621). Field dynamics impacts differently in different environments and some struggles that were highly important in one site were hardly present in another. Not only were the internal dynamics of sites different, so were their positions, relative to each other and to these wider fields. Consequently, to understand the learning culture of any one site, it was necessary to understand the field of Further Education as a whole, and the relationship of the site to that field, and to other fields of which it was part or with which it interacted.

There is a strong argument that developing a more complex understanding of the factors affecting teachers' thoughts and behaviours is required, because research into pedagogy does not on its own provide the vital link to improving actual teaching practice (Grenfell & James, 2004). Adams and Felder (2008) argue that fundamental questions need to be asked if we are to understand the role of engineering educators and develop them as teachers.

Enhancing Responsiveness using Bourdieu's Ideologies

In increasing responsiveness in engineering education a key question that needs to be tackled is; how do we enhance teaching practice in engineering education, so that students' learning outcomes can also be improved? Triggering or increasing positive responsiveness and rate of students' assimilation in higher institutions will require some restructuring of curriculum content, pedagogy, learning techniques and more.Presently, most engineering institutions and teachers favour the predominantly theoretical approach to teaching with little practical aspects, which typically occurs in the traditional classroom setting. In recent times, some western and Asian countries have embraced technology and added aspects of modern technology like simulation, artificial intelligence and machine learning to make learning more practical. Such institutions take advantage of digital, online learning methods to improve pedagogy and responsiveness to learning. The necessary educational upgrades include: rebalancing the research/teaching emphasis, switching educational strategies from lecturing to learning facilitation, altering program structures to be project centred, facilitating work experience, provision of technical facilities as learning space as opposed to large lecture theatres, modifying assessment policies and practices by changing from traditional lectures and formal examinations to newer, more practice-centred individualistic methods as learning evaluation techniques, changing staff hiring and promotion criteria, enhancing project and IT facilities to develop students who are independent and effective learners. Institutions of engineering need to cultivate a co-beneficial and consistent relationship with major employers to get access to current issues and challenges in engineering. This will help streamline or focus program content and practical teaching to align with modern engineering needs. Government should be willing to fund a student-inquiry method centred on project-based learning. Governments also need to partner with faculties on the provision of high quality staff training programs relevant for transforming engineering education. Engineering Academies need to develop a comprehensive and consistent relationship with the major employers and advocate a coherent message to government and universities in relation to the need for major change in engineering education, in their national interest. Again, a national forum should be created online and offline for periodic interaction between local and international engineering students, faculties, employers, multinationals and professionals where current trends, techniques, research and other useful materials are showcased for the advancement of engineering education. Employers should advocate for, and collaborate with engineering institutions to advance the course of engineering through provision of access to engineering software and applications to facilitate staff and student learning, research funding, industrial training work experience for teachers and students, advise on current trends, projects and problem solving techniques and other means of aiding institutions. According to Bourdieu, an agents habitus is an active residue or sediments of his past that functions within his present, shaping his perception, thoughts and actions and therefore moulding social practice in a regular way. Current teaching and assessment method combine to give an indication of a teacher's habitus. Taking this into consideration, teachers should be made to understand the importance of practical application of theoretical knowledge, universities should arrange for mandatory practical training courses for new staff which will help them embrace practical teaching and also equip them with tools for enhancing students practical skillsvia practical application with every topic taught. Also, STEM subjects, particularly, science and mathematics should be introduced to children early in life. Elementary and secondary schools should emphasize the importance of STEM subjects and find innovative and interesting methods of encouraging children to explore these subjects, especially by using technology in a fun way. A major point in teaching engineering is the importance of striking a balance between theoretical bases of the discipline while maintaining the skills basis of professional practice. Again, Bourdieu posits that practices are generated by a certain habitus, so all practices give evidence of the structure of the habitus that generated them (Nash, 1999, pg. 178). Going by this, there should be a scaling down of theoretical knowledge, which dominates most STEM curricular, particularly in developing countries, where there is very little practical application due to a lack of skills and facilities. Simple practical demonstrations should accompany every topic introduced. Imbibing this practice will normalize practice, so teachers who learn this way will be better equipped to teach this way. Genuine experience or a very strong understanding of it is essential to teach engineering education in a way students can relate with and respond to. The type of learning and environment a teacher was, and is currently exposed to, can act to support the teaching of engineering. There is a need to keep skills current through industry experience even as an academic engineer, particularly the structural aspect of it. Teaching activities can be far removed from the nature of engineering practice so updating skills is required for academics through work experience, likened to apprenticeship, and regular research can lead to better decision making on teaching. Contextual rather than theoretical knowledge in engineering is required for effective teaching or teaching development. Academics have to focus on continuous teaching, service and research development in line with the evolution in engineering. If habitus pronounces that an academic teaches engineering based on what he did, not what he knows then what are the changes that need to be made to learning methods so as to equip new learners with knowledge and skills to become effective teachers in the future?

An academic taps from his prior industry experience to teach effectively, therefore a criteria for hiring academics should be prior industry experience and continuous practical experience via industry apprenticeships for academics, through partnerships with engineering professionals, as a means of accessing capital in the field to form and increase effective teaching practices for improved student learning. Habitus, field and capital are therefore inter-related.

Using feedback from students optimizes future teaching. Such feedback is vital for structuring curriculum content, therefore teaching should be adjusted in line with students feedback to improve effectiveness and address current issues, this is achieved by ensuring flexibility in planning teaching structure to leave room to respond to students challenges and work this into the curriculum content as a means of addressing current theoretical and practical issues. This will ensure continuous improvement in course delivery by including content students determine to be useful or challenging. Feedback also helps determine what short and long-term goals to set in terms of teaching activities and this is an indication of a teacher's habitus for participation in the field of engineering education. Acting on feedback is an example of a teacher equipping himself with a form of capital relevant to the field of engineering by adjusting his teaching habits. This in turn influences the students learning habits, moulds them into potentially better engineers and forms the foundation for the students teaching habits as well, for those going into academia. This highlights the link or inter-relationship between capital, field and habitus in engineering education. Teaching habits should be adjusted to align with the change in student cohorts over time. Effective teaching practice will earn academic recognition in the field, thus acknowledgement amongst colleagues is capital that can yield even more capital in the field if properly utilized, while also encouraging better pedagogical content. Universities should organise contextualized training courses for academia on how to teach effectively. Staff should also be developed that are able to teach based on content flexibility. This involves structuring curriculum and course content based on a combination of theory, practical work experience and student feedback. Engineering academia must develop a habitus for working in the field, that is conducive for developing an integrated form of pedagogical content knowledge that emphasizes teaching for practice in the engineering industry (Jolly, 2016). Student forums for interactive learning and online projects should be created to promote responsive learning in engineering. The interactive nature of responsive learning allows a high rate of innovative and interactive teaching styles that encourages a higher learning and retention rate which is essential for a technical course like engineering. Responsive learning will also allow teachers concentrate on individual students who learn at their own pace and have their performance tracked to determine areas of weakness where extra assistance is required. Students should also learn at their own pace and tap into course content via a device. Further, students should be considered as engineers-in-training and be given the opportunity to carry out engineering tasks of increasing complexity every semester. Bourdieu postulates that an individual's belief, perception, ideas or notions of disciplinary structure influences their willingness to expand their pedagogical knowledge base, this differs from the conventional notion of teachers teaching as they were taught and as they learned (Major & Palmer, 2006, p. 627). Teachers should therefore be made to understand the importance of broadening their pedagogical knowledge base early on, and be regularly required to do so, also a periodic review of their techniques should be put in place, while providing them with a structural base on which to build for proper streamlining and coherence. Institutions must also ensure continuous assessment and evaluation of teachers professional development. (Adams and Felder, 2008, p. 240)

IV. METHODOLOGY

The research methodology is based on literature review and explored various theories and concepts by academia across the world through research papers, online articles and surveys. These 30 publications spanned from 1990-2019.

V. FINDINGS

This study found that engineering education is deficient in numerous countries across the world anda large proportion of the challenges facing engineering education stems from ineffective curriculum and pedagogy adopted by academia , which in turnlimits students learning capacity. There is a link or inter-relationship between all three concepts as habitus determines an individual 's behaviour in the field and ideologies prevalent in the field also affects an individual's perceptions and actions. A teacher's ideologies, practices and pedagogy are shaped by his environment and common behaviour and beliefs the individual is frequently exposed to in that environment, these often recurring pattern of belief and action impacts the individuals ideas and convictions in several areas of life,including how he articulates and transfers knowledge and his actions are predictable because an individualexposed to habitus, with follow certain patterns of behaviour under particular circumstances (Bourdieu, 1990, p. 77). This predictable behaviour reflects in his teaching and in turn has an effect on the field he is involved in. Again, the perception and reception to his methods and ideas can be either positive or negative, the responsedeterminesif there will be an increase in the capital that the individual wields in his field. Ineffective behaviour, practices or actions stemming from ideologies formed from one's environment and (habitus) limits an individual's capital in the field and vice versa. All these determine the quality of pedagogy a student is exposed to and his subsequent response. Teaching methods adopted by engineering teachersimpacts students'level of comprehension and assimilation and their earning can be accelerated or stunted by the pedagogy adopted. This in turn shapes the future teaching patterns of these students and the cycle shows how habitus can impact generations of students and teachers.An understanding of factors affecting teachersideas, opinions and actions will help to determine what tools are needed to build more effective engineering educators

VI. CONCLUSION

Engineering degrees are perceived as difficult by prospective students, this is largely due to underemphasizing of science and mathematics early on in elementary and secondary schools. The result of this is an unfamiliarity with these subjects and students are unwilling to enrol in engineering programs for fear of failure.

Also, engineering academic staff are poorly prepared to take on teaching these degrees as their learning was deficient based on their habits and environments and therefore they pass on these ineffective pedagogy to students. This dampens students responsiveness to learning in the field of engineering.

RECOMMENDATION

A restructuring of engineering curriculum content, pedagogy and learning methods is essential for eliciting a positive response from engineering students. Teaching should be responsive to feedback from students and academia should consciously cultivate new habits in their environment that enhance learning in the field and constantly pursue professional development. Digital technology and practical application for both academia and students is vital to enhancing learning in the field of engineering. Early introduction to STEM subjects and partnerships with industry are essential to altering the habitus to reflect content and practices that students can relate and respond to. Academia can better supervise and assess students learning process without traditional lectures. Moulding graduates who are efficient independent learners equipped with vital skills for practising engineering can be better achieved by applying the principles and ideas proposed by Bourdieu's habitus, field and capital theories.

CONTRIBUTION OF NEW KNOWLEDGE

Engineering education in taking advantage of digital technology, especially in developing countries, should explore the usage of simulated models as well as engineering software and applications to show practical techniques and their potential outcomes.

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AUTHOR PROFILE

Dr. Kehdinga George Fomunyam, Institute for Systems Science, Durban University of Technology, Durban, South Africa