A social realist case study exploring the utility of structural-agentic interplay in characterizing the role of agency in the enactment of teaching approaches in a chemistry department at a higher education institute

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This thesis results entirely from my own work and has not been offered previously for any other degree or diploma.

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Abstract

Chemistry, often perceived troublesome to teach and learn, is identified at the higher education level as a *hard* discipline with strong indications of information transfer teacher focus (ITTF) rather than conceptual change student focus teaching approaches (CCSF). While some higher education institutions (HEIs) are beginning to promote them as separate enterprises, the duality of teaching-research expectations, amongst other constraints, often positions significant structures often in the form of rules and resources and induces varied *agencies* related to teaching approaches and enactment of the pedagogical *practice* even at the sub-disciplinary level. The literature highlights teaching chemistry as a social practice and debatable issues with the teacher-researcher-nexus, disciplinary essentialist epistemology, departmental, institutional and self-efficacy without properly articulating agency and the mechanisms of how the approaches and enactments are realized in this context. To gain an improved understanding of the underlying mechanisms, this research adopts a social realist perspective employing qualitative methodology, to capture the interplay of structure and agency in teaching in a chemistry department. I examine teaching chemistry practice and approaches, through in-depth semi-structured interviews with chemistry academics (*n=9*) at a HEI in the UAE. The data generated was analysed retroductively in reference to the theoretical framework generated from the literature, applying both inductive and deductive approaches to thematic analysis to propose a modified theoretical framework. The findings correlate with the literature while profoundly highlighting agentic *utility-based* practices, the importance competencies and meaning with tangible embedded references to Bourdieu's practice theory (Habitus-Field-Capital). It also provides better capture of the teacher-researcher-nexus, the perceptions of content, students, year level as rigid structures representing significant considerations by the academics. The characterization of the structural-agentic dynamics and the subsequent proposal of theoretical model provide indicators of tendencies for how teaching approaches are realized when contextual agencies are activated. The work illuminates the need to re-conceptualize the perceptions of the role of teaching academics in HEIs and the forces conditioning practices and changes in them.

Key words: Agency-structure-chemistry-practice-social practice-epistemological essentialism-disciplinary tribe

Acknowledgement

List of Abbreviations

ITTF	Information Transfer Teacher Focus
CCSF	Conceptual Change Student Focus
SMK	Subject Material Knowledge
HEI	Higher Education Institute
TLA	Teaching Learning and Assessment
TLR	Teaching and Learning Regime
SPT	Social Practice Theory
SoTL	Scholarship of Teaching and Learning

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Chapter one: Introduction

Chapter Overview

This first chapter introduces the research study, context and purpose. It establishes the reasoning for the research, aims of the thesis, and the methodological underpinnings used. A social realist qualitative case study approach stemming from critical literature review using structural-agentic theoretical underpinning to capture the interplay between structures and agency to examine the role of agency in the conceptualization of the approaches of teaching chemistry as a practice in a HEI context. Initial findings highlight the variations in agencies related to the teaching approaches in the context of some rigid and newly deductively generated structures. The chapter is structured to include: Introduction - Background and motivation -Research questions-Research design-Theoretical tools -Significance and Limitations-Thesis Structure-Chapter summary.

Background and Motivation

Teaching chemistry is a social practice. Yet, teaching is often approached from a theoretical context e.g. behaviorism (Thorndike, Pavlov, Skinner), cognitivisim(Piaget, Koffka), Constructivism (Vigosky, Bruner), connectivism (Siemens, Downs) without adequately capturing the interactions between the individual and the social. How teacher practices and aspired trajectories are realised in HEI educational context (Cox & Trotter, 2016; Hodgkinson-Williams & Gray, 2009) often greatly vary. As a lecturer (no research expectations) at this HEI, I often attributed my passion for teaching and learning to the sense of purpose and excitement in seeing students develop interest in the subject. My interaction with students and ability to contextually provide different learning environments based on recognizing the diversity of the content and students represented a cornerstone to my success. In this teaching context, I observed variations of teaching practices (individuality of actions or agency) as teachers manoeuvred through departmental, institutional and social expectations (considerations or structures). For example, there were diverse practices and enactments including use of innovative technology, content delivery and lecturing, emphasis on laboratory, tutorial and problem-solving, inquiry-based, models…). Some of which placed the teacher as the focal point while others had the students. At the introductory chemistry level, the content too, was not quite uniform; threshold concepts (e.g., stoichiometry), memory (e.g. nomenclature), analysis, practical-based (e.g. identification of ions). Each of which potentially mandated a different type of teacher and set of skills. Yet there was often a wholesale approach. This inspired an interest in attempting to gain better understanding by focusing on the practice in terms of the individual and the social. In other words, how this thesis accounts for the interplay of structure and agency which are coupled and are existentially intertwined will raise some fundamental conceptual and methodological issues that,

whilst frequency discussed in textbooks on social science methodology (for example Silverman, 2001), are largely ignored in research into TLA in higher education and particularly in chemistry education. To begin with, the question of whether teachers can be academics or vice versa, (and the rationale of *why and how*), is centred on the interplay of structure and agency whilst being subject to intense debate and research as teachers struggle to do both; teaching and research (e.g., Remmik et al., 2013; Skelton, 2012). Furthermore, studies show that academics are frequently predominately hired for *technical expertise* (Adams, 2002; Boyer, 1990; Pals, 1988) and with little teaching or *pedagogical experience* (Adams, 2002; Austin, 2002; Pals, 1988; Wardlow and Johnson, 1999, Griffiths, Thompson and Hryniewicz 2014) or lack of preparedness for the practice of teaching (Gannaway et al., 2007) and gaining experience through teaching (Bransford et al. 2000). This lack of proper understanding *or meaning and associated competencies* of the role of teaching [*practice*] in the presence of varied structures in HEI often underpins *agency* and leads some teachers to rely instead on developing teaching skills from their own practice (Paran, 2017; Rose & McKinley, 2017). This of course may depend on how they view teaching contextually; therefore recognizing agency. Agency can be described as individuals' capability to engage in intentional, self-defined, meaningful, and autonomous action in circumstances constrained by power relations and structural, contextual factors (Archer and Archer, 2003; Foucault, 1975; Giddens, 1984) or individuals' self-processes, intentionality, and self-reflection (Bandura, 2001), motivational beliefs such as utility value (Eccles, 2005; Ryan and Deci, 2000), and efficacy and competence beliefs (Malmberg and Hagger, 2009; Schunk and Zimmerman, 2012). Meanwhile, structures refer to all the forces (rules or schemas according to Sewell 2005 and resources; human and nonhuman) or mental structures (Bourdieu, 1977), which Giddens (1984) arguably proposes leads to predictable practices over time. Sewell (2005), however, contests the notion of structures constituting of rules and resources as separate entities. He further clarifies "*they can be rules while resources can be thought of as an effect of structures*" or academic structural filters (Fanghanel, 2007). In this context, a perplexing issue is the unsatisfactory rationale of how despite recognition of disciplinary teaching approaches (Trigwell, 1994), teaching practices often remain situated in traditional context (e.g. teacher centred lecturing) or in other words static (Davies, Mullan and Feldman, 2017). Critical review and synthesis of the literature on teaching [chemistry] a practice materialized in the nature of the topic itself and how interconnected to many conceptual and social activities. Nonetheless, the following themes were identified: teaching-research (service) Nexus, self-efficacy-pedagogy, teacher training, institution, disciplinary tribe and epistemological essentialism and other external factors. They represent the conceptual framework for the determinants when examining the topic. The synthesis did recognize [*some elements of*] agency and structural constraints

on teaching practices. However, it is an insufficient account of this critical conceptualization and more importantly presumes chemistry disciplinary generalizability. The dynamic of these two entities (agency and structures) in the teaching, learning and assessment framework where "*Success in school tasks consequently bore little significance to the field of science*" (Ritchie, S. et al., 2016, p.2) or TLA in general is hardly discussed (Ashwin, 2008), and more especially in the context of chemistry. Therefore, the role of teaching agency through surveying different specialisms and experiences teaching academics is examined in relation to these structures. The findings of this study highlight other relevant (rigid/soft) structures (rules/resources) and different types of agencies contextually and peculiarly activated when teaching chemistry. The question here is not simply what the approaches to teaching chemistry are, but how and why? What this informs, its implications for policy and pedagogical considerations. Consequently, through an in-depth exploratory social realist design, a deeper understanding of the interplay between empirically identified structures and agencies which aims to address the following questions:

Research Questions

1. How do structures inform teaching approaches and enacting the teaching practices?

2. How do teachers in a chemistry department in a HEI characterize their teaching approaches and practice and the role of teacher agency?

3. What are the epistemological and pedagogical implications of better conceptualization of the role of agency in the structures-agentic context?

Context

It is critical select an appropriate research context in order to conduct these complex investigations (Patton, 2002). The research was conducted at a chemistry department at higher education institute in the UAE. It is newly formulated from a merger of three institutions and three different departments with differences in departmental cultures and priorities. One was focused on teaching ''service courses'' to engineering students. The other was heavily focused on research as the primary enterprise. The third serviced graduate research students. Tangible and tacit tensions existed as a result. In my practice and perhaps not directly related to this tension, I saw several teaching approaches, pedagogical understandings and students' learning and engagement within the department under similar (not identical) structural realities. This raised questions and propelled this research in order to gain better understanding of how and why in an effort to highlight the role of agency in pedagogical practices and inform policy change. While all the interviewees had teaching and research responsibilities in the chemistry department, their abilities to navigate the new terrains and hence enactments of the teaching practices varied. This situated the thesis to examine how enactments

are generated from the contextual agentic-structural interplay rather than focusing on the context itself. I worked in this department for a period of four years and left before the interviews were conducted.   Therefore, I might be considered an insider research with some dispositions on the practice and knowledge of some of the elements explored in this research. Nine teaching academics were purposely sampled and interviewed. They represent various backgrounds, age, gender and specialisms.

A Social Realist Research design

In this study I investigate [pedagogical] agent's reflexivity in relation to the agentic-structures interplay. The use of Archer's 2003 socialist realist theoretical framework is employed to probe how chemistry teachers' practices and aspired trajectories are realised in this educational context (Cox & Trotter, 2016; Hodgkinson-Williams & Gray, 2009). It recognizes the existence of [immutable] structures which often govern the behaviours of agents and their practice.   Yet, interaction with the agents may not always leave these structures unhinged and thus not exactly immutable. My theoretical framework is inductively derived (M. Miles et al., 2020) and provided guidance in the journey from the conception of ideas to the data collection and findings dissemination (Ravitch & Riggan, 2016). This framework "*lays out the key factors, constructs, or variables, and presumes relationships among them*" (1994, p. 440). In reference to the literature review, the theoretical framework might be informed through self-efficacy, discipline, departmental cultures, institution, pedagogical competence and other external factors. This was empirically cross-examined in the study and generated a refined framework used to better understand the *real* interplay between structure and agency in this context.   The theoretical framework structural-agentic approach is the foundation from which knowledge is constructed (metaphorically and literally) for this research study (Grant and Osanloo, 2014 p.12). Therefore, the focus of this research is how these two entities (*agency and structures positioned as the theoretical blueprint)* interact and how this interplay yields realities, and practices in teaching (chemistry) in a higher education context with implications on policy and institutional reform.

Methodology

A socialist realist paradigm is adopted in recognition that the social world is complex in that it is made up of a large number of elements, is uncertain, unpredictable, and is emergent (Sayer 1992, 2000; Sibeon 2004). The meaning of the social world is constructed through practices (Reckwitz, 2002). Thus, the act of situating the research and developing an appropriate research methodology begins with a "socially situated researcher" (Denzin and Lincoln, 2005, p.8). Given the depth of the topic, this study followed a qualitative exploratory approach, which is "*an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem*" (Creswell, 2018,

p. 4) through the embedded case design (Yin, 2008), which allowed for the "particularities" of the single case to emerge (Simons, 2009, p.32) and generate new insights a "thick-description" (Geertz, 1973, p.6). According to a descriptive case study normally begins with wide-ranging and extensive literature review (Yin, 2009) and studies a phenomenon in depth and in detail (Mills, Durepos, & Wiebe, 2010). More importantly, a case study technique provides a leeway for the person reading the study to see the phenomenon through the researcher's theoretical lens.

Data collection

The participants (n=9) representing both genders, varied backgrounds and nationalities working a teaching academics in the chemistry department at the institution are purposively sampled in line with high ethical research considerations. Purposeful sampling was used to select "information-rich cases" (Patton, 1990, p. 169), allowing me (the researcher) the ability to "compare and contrast, to identify similarities and differences in the phenomenon of interest" (Palinkas et al., 2015, p. 534). Data is collected through semi-structured 40-60 minute interviews [using Zoom]. This approach allows depth and flexibility when discussing complex issues (Bamball and While, 1994) and convenience given the pandemic. This is further substantiated by, keeping a second record (Boslaugh, 2007), non-participant unstructured observation (Mays & Pope, 1995) of informal practice activity (field notes), meetings (video-recorded lectures), and policy document review (discourse analysis).

Analysis

In the data analysis, I examined all data in deriving an empirical conclusion from all sources of data (Yin, 2014). All forms of discourse, expressions, diary, text, reflection and response to teaching chemistry activity are analysed. The discourse is transcribed and analysed for thematic findings (Braun & Clarke, 2012) retroduction and retrodiction to capture practice *tendencies* with emphasis paid to rigor and reliability. To ensure, qualitative trustworthiness, clarity, transferability, and validity, data triangulation was utilized.

Theoretical tools

Situating [chemistry] teaching as a social practice through structural-agentic lens draws on the initial work of past social practice theorists, to conceptualise teaching as a routinized practice (Giddens, 1979; Reckwitz, 2002; Schatzki et al., 2001). Understanding individual agency in face of (mental, academic, institutional and social) structures provides insight into the enactment of teaching as a practice. *The headings below will provide synapses of some of the components of the theoretical underpinnings of the research and rationale for their significance. They describe the practice, literature identified structures and situate agency.*

Situating Practice

HEIs do not only express intellectual and scientific values directly through their mission of teaching and research, but also embody in their practice powerful organizational, instrumental and wider social and cultural values. Teaching has been situated contextually (Ashwin 2008, Haggis 2003) as social practice (Mann; 2000; Trowler and Cooper; 2002; Jones et al, 2005; Trowler, 2005). Many practice theories (e.g. Bourdieu, 1997, Giddens, 1979, 1984, Latour 1990, Taylor 1993 and Schatzki 1996) attempt to provide substantial account of human activities in context can conceptualise what teachers do and why, located in their particular contexts (e.g. Boud, Dawson, Bearman, Bennett, Joughin and Molloy, 2016). Of particular interest and in the context of agency is the rendering of practice presented by Reckwiz (2002) in reference to mentalism, texualism and intersubjectivism and how the agent processes them and manifest practice. Furthermore, Shove et al. (2012, p. 23) characterize social practices based on three elements: material, competence and meaning. *Meaning* is informed by cultural conventions and expectations and socially shared meaning to the practice of teaching represent a key component of understanding the sequence of events which lead to certain or embodied enactment (Shove et.al, 2014). Yet, Giddens' approach in conceptualizing practices in terms of the interplay of structures and agency is most fitting as it provides a comprehensive overview through which this research aims to provide a more nuanced capture. More precisely, Ashwin (2009) uses the term 'structural-agentic processes" to characterize teaching practices. He emphasises that "*structure and agency are not different kinds of processes but different ways of grouping or conceptualising complex social processes*" such as chemistry teaching. Furthermore, the work of Ritchie S. and colleagues on teaching agency (2014, 2015, 2016, 2017 and 2019) and context-based chemistry (2013) had been quite insightful in providing sociocultural and emotional insights into teaching practice, while focusing on the interaction between teacher, students and structures. Therefore, significant attention should be given to the individual agency and the very complex social entities and cognitive processes (Archer, 1995) which may guide their actions to provide more *nuanced* characterization of the contextual practice of teaching chemistry in HEIs.

The highlighted structures and agencies to follow are based on the literature review. Detailed examination of these in relation to the findings will be discussed in chapters 5 and 6.

Situating Structures: Rules and Resources

Social realism's identifies the existence of structures which exert certain conditioning forces with varying magnitudes on agents and subsequent actions. Structures can be mental (Bourdieu, 1988); perceptions and expectations at the departmental, institutional and social levels. They can be embodied (e.g. teaching load, academic research efficacy, tacit as in recurrent practices, assumptions

and perceptions or even by-product of certain agencies). Giddens (1992, 1984) identifies structures (orders of knowledge) which cannot be explicitly treated as separate entities as sets of rules (or schemas, Sewell, 2005) and resources (human and nonhuman). At the same time, rules often need resources and vice versa. For example, a chemistry teacher introducing digital simulation will face challenges implementing if the resources (material and human) are not available and will need to observe power domains and comply with departmental and institutional rules. Furthermore, Fanghanel's (2007) describes academic filters (structures) which govern teaching practices in HEI context. While their characterisation is significant, the agency reaction is more informative. Agents must always negotiate the enactment of their actions in reference to the structures, and therefore different forms of contextual agencies may be realized. Some of these identified structures are examined next.

Teaching-research nexus

Chemistry is classified as a *hard* (Bilgan, 1973) discipline with significant emphasis on research productivity. Consequently, a systematic cognitive structure is the dilemma produced by the teaching-research nexus. There is a pressure of producing research or publication efficacy (hence appraisal) on the teachers (Hattie and Marsh, 1996; Seagram et al., 1998; Malcolm, 2014; Gilmore et al., 2015; Cadez et al., 2017) whereby "*using research performance as a yardstick of institutional value*" (Henard & Leprince Ringuet, 2008, p. 5). Furthermore, researchers highlighted but often struggled to deal with "teaching-research nexus" (Trowler and Wareham, 2007, Colbeck 1998; Robertson 2007; Brew 2010). Others describe the complexity of achieving both as *"The Myth of the Teaching Research Nexus"* Alex (McKenzie, et al., 2018). While some refer to the complexity of collaborating with other disciplines as *interdisciplinary research is generally less likely to receive funding (Bromham et al., 2016).* This places considerable constraints on the chemistry teachers and their decision making process related to teaching and their perceived priorities and hence teaching agencies. In many cases, *"teaching"* was viewed as a *"chore'* in the context of individual agency (Contu and Wilmott, 2003) and its importance within the department (Van Lankveld et al., 2017). Nonetheless, teachers' beliefs, and hence agency and interplay of agency-structures that have effects on academics' experience of the relationship between teaching and research include conceptions of research (Coate, Barnett, & Williams, 2001; Prosser, Martin, Trigwell, Ramsden, & Lueckenhausen, 2005) and of learning (McLean & Barker, 2004). This is perhaps why professors who are heavily engaged in research and often gave teaching secondary considerations which in turn affects teaching approaches: *"Research universities have teaching expectations that are much lower than at other schools"* (David N. Figlio and Morton Schapiro,

2017, p.6).   This of course may not be the same for all chemistry academics and is subject to agentic consideration.

Tribes and territories

Åkerlind (2011, p.190) states *"it seems likely that this variation within the same way of experiencing growing and developing as an academic may be associated with different ways of experiencing growing and developing as a teacher".* Epistemological essentialism might guide some of the teaching approaches. Often, teachers in chemistry as a discipline might teach in the same manner they were taught and resort to strong epistemological essentialist approaches as there are certain concepts students must know (e.g. stoichiometry in chemistry) and hence more of ITTF approach is utilized. A simplistic rendering of disciplines is a follows: '*Ways of thinking and doing'* (Entwistle, 2005). Departments and disciplines (*and the subsequent disciplinary epistemological essentialism*) are far more complex. For example, the *recurrent practices and tacit assumptions* (Trowler, 2011) within the discipline often set the tone for the expected accepted and encouraged thus constituting structures. Furthermore, extensive studies on the contextualization of departmental cultures (Knight and Trowler 2000, 2011, 2013) proper induction (Barkhuizen, 2002; Dearn et al., 2002; Staniforth & Harland, 2006; Trowler & Knight, 2000 Kember and Kwan 2000; Parpala and Lindblom-Ylänne 2007; Prosser, Martin, and Trigwell 2007; Wegner and Nückles 2015) and professional development of university teachers (Åkerlind 2003, 2011; Gibbs and Coffey, 2004; Postareff et al., 2007; Knight, Tait, and Yorke, 2006; Stes et al. 2012; Trautwein, 2018) only reveal part of this complexity and its potential influence on agency. Teaching, learning, policies and change are not simple activities devoid of their societal, historic, cultural, linguistics connections. Trowler (2013, p. 1730) insightfully points out*: "Nuancing the understanding of disciplines, and shifting towards a postmodern perspective on them, therefore, adds complexity in a number of fields, but offers a less simplistic, essentialist and reductionist account; one that is more appropriate for higher education in the twenty-first century".* This highlights the stressing need to examine this structural influence on agency and implications on teaching approaches.

Disciplinary troublesomeness

Chemistry is often perceived as difficult to teach and learn. The process of teaching chemistry in modern conditions in higher education is a difficult task (Shepelyuk, 2020) as students are expected to make connections between the macroscopic (tangible and visible phenomena), the submicroscopic (particles), and the representational (pictorial representations, chemical symbols, equations, etc.) domains in chemistry, yet often have difficulty in understanding how these domains are related (Ware, 2001; Treagust, 2015; Park, Liu, and Waight, 2017). At the same time, chemistry is described as a *hard discipline (*Becher, 1989) with strong positivist epistemological perspectives (structure) on the

teachers. This is also suggested by Kember & Gow (1994) who arguably without accounting for agency found that, at departmental level similar to a chemistry department, a transmission of knowledge orientation '*seems to discourage meaningful learning approaches*' (p. 71) and deep learning. Trigwell et al. (1999) cautiously conclude that: *'Teachers who themselves reports adopting more of an information transmission/teacher-focused approach to teaching have students who themselves report adopting a more surface approach to learning".* Therefore, teaching approach agency might be deeply rooted in, or at least influenced by epistemological essentialist perspectives related to the concepts and is examined further.

The Institution

Similar to other HEIs, chemistry teachers are part of an institution which faces numerous mounting (isomorphic-mimic-normative) pressures to improve the quality of learning (O'Flaherty & Phillips, 2015), massification (Trow, 2010), "become international" (Robson 2016) and hence perhaps a situational restructuring of agency. For example, the massification of higher education or expansion is now a global phenomenon and represents another institutional structure. There is significant competition and pressures (Battilana et al., 2009) taking place at the institutions (Altbach, Reisberg, and Rumbley 2009; Mulryan-Kane 2010) and adopt *innovative pedagogies* to meet the needs of a more diverse student body and improve student learning (Bonk 2007; Henderson, Selwyn & Aston 2015; Porter, Graham & Spring 2014). Unlike school teachers, many professors have neither the inclination nor the *institutional* mechanisms which force them to subscribe to the all-important professional development activities (Meirink, et al., 2010; Vescio, et al., 2008, Hicks et al., 2010). At the same time, recent research reflects a trend in higher education in which research and teaching are increasingly separated as two distinct activities (Leisyte, Enders, and Boer 2009). In some cases, this is perhaps realized in the introduction of adjunct teaching professionals (Whitchurch, 2008) and the emerging concept of 'third space', which has brought multiple challenges with regard to pedagogy (Kreber, 2007) and presented practical problems for academics in dealing with ever larger and more diverse student numbers (Macfarlane, 2004) and positions the institutional pressures on the *agentic* as further layer for consideration.

Situating Agency

Pedagogy

The concept of agency and the assumption of *knowledgeable* actors was popularised by Giddens (1984) in structuration theory and has since been used widely (Eteläpelto et al. 2013). Many other theoretical models have attempted to provide and account for agency: performativity theory (e.g., Miller, 2014), sociocultural theory (e.g., Arievitch, 2017; García, 2014), sociocognitive theory (e.g.,

Dufva & Aro, 2015); critical realism (e.g., Block, 2015; Bouchard, 2018). Many studies on academics' conceptions of learning and approaches to teaching have recognized the role of agency (e.g. Kember and Kwan 2000; Parpala and Lindblom-Ylänne 2007; Prosser, Martin, and Trigwell 2007; Wegner and Nückles 2015) and high quality dialogic interactions (Ritchie et.al 2016, p.15). Yet, little is known in reference to agency in teaching chemistry at the HEI context whereby the teacher who is the enactor of the practice is central. In some studies, the significance of professional development (or lack of pedagogical knowledge) of university teachers is highlighted (Åkerlind 2003, 2011; Gibbs and Coffey 2004; Postareff et al. 2007; Knight, Tait, and Yorke 2006; Stes et al. 2012; Trautwein 2018). At the same time, academics with heavy teaching load and emphasis on research result in little time for professional development (Burston, 2016) or achieve formal qualifications in learning and teaching (Light, Calkins & Cox 2009) have resorted to the model of lecturing and tutorials (Laurillard 2002, Morrison, Lorens & Bandiera 2014; Robson & Turner 2007) This glimpse of the complex interplay between agency and the structures perhaps explains why instruction in higher education has been predominantly lecture-based, where the instructor gives lectures, and becomes the primary source of information for students (Cohen, Shamatov, & Merril, 2018) or a teacher-centred approach (or ITTF) to teaching (Lindblom & Nevgi, 2003). Yet, PD engagement may not give an indication of teaching approach as the teaching practices contexts are not necessarily consistent for all or are the agents, thus highlighting again the role of agency, variations and magnitudes of structures.

Self-efficacy

Chemistry teachers enact practice based on individual beliefs and personal aspirations. Self-efficacy and teacher confidence are significant (Appelton, 1995; Harlen & Holyrod, 1997; Kind et al., 2011) and are subject to individual agency and as meaning-competency-materials are aligned to enact the practice. The teacher-academic's sense of achievement and commitment to both teaching and research is the focus here. This often underscores how teaching is viewed and enacted. For example, innovations in teaching approaches are often practiced by academics who are '*passionate about their subject matter, towards their duties as teachers, and most significantly towards their students*' (Yair 2008, p. 456) with a heightened sense of *pedagogical* self-efficacy. This in turn may influence student learning (Raved & Assaraf, 2010) and attitude and merit further examination and understanding as it constitutes a significant component of agency.

Theoretical underpinnings: Structural -Agentic Lens

Reckwiz's (2002) positioning of cultural (practice) theory presents a strong argument for chemistry teaching agency, when described as routinized forms of mental activities and physical performance (Rasche and Chia 2009). Of particular interest is the emphasis on mentalism, texualism and

intersubjectivism as they represent an exchange between chemistry teacher-researcher agents and perceived structures. The meaning itself is contingent for those seeking change as it is constantly challenged by tangible experience through a reflective rational inquiry approach (Lawrence, Wilkes and Ashmore, 2014). Meaning is heavily anchored in mental activities which lead to adopted contextual understanding by agents. This mean is multifaceted and very complex; related to critical situational analysis and knowledge depth, background, motivational levels and self-efficacy and therefore agentic enactment. Teachers are agents operating within structural parameters (Hall et al., 2019). They are part of the whole and therefore they are bound to influence and are influenced by the social. Entangled in all of this is the recognition that any practice is based in agentic attributes as it responds to externals, interacts and negotiates with the social. *This moves the focus from agents to agency and differential enactment and possibly pedagogical change.* Mathieson (2011, p.563) reiterates the significance of this interplay and states "*Attention to agency and structure highlights the potentially significant role of academics as agents of change in enhancing TLA cultures, as opposed to seeing them as passive recipients or even resisters of external change forces.*"

Significance and limitations

The realist lens on agency and structures to gain deeper understanding of the teaching practices in a chemistry department was informative and provided considerable implications for policy, pedagogy, (Burston, 2016, Harder et. al. 2009) and epistemology. Ashwin (2008) emphasizes the utility of examining the conditioning forces in the enactment of teaching approaches. Explicit discussions of how structure and agency are accounted for in research into TLA in higher education can provide a useful starting point to improve the quality of explanations that are constructed in this area of educational research. It is important to indicate that there was a merger and the institution I worked in became part of a larger conglomerate with a more research oriented focus. The interviews were conducted through Zoom. This may have reduced the comfort level of the respondent and prevented me from noticing bodily expressions which might have triggered better leading questions. Despite the in-depth design and openness in inducing discourse, some respondents may not be fully candid for personal reasons. My role as a previous colleague might add elements of unintentional bias. Therefore, I remained cognisant of this and ensured that the reflections and interpretations were contextual and objectively positioned. Agency is highlighted in the context of teaching approaches in a higher education context and condition approaches to teaching chemistry. The significance of this research is in examining the processes and mechanisms which might exist. This includes curriculum change (e.g. instructional design and technology) through changes and improvements in teaching practices and providing insight role of teaching agency in a structure-agentic lens and potential changes to the

expectations of academics in response to global changes. While sometimes curtailed by institutional and disciplinary structures, teacher agency situated in structural context is heavily based in the teacher's sense of self-efficacy and pedagogical knowledge and belief. Yet, the meaning of the practice of teaching and hence approaches and enactment remain troublesome and are subject to disciplinary essentialist perspectives at least at the introductory levels. This positions again the question of how can the teachers achieve the somewhat elusive balance between teaching- research and service? In fact whether the teaching and research nexus is practical and the need to explore more academically the essentialist approach to divorce teaching from research. While the context of this research is specific and focuses contextually on only chemistry department in a single institution, it does provide a framework for examining other departments in other institutions with implications for policy change as it captures the interplay of agency and structures. At the same time, focusing only on situating the issue in agentic-structural context may also have prevented other considerations. Further research with a larger sample in multiple settings may illicit deeper understanding of this interplay and sharper capture of sub-disciplinary variations.

Thesis structure

Chapter 1 introduces the research and provided an overview of the scope and significance. Chapter 2 provides an extensive literature review of the research topic identifying established knowledge, gaps and synthesis of the findings as a guiding force in the research to gain better further depth. Chapter 3 discusses and explores the epistemological methodological underpinnings and research design. Chapter 4 focuses on the concepts of teaching as a practice in the higher education context. Chapter 5 identifies structures and characterizes them in the context of teaching chemistry practice. The next logical step is to explore agency in a similar context (chapter 6). Chapter 7 examines the dynamics of agency-structures interplay and connecting the findings to the research questions. Chapter 8 provides concluding remarks with emphasis on the significance of the research (how well substantiated truth claims were and their claim to significance), potential limitations and provisions for further work. References, appendices, ethical approval forms and samples of consent are placed at the end.

Summary

This chapter positioned the context and significance of the issue and provided the rational for examining it in the social practice lens. A case study social realist qualitative approach with considerable emphasis on critical literature review and discourse analysis was utilized. Teaching (and learning) in chemistry higher education is complex and related to research, self-efficacy, pedagogical epistemologies and other deliberations. Teachers face many challenges as they make pedagogical decisions. Departments and disciplinary differences exist. They often approach knowledge in

different epistemological lenses. While, I reflect on learning theories in relation to higher education, the scope of this research is not quite to investigate learning theories. The focus is on teaching as a social practice highlighting the role of agency and structures and how their interplay informs teaching practices which subsequently provide implications for policies in higher education.

Chapter Two: Literature Analysis

Chapter overview

This chapter underscores the importance of the literature review in epistemological methodological foundations, explores and critically examines the literature on the topic. Several overarching themes related to chemistry teaching approaches through the structures-agency lens are highlighted. They include but are not limited to the characterization of different agency domains, identity and self-efficacy of the teacher, practice and difficulty in operating within the teaching-research *nexus* as the agent responds to different *forms* of structures which often guided the epistemological agentic positioning of the teacher and the subsequent approaches to teaching.

Introduction

To gain an improved understanding of the interplay of structures and agency in teaching chemistry it is important to situate the research in the literature. Situating the research in the literature is a critical and complex phase in capturing knowledge or geographical landscape of the subject. It is a process of "*Review of existing research facilitated a familiarity with what in the topic and establishing the ground work for further work*" (McMenamin, 2006, p. 134). Examining the issues entails reviewing prior research as part of the research process (Babbie, 1998; Creswell, 2012: Fraenket & Wallen, 2003 ; Gay & Airasi, 2000; McMillan & Schumacher, 2001) in a methodical and systematic epistemological attempt to capture analyse and critique established knowledge, identify knowledge gaps (agency in teaching chemistry at HEI) and establish rationale and significance for further insight. This process is perhaps non-linear in the social field and requires clear and very specific aims as the issues are often intertwined, contextual and unintentionally objectively guided. Therefore, the literature review examined different overlapping concepts with dedicated focus on the agency and structure interplay in relation to chemistry teaching approaches and practices.

The Problematic

Chemistry teaching in HEIs is a social practice subject to many individual and external considerations. At the same time, there are different types of chemistry (organic, physical, instrumental...) and teachers' backgrounds, aptitude and inclinations whose responses to perceived structures and subsequent enactment of practices thus vary. There is significant body of work focusing on teaching and learning as social practices (for example see Mann; 2000; Trowler and Cooper; 2002; Jones et al,

2005; Trowler, 2005). Several structures in relation to agency are identified in the literature. For example, Becher and Trowler (2001), address the relevance of disciplinary knowledge culture in academic work. Fanghanel (2007) quite appropriately describes seven academic filters which govern teaching practices in HEI context *"They operate at different levels of practice, although there is some overlap. Four of them operate at the macro level – the institution, external factors, academic labour and the research-teaching nexus. Two operate at the meso level – department (or equivalent) and discipline – and one at the micro level of the individual – pedagogical beliefs"*. Furthermore, Knight (2002) identifies the department as the primary locus for the development of teaching. Read. Archer and Leathwood (2003) also consider the role of power relations in any enactment. Indeed, there is a similar tendency within social theorising at large to explain human action foundationally in terms of social structure, as with Bourdieu (1998) or Foucault (1970). By contrast, studies in this area rarely consider interplay between personal powers exercised by individuals particularly in relation to teaching chemistry, and structural and cultural factors; although Clegg (among others) offers a notable exception. Her study (2005), for instance, addresses personal development planning and practice predicated on notions of 'learning outcomes' describes ways in which the agency of specific actors mediates the impact of structural factors. In this she draws on the social theory of Margaret Archer (2000, 2003, and 2007) to consider the interplay between structure and agency. Archer (2008) focuses on ways in which the professional identity of younger academics is shaped by neoliberalism, while acknowledging some scope for resistance. It is clear, however, that such studies reflect a dominant socio-cultural approach in this area of research, with individual agency effectively determined by structural influences. This positions a need to examine agency in reference to structures or even vice versa. More precisely, Ashwin (2009) uses the term structural-agentic processes. He emphasises that *"structure and agency are not different kinds of processes but different ways of grouping or conceptualising complex social processes"*. Rather than regarding agency as residing in individuals as it recognizes the difference between *ability and doing*, in this framework agency is viewed as an interactional process that results from the interplay of individual efforts, available resources (and issues of access/power) and contextual and structural elements (Biesta & Tedder, 2007). In other words, agency is seen as an interactional achievement that is constructed relationally in dialogue with immediate as well as temporally distant currents and contexts (Leander & Osborne, 2008; Sewell, 2005) or structures. In this conceptualization, agency and structure are not opposed but build on each other in a dialectical relationship; structures shape people's agency, and conversely, people's agency reproduces or transforms structures (Sewell, 1992; Giddens, 1984; Emirbayer & Mische, 1998). While not directly related to teachers (but teaching) Arnold and Clarke (2014) note, "the contemporary interest in

researching student [or teacher] agency in science (chemistry included) also reflects a shift in science education toward understanding science learning as a complex social activity" (p. 736). This generates an interest in both examining teaching as a social practice and examining in depth the role of teachers' agency as they adopt teaching approaches and enact the practice. The issue is not to favour one particular teaching approach over others, but rather to examine in the context of HEIs the processes which might be at play through a structure-agentic lens and how they condition enactment of approaches

Structures and agency

Reckwiz's (2002) positioning of cultural (Practice) theory presents a strong argument for agency. It describes practice as routinized forms of mental activities and physical performance (Rasche and Chia, 2009). Of particular interest is the emphasis on mentalism, texualism and intersubjectivism as they represent an exchange between agents and structures in a complex discourse process of enactment based on perception of the physical and subliminal discourse of the externals and individual response. This discourse analysis can provide evidence of "*how specific actors construct an argument and how this argument fits into wider social practices*" (2013, p. 5). Individuals or agents, chemistry teachers in this case, operate within contexts, socially constructed norms and parameters or structures. The extent of agentic enactment of practices is often related to the agent's attributes (or agency) and the external domains (or structures) which are in congenial existence and inherently subject to agentic input to organize and institutionalize this behaviour. While it is useful to describe these two entities (agency and structures), it is rather profoundly erroneous to treat them independent of each other as their contextual interplay is what yield the enacted practices. A structure is defined [*more aptly described*] as the contextual organized rules and resources that enable individual agent's actions (Giddens, 1984). Rules (e.g. assessment procedures) are guided by structural common practice, or routines, by which actors are enabled to make decisions, as well as demonstrate an understanding of the normative behaviours within the structure, reconstituting the routine (Veliquette, 2013; Oppong, 2014). Where rules often dictate the range of possible decisions or behaviors, resources are the means through which an agent performs an act (Giddens, 1984). Both the interpretation of rules related to teaching chemistry, procurement and utilization of resources (material and nonmaterial) are problematic and vary at the individual level, hence restating the role of agency. Eteläpelto et al. (2013) conceptualize teacher agency from a subject-centred socio-cultural perspective, taking individual agency and social context to be analytically separate but mutually constitutive, and in complex ways highly interdependent. Trowler and Cooper (2002; Trowler, 2019) suggested within their context of teaching and learning regimes, an academic's identity (a component of agency) needs to be considered

in relation to others. This identity is a reflection of agency in structural contexts and subsequent enactment of the practice. Meanwhile, Goller and Paloneiemi (2017) refer to the two approaches to agency as individual characteristic *capacity* and the other being directly associated with action; in other words ability and enactment. While the first might be attributed to knowledge, meaning, competency and other factors, the second might be more directly correlated with all of what preceded in addition to the social and structural consideration which might ''enable'' or ''constrict'' agency. This of course implies that that there are different classifications of agency and perhaps structures.

The next part and the remainder of this chapter will examine examples of structures and elements of agency identified in the literature. This will be followed by an investigation of the interplay between the two in reference to teaching approaches and practices.

Situating Structures: Rules and Resources

Teaching and Chemistry Troublesomeness

Perhaps as a result of the content, chemistry teaching is somewhat difficult. This is further complicated by language barriers as students are learning in a different language. In chemistry, students are expected to make connections between the macroscopic (tangible and visible phenomena), the sub-microscopic (particles), and the representational (pictorial representations, chemical symbols, equations, etc.) domains in chemistry, yet often have difficulty in understanding how these domains are related (Treagust, 2015, Park, Liu, and Waight, 2017). Learners see examples of chemistry manifest in the laboratory or in authentic context. But they often struggle at the smaller micro level, the ideas of molecules, orbiting electrons and electron clouds become less tangible and approachable. Teachers do not have it any easier as they must make more of pedagogical initiative (if they wish). This positions the realization that the disciplinary domain itself representing cognitive structure which can in reality be empowering or constraining depending on agency. Ware (2001) points out the challenges with teaching chemistry: *"It has been well demonstrated that many undergraduate chemistry students do not fully comprehend the concepts that they can, in fact, successfully apply, in algorithmic problem solving" (p.1210).* Furthermore, according to Espinosa, Monterola and Punzalan, (2013) chemistry students find chemistry too abstract and mathematical. Brickhouse and Carter, (1989) also pointed that many students get lost in the concepts in chemistry if they are unable to interpret the correct idea. In terms of understanding how academics experience teaching, the work of Trigwell, Prosser and Taylor have been informative; building on earlier studies (see, for example, Entwistle, 1984; Dall'Alba, 1990; Samuelowicz & Bain, 1992), and noting the lack of research on '*the associated intentions or motives of teachers*''. Learning can be described as a phenomenon that is situated in its cultural context (e.g. Brown et al. 1989; Darrah 1995; Resnick 1987) where in teaching-learning connection; teaching is

[arguably] viewed as means oriented (Noddings, 2003, p. 242) where student-centered unguided methods of instruction is highlighted (Kirschner et al., 2006). The literature identifies presumed teaching approaches at institutional levels despite the presumed differences in disciplinary (not quite at the sub-disciplinary level e.g. physical vs. organic chemistry) contexts. At the same time, despite theoretical agentic momentum, information transfer models are dominant as the instruction in higher education has been predominantly lecture-based (information transfer-teacher-focus ITTF) (Cohen, Shamatov, & Merril, 2018) or a teacher-centred approach to teaching (Lindblom & Nevgi, 2003) most employed means of transmission of knowledge in higher education (Schmidt, Wagener, Smeets, Keemink, & van der Molen, 2015). This may be related to professors (teachers) being used to it, and professors and students resisting changes to this mode of teaching (Pale, 2013) with assessment strongly focussed on examinations (Laurillard 2002), the necessity of covering content, having large classes, introducing new information, and helping students with difficult readings (Mazer & Hess, 2017). It is attributed to the traditional notion of knowledge from philosophical traditions is that knowledge is true, reasoned, belief (Bhaskar, 1981; Matthews, 2002). At the same time, teachers who experience different contexts may adopt different approaches (Lindblom, Trigwell, Nevgia and Ashwin, 2006) and that lecturers who take a student focused approach to teaching and learning will encourage students towards a deep approach to and teachers' approaches to teaching influence students' approaches to learning (Prosser and Trigwell, 1999). Biggs and Tang (2007) also suggest active styles of learning can increase students' performance. Ceyhan Çiğdemoğlu (2012) also found out that context-based approach is very effective in improving students understanding, achievements, and literacy. Still not common is the adapting teaching to differences among learners, on the social and institutional context of teaching in higher education and more recently, on the theory and methods of research on teaching (e.g. Wittrock, 1986; Ramsden, 1992; Knapper, 1995; Biggs, 1996; Entwistle, 1998). Furthermore, many argue that teachers should be helped to apply student-centred approaches instead of teacher-centred approaches (e.g., Gibbs & Coffey, 2004; Samuelowicz & Bain, 2001; Trigwell & Prosser, 1996b) because the student-centred approach to teaching is likely to have a positive effect on student learning (Trigwell et al. 1999) if carried out properly. Trowler et al. (2005) suggest that one way to enhance teaching, learning and student experience is to *"encourage reflective practice within reflexive departments that are situated in learning universities"* (p. 440). Conversely, some faculty question whether this pedagogical practice truly enhances students' sense of involvement given that it also assumes that learners are motivated and engaged (Harju & Åkerblom, 2017). Engagement can often be defined in terms of behavioral, emotional, and cognitive ways of students actively participating in the task at hand, positively liking or valuing the process of learning, and consciously

using learning strategies for deeper understanding (Fredricks, Blumenfeld, & Paris, 2004). Wilensky and Resnick (1999) have argued that many problems (*for the teacher and presents ample opportunities for agentic locus*) in learning science relate to learners not appreciating the nature of emergent systems. At the same time, chemistry teachers have a unique perspective that ideally should allow learners to ask the quintessential questions and utilize the practical sessions to perhaps shift the dynamics in favour of student centred learning and offer a more conceptual change student focus (CCSF) approach. These questions allow students to visualize, manipulate, and predict the behaviour of unseen molecules and gain an understanding that is uniquely situated in chemistry (Brown, Collins, and Duguid 1989; Cognition and Technology Group 1990; Lave and Wenger 1991). However, this is not a common practice. Thus this structure is permeable and perhaps *soft* in its nature as there is a choice for enactment and may be considerably linked to self-efficacy.

Discipline: tribes, territories and epistemological essentialism

Chemistry as a discipline is not quite uniform. There are sub-disciplines (e.g. physical and organic) which have as much differences between them as commonalities. Based on Bilgan's topology they can range from hard to soft and others in between. Bain et al. (1998) suggest that "*the educational context in which students learn is heavily influenced by the epistemological and educational assumptions of their academic teachers*" (p.49). Knight et al. (2006) states that heads of departments are key people in the development of the institutions' educative capability. For chemistry to be assumed to implement an ITTF approach assumes correlates with Entwistle's (2005) characterization of a discipline as having similar with "*Ways of thinking and doing*". This is quite problematic as it assumes a universal and wholesome confining perspective and treats all the sub-disciplines within chemistry as identical whereby the teachers are machine-like agents. More precisely, Trowler (2013) has shown how academic disciplines are similarly situated in their character, enacted differently in different contexts yet still recognisable to the observer as somehow 'the same' even across multiple manifestations through self-regulation and the ability to control one's behaviour, emotions, or thoughts, appropriate to the given context or situation (Cook & Cook, 2014). Even more significantly, Trowler, (2014) adopts a revised position on the concept of discipline "*firstly, the category 'discipline' does not have a set of essential characteristics which are all necessarily present in every instance. Secondly that each individual discipline has no essential 'core characteristics' either, in the sense of being all present and identifiable at all times.* Finally the he argues *that the generative power of disciplines, the power to affect other phenomena in significant ways, does exist, but is more like the power output of a wind turbine than that of a power station*" (p.1722-1723). In other words, each discipline has its own intellectual history, agreements, and disputes about subject matter and methods that influence what is taught, to whom,

when, where, **_how,_** and why (Huber et.al, 2002, p.15). For example, we might question the order of chapters in the textbook for chemistry 101 or why certain concepts require more elaborate experimentations procedures while others are treated superficially. How this impacts and explains agency is still not entirely clear. Furthermore, disciplinary differences have been studied by a number of educationists over the past few decades (see, for example, Biglan, 1973; Kolb, 1981; Donald, 1986; Moses, 1990; Becher, 1994; Healey, 2000) and different teaching contexts and disciplines (Lindblom-Ylänne, Trigwell, Nevgi, & Ashwin, 2006; Postareff, Katajavuori, Lindblom-Ylänne, & Trigwell, 2008; Stes & Van Petegem, 2014). Becher and Trowler (2001) consider the clustering and characteristics of disciplinary knowledge, drawing on the 'Kolb-Biglan Classification of Academic Knowledge', and on earlier work by Becher. Authors have also highlighted disciplinary community of inquiry (Garrison et al, 2000; Garrison, 2011 and 2016, Pardales and Girod, 2006, p.308) and resilient and confident learners (Anthoney et al., 2017). Stark (2000) found disciplinary differences and departmental context (Zetter, 2002) in course goals, student characteristics and _teaching practices_ that led to different design outcomes. The literature also shows that rhetorical choices vary enormously across disciplines because they express very different epistemological and social practices (e.g. Anderson, Evans, & Harshorn, 2014; Hyland & Bondi, 2006; Swales, 2004). More so, academics' mode of communication (as part of the teaching approach and agency) in its disciplinary context is an important factor that contributes to effective teaching (Trigwell & Shale, 2004; Young, 2006). Hence, for example, disciplinary background and departmental cultures, for example, have been found to be _strong_ influences, shaping preferences for particular pedagogical approaches. Related to this research, the work of Biglan's (1973) typology of disciplines classified them as hard and soft, pure and applied (further developed by Becher & Trowler, 2001; Trowler, Saunders, & Bamber, 2012; and others). Chemistry being a _hard_ discipline is considered to have stronger emphasis on research (Coate et al., 2001; Jensen, 1988; Smeby, 1998, Robertson, 2007). One such explanation might be that members of hard disciplines such as chemistry tend to consider knowledge rather as discrete elements that are known with certainty (Hofer, 2000; Päuler & Jucks, 2017). Each group described knowledge from a completely different set of interests. Put differently, this is about focus, where focusing on one thing is that you must ignore others. As Woelert and Millar (2013, p. 757) put it, 'certain things and aspects become visible and in this sense "real", while others are rendered invisible.' Categories to typify disciplines have been stated by, for example, Kolb, Biglan, and Becher and Trowler, yet the hard-soft dimension has proven to be the strongest in terms of explained variance (Neumann, 2009) albeit a realization rather than an explanation. Furthermore, Lueddeke (2003) showed that teachers who teach in the 'hard' disciplines, such as physical sciences, engineering and medicine, were more likely to

apply a teacher-centred approach to teaching, whereas teachers from 'soft' disciplines such as social sciences and humanities took a more student centred approach to teaching and perhaps more liberal. Nevgi and Ashwin (2006) confirmed these results, and showed more specifically that teachers from the pure hard sciences (such as chemistry) scored significantly lower on the CCSF (*Conceptual Change Student Focus*) scale than teachers who represented the pure soft (e.g. history) and applied soft sciences (e.g. education). Furthermore, academics who approach their teaching in a teacher/content-oriented way concentrate on what they 'do' in teaching to *transmit* particular information (Kember & Kwan, 2000; Trigwell, 2012) based upon their own knowledge (Trigwell, Prosser, & Ginns, 2005). An embodiment of this hypothesis is Chichekian's (2018) research into the chemistry professors' perceptions of Learning in Undergraduate Education yielded interesting results. It highlighted the role of *traditional ways of learning* (67%), active learning (19%), and a balance between traditional and active ways of learning (15%), significant emphasis on students' *knowing the basics* (33%) and receiving information (22%) and the dominance of a lecturing style. The data also *generally* support the working hypotheses suggested by Trigwell et al., (1994); that is, staff teaching hard/pure or applied subjects are more likely to bring an ITTF orientation to their teaching, while staff teaching soft/pure or applied subjects generally take a more developmental (constructivist) approach in classroom situations i.e. CCSF (Lueddeke, 2003). Yet, it is a universal approach and accounts very little for the agentic enactments seen within the department (and why some resort to different approach and at what level) and why are some teachers involved in student-centred or active learning approaches. Consequently, there is an indication that this structure might be characterized as *rigid.* Yet, there is often little account for outliers and rationale of how and why. Disciplinary learning therefore includes a great deal of learning to ignore or discard information that is of little or no use; perhaps adding a further dimension to how approaches are realized and enacted.

Teaching-Research Nexus

> *Many institutional leaders are reconsidering how to manage the balance in fulfilling their teaching and research missions and how to raise the quality of teaching and learning they deliver. (Hénard and Roseveare, 2012 p.13)*

Faculty members report their activities annually to their department chair or program director. These annual reports vary in format from college to college, but all collect information on the three main areas of responsibility: teaching, research, and services. The weight distribution of each of these areas may vary from one faculty member to another depending on course offerings, research engagement, and institutional and contribution to department services. A typical load distribution of research active faculty members is: 40% teaching, 40% research, and 20% services. The weightage distribution of non-research active faculty members is typically: 50 - 75% teaching, 15-30% research, and 10-20% services. Faculty members who have administrative positions, such as a Dean, Chair, Deputy Chair, Director, or Coordinator, are expected to do less teaching and research activities and more administrative service. All faculty members must be reviewed annually (*HR Policy F2005/18*) by the respective department Chair/Director.

(*Excerpt from the faculty Handbook 2015, HEI)*

Chemistry teacher-academics variably operate within this continuum. Originally referred to by Neumann (1992), the teaching research nexus (Trowler and Wareham, 2007a, Jones, 2011) represents a contestable issue in academic life and teaching presence (Clarke and Bartholomew, Page et al.,2020, Colbeck,1998; Robertson 2007; Brew 2010) and the complexity of collaborating with other disciplines as interdisciplinary research is generally less likely to receive funding (Bromham et al., 2016) and tensions (Light and Calkins, 2015; Lucas, 2006; Malcolm, 2014, Blackmore, 2016)*.* Others identified a "*nexus*" (Elsen, Visser-Wijnveen, Van der Rijst, & Van Driel, 2009; Henkel, 2004; Neumann, 1994; Visser-Wijnveen et al., 2010; Zubrick et al., 2001), a "positive link" (Elton, 2001) or a "useful link" (Badley, 2002), notions which connote a synergetic link between the two, or as "scholarship" (Brew, 1999, 2003), in addition to research and teaching being two sides of the same phenomenon – learning. Many other authors have proposed a wide range of models to describe different relations or mechanisms between research, teaching and learning (e.g. Griffiths, 2004; Healey, 2005a; Jenkins, Breen, & Lindsay, 2007; Trowler & Wareham, 2007). Nonetheless, teachers in HEIs have been relegated to a technical role that undermines their reflexivity, autonomy and inquiry (Giroux, 2013; Biesta, 2017). The difficulty of how to successfully operate competently at two highly demanding endeavours is problematic and varies at individual levels. The concerns were first voiced by Newman (1852), Hattie and Marsh (1996) or Henkel (2004) about incompatibilities between research and teaching could also be revisited using this framework and is repeatedly raised in the literature on the development of education in research-intensive environments (Light and Calkins, 2015; Lucas, 2006; Malcolm, 2014). Trowler and Wareham (2007) further argue for addressing the need for defining the

level of specificity in terms of the extent and significance of causal effects. They criticize the literature on the research-teaching link to be vague, using a variety of terms such as 'interaction', 'interconnection', or 'integration' between research and teaching on the one side, or just an 'influence' or impact on the other (Neumann, 1996). Blackmore (2016) has also discussed some of the tensions in academic life between research and teaching. In reality it should not necessarily be problematic for chemistry teaching academics for precisely for two important reasons: the role of experimentation in concept building (which is often treated as a complimentary rather than a core activity) and researching the concepts from a student perspective. In other words, why are not the students a part of the academic research? This opens the door to a host of questions related to the purpose of HEI, tacit yet engrained pedagogical structures, roles and rules, pedagogical appropriateness, and active attempt to distance HEI from any vocational reference. Healey (2005) who distinguishes between four different types of relations between research and education, and different ways of how these relations should be organized, namely research tutored research-based, research-led and research-oriented education. However, teacher-researchers do not necessarily equate this with doing pedagogic research (even when they do there is no indication if and how it is adopted and enacted), as pedagogic research is often outside of methods teachers' own disciplinary domains. As Adendorff (2011) observes, this trans-disciplinary scholarship inducts challenges to researcher identity, mastery of educational discourses and reward concerns. This is added to the pressure of producing research work whereby "*using research performance as a yardstick of institutional value*" (Henard & Leprince Ringuet, 2008, p. 5). Ozay (2012) proposed to emphasize "research informed" as a central element of this continuum. In turn, this highlights the need to examine teaching in the context of agency and this structure (when critically and thoroughly examined) as the two entities represent the dimensions of any human activity. As a result this structural dimension represents a considerable strain on the agentic enactment and therefore might be considered to be rigid and highly correlational. At the same time, generalizations are never appropriate as Rowland (2000, p. 1) quite appropriately put in a clear exemplification of the different realities when operating within the teaching-research nexus and the role of agency:

> ***Some of the most inspiring teachers are able researchers, but not all; that some prominent researchers are good teachers, but not all.*** "

Institution

> Working in turbulent times has not been particularly easy. *"At every level, chemistry instructors have been finding ways to address the needs of students who find themselves in unfamiliar circumstances"* (Holme, 2020).

Chemistry teachers working in HEI are subject to institutional considerations. Recent changes in HEIs are due to a number of powerful external factors (Allais, 2014; Henkel, 2016) such as a larger and more diverse student population, increasing use of educational technologies, the marketization of higher education, and the demand for accountability (D'Andrea & Gosling, 2005; Hornsby & Osman, 2014). Institutions face numerous mounting (isomorphic-mimic-normative) pressures to improve the quality of learning (O'Flaherty & Phillips, 2015) and hence perhaps a situational restructuring of agency. These pressures generate responses to increasing geopolitical and economic imperatives, to 'become international' (Robson 2016) which will ultimately influence teaching approaches. Research led institutions in particular have reviewed their core missions in the struggle to be entrepreneurial and market-relevant (Pusser and Marginson 2013). A prestige culture has arisen, influencing whether universities, including this, are perceived to be 'excellent' or 'world class' in terms of research, teaching and the student experience (Blackmore, Blackwell, and Edmondson 2016; Knobel, Simões, and de Brito Cruz 2013). For example, the massification of higher education or expansion and massification (Trow, 2010), is now a global phenomenon and represents another institutional structure. HEIs are changing rapidly in response to increasing geopolitical and economic imperatives, to 'become international' (Robson 2016) and competition and pressures (Battilana et al., 2009) taking place at the institutions (Altbach, Reisberg, and Rumbley 2009; Mulryan-Kane 2010) and adopt *innovative pedagogies* to meet the needs of a more diverse student body and improve student learning (Bonk 2007; Henderson, Selwyn & Aston 2015; Porter, Graham & Spring 2014). Internationalisation is thus potentially and generally positioned as a positive and important element in the development of HEI (Marmolejo 2010; Noorda 2014). However, its impact on the quality of TLA practice is unclear. Concurrently, others refer to international education as a social process is in need of regeneration and re-articulation (Knight 2015; Robson 2011; Trahar et al. 2016) at the boundary of a dominant internationalization imaginary (Andreotti and Stein 2016). There is also the need for curriculum renewal of shared knowledge within the field (Altbach and Knight 2007; Hellstén, Reid, and 2008; Leask 2015; Marginson and Sawir 2011; Ninnes and Hellstén 2005). Macfarlane (2011) argues that, the 'all-round' academic is being progressively replaced by 'paraacademics' such as "skills advisers, educational developers, learning technologists and research management staff" (p.59) and growth of the for-profit sector (Robertson & Komljenovic 2016a; 2016b). At the same time, unbundling in relation to the teaching

role is firmly related to the growth of online technology and the emergence of private, largely online universities (Macfarlane, 2010). Teachers are challenged on a regular basis to deal with notions such as "knowledge economy' Davies (2014a, p. 310) and rapid technological change (Goodyear, 2015). Educational change and development is seen as an integral part of HE teachers' professional lives (Vähäsantanen, 2015), necessitating the development and adaptation of teaching and learning practices in HE (Kirkwood & Price, 2006). Unlike school teachers, many professors have neither the inclination nor the *institutional* factors which force them to subscribe to the all-important PD activities (Meirink, et al., 2010; Vescio, et al., 2008, Hicks et al., 2010). At the same time, recent research reflects a trend in higher education in which research and teaching are increasingly separated as two distinct activities (Leisyte, Enders, and de Boer 2009). This is perhaps realized in some instances in the introduction of adjunct teaching professionals (Whitchurch, 2008) and the emerging concept of 'third space', which has brought multiple challenges with regard to pedagogy (Kreber 2007) and presented practical problems for academics in dealing with ever larger and more diverse student numbers (Macfarlane 2004) and positions the institutional pressures on the *agentic* as further rigid layer for thorough consideration. Thus, teacher agency is a key capability in the negotiation of the increasingly complex HEI environment and development of academic practice (Delanty, 2008; Mathieson, 2011). Yet, Fleetwood (2008) suggests that there is no satisfactory explanation of the way in which institutions shape agents' behaviour, instead they "*take refuge in deliberately vague phrases like 'institutions and structures condition, govern, influence, or shape agency'*" (2008, p.183; emphasis in original). The importance of recognising institutional forces is highlighted by Barman et al. (2016), who suggests polices and hence practice require better collaboration between academics and local managers. Hence, a better understanding of this interplay is significant.

Situating [Teaching] Agency

> *Any coherent and complex form of socially established cooperative human activity through which goods internal to that form of activity are realised in the course of trying to achieve those standards of excellence which are appropriate to, and partially definitive of that form of activity, with the result that human powers to achieve excellence, and human conceptions to the ends and goods involved, are systematically extended. (MacIntyre 1985, p.187)*

While not significantly discussed in the context of teaching chemistry, the concept of teacher agency in is in focus in recent years (Orland-Barak 2017; Toom, Pyhältö, and Rust 2015). Bandura (2001, p.1) defines agency as ''*the capacity to exercise control over the nature and quality of one's life*''. Another approach to agency is directly associated with action [or enactment], that is things that individuals or collectives actually do while affecting their work and professional identity. According to Eteläpelto et

al. (2013), "*professional agency is practiced when teachers and/or communities in schools influence, make choices, and take stances in ways that affect their work and their professional identity*" (p. 61). All human beings have the capacity for agency-for forming intentions, capacity for desiring and acting creatively (Sewell, 1992). The term agency also implies the "power of effect" (Giddens, 1984, p. 41), and so is not determined by the intent or outcome of an act, but that the individual is the perpetrator of the act. Agency additionally refers to the ways in which actors "critically shape their responses to problematic situations" (Biesta & Tedder, 2006, p. 11; see also Biesta & Tedder, 2007; Priestley et al., 2013) and as something that is "*achieved through engagement with very specific contextual conditions*" (Priestley et al., 2013, p. 188). Thus, the construct is based in the capacity of the individual to have chosen a different act (or none at all) at any given time and context. At the same time, there are many types of agencies highlighted. For example, *instrumental* agency focuses on human mastery; having the capacities to do and accomplish something successfully (Edwards and Mackenzie 2005, p. 294). Meanwhile, e*ffortful* agency focuses on the individual having a strong enough desire and commitment to carry out an action pre-set in advance, Ban actor's ability to initiate and maintain a program of actions [despite internal and external resistance] (Campbell 2009, p.409). Several other empirical studies (e.g., Erss 2018; Eteläpelto, Vähäsantanen, and Hökkä 2015; Kauppinen et al. 2020; McNicholl 2013; Rajala and Kumpulainen 2017; Quinn and Carl 2015; Ruan, Zheng, and Toom 2020; Stillman and Anderson 2015; Van der Heijden et al. 2015) have focused on understanding and supporting teacher agency in professional settings but not exactly as chemistry teachers. Teachers are agents operating within structural parameters (Hall et al., 2019) and hence adapt and enact certain understandings of the role or practice. The meaning itself is contingent for those seeking change as it is constantly challenged by tangible experience through a reflective rational inquiry approach (Lawrence, Wilkes and Ashmore, 2014). Meaning is heavily anchored in mental activities which lead to adopted contextual understanding by agents (*which is multifaceted and very complex; related to prior experiences, beliefs, critical situational analysis and knowledge depth, background, motivational levels and self-efficacy to name a few*), and therefore agentic enactment. Teacher agency as a construct emphasizes the capacity for doing the work of teaching given the resources and limitations of the working environment as well as considers teachers' personal beliefs, values, and attributes (Brevik et al., 2019; Lennert da Silva, & Mølstad, 2020; Lund et al., 2019). Similarly, the ecological model (Leijen, Pedaste, and Lepp 2020; Priestley, Biesta, and Robinson 2015) sees teacher agency primarily as a decision-making process, which is influenced by three dimensions: past histories of the person (iterational dimension), future prospects (projective dimension) and by the cultural, structural and material conditions of a practical situation (practical-evaluative dimension). Several articles on teacher

agency have also been published with a focus on development of the concept (Biesta, Priestley, & Robinson, 2015; Eteläpelto, Vähäsantanen, Hökkä, & Paloniemi, 2013; Priestly, Edwards, Priestly, & Miller, 2012). Thus, agency is something people do or achieve by means of their environment and is a result of "the interplay of individual efforts, available resources, and contextual and structural factors as they come together in particular and, in a sense, always unique situations" (Biesta and Tedder, 2007, p. 137); *or in other words holistic structural-agentic interplay*. Moreover, according to Hewson (2010, p.13), a person's agency is his or her independent capability to think critically and act of his or her own will, while structure refers to social forces or influences that impact positively or negatively on individuals' agency. But this is far too general and there can be a better account to situate agency contextually in an elaborate decision making process. In this regard, I propose *functional* agency (normative, pragmatic, static, practical, expected and achievable); *adaptive* agency (dynamic, evaluative and negotiable; and *progressive* agency (reformist, impetus). Related to the current research, agency has been used increasingly in the science education literature. Within close proximity, identity development has been also receiving more attention as a construct in science teaching and learning (Varelas, 2012). Science teacher identity is "*the ways in which a teacher represents herself through her views, orientations, attitudes, emotions, understandings, and knowledge and beliefs about science teaching and learning*" (Avraamidou, 2014, p. 826). Meanwhile, Tan (2011, p.26) adopts one of an array of opposing opinions among leading sociologists, which assumes one view and portrays structure as exerting a constraining effect on individuals' agency. Yet, the characterization of teacher agency, and its importance for effecting change in [chemistry] education, has been largely under-researched, both in terms of theory development and practice research (Biesta, Priestley, and Robinson, 2015) and more importantly the influence on structures on agentic momentum. At the same time, despite the variety in how the concept is defined there is often there is a lack of a clear operationalization (Arnold & Clarke, 2014) particularly in teaching chemistry in HEIs.

Agency and Pedagogical Competence

Approaches to teaching chemistry might also be contextually need-based practice. Social practice theory (Engeström, 2001; Wenger, 1998) addresses the meso-level and the social and affective dimensions of change. According to this theory, the most significant aspects of change processes in teaching, learning and assessment involve social interaction at the level of the workgroup'. An important consideration in the enactment of a practice is the understanding its meaning and scope in relation to other tasks such as research. Teachers' approaches to teaching are influenced by their conceptions of teaching and pedagogical aptitude or competence. Studies of university teachers' conceptions of teaching have showed a range of variation (e.g., Kember & Kwan, 2002; Prosser,

Trigwell, & Taylor, 1994; Samuelowicz & Bain, 1992). However, there is an absence of evidence of the impact of training on teaching behaviour (Coffey & Gibbs 2000; Norton, Richardson, Hartley, Newstead, & Mayes, 2005). At the same time, faculty in higher education institutions are predominately hired for *technical expertise* (Adams, 2002; Boyer, 1990; Pals, 1988) and with little teaching experience (Adams, 2002; Austin, 2002; Pals, 1988; Wardlow and Johnson, 1999). Bransford et al. (2000) postulated that practicing teachers (in this case hired lecturers and tenure track faculty) learn about teaching through a variety of **experience**; hence *adaptive agency.* Darling- Hammond (2010) reports the inadequate   pedagogical knowledge of novice teachers. Biesta (2013) argues for changing teacher's role from transmission to construction and situatedness between monological and dialogical approaches to pedagogy (Vlieghe, 2016). Furthermore, students had learned one way to learn in K-12 settings and were asked to learn in *a different way* when attending post-secondary programmes, in particular, for introductory courses (Lape et al., 2014; Strayer, 2012; Yong et al., 2015. Ball and Lindsay's view (2013, p.49), teaching in another language, particularly at advanced conceptual levels, demands a greater focus on methodology and practice than in the past, when pedagogic skills were not an essential prerequisite to a successful university career. Weller (2016) in an effort to promote the academic practice and developing as a professional in higher education calls for experts to disseminate the difficulty of disciplinary threshold concepts which can be quite problematic in disciplines such as chemistry. Blake et al. (2013) considers inter-disciplinary learning as a needed positive progression from the constraints and futility of disciplinary bunkering. This might be easier to achieve at the undergraduate level (Spelt et al. 2009). Researchers working in this area have developed a cycle to support *novice teachers* as they learn to practice (Lampert et al., 2013; McDonald et al., 2013; Troyan et al., 2013). Bain (2004) found out that the best teachers know their subjects, and they used their knowledge to develop techniques for grasping fundamental principles and organizing concepts that others can use to begin building their own understanding and abilities. They know how to simplify and clarify complex subjects, to cut to the heart of the matter with provocative insights, and they can think about their own thinking in the discipline, analysing its nature and evaluating its quality (p.16). Biggs (1999) however suggests that good teaching depends on the perception of pedagogy that an individual teacher has. Prosser & Trigwell (1999) explain this in the following way: "*different prior experiences of learning....meant that different learning situations were constituted for each student and different perceptions of their learning situation were evoked*" (p. 9). Thus, competent teacher educators play a pivotal role in enhancing the quality of education (Cochran-Smith, 2003; Goodwin & Kosnik, 2013; Liston, Borko, & Whitcomb, 2008) and exert a significant influence on existing structures (e.g. students, institution).

Teaching Agency and Pedagogical Development

Teaching as a practice comes with inherent operational considerations. For example, the literature identifies the lack of pedagogical knowledge and competence of teachers. Academics often replicate traditional and familiar ways of teaching (Postareff & Lindblom-Ylänne, 2008). Many other studies report that faculty were not given formal training in pedagogical methods, they simply mimic the types of instruction they observed as students (e.g., Halpern and Hakel 2003; Mazur 2009); hence perhaps reduced agency by relying on disciplinary essentialist perspectives or *functional agency*. The lack of induction into these roles experienced by so many teacher educators' is well documented (Murray, Czerniawski and Barber 2013; van Velzen et al. 2010). Teacher educators are drawn mainly from academic disciplines, often lacking practical teaching experience in schools (Griffiths, Thompson and Hryniewicz 2014). Learning and teaching in higher education institutions has been increasingly characterised throughout the globe by the 'shift from teaching to learning' (Barr & Tagg, 1995; Fendler & Gläser-Zikuda, 2013; Harvey, 1997; Schneider et al., 2009; Wildt, 2004). However, as Fleming, Shire, Jones, McNamee and Pill (2004) further observe it is not simply a matter of increasing the skills of academic staff but of encouraging university teachers to become professional by offering opportunities "*to engage in critical reflexive pedagogy*" and that this "*is being widely acknowledged as an important element in [the] continuing professional development*" (p. 165). Implicit within this commonly held view is that faculty generally lack sophisticated views regarding pedagogy and learning theory (Halpern and Hakel 2003) and that their teaching simply replicates that of their mentors (e.g., Mazur 2009). While, the notion of professional development of teacher educators has begun to emerge as a touchstone for not only what it means to become a teacher educator, but also to learn as a teacher educator (Loughran, 2014, p.217), however it is not always that simple. Teacher preparation has arisen as a way to provide more meaningful preparation to new teachers (e.g., Ball & Forzani, 2009; Darling-Hammond, Hammerness, Grossman, Rust, & Shulman, 2005; Grossman, Hammerness, & McDonald, 2009), in ways that more explicitly link university and field experiences (Darling Hammond, 2006, 2012) or "knowing through experience" (Kessels & Korthagen, 2001, p. 25; Loughran & Berry, 2005). This dialectic, or "reciprocal, recursive, and symbiotic [relationship] of scholarship and practice" (Cochran-Smith, 2005, p. 219; Cochran-Smith & Lytle, 2009, 2004, Orland-Barak & Yinon, 2007) occurs when teacher academics practice "theorizing and doing" (Cochran-Smith, 2005, p. 219). Brian P. Coppola and Dennis C. Jacobs (2002) highlight the significance of the educational research related to chemistry teaching:

> *"Chemistry instruction and its investigation can advance through a large community whose informed practices complement and build off each other. The scholarship of teaching and learning, as a philosophical construct centred on investigating classroom work, can pull the pieces of chemistry education together for the mutual benefit of individual present and future faculty members, their students, and also for the profession of the chemistry professoriate as a whole (Coppola, 2001, p. 20)*

At its core, a deeper understanding of SoTL provides an additional dimension of the structural-agentic interactions as it adds further aspects knowledge of the agent and structures precisely related to practiced pedagogy. Healey (2000) trying to understand and implement the idea of appropriate faculty scholarship so that the quality of teaching in higher education might be improved (Richlin, 2001; Watters & Diezmann, 2005). Yet, Tight (2018, p.2) states that the scholarship of teaching and learning has been influential in terms of thinking, practice and policy – particularly at the level of the individual, course or department - it has not led to the development of new or innovative lines of research. Harder et al. (2009), recommended that professional development activities be developed and presented to address getting students engaged in learning, teaching critical thinking, effective lecturing, questioning techniques, and active learning strategies. In particular, some experts criticise the tendency to focus on raising the profile of, and rewarding, individual teaching rather than on the strategic development of teaching and learning across the sector (Trowler, Ashwin, & Saunders, 2014, p. 4) and the need for teacher educators' professional learning (see Bates, Swennen and Jones 2011; Beauchamp et al. 2015) and development of knowledge currency (Lindsay et al., 2002) in the pedagogical context. Others also suggested that teachers should integrate new teaching pedagogies through different hands-on activities connecting to the experiences of the learners (Reyes, Espana and Belecina, 2014). However, for example, the strategy of the University of Helsinki (Strategic plan for the years 2004–2006, University of Helsinki, 2003) highlights, that every new teacher should have the possibility to participate in an introductory seminar on university teaching in order to improve teachers' pedagogical thinking and skills without stating the aspired trajectory of this engagement while treating all teachers as pedagogically equal. In a similar way, teachers' professional development is considered another powerful reason for teachers' research, since conducting research has a great positive impact on teachers' progress and learning of their everyday professional practice (Ulla et al., 2017).

Agency as self-efficacy

Similar to Bandura's notion of self-efficacy is Vygotsky's notions of the zone of proximal development and self-regulation (Vygotsky 1978) that also tries to address the issue (of the development and nature) of the human will through cultural signs and tools of mediation. Bandura defines self-efficacy as "*generative capability in which cognitive, social, emotional, and behavioural sub skills must be organized and effectively orchestrated to serve innumerable purposes*" (Bandura, 2000, p. 36–37). Bartimote-Aufflick et al. (2016) describes it more generally as "*a person's perception that he or she has the skill and capability to undertake a particular action or task*" (p.1918-1919). Self-efficacy about teachers' beliefs regarding their ability to perform their academic tasks (Lindblom-Yla¨nne & Nevgi, 2003; Trigwell et al., 2004) is a constant thought in the minds of teaching academics. However, there are significant issues with the concept of beliefs as they internally generated. They can be mischaracterized by the teachers but can be directly related to pedagogical competence. Gordon & Debus (2002) have shown that teachers with high self-efficacy beliefs are likely to engage in a wide range of more *productive teaching practices* than teachers with low self-efficacy (Bailey, 1999). Postareff et al. (2004) showed an effect of pedagogical training on teachers' self-efficacy beliefs. Teachers who had completed an extensive pedagogical training course scored the highest on the self-efficacy scale. There is also a premise that the quality of the academic is often related to the H-index (Hirsch, 2005) in relation to the number of citations received. Meanwhile, current teaching evaluation methods relying on student output and institutional controls have not been scientific enough and subject to criticism at the (Spooren, Brockx, & Mortelmans, 2013). Ozay (2012) proposed to emphasize "research informed" as a central element of the whole mode. While teachers' self-efficacy reliably predicts their instruction, learner engagement and classroom management over time (Künsting, Neuber, & Lipowsky, 2016) and is widespread in its agentic effects (Zee, Koomen, Jellesma, Geerlings, & De Jong, 2016), there are questions as to the influence of teacher efficacy on learner achievement (Klassen, Tze, Betts, & Gordon, 2011). In addition, even in cases where teachers have had positive conceptions about research as a means of improving students' learning, they still might decide not to undertake research because of constraints linked to lack of research skills, intense workloads and lack of support (Schiera, 2014; Ulla et al., 2017; Cloonan, 2019).

Situating Practice: Practice in the context of Agency and Structure

> *Administrators who regulate the practices of educators need to understand that caring in a deeper sense can only occur where contexts, structures, teacher student ratios and schedules provide opportunity for the occurrence of genuine caring relations, even though these cannot be controlled or predicted. (Van Manen 2005, p.227)*

Social practice theorists such as Bourdieu, Giddens, Foucault, Latour, Taylor and Schatzki examining different lenses of practice provided substantial account of human activities (such as teaching practice) located in their particular contexts (e.g. Boud, Dawson, Bearman, Bennett, Joughin and Molloy, 2018). Their work has been influenced by ideas from Heidegger (1962) and Wittgenstein (1967), as well as Schutz (1967, 1970) and Garfinkel (1967). More recent influences on contemporary practice theory include the works of Latour (1987, 1992, 2005), Lave (1988), Engeström (1999), and Schatzki (2001, 2002, 2005 and 2020). While Trowler (2021, Email Communication, May 31) disagrees and calls practices as incommensurable, recent work of Schatzki practice (2020) refers to the work of Freeland (1992) on institutionalism and calls for forming an Alliance between the theories of practice and institutions stating that no single theory has been able to fully capture practices and that practices can be viewed as constellations or plenums; better understood as slices of bundles of actions. This might be an overly philosophical view yet it underlines the complexity of characterizing practice. Yet, the issue is highlighted as existentially problematic as there is no single case can deal with the complexity of teaching as a practice (Fitzmaurice, 2010, p.53). Nonetheless, examining the agent/agency and structures is both comprehensive and illuminating since the repertoire of instructional practices that faculty draw upon is the result of a socialization process into a unique cultural group, a process that is not dissimilar to an individual's socialization into any social group (Oleson & T. Hora, 2013). The structure-agency debate related to social practices is on-going (Bourdieu, 1986; Frohlich, Corin, & Potvin, 2001; Giddens, 1984; Hays, 1994; Sewell, 1992, Ashwin 2010). In developing structuration theory, Giddens characterizes structures as rules (normative or interpretive) and resources. Normative rules represent structures of legitimation, while interpretive rules represent structures of signification. The latter perhaps does allow a greater margin for individual agency. Giddens identifies two resource categories: allocative (capital and things) and authoritative (status) whereby the agent's enactment of practice is influenced by access to these resources. In this regard, new teachers with lower academic status than seasoned well-established professors might face greater challenges in implementing unconventional teaching approaches and may have a harder time deviating from the norms. Lee and Roth (2004) write that not only does structure enable (soft, nurturing, and permeable hence greater agency) and constrain action (rigid, confining and limiting)

but also by engaging in praxis, people reproduce the structures. Structures can also be referred to as metacognitive or latent structures and correlate well with some of the academic filters previously discussed and constitute relevant elements of habitus, field and capital in Bourdieu's field theory or even Reckwitz's mentalism. Contingent structures exist independent of agency but their causal powers "*are at the mercy of two open systems: the world and its contingencies and human agency's reflexive acuity, creativity and capacity for commitment*" (Archer, 2003, p. 7). Every interaction with agency will not leave them unchanged. The previous sections examined some structures in detail and more focus is required on agency. Empirical studies examining the agency-structure dialectic in science education shows that the theoretical perspectives used in science education include sociological, critical/poststructural, and psychological perspectives (Fu & Clarke, 2019). Based on the review of Fu and Clarke (2019), the research on agency in science education can be divided into four categories: teacher agency, teacher-and-student agency, student agency, and administrator agency. Despite the possible interdependence of the four, the focus here, due to significance, is on the first: *teacher agency*. One of the theoretical models of agency focusing specifically on teacher agency is Biesta and Tedder's (2006, 2007) ecological approach (individual-interpersonal-settings-policy and system) which builds on three dimensions of agency: the iterational, the projective, and the practical-evaluative dimension. The iterational dimension is rooted in teachers' previous experiences and could be related to the personal profile, how they were taught and how they viewed their role. In Trowler and Cooper's (2010) teaching and learning regime or TLR they refer recurrent practices or repertories in a close proximity to iterational agency. The iterational (functional) dimension includes elements, where "personal capacity (skills and knowledge), beliefs (professional and personal), and values" (Priestley et al., 2016, p. 139) are selectively reactivated by the teachers. In this context they are possibly connected to pedagogical competence and beliefs. The projective dimension of agency involves the "*imaginative reconstruction of the future*" (p. 140) or progressive agency and includes elements aligned with self-efficacy, in the form of, for example, educational goals and motives. In this regard, their self-efficacy is important. The projective elements can be both short term and long term. Priestley et al. (2016) argue that "*people who are able to form expansive projectories about their future trajectories might be expected to achieve greater levels of agency … they have access to a wider repertoire of alternative futures*" (p. 140). The practical-evaluative dimension of agency involves practical and normative judgments of different trajectories (for example teaching approached and alternatives). Quite strikingly, Boyer (1990) highlights the little attention given to the teaching agency and states: "*teaching is often viewed as a routine function, tacked on, something almost anyone can do*" (p.23). Teaching agency is about teachers' active contributions and an important dimension of teachers' professionalism (Priestley et

al., 2016) and how teaching is enacted. This of course cannot be considered independent of the structures. Shanahan (2009) criticizes the limited focus as identity studies in science education often emphasize *"aspects related to the individual and especially to individual agency"* (p. 44), rather than the dynamic interplay between structure and agency. Dutta's (2011, p.9) statement that structures refer to the recurrent patterned arrangements that influence or limit the choices and opportunities available to people is inadequate as it assumes a *clash* and does not recognize that agency and structures exist in a symbiotically in a more of a "dance" and "coupling" (Sewell, 2005) coexistence. I am in favour of examining the dynamics of the agent (and individual agency) and the structures (metacognitive and externals) as they will potentially provide greater understandings of the practice through a critical examination of its two characterized constituents. Here, I propose the terms *soft and rigid* structures to move away from this differentiation based on the descriptive and focus on functionality. In fact, examining the elements of what constitutes as structure.

To summarize, the review of the literature yielded four important findings:

- *Structures and communities impact on the way individual lecturers conceive and approach teaching and learning, but this impact is moderated by agentic/ideological responses to structures and communities*

- *Ideological beliefs impact particularly on the way lecturers understand their discipline and shape their pedagogical beliefs.*

- *Agentic responses to structures and communities are possible but there exist areas of practice where lecturers are constrained by structures (e.g. the research-teaching nexus, academic labour)*

- *There are implications for educational development practices*

Richardson (2005) proposed a synthesized a theoretical model for teachers' approaches to teaching
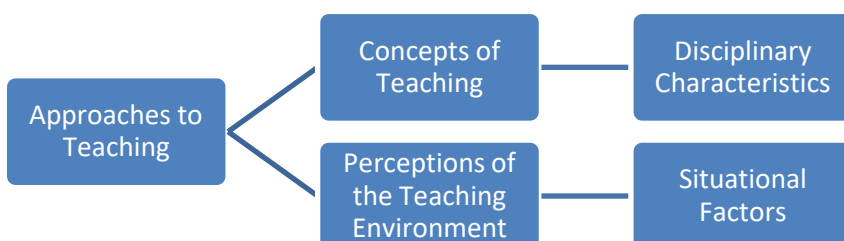
Fig 2.1: Approaches to teaching in HEI Adopted from Richardson (2005), p.679

Table 2.1: Force domains to the interplay between agency and structures

Agency	Structure ▪ *Rules(normative, interpretative* ▪ *Resources* **(allocative, authoritative)**
Iterational (past history):Competency , Experience Pedagogical beliefs Epistemological essentialism)	Discipline
Projective (future): self-efficacy, personal beliefs	Institution
Practical-evaluative: contextual-structural-cultural-material-habitus-field-capital	Teaching- Research nexus
	Materialism and Undefined external factors
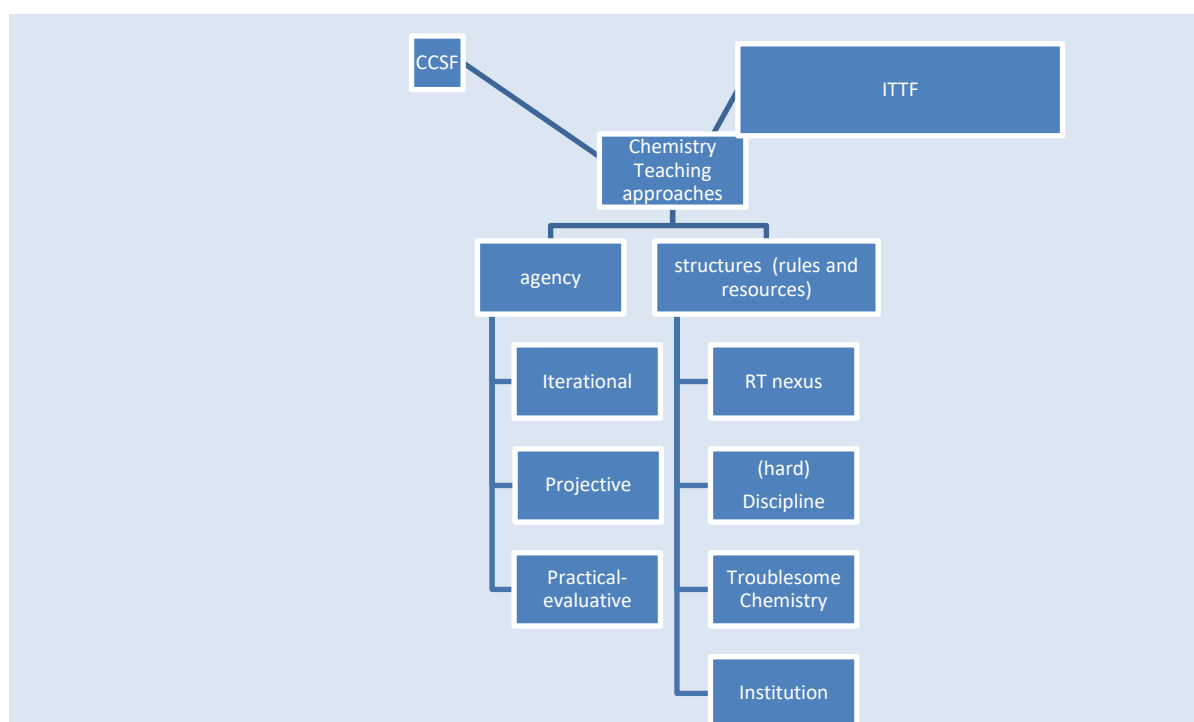
Figure 2.2: Synthesized and proposed theoretical framework for approaches to teaching practices of chemistry in HEI.

Summary

This chapter examined the current understandings of concepts related to teaching chemistry in higher education through a realist lens. The literature review examined different overlapping concepts with dedicated focus on the agency and structure interplay in relation to teaching approaches and practices. While recognizing the complexity of capturing this social practice, different types of (contextual) structures and agencies were characterized and provided the conceptual framework which will be empirically examined in this research through both inductive and deductive retroductive analysis.

Chapter Three: Methodology

Introduction

Originating from an ontological social realist position, certain approaches variation to teaching chemistry is observed. They can be attributed to agency and structures. The literature review highlighted the conceptual framework which influences these approaches. The purpose of this chapter is to through an epistemic relativist approach elicit data to examine the credibility of these influences and understand them in terms of *tendencies* of realizations. This chapter underpins the rational of the research design and utility of social realism's approaches to knowledge elucidation to the understanding of the teaching practices in the context of agency and structure. It highlights *summary and rational of the design, choices made and why, details of methods deployed and analysis, limitations, ethical considerations, robustness, researcher positionality, significance and implications of* proposed causal mechanisms.

Research Questions

1. *How do structures inform teaching approaches and enacting the teaching practices?*
2. *How do teachers in a chemistry department in a HEI characterize their teaching approaches and practice and the role of teacher agency?*
3. *What are the epistemological and pedagogical implications of better conceptualization of the role of agency in the structures-agentic context?*

Rational of Research Design

The act of situating the research and developing an appropriate research methodology begins with a "socially situated researcher" (Denzin and Lincoln, 2005, p.8) in alignment with the research questions. In the social world, despite the unbridgeable divide between academia and practice (Kieser & Leiner, 2009) our perceptions of appropriateness and practice, reality is socially constructed by the humans, which can be changed and understood subjectively (Corbetta, 2003; Marcon & Gopal, 2005; Kroeze, 2012 ;Bogdan & Biklen, 1998) and understandably incommensurable (Hunt 1993; Hughes and Sharrock 1997). The aim of the ''knowing process'' guided the selection and the rationale of the research design. For me, as a researcher, it was critical to choose a design which not only will be informative and robust but also practical and focused. My personal depictions of observed teaching chemistry practices in a higher educational institute prompted me as *"why are they as such"*? There were many ontologically observable structurally elements of predictability and routineness with certain degrees of individual agency. At certain levels of knowledge there was the empirical (what

happened), the actual (why it happened) and the real (how it happened). Based on realism, ontologically realist knowledge and epistemological relativism and hence inductive (qualitative) methodology is used (Crotty, 1998). This was not entirely the case. The casual explanations of events necessitated the use of *deductive reflection and* analysis in a retroductive process to postulate on how they happened. A realist research requires 'an intensive study, with a limited number of subjects (n=9), where the researcher systematically analyses the interplay between the ontological layers' (Bygstad et al. 2016, p. 85). Moreover, in this paradigm, theory does not precede research but follows it so that it is restructured on the data generated by the research act in the case study. Central in critical realism is the notion of generative mechanisms, or the causal structures [and agencies] that explain phenomena (Bhaskar, 1998). It allows the researchers to develop a causal explanation of a social phenomenon (*in this case teaching chemistry practices in higher education*), through a holistic approach, considering the breadth of the organizational and social factors having a causal role in the explanation of the phenomenon (Bhaskar, 1998; Ragin, 1997, 1992; Wynn and Williams, 2012). Furthermore, as Merriam (1998) points out, the key to understanding qualitative research lies in the idea that meaning is socially constructed (Ituma et al. 2011) by individuals in the interactions with their world and that the choice of a qualitative approach should rely on the nature of the questions (Patton, 2002; Denzin and Lincoln, 2005; Creswell, 132 2007) represents established forms of enquiry in the domain of social science (Guba and Lincoln, 2005; Creswell, 2007; Silverman, 2011). The usefulness of this methodology is its ability to gain insights through discourse, which can be interpreted (to the highest degree of objectivity) in its context. Most importantly, qualitative data (interviews) also helps in identifying the mechanisms that emerge from the components of a physical and social structure to produce the events of interest (Sayer, 2000, 2010). A causal explanation in critical realism accounts for a set of existing and enacted mechanisms, along with the impact of any structural factors and contextual conditions that generated the outcome being studied (Wynn and Williams, 2012). Boblin et al. (2013) indicated that case study design to gain deeper understanding (Bogdan & Biklen, 2007; Creswell, 2007; Merriam, 1998; Seidman, 2013) when exploring the teaching approaches through the structures-agency lens is suitable to conduct in-depth studies in various organizational settings. While, Welch et al. (2013) indicated that this approach is suitable to cover various matters [e.g. practice] and social institutions such as higher education. Furthermore, according to Yin (2014) and relevant to the RQs, case study designs are suited when *"what" or "how"* questions or *"why"* research questions (Poulis et al., 2013). Therefore, I chose a single case study social realist research design for my study.

3 Methodology

Summary of Research Design

Table 3.1: Modified and adopted Research design from Hays, 2002 and Crotty 1998

Axiology	Ontology	Epistemology	Theoretical perspective	Methodology	Methods	Sources	Analysis
What do we value?	What is reality	How can we know "knowledge"	What approach can we use to acquire knowledge	What procedure can we use to get knowledge	What tools can we use to acquire knowledge	What data can we use?	How can we use the data?
Role of values : Value-laden Researcher is part And reflexive	Nature of reality : layers of realities Processes experiences and practices	What constitutes valid knowledge: Subjective Narratives Experiences New/common understandings	(Social) Realism	Assumptions about the research process : Inductive/ Deductive Explanatory Exploratory Theory modification	Qualitative	Interviews Content analysis Observation	Conceptual analysis Coding Thematic Model
Inductive knowledge interrogated to How and What RQs about a social phenomenon in context			Case study Approach Context: Higher education chemistry department sample : 9 teaching academics				

Exploring Other Designs

The social world is complex in that it is made up of a large number of elements such as practice, is uncertain and unpredictable, and is emergent (Sayer 1992, 2000; Sibeon 2004). *"Meaning and intentional descriptions are important, not merely because they reveal subjects' states of mind which can be correlated with external behavior, but because they are constitutive of those behaviors*" (Orlikowski and Baroudi 1991, p.13). Hu (2018) states, in practical terms, the difficulty of using quantitative methods in critical realism philosophy is a result of the question of what kind of research objects can be quantified. At the same time, some elements of the teaching practice could have been examined quantitatively to develop further depth of knowledge. For example, some statistical regression analysis based on [an ill-defined factor and understanding] quantitative component of the research may have been used to highlight a correlation between teaching approach and pedagogical belief or years of experience or event gender. While not suitable for my purposes, positivists will argue that only one reality exists, based on objectivity and truth, and that the purpose of research is to provide measurable accounts of this reality (Oltmann & Boughey, 2011.) In contrast to capturing the nuances of a complex phenomenon explored in this research, a positivist would employ the methods of the natural sciences and, by way of "allegedly value-free, detached observation, seek to identify universal features" of the phenomenon that offer explanation of "control and predictability." Furthermore, in quantitative

paradigm knowledge is viewed as singular and independent of the researcher and is based on objectivism and positivism and follows clear inductive scientific research methods (Creswell, 2014; Ma, 2012; Jonker & Pennink, 2010) to measure causal relationships (Johnson & Onwuegbuzie, 2004; Sale et al., 2002; Biggam, 2008). Meanwhile, constructivists suggest that; "*there is no reality which can be used as a standard, and that there are therefore many truths which are all equally true even if they are contradictory*" (Kazi, 2003, p. 13). Interpretivism in qualitative research seems to be opposite to the positivism when the researchers argue that interpretivism is an ideographic research (the study of individual cases or events) (Kelin & Myers, 1999), and knowledge is derived from the meaning of events (Richardson, 2012). In other words, reality is "socially constructed" (Bergin et al, 2008, p. 171) and specific to the circumstance. For constructivists, the enquiry is focused on what "individuals perceive to exist" (Wainwright, 1997, p. 1264) which is not a full capture of what is real. Critics of constructivism also argue that it lacks depth in understanding "constraining and enabling social structures and mechanisms" (Wainwright, 1997, p .1268). Perceptions may mean empirical. This is clearly not the case in this investigation as multi (layered or stratified) realities possessing similar features exist. In contrast to positivist research and intepretivists, critical realists do not look for universal laws and predictability or multiple explanations. Instead, they consider these generative mechanisms or [deeper reality] responsible for certain realizations, of which the outcome is situational, depending on time, and space specific conditions (Fleetwood, 2014). There is little evidence for accounts for the ''actual'' and ''real''. Realists thus assume a complex causality, that is, a reality that is non-deterministic, contingent, and emergent (Byrne and Callaghan, 2014; Gerrits, 2012): In an (unstable) space of possible outcomes, a particular outcome is actualized by the conjunction between generative mechanisms and conditions at a given point in space and time (Fleetwood, 2014). Generative mechanisms can to some extent be uncovered as they are mediated by structures with some degree of durability (e.g. formal planning rules or informal codes of conduct in an urban community). This is clearly not practical for this as a research design in my context as it assumes "confirmatory" or a "deductive" approach as its main goal is to test theories and hypothesis by examining the relationships among variables (Antwi & Hamza, 2015; Bryman & Bell, 2007; Johnson & Christensen, 2012; Creswell, 2014, Collis and Hussey 2009; Saunders et al. 2012) and follows the quantitative research paradigm and depends on the collection and analysis of quantitative data (Bryman & Bell, 2007; Johnson & Christensen, 2012).

The Ontology and Epistemology of realism and structure-agency

Realism emerged in the 1970s and 80s through the work of Bhaskar and was further discussed and elaborated by critical realists such as Andrew Sayer (1992), Margaret Archer (e.g., 1995), Andrew Collier (e.g., 1994), and Tony Lawson (e.g., 1997). It originated as a scientific alternative to both positivism and constructivism (Denzin & Lincoln, 2011), but draws elements from both methodological strains in its account of ontology and epistemology. Realism, stemming from an alternative epistemological and ontological perspective, recognises that the "patterning of social activities are brought about by the underlying mechanisms constituted by people's reasoning and the resources they are able to summon in a particular context" (Pawson & Tilley, 1997, p. 220). A primary objective of realist based research is to provide empirically supported causal explanations, rather than predictions, of how and why events occur (Wynn and Williams 2012). Hence, realism offers an alternative position that neither rejects nor endorses the different stances offered by the positivist and constructivist paradigms (Pawson & Tilley, 1997; Julnes et al, 1998), but offers a different approach to understanding reality. One paradigm shift of realism is the ability; "to shift the emphasis back from epistemology, the theory of knowledge, to ontology" (Outhwaite, 1987, p.18). The realist ontology relies on a belief that features which form our world are not essentially visible (Wainwright, 1997) and hence most significantly allows active research even when the *tools* are not necessarily at hand, therefore advancing knowledge. As Bhaskar (1989) contended, all ways of organising knowledge (including philosophy), believe in advance in some form of realism, a way of understanding and explaining the nature of being or existing (ontology). The importance of realism is emphasising ontological questions (what is something? how does it work?) over epistemological questions (how can we know something?) means that realism is methodologically ecumenical. It is quite appropriate in my case and the question to answer the research questions. In order to achieve this level of explanation, critical realism uses a transcendental realist ontology, whereby the researcher is able to look for explanations that lie beyond daily cognition and perceptions. Mole (2012) posits critical realism as being unique in its ability to claim deeper explanations of social life. Critical realism recognises that knowledge is socially produced, yet changeable and fallible and that science is an on-going social activity in a continuing process of transformation (Bhaskar, 1975). Fleetwood (2014) further notes that positivism collapses structures and mechanisms into agency or the outcome of human actions while interpretivism/constructivism insists that both people and structures are socially constructed via discourse. From this understanding, there is no genuine agency or structures under constructivism. Realism commits to both ontological realism and epistemological relativism, yet the picture is more complicated than this, as realism, whilst accepting that actual events do occur, also proposes that these events are caused by real mechanisms that are often invisible to the researcher or

constitute difficulty in being captured at the empirical level. It underpins the importance of explaining behaviours, such as the relationships between structures and values (Porter, 2001). According to Bhaskar, it is more meaningful to be able to describe phenomena in an understandable way, rather than seek the "absolute truth" (Wilson & McCormack, 2006, p. 46). Action and implementation involves people making decisions based on reasons, knowledge and values so realist research recognises '*the interaction of a real environment with the casually efficacious interior world of the individual agen*t'' (Shipway, 2011, p.176).

Social realism and structure-agency

According to Egbo (2005), realism enables individuals' accounts to be considered as valid research data to identify the structures around us containing reasons which are also causes and that emancipation and social transformation are the legitimate ends of research. However, for realists, it is argued that human agents and social structures are ontologically distinct entities "*starts from the ontological claim that structure and agency each possess distinct properties and powers in their own rig*ht'' (Carter & New, 2004, p.5). The first is the empirical level, which is the realm of events as we experience them. At this level, events or objects can be measured empirically and are often explained through 'common sense', but these events are always mediated through the filter of human experience and interpretation. This is the transitive level of reality, where social ideas, meanings, decisions, and actions occur – but, importantly, these can be causal. The middle level consists of the actual. At this level, there is no filter of human experience. Events occur whether or not we experience or interpret them, and these true occurrences are often different from what is observed at the empirical level (Danermark et al., 2002, p. 20). Finally, the third level is the real. At this level causal structures, or 'causal mechanisms' which may explain the real rationale of teaching practices, exist. Social Realism clearly distinguishes amongst three layers of social reality: the empirical, the actual and the real (Bhaskar, 2010; Case, 2013; 2015). As Case (2013) notes, research in education often privileges either structure or agency, whereas realism enables a more nuanced understanding of the interplay between the agent and the social context. Again, this aligns with Kahu and Nelson's (2018) framework where that interplay is depicted by the educational interface. From this standpoint, the central relation of social reality is between agency and structure which aligns well with the research questions as it anchors on the central relation of social reality is between agency and structure. Margaret Archer elaborates and offers four versions of existing understanding of the relationship. The first comprises a neglect and marginalisation of agency so that '*structure and agency are conflated because action is treated as fundamentally epiphenomenal*' (Archer, 1990, p. 81). The second takes an opposite form so that structure is treated merely as the creation of agency, and therefore has no independent powers from those potentially exerted through agency. The third lens presented by Anthony Giddens (1984)

as a theory of structuration, ties agency and structure closely together and gives explanatory primacy to neither, because they are mutually constitutive. Archer's fourth view, a morphogenetic/morphostatic position, conceived in opposition to the theory of structuration, argues that agency and structure have distinct properties and powers that cannot be incorporated into the other. While I somewhat agree that social structures pre-exist agential operations, and in turn human beings reflexively monitor the social world, individually or collectively exerting an influence, and changing relatively enduring but emergent structures. In agreement with this notion, Donna Therese King & Stephen M. Ritchi (2017) while referring to teaching and learning agency in chemistry pedagogy state" *If people use their agency or 'power to act' in creative ways, their actions may change the structures that initially gave them the power to act. Conversely, modified structures may afford people more agency (p.1160)".* My personal position is a closer to the fourth perspective. This presents a wicked problem by can be simplified, as in the conceptual framework (soft/rigid) by categorizing structures and the degree of influence and flexibility. It therefore, must be assumed that "structures and mechanisms, then, are real and distinct from the patterns of events that they generate; just as events are real and distinct from the experiences in which they are apprehended" (Bhaskar, 1975, p.56). A fitting position is that social realism nesting between the poles of realism and relativism, accepts that agency strongly influences social structures, but equally recognises the external forces that shape and limit that reality (Huckle, 2004). A social realist design based on this perspective underpinning the research design, allowed me to examine a considerable depth of the issue illuminating more aspects and layers of knowledge acquisition. Furthermore it provided a position to critique the various HEI structures that support teaching practices and the degrees of personal agency in adapting and realizations of certain teaching practices. This is important because research inquiry becomes "a quest for non-observable generative mechanisms whose powers may exist unexercised or be exercised unrealised" (Archer, 1998, p.190).

Social realism and the RQs

Focusing on the first research questions as an example, the concern is to (with a considerable sense of reality and existence) unravel the structural elements and agentic attributes which might be in action and contribute to the externalization of the teaching practice. This gives the freedom to me a researcher to work with the ontological realism but equally be open to the possibility that the epistemic approaches while varied may not fully capture what is out there in relation to time and space. That also the findings too may be as valid as they are contingent and far from wholesome and absolute. This stratified or 'depth ontology' makes a distinction between the '*empirical', the 'actual' and the 'real'*. The empirical is what we perceive to be the case: human sensory experiences and perceptions (a chemistry teacher teaches in certain ways). The 'actual' is the events that occur in space

and time, which may be different to what we perceive to be the case (a chemistry teacher teaches in certain ways because they are trained this way). The real or deep is constituted of the mechanisms and structures which generate (and explain) events (chemistry teacher teaches in certain way because of the complex interactions between agency and structures at a given time and space). Realists resolve the tension by arguing that the world is socially constructed but not entirely so, moving the focus from epistemology in favour of ontology.

Methodology

While some authors struggle to demonstrate how realism ultimately contributed to their findings. Few authors too have demonstrated how the ontology and epistemology informed their data collection (for notable exceptions on this see Edwards, Mahoney, &Vincent, 2014; Parr, 2013) and data analysis (e.g., coding). Danermark and colleagues (2005) consider critical realist methodology as pluralist. They argue that "the distinction between quantitative and qualitative method is no longer relevant" and "there is no such thing as a 'universal method' – both approaches have their domains and relevance" (ibid., 167). As a philosophy of science (Brown et al., 2002; Nielsen, 2002), CR functions as a general methodological framework for research but is not associated with any particular set of methods. As a result, qualitative researchers hoping to conduct realist research may find themselves without methodological guidelines to help ensure reliability throughout the research process (Morse, Barrett, Mayan, Olson, & Spiers, 2008). This can be quite problematic as it does not specifically subscribe to a methodological approach and gives the liberty to the research to make those decisions as seen appropriate. Ackroyd and Karlsson (2014) noted the *"serious lack of appealing and accessible material on CR-informed methodology to set those new to these ideas off on a path to accomplish interesting and insightful research"* (p. 45). To date, there is considerable literature on qualitative approaches developed for social inquiries, such as narrative, phenomenology, grounded theory, ethnography, and case study, to name a few (Creswell and Poth 2018). A number of researchers attempted to explore these approaches through the lens of realism, for example, critical realist grounded theory (Oliver 2012), ethnography (Porter 1993; Rees and Gatenby 2014), and case study (Easton 2010; Kazi 2003). Realist based research embraces both qualitative and quantitative methods (Zachariadis, Scott, and Barrett 2013; Wynn and Williams 2012; Easton 2010). The research questions are positioned to illicit an in-depth, reflective and contextual understanding of teaching approaches and hence practices. This will only be possible if the methodology and approach are strongly aligned.   I chose qualitative methods since they are particularly appropriate to provide "*answers to questions that stress how social experience is created and given meaning"* (Denzin and Lincoln, 2005, p.4). To achieve this, a qualitative *case study* research approach was used which focused on gathering, analysing and triangulating data from: personal interviews, observations and documents. Yet, it remains be potentially heavily

subjective rather than objective (Mack, 2010). I, while making all attempts at every stage of the research to remain grounded in unbiased, remained still part of the process. For example, I reminded myself many times before and during the interviews to exercise great caution in order not to induce certain responses. The same was applied during discourse analysis for themes or codes, consistent phrases, expressions, or ideas that were common among research participants (Kvale, 2007). Although, some existing research promotes grounded theory methods for realist research (e.g., Oliver, 2012; Redman-MacLaren & Mills, 2015; Yeung, 1997), the inferential processes associated with grounded theory are also primarily inductive whereas realism uses abduction and retroduction. For me, the considerations were based on the ability to gain sufficient insight about the practice of teaching and the drivers which guide its enactment, not only how it is perceived by the outsider, but the actual perceptions of the agents who are enacting them and move deeper to uncover the mechanisms which interact to generate certain realities. First, it was important to gather enough data to characterize the empirical actions (observations, document analysis, interviews; RQ1 and RQ2). Second, the goal was characterization and explanations of the *actual* originating from the understandings of the agents involved (interviews; RQ1 and RQ2). Third, it was important to seek how the mechanisms can be used to predict *real* tendencies and outcomes (critical analysis of the data; RQ3).   I used a primarily deductive yet flexible (i.e., 'directed') coding process (Hsieh & Shannon, 2005) that drew on existing theory and literature. A list of codes was drawn from the literature review, theoretical framework, and key realism concepts; however, these codes were changed, eliminated, and supplemented with new codes during the process until every piece of text was coded (Gilgun, 2011). In this way, the deductive codes were treated as a way to reformulate the existing model or theory from which they were drawn (Gilgun, 2011).

(Focus Specific) Case study

Merriam (1998) defines case study research as "*an intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process, or a social unit*". The essence of a case study, the central tendency among all types of the case study, is that it tries to illuminate decision or set of decisions, why they were taken, how they were implemented, and with what results (Schramm, 1971, Yin, 1989). The uniqueness of this context and enactment of teaching practice related this particular group of individuals in their setting positioned this exploration as case study. Although Bhaskar does not recommend a specific research method, a case study approach is often considered to be the best research method to use when conducting realist research (Wynn and Williams 2012; Easton 2010; Kessler and Bach 2014). In engulfing this case study within a socialism realist paradigm is complex. Many authors argue for case study to be viewed as a choice of what is to be studied viewed [*for example, teaching as a practice has many layers, there is macro (global level),*

meso (community/network level), micro (individual level), and nano (interaction level)], as a result of complexity, rather than a methodological choice, rather a (Sparkes & Smith, 2014). For example, Danermark et al. (2002) suggest that qualitative methods can be summarised as having four principal features: a case study design, a study of the cases in their context, emphasis on understanding, and the generation of theories (Ridder, 2016). Other authors referred to the inductive exploration of yet unknown phenomena, theory testing (Yin, 2013), theory elaboration   (Ketokivi and Choi, 2014), or a holistic understanding of cultural systems of action (Feagin, Orum, & Sjoberg, 1990). In general, a case study approach is particularly useful in explanatory research which addresses 'how' and 'why' questions (Yin 2009) *as in how teaching as a practice is approached and why*, in an attempt to understand complex and dynamic relations and interactions within single or multiple settings (Eisenhardt 1989) but can also be exploratory in characterizing the hidden forces at play   . It is therefore well suited for research that is intended to explore social events that involves investigating one or a small number of social entities or situations about which data are collected using multiple sources of data and developing a holistic description through an iterative research process in contexts and to reveal underlying causal powers and mechanisms that reflect the complex interaction between structure and agency (Kessler and Bach 2014) while fully realizing that it cannot be simply treated as a closed system. In other words, it is case study in terms of subject selection and context but not in uncovering the layers of knowing about the real events, practices and their tendency of manifestations. What is relevant to this research is that case studies investigate "a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident" (Yin, 2017, p. 18). The phenomenon (teaching approaches) and its context (Chemistry at HEIs] are intertwined, but the case should represent a bounded system, in which the case is clearly defined and delimited (Merriam & Tisdell, 2015). This is a process of iterative–parallel research which "…*implies a continuous moving back and forth between the diverse stages of the research project*" (Verschuren, 2003). The flexibility that case research allows in this respect is one of its major advantages and one that is not shared by, for example, survey based methods. Yin (1993) presented Giddens' view that considered case methodology "microscopic" because it "lacked a sufficient number" of cases. Hamel (Hamel et al., 1993) and Yin (1984, 1989a, 1989b, 1993, 1994) forcefully argued that the relative size of the sample whether 2, 10, or 100 cases are used, does not transform a multiple case into a macroscopic study. Nonetheless, they have been frequently used in higher education "active learning" in business (Boisjoly & DeMichiell, 1994). Many researchers have explored the purpose of a case study methodology e.g. Yin (1984, 1995) Stake (1995) Tellis (1997) Merriam (1998) Voss et.al (2002) Dul and Hak (2008). There is significant debate whether case study can be considered a methodological approach on its own or a component of methodology. In this

research it is viewed as the later. Furthermore, case studies address the full complexity of a research problem by incorporating multiple sources and types of evidence [e.g. interviews, documents and observation] (Yin, 2017) in rigorous attempt at triangulation as emphasised by Creswell (2007, Maxwell, 2005) and investigate complex problems in natural settings (Crowe et al., 2011; Harrison, Birks, Franklin, & Mills, 2017). Nonetheless, in its core, a case study design is exploratory and follows an inductive and qualitative research paradigm and depends on the collection and analysis of qualitative data (Bryman & Bell, 2007; Johnson & Christensen, 2012 and Creswell, 2014). In this research I used an instrumental single-case study design (Yin 2009, Eriksson & Kovalainen, 2008) to answer the research questions to explore the singular, the particular, the unique (Simons, 2009, p.3). This means that one single case study can entail all elements that needed to be included in this design: unit of analysis/social phenomenon, real life context and no evident boundaries between context and phenomenon (Yin, 2008, p.13).

Case Study Design

Teaching approaches (experiences) ➔Realist ontology (complex phenomenon) ➔ Relativist Inductive epistemology (what and how it is enacted)➔ Qualitative methodology (what is the best approach to learn more)➔ methods (what procedures can be used?)➔ Data (what can be collected?)

Experiences and Motivation ➔ RQs: Wha t& How (social-behaviour-meaning) ➔ Literautre Review ➔ Conceptual Framework (Theory development) ➔ Data Collection Desgin (Case study) ➔ Interviews ➔ Data Analysis (cross-case findings) ➔ Abduction Retroduction Modify Theory

Figure 3.1: Research design process and implementation

3 Methodology

Data Collection

Approach

In realist data collection the data collection needs to be multilevel to search for mechanisms operating across multiple levels (Langley, 1999; Pettigrew, Woodman and Cameron, 2001). Case studies are designed to induce the details from the viewpoint of the participants by using multiple sources of data (Tellis, 1997) including open-ended questions with in-depth semi-structured interviews, observations and documents, to examine the complex social phenomenon (Glesne 2010; Yin 2009). Realism's ontology and epistemology informed their data collection (for notable exceptions on this see Edwards, Mahoney, &Vincent, 2014; Parr, 2013) and data analysis (e.g., coding). In case studies the data collection method (e.g. interviews, observations (direct and participant), questionnaires, and relevant documents (Yin, 2014) is dependent on the nature of the research questions and overall research design. Yin (1994) and Stake (1995), list typical sources of data collection to documents, archival records, interviews, direct observation, participant-observation and physical artefacts. The researcher can decide what data to search for and to collect next in order to [*saturate*] each emerging category/concept (Charmaz, 2014; Glaser & Strauss, 1967; Hallberg, 2006). Much of the data in case studies is contingent on informed information provided through historical documents, indirect and direct observation, interviews, and tangible objects (Yin, 2003). I relied more disproportionally on data (discourse, observation, reflections) from the interviews. I collected codes and analysed this initial data before further data collection/generation is undertaken. Events are observed at the empirical level using two types of data: extensive (i.e., data on widespread trends, such as statistical data) and intensive (i.e., in-depth interpretive data, as obtained through interviews or focus groups for example).

Purposeful Sampling

In realism, the observed events enacted guide the researcher to the subjects in alignment with the qualitative sampling which seeks information richness and selects the cases purposefully rather than randomly (Crabtree and Miller, 1992). Initial purposive sampling directs the collection and/or generation of data. I purposively select participants and/or data sources that can answer the research question. Purposeful sampling provides the initial data that the researcher analyses. The process of soliciting the respondents was not easy. There were many complications related to scheduling, timing and reluctance on the part of a few for various reasons. The subjects were approached by email and telephone. It was made very clear that their participation while highly appreciated is not mandatory. At the end, there were nine respondents interviewed separately using semi-structured questions in order to understand how they viewed this change in their capacity based on what they came to know of it. The interviews lasted for about 50-60 minutes each and were conducted separately on different

dates. They were actively chosen because they were members of the chemistry department. In all, they had different teaching experiences and qualifications and represent different nationalities. The goal is to draw on some insights of how they perceived their teaching practice while maintain objectivity and neutrality (Locido et al, 2006, p.7).

The institution

The institution is multi-disciplinary research across the fields of energy, renewables and engineering. Based on numbers for September 2016, the institution has over 4600 students, including 2640 undergraduates and 1011 postgraduates, which together have filed over 190 patents. There is over 465 academic staff at the three institutions. (oxfordbusinessgroup.com, 2017)

3 Methodology

Department

This department is relatively new and unique. With a strong mission: "*The department is dedicated to supporting excellence in chemical education and research to meet the strategic needs of Abu Dhabi, the UAE and the international community. We are committed* **to teaching** *and developing the next generation of scientists through a strong,* **innovative teaching program** *that equips students with skills that are useful whatever their choice of career*. The chemistry courses offered before were to service engineering students. The professors had varied research interests and teaching backgrounds and came together to form the nucleus of a fully-fledged chemistry department as parts of the Arts and Science College. The group represented a heterogeneous mix of academic who are slowly forming an identity of a chemistry department. Currently, it comprises 17 academic. Of the department and not included in the research   4 senior lecturer/ lecturer, 7 technical staff and 5 researchers. In this context, while there might be similarities with other chemistry departments in terms of research expectations and teaching content based on isomorphic international globalized curricular expectations (*e.g. chemistry 101, 102 universally aligned in terms of content, topic order and recognized textbooks and resources*) , standardizations (e.g. ABET). While the study of this institution might provide certain conditioning forces for practice enactment, it may not representative of other chemistry departments for the following reasons:

1. *It is relatively new.*

2. *Formed after the merger of three institutions with different traditions and missions.*

3. *Most students who are mostly UAE nationals enrolled in chemistry courses are at the introductory levels as a requirement for engineering (applied hard science) programs.*

4. *The number of teaching faculty who were part of the "servicing" activities to the engineering college is significantly high.*

5. *The number of students in the actual "chemistry major program" is relatively low.*

6. *At the time, the number of students in course beyond second year in each course is very low.*

7. *The university and department have a higher female to male student ratio (58%; 42%).*

8. *Ambitious plans to improve the international ranking of the university through innovation and research.*

9. *Ambitious plans to improve the number of UAE students in non- engineering science domains such as chemistry.*

Respondents

The aim of the research was to examine teaching approaches in the by academics (researchers) in a higher education institute. Therefore, only those who had both research and teaching duties were solicited for the interviews. The respondents represent diverse nationalities, disciplinary specialisms (e.g. organic, physical, instrumental, biochemistry, and polymers), research interests and teaching experiences. Both genders are almost equally represented, 4 females and 5 males and represent a diverse age range. Some have worked in other institutions in the UAE; others are new to the culture and setting. They also represent different ranks: *senior lecturer, assistant professor, associate professor and professor.* Some are at the start of their careers; others are in the middle and senior academics with established research records. They have different teaching responsibilities and course load and level depending on the rank beginning with introductory chemistry to supervising post graduate (masters and PhD students).

Interviews

"*One way to provide more structure than in the completely unstructured, informal conversational interview, while maintaining a relatively high degree of flexibility, is to use the interview guide strategy*" (Patton, 1990). This phenomenon is better captured through discourse for insightful and in-depth understanding of the mechanisms in context and survey to gauge inclination. In search of better understanding, questions cannot have simple answer, nor was this the objective of the research. The aim is to gain knowledge to understand more. This understanding becomes knowledge once validated. Ultimately the findings will be held to academic rigor and knowledge construction will ensue. From a realist perspective an important aim of the research interview is to ensure that a respondent gains awareness of the causal mechanisms affecting a context under investigation. According to Grix, (2002) "*The method(s) chosen for a research project are inextricably linked to the research questions posed and to the sources of data collected*" (p.179)*.* Moreover, methods are the "*range of approaches used in educational research to gather data which are to be used as a basis for inference and interpretation, for explanation and prediction*" (Cohen et.al 2007, p.47). Thus, in this context, interviews are particularly useful for getting the story behind participants' experiences and can ask in-depth questions (McNamara, 1999) and probe an interviewee's thoughts, values, prejudices, perceptions, views, feelings and perspectives" (Wellington & Szczerbinski, 2007). Frey (2000) also described interviews as one of the most powerful tools for gaining an understanding of human beings and exploring topics in depth. They can elicit rich information about personal experiences and perspectives (Russell, Gregory, Ploeg, DiCenso, & Guyatt, 2005). Furthermore, Turner III (2010, P.756) states "*standardized open-ended interviews are likely the most popular form of interviewing utilized in research studies because of the nature of the open-ended questions, allowing the participants to fully express their viewpoints and*

experiences". This level of awareness is based further around the respondent reflecting on how they 'reason' about a particular context and what resources they feel will enable or constrain them to act in particular ways in the very same context (Pawson 1996, p. 306; see also Maxwell 2012, p. 101). Conducting the interviews was made easier due to prior knowledge with the participants and in some ways more effective at inducing insightful discourse. The questions which were carefully structured though a subtle balance of clarity and ambiguity (*this was to avoid prompting expected responses and give ample opportunities for deep processing and reflection*) were aimed at inducing significant unguided free discourse for later analysis. Due to the pandemic, Face to face interviews (Charmaz 1983; Regen et al. 2008; Bahora et al. 2009; Boyle et al. 2009; Cameron et al. 2009; Nissim et al. 2009) face to face interviews which tend demonstrate clear reactions and perhaps lead to more insightful questions were not possible. Instead, Zoom a videoconferencing platform extensively utilized for research purposes (Archibald et al., 2019; Daniels et al., 2019; Kite & Phongsavan, 2017; Lobe, 2017; Matthews et al., 2018) was used. At the same time, some might also be uncomfortable with technology. Fortunately this was not the case in this research. The interviews informed pedagogical beliefs, agency, self-efficacy and perceptions of physical and social structures. The interview questions were constantly being modified (mostly rephrasing) to generate responses. In order to achieve this, a qualitative deductive approach using semi-structured interview questions   was employed. All interviews were recorded and transcripts were produced. The transcripts were analysed, codes and overarching themes were established. The organisation was selected as an information-rich case study (Patton, 2002, p.230).

Observation

The interest in the research began with personal observations of teaching practices. As described earlier, there were varied approaches to the teaching practices with the chemistry department. Observation is important because it produced deeper understanding of behaviours or events (Sanchez, 2006) and provides discrepancies between what people said in the interviews and casual conversations and what they actually do (Pettigrew 1990) and the empirically observed. The role of the personal observations is mainly to reposition the data of the interviews within the context of the observed in an attempt to regenerate significance and better understanding. In addition to the integrative literature review (Torraco, 2005) where the purpose is to critique and synthesize frameworks, other sources of data included extracts captured in the form of a learning journal to allow further reflection (Moon, 2006), and informal conversations which were held with participants (Patton, 2002), in a relaxed environment that allowed participants to share relevant data in a different way. These conversations were spread across the data collection period with coordinator and

practitioners, and personal observations were captured in my learning journal. This constituted a significant portion of the thesis.

Documents/Artefacts

In addition to ''things'/artefacts (Roth, 2001)', documents represent a trail or a by-product of human activity Olson (2010). Documents analysis (course syllabus, assessments, material display, lecture presentation) and direct observations [unobtrusive and does not require direct interaction with participants as stated by Adler and Adler (1994)], provided further data. Such sources were primarily used to gain insights on structures such as the institution, department and disciplinary context. Deeper analysis gave agentic expectations. For example, examining course syllabus, content presentation, terminology used (e.g. deliver) and the concept of ''lecture'' and physicality of didactic ITTF teaching, duration and learning outcomes in reference to the assessments and grade scale. At the same time, the College Handbook with reference to teaching and research expectations of professors provided insights on the teaching-Research nexus.

Reflective Recollection

Being somewhat considered as insider researcher Bonner and Tolhurst (2002) poised a challenge to balance between being an ex-colleague (instructor) and a researcher (DeLyser, 2001; Gerrish, 1997). This constituted my own experiences within the department focusing on the approaches to teaching practices. This represented a considerable ethical concern. The research was propelled by my own experience which positioned my belief of the practices in an ITTF approach while highlighting the structural constraints on the teachers with marked provisions for agency. A genuine attempt was to reduce the influence of this understanding on the course of the research, other data collected and subsequent analysis   yet there was little reasonable rationale as to why. Reflections on the practice often indicated that there are many forces at play. The utility of these neutral reflections was to juxtapose them against the discourse yielded in the research for further insight and enhanced robustness.

Data Analysis

The goal of this research was to get to the real mechanisms which tacitly take place represent guiding forces for the empirical teaching practices within a chemistry department. The conceptual framework characterized in the literature review provided a theoretical mainframe for the different elements situated with the context of structures and agency which might be at play in prescribing projections of approaches. While it holistically, treats chemistry teachers as those in the hard science domain with strong epistemologically essentialist positions, it has two problems 1) it remains theoretical and 2) it does not provide explanations for possible causal interactions of the mechanisms and respective tendencies. The purpose of the data analysis is not to superimpose the findings (as in a stickily positivist paradigm) in the context of the conceptual framework but rather to invoke deeper understandings (not in the strictly interpretivist parody) while alluding to the proposed *theory*. In other words, the conceptual framework might be considered as the *empirical* theoretical framework (still supported with previous findings and observations but mired with issues) and the research would be aspired to generate two further frameworks: *actual* (based on re-description of knowledge and resituating understanding through abduction and *real* (based on reproduction and explanations of the practices in the context of casual interactions of mechanisms). Full description of data analysis will be discussed in detail in chapter 4.

Ethical considerations

Axiology refers to the ethical issues that need to be considered when planning a research proposal. It considers the philosophical approach to making decisions of value or the right decisions (Finnis, 1980). As the investigator I served as the investigator for the study, serving a necessary role which affects the study design (Creswell, 2014; Patton, 2015). As the researcher, I defined the central phenomenon to be studied, the central question, limited the conditions of entry to the study, the scope of the reviewed literature, and restricted the scope of analysis (Lindlof & Taylor, 2011; Marshall & Rossman, 2016). This collaboration requires a significant level of willingness by the participants to develop a relationship of trust and openness with the researcher (Patton, 2015; Webster & Mertova, 2007). Ethical considerations have been discussed extensively in the literature (Laine, 2000; Guillemin and Gillam, 2004; Denzin and Lincoln, 2005; Shaw *et al.*, 2006; Silverman, 2011). Rightly this research followed the ethical approval process. A major concern in this project is the potentiality of conflict of interest, which is minimized by adhering to the ethical practices of proper research. The research was carried out observing stringent ethical by providing comfort and respect to the respondents. Hence, information was secure and the subjects were made conformable and were informed of the anonymity of the names. The respondents were also informed that they could withdraw from interview at any

time and even that the information would not be used if they changed their mind before the paper is finalized.

Epistemological and ontological issues, truth claims and its limits

I began with characterizing the theoretical underpinnings of the research design in reference to ontology, epistemology, and moved to methodology and methods to be deployed in the search. Neuman (2006) defines a paradigm as being a, 'general organizing framework for theory and research that includes basic assumptions, key issues, models of quality research, and methods for seeking answers' (81). Meanwhile, Thomas (2009, p.72) defines the term paradigm as *"the technical word used to describe the ways we think about and research the world"'*. He further highlights that, the methodological literature; the prominent research paradigms in social sciences are 'positivism' and 'interpretivism' without a proper scientific account for realism. The central foundation of realism is the recognition of the existence of structures and agencies. This often represents an epistemological concern as the ontological domain is predetermined and places greater accountability on the research to survey the best approaches to capture the ''real''. Furthermore, since a clear methodological approach is not well established poses certain levels of scepticism within the academic community. Some might argue that replicating positivism in devising effective frameworks for characterizing reality as in the case of creating a test for a new virus. The situation is far more complex because of the deep reality sought is an interaction of hard to quantify mechanisms subject to an ever changing human psyche and how much can be known. This is further emphasized by recognition of the stratified nature of reality in this research as it explores perceptions of practice, deeply intertwined in social and cognitive perceptions situated the research questions situate knowledge in an epistemological relativist paradigm in alignment with ontological realism. At the same time, internal realism (truth is layered, obscure and facts exist but hard to uncover) presents a significant challenge to researchers as it assumes limited capacity for knowledge building because of the complexity in the articulation of approach and tools. What constitutes knowledge might mean different things to different people at different times. There is knowledge based on facts and empirical evidence (often associated with a positivist approach). Inherently truth must be justified or validated contextually. It is at best a case of reasonable explanation at likelihood; a tendency of realizations. What is ethically worth knowing; at what expense? How and why? (Remenyi et al., 1998). Answering these questions is the most significant part of my research since it sets out the moral code of conduct partially in cases where in the social world, individuals and their behaviors are subjects of the study. Examining the ontological perspectives in reference to the research questions was useful in anticipating the efficacy of the research.

3 Methodology
Researcher Positionality

The interest in the topic and focus of the research is derived from the genuine desire to understand the mechanisms which aid in shape our practices and the acceptance of time dependent norms which are born out of what constructed knowledge. Understanding how teaching practices are enacted in this context is significant. Even more so is the potential identification of missed informational build due to improper practices and transfer of knowledge which result in gaps in effective practice. To make things clear, why is there a noticeable pedagogical gap or at least variations in teaching chemistry in HEI context where knowledge is the cornerstone of all activities? This highlights the non-linear accumulative nature of knowledge building. Another important question according to Crotty is what epistemology will inform a research proposal or what is "the theory of knowledge embedded in the theoretical perspective and thereby the methodology" (p. 3)? The philosophical position adopted herein is aligned with critical realism, which borrows from a realist ontological perspective and a constructivist epistemology (Bhaskar, 2013; Huckle, 2004) as it embraces the idea that reality has an objective existence outside human cognition (Danermark et al., 2002). Since our knowledge about reality is generated by agents in a complex social world (Pratt, 1995), realists recognize that explanations and accounts of the world are never complete and socially constructed, and therefore fallible. Social structures pre-exist agential operations, and in turn human beings reflexively monitor the social world, individually or collectively exerting an influence, and changing relatively enduring but emergent structures. Bhaskar (2008) argues that social reality is constituted at a range of levels or strata, incorporating structures and mechanisms that bring about the events that shape our experience. This provisionality of knowledge stems in part from the way in which our understanding must adapt *"to accommodate the progressively deeper strata that it discovers and the reconceptualization of more superficial strata in light of this"* (Hartwig, 2007, p. 240). However, realism holds that some explanations approximate reality better than others based on their theoretical and empirical thoroughness (Alvesson and Sköldberg, 2009; Bygstad and Munkvold, 2011)**.** As Archer et al. (2016, p.4) explain, critical realists highlight a dissatisfaction with, scientistic forms of positivism concerned with regularities, regression-based variables models, and the quest for law-like forms; and also to the strong interpretivist or postmodern turn which denies explanation in favor of interpretation, with a focus on hermeneutics and description at the cost of causation. An alarming sentiment voiced by (Connell and Nord 1996, p.1) that we do "...*not know how to discover a correct position on the existence of, let alone the nature of, reality."* Nonetheless, we are always part of the active and vibrant process of designing approaches to make sense of what is [perhaps tentatively and contextually] out there and how we can acknowledge. There are quite problematic areas to recognize when carrying out the research. There is an *operational* truth that governs the practice of the

individual teacher while many truths exist at the departmental level for the different teachers. Furthermore, there is the concept of what I will regard as true as I examine the issues further through these teachers and how might it be viewed by others. This positions the ontology of this research as rests on internal realism and relativism in other words, to realize that knowledge of the empirical practice while constructed in the minds and actions of the individual may exist (while temporarily and contextually) and therefore might well be independent of the researcher. Temporary consensus (yet debatable, questionable) on knowledge is crucial in some case to archer the foundational structures for knowing, otherwise scepticism dominates. There is the understanding myself as a researcher will construct knowledge socially as a result of his or her personal meanings of experiences of the real life within the natural settings investigated (Punch, 2005). There is also the acceptance that there is inevitable interaction between the researcher and his or her research participants and the acceptance that context is vital for knowledge and knowing. Furthermore, there is the belief that knowledge is created by the findings, can be *value laden* and the values need to be made explicit based on the need to understand the individual rather than universal laws and the belief that causes and effects are mutually interdependent. As Charmaz (1995, p. 30) underlines "*the researcher seeks to learn how they [the participants in the research] construct their experience through their actions, intentions, beliefs and feelings*" or agency theory from Emirbayer and Mische (1998). This is in addition to the assumption that the researcher and their subjects are engaged in interactive processes in which they intermingle, dialogue, question, listen, read, write and record research data with no real method to gauge how this presence influences the discourse and actions of the subjects. Yet there is no way to know without an observer. Findings are contingent and absolute knowledge born out of the coupling of truth and belief may be impractical and intangible and often unpredictable.

Significance and limitations

The social realist case study design was suitable and effective in gaining an understanding the nuances of chemistry teaching practices in HEI underpinned in a structural-agentic context. Most importantly, the design and subsequent enactment characterized the considerations to teaching approaches with a reasonable attempt at understanding how these considerations may be deployed to predict tendencies. The thesis did highlight the role of different types of agency in adopting and enacting different teaching practices in the context of different forms of structures (soft/rigid) and its potential implications for pedagogy and policy. The synthesised and proposed *functional, adaptive and progressive* agencies represented a significant consideration into the providing understanding of the capacity and *elasticity and trajectory* of agency. While categorising structures into soft and rigid might provide a framework for future research. Meanwhile, there were issues with this qualitative research such as: not

generalizable, time-consuming, more easily influenced by researcher bias (Griffin, 2011). As Yin (2009) explains case study research findings are "*generalizable to theoretical propositions and not to populations or universes*" (p. 15) since the sample size in relation to generalizability is rather controversial in qualitative investigations (Malterud, Siersma & Guassora, 2016) and several information-processing biases (Eisenhardt 1989). This is added to the specificity in terms of population, discipline (chemistry in this case) and setting. However, this design can lead to a better understanding, and perhaps better theorizing, about a still larger collection of cases" (Stake, 2005, pp. 445-446). While these present concerns and impede any generalizations which ultimately is not the goal, the empirical gain is in establishing certain indicators or parameters critical choices made by teachers related to their practice in different disciplines and settings. This depends on the notion of knowledge and change, and how they can manifest at different times. The discourse and findings will potentially lay the groundwork for further research which will substantially add to our knowledge and focus HEI active efforts to enhance teaching practices.

Summary

In this chapter, I examined knowledge concepts through a social realist qualitative case study design and provided rationale for the choice of methodology used. I provided detailed representation of the process and decisions made while reflecting carefully at each stage. The research must be demonstrated validity and robustness. Originating in an in depth discourse analysis, construct established represented an institute theoretical framework. While this research is not built on a hypothesis, the literature review illuminated aspects which pushed me in the direction of empirically examining their validity. Therefore, the experimental findings from the research would ultimately represent an opportunity to align with the themes established.

Chapter Four: Data Analysis

Introduction

This chapter describes the rationale for the procedures utilized in data analysis embedded in a social realist design with the aim to answer the research questions and capture the interplay of structure and agency in this context. It begins with highlighting the procedures in detail and the approaches employed to ensure accurate rendering, analysis of the content. Emphasis was placed on the interviews conducted, triangulated with observations and documental evidence, to gain *real* understanding of structures and agency and their dialectical interplay in predicting tendencies on enactment of teaching approaches in this chemistry department. The transcripts of the interviews were labelled, inductively coded, deductively categorized to generate themes. Further analysis employing retroduction and retrodiction was used to describe the mechanisms and provide predictions of tendencies for enactment.

Research Questions

1. How do structures inform teaching approaches and enacting the teaching practices?

2. How do teachers in a chemistry department in a HEI characterize their teaching approaches and practice and the role of teacher agency?

3. What are the epistemological and pedagogical implications of better conceptualization of the role of agency in the structures-agentic context?

Data analysis

Case study analysis can be overwhelming because of its "purpose is to identify, sort through, and pattern relationships, dynamics, or other phenomena of interest in a bounded system" (Swanson & Holton, 2005, p. 341). Once all the interviews (n=9) were conducted and transcribed verbatim, anonymized, and analysed in a process of bringing meaning and significance in context to the data. According to Stake (2005), the case study is constructed by qualitative data, such as observations, interviews, and documents. The data collected was analysed through constant comparison method and holistic coding (Creswell, 2007; Glaser & Strauss, 1967; LeGary, 2017; Merriam, 1998; Seidman, 2013; Yin, 2018) so categories and themes can be refined as they begin to emerge (Anderson & Butt, 2017; Creswell, 2007; Glaser & Strauss, 1967; LeGary, 2017; Merriam, 1998; Seidman, 2013) and constantly compared to the themes in the conceptual framework. The information produced is analyzed and grouped into themes and triangulated (interview-observation-document analysis-literature) to ensure validity and credibility. Pinning the data analysis in close alignment to the exploratory nature of the RQs is a critical consideration. Therefore, in this design it was always a process of going back and forth to conceptual framework generated in the literature review to critically and deductively characterize further understanding.

Table 4.1: Interviewee profiles (more details in Appendix A)

	Interviewee	Discipline specialization	Duration /min
1	A	Physical chemistry	74
2	B	Organic chemistry	55
3	C	Physical Chemistry	70
4	D	Organic	45
5	E	Organic	59
6	F	Biochemistry	49
7	G	Phytochemistry	56
8	H	Analytical	41
9	I	Organometallic	36

Table 4.2 displays the interview questions and how they were crafted to induce responses related to the research questions. While there distinct questions RQs, the aim was to prepare and present the interview questions in a manner that will invoke the most depth of responses without directing the respondents. This produced more authentic and reliable responses.

Table 4.2: **Situating the Interview questions in the Research Questions** *(* scale represents how relevant the answers to each research question*)

Interview Question	RQ1	RQ2	RQ3	Literature reference
How would you characterize your approach to teaching chemistry?	**	*****	***	Pedagogy
What influenced your approach to teaching chemistry?	*****	*****	***	Pedagogical competence
Can you describe some of the factors which shaped your approach to teaching chemistry?	*****	*****	*****	View of knowledge Self-efficacy
Can you describe chemistry students? How do you view them?	**	****	*****	Self-efficacy practice
In your opinion, how does the subject and discipline affect how the ideas are taught?	****	***	***	Troublesome Department Academic discipline tribe
Can you describe your teaching approach? How might you change your teaching style at a different content (organic/ physical) for example?	***	***	***	Teaching Agency Discipline Pedagogy
Can you describe how you deal/dealt with the challenges you face in teaching chemistry now? (if a veteran academic , I would ask about other institution where they worked before)	****	****	****	Institution Teaching-research nexus

Do you teach differently depending on the course level? How?	**	****	****	Pedagogy Self-efficacy
''Teaching Chemistry is different than other disciplines''. To what extent do you agree with this statement and how might it vary in different areas of chemistry?	****	***	***	Troublesome Department Academic discipline tribe
Can you describe and explain the rationale of some of the teaching practices in your department and how you relate to them?	****	**	***	Department Institution Tribe
Can you please elaborate on how your approach to teaching is similar or different than your department's or institution's?	****	**	**	Discipline Institution Tribe
How do you balance between research and teaching duties?	*****	****	****	Teaching research nexus Self-efficacy
How might your teaching style be different if say you are teaching English or Mathematics? Why?	****	***	***	Discipline Troublesome
How would you describe your role and any considerations (evaluative steps) when you think about changing the way you teach chemistry?	**	*****	***	Pedagogy Professional development Self-efficacy
How does the departmental culture (and institutional) and existing practices or expectations guide or influence your approach to teaching?	****	***	***	Department Institution
Can you describe situations or factors that guided, challenged or led to changes in your teaching practices or those in your department?	****	****	****	Self-efficacy Teaching agency Department
How would you characterize your role and that of your department in changing teaching practices? How prepared was it for COVID19?	****	****	****	Institution Department Agency
How has your teaching style change over the years?	**	*****	***	Pedagogy Professional development Agency
What is the role of chemistry education research in influencing your teaching practices	***	****	***	Professional development Pedagogy

Data analysis Procedure

Data analysis can also be retrospective analysis (Saldana, 2002), iterative analysis (Huberman and Miles, 2000), transformation of data (Wolcott, 1994; Simons, 2009) computer-assisted analysis (Shove et al. 2012). Realism looks for tendencies, not laws (Danermark et al., 2002, p. 70). Data analysis began with the search for 'demi-regularities' at the empirical level of reality. Demi-regularities can be effectively identified through qualitative data coding. I used a primarily deductive yet flexible (i.e., 'directed') coding process (Hsieh & Shannon, 2005) that drew on existing theory (practice) and

literature (conceptual framework). Social structures include relatively enduring (but not permanent) features of the world that often precede and succeed our individual lives, but which human agency can reproduce or transform over time (Archer, 2010; Bhaskar, 1979). Thematic analysis is a method for analysing qualitative data that entails searching across a data set to identify, analyse, and report repeated patterns (Braun and Clarke 2006). Thematic analysis recognises that there are facets of the externally verifiable social world (Fincham, Langer, Scourfield, & Shiner, 2011) discoverable through documents and that coding, carried out with both rigour and creativity, can be an effective tool to obtain trustworthy findings and offer alternative insights into that social world. By categorizing the themes I was able to analyze the perceptions and experiences of the studied subjects (Marshall & Rossman, 2011). Drawing on other studies taking a realist perspective (Wynn and Williams 2012, Davis 2013, Tao 2013, Bygstad et al. 2016, Fletcher 2017), a framework for the analysis was devised, based on realism's stratified ontology. I used the existing theories (Fletcher 2017; Maxwell 2012) or inductively drawing from the data (Oliver 2012; Craig and Bigby 2015) to identify structures and causal mechanisms. Key concepts in this framework are abduction and retroduction. Retroductive/Abductive reasoning involves making a reasonable explanation which appears to explain what has been observed; it is observing some phenomenon and then claiming what it was that gave rise to it. The analysis begins with labelling text of significance and interest, data coding which often starts with theoretical pre-understanding or concepts to construct the codes from the data while the later, associated with the grounded theory approach, generates the codes from the collected data. Various procedures in critical realist data analysis have been highlighted by scholars e.g. Fletcher 2017; Danermark, Ekström, and Karlsson 2019; Houston 2010; Oliver 2012; Craig and Bigby 2015; Arroyo and Åstrand 2019. Bhaskar (1975, 1998) and later Danermark and colleagues (2019) proposed a process (RRREI) to include the following: 1. Resolution of a phenomenon into component parts (agency-structures-practice). 2. Redescription of components in terms of a theoretical orientation (elements of agency, structures, practice) 3. Retrodiction to posit the causal mechanisms that would explain the phenomenon (possible interplay of components at different levels and magnitudes). 4. Elimination of alternatives (what is not plausible?) 5. Identification of the best explanation (what came together?). I used the existing theories (Fletcher 2017; Maxwell 2012) or inductively drawing from the data (Oliver 2012; Craig and Bigby 2015) to identify structures and causal mechanisms. However, specificity and focus in this design often undermines its significance as a theory particularly its inability and impossibility to provide a compressive account of ''everything'' related as a result of its clear and narrow lens.

Figure 4.1: schematic of the data analysis steps

Using mostly deduction to generate first order codes

A list of codes was drawn from the literature review, conceptual framework, and key realism's concepts. These codes were changed, eliminated, and supplemented with new codes during the process until every piece of text was coded (Gilgun, 2011). In this way, the deductive codes were treated as a way to reformulate the existing model or theory from which they were drawn (Gilgun, 2011). Saldaña (2013) warned against a rigid approach to coding, pointing out that 'your preconceptions of what to expect…may distort your objective and even interpretive observations of what is "really" happening there' (p. 146). I was therefore cognisant not to limit my coding process to the conceptual framework, therefore, I used inductive techniques to account for the ideas and concepts which did not fit any of the pre-determined coded. The examples below represent a set of codes selected to which can be group in one category (next step).

> *Chemistry is an interesting discipline*
> *Chemistry is hard*
> *Macro to micro*
> *Many sets of skills needed for chemistry*
> *Many pockets of knowledge*
> *Some things must be known*

Abduction and the "Actual" Layer

Once all data was coded in the form of first-order codes, the first-order codes were grouped into second-order codes based on their underlying similarity. This phase introduced the deductive component of the analysis since the majority of second order codes were drawn from existing literature. During this exercise, the corresponding level of the first-order codes was maintained, thereby assigning levels to second-order codes as well. It is acknowledged here that procedure was not one-way and these codes were subject to revision, merger or deletion based on researcher's emerging understanding of the constructs (Miles, Huberman and Saldaña, 2013). Abduction and retroduction/retrodiction are the foundational modes of inference in social realist analysis (Danermark, Ekström, and Karlsson 2019). The focus will on the data to compare to the conceptual framework synthesises in the literature and determine if it represents a certain alignment. After the main empirical findings (demi-regularities) of the research had been identified through coding, the next step was the process of abduction—also known as theoretical redescription—in which empirical data are re-described using theoretical concepts. Agency, which is arguably shaped but not determined by structures, can consciously or unconsciously shape those social structures (Bhaskar, 1979). Importantly, agency includes our individual values, meanings, and ideas, and these can also shape the world around us (Carter & New, 2004). Abduction, a creative form of reasoning coined by Peirce (1955), involves redescription or recontextualization of findings as a causal mechanism or process which serves to explain them. The step involves redescribing that which is observed (interviews, observation, documents) in terms of theory in order to describe the sequence of causation that gives rise to observed regularities in the pattern of events. It involves combining observations, often in tandem with theory [or conceptual framework] identified in the literature review, to produce the most plausible explanation of the mechanisms that caused the events. Abduction seeks to interpret and re-contextualise individual phenomena within a contextual framework or a set of ideas in a way that seeks to elucidate underlying structures and causal mechanisms' (Tikly 2015, p. 257); a process of 'inference or thought operation, implying that a particular phenomenon or event is interpreted from a set of general ideas or concepts' (Danermark et al., 2002, p. 205). Abduction raises the level of theoretical engagement beyond thick description of the empirical entities, but with an acknowledgement that the chosen theory is fallible. It involves looking for potential explanatory patterns and is the first step in developing theory (Åsvoll 2014) as it attempts to provide tentative explanations to make sense of the observations for which there is no appropriate explanation or rule in the existing knowledge domain. If the explanation of the mechanisms is successful, theory and data will be consistently and effectively 'fitted together' in such a way as to render the nature of the

mechanism clearer. The study generated a considerable amount of data: interview transcripts, field notes, observation notes and documentation. In this research, thus, a theme 'structure was created, and existing organizational or theoretical codes were re-coded into it in order to identify some possible structures at play. A theme marked agency was used similarly. In addition to this secondary coding, I used retroduction and retrodiction techniques to provide prescriptive predictions of tendencies.

Thematic findings: Structures

Theme generation

Table 4.3 shows how codes were used to generate categories and subsequently themes relying on different sources of information to achieve certain reliability and authenticity. These data generated structural themes are presented more clearly in figure 4.2 which respects a different shift from the literature analysis structural themes in Figure 4.3.

Table 4.3: *Data identified codes and themes and triangulation elements*

Code	Category	Triangulation	Theme
▪ Interesting discipline ▪ Chemistry is hard ▪ Macro to micro ▪ Many sets of skills ▪ Many pockets of knowledge ▪ Some must be known	Troublesome	Literature review Second records Document analysis Reflective collection Observation	Structure
▪ Time to do research ▪ Research expectations ▪ Contractual obligations ▪ Credit taught per semester	Teaching-research nexus	Literature review Second records Document analysis Observation	Structure
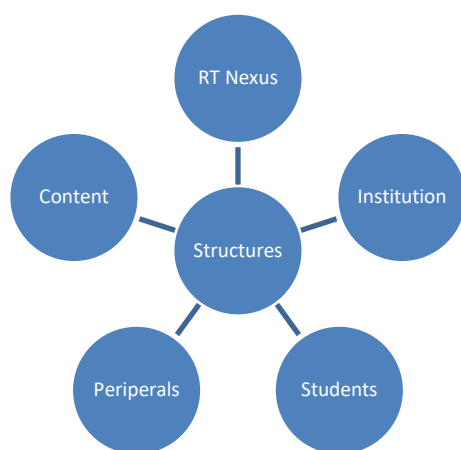
Figure 4.2: schematic of the data analysis step thematic finding synthesised from data
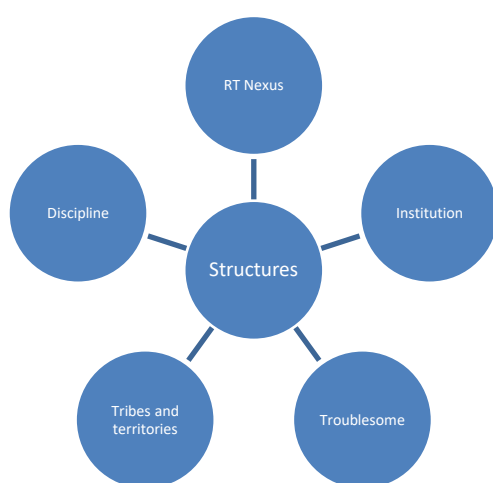
Figure 4.3: theme synthesised in the literature generated conceptual framework

Table 4.4 unpacks data identified structures into relevant components, examples or considerations as perceived by the agents. Following the dialectical interaction between agency and structures, these structures and the corresponding components exert conditioning forces on how agency in general is activated which will inherently affect approaches to teaching chemistry.

Table 4.4: *Data identified components of identified structure*

Structure	Teaching Research nexus	Institution	Content	Peripheral	Students
SPT social practice theory reference	Research productivity	Normative controls	Peculiar Troublesome	Lecture hall	Background
	Credit hours	Isomorphic Changes	Practical component	Student numbers	Core competencies

Material Field	Contact hours	Student evaluation	Epistemological essentialism	Remote learning	Language
	Job description	Appraisal	Year level	Simulation	Assessment of learning
	Tribal Hierarchy	Grade thresholds	Sub-discipline	Digital resources	Cultural context
		Teaching excellence	Collaboration		

Thematic findings: Agency

The data generated agency themes are presented in figure 4.4 which respects a different shift from the literature analysis structural themes in Figure 4.5. Table 4.4 unpacks data identified agencies into relevant components and activators. Following the dialectical interaction between agency and structures, these agencies and the corresponding components exert conditioning forces on how agency in general is activated which will inherently affect approaches to teaching chemistry.

Figure 4.4: Thematic finding of teaching agency synthesised from data

Figure 4.5: Thematic finding of teaching agency synthesised from literature

Table 4.5: *Data identified components of agency*

Agency	Self-efficacy	Pedagogical competence	Professional development Innovation	Experience	Position
SPT reference Meaning Habitus Capital	Perception of role	Professional development	Educational research	As a student	Leverage
	Managing nexus	Learning theories	Resources	Prior experiences	Non conformity
	Student knowledge	Peer coaching			Driving Change
	Purpose				
	Appraisal				

Retroduction and the Real Level

The literature review highlighted two approaches CCSF and ITTF which have been associated with the classification of hard and soft disciplines. However, little account has been provided to role of agency and structures in the tendencies for empirical enactment of chemistry teaching practice, let alone the real mechanisms behind them. Realism adopts a distinctive form of inference called retroduction, a "*central mode of inference*", (Lawson, 1998, p. 156), which ascertains that events are explained through identifying and hypothesising causal powers and mechanisms that can produce them (Bhaskar 1978; Sayer 1992; Hu 2018, p. 122). The goal of retroduction is to identify the necessary contextual conditions for a particular causal mechanism to take effect and to result in the empirical trends observed and focused on the identification of underlying mechanisms and theory development. The

logic of retroduction refers to the process of building hypothetical methods of structures and mechanisms that are assumed to produce empirical phenomena (Bhaskar 1979, p.15), 'inferential judgements from the analysis of indirect evidence' (Lotz-Sisitka and Price 2016: 6; Price 2016, p. 29) most complete and logically compelling explanation of the observed (Wynn and Williams, 2012); 'a better explanatory grasp' of the research context (O'Donoghue 201, p.173); mechanisms (domain of the real) which makes the phenomenon possible (Zachariadis, Scott, and Barrett 2013; Volkoff, Strong, and Elmes 2007). Retroduction underlines 'the manifest phenomena of social life, as conceptualized in the experience of the social agents concerned, to the essential relations that necessitate them' (Bhaskar, 1979, p. 32). It involves inference – identifying the mechanisms that could explain the outcomes (or in this case the prospects for pedagogic change) and testing them against the evidence, through higher-order coding and cross-case analysis (Wynn and Williams 2012, Bygstad et al. 2016). Oliver (2012) views retroduction as a form of abduction with a question "what makes this phenomenon possible? Compared to the coding process, this stage was more iterative and creative in nature as the analysis moved back and forth between the data and explanation. Along with the identification of mechanisms, explanation building goes hand-in-hand in a social realist analysis. This is what George and Bennett (2005) call 'analytical process tracing'. This involved converting the codes and the descriptive narrative into an analytical causal explanation presented in explicit theoretical form. The goal here was to build an explanation of the events on how or why something happened. This phase involved a series of iterations and revisions to attain greater explanation and theoretical coherence (Yin, 2013, p. 149). Retroduction involves imagining a mechanism, which, if it were real, would account for the phenomena in question. In other words, it seeks to ascertain what the world (i.e. the broader context) must be like in order for the mechanisms we observe to be as they are and not otherwise. This often involves first identifying patterns over periods of time and in different contexts to creatively asking '*what if*?' to identify often hidden causal mechanisms. Retroduction requires researchers to move from empirical experiences and descriptions of an unexplained event (domain of the empirical) to a deeper level of causal powers and In practical terms, a retroductive study requires at least two things: 1) explication of the focal event (domain of the actual) from empirical observations and, 2) a hypothesis of the existence of causal powers, mechanisms and their underlying structures that are not subject to direct observation. This gives realism an ontological depth and makes it possible to not only understand what things are different, but also how things could have been different. A significant challenge at this stage was to ensure theoretical validity and (theoretical) generalisation when developing and explaining the theoretical framework. That meant ensuring that the identified mechanisms were logically consistent and based on the empirical evidence, and was generally supported by the literature (Maxwell, 2012). However, it may be noted here that in some cases, the

researcher might need to use creative or meta-retroduction (Eco, 1983) because existing theory does not offer any suitable mechanism. A key outcome of successful retroduction is to modify, support, or reject existing theories to provide the most accurate explanation of reality related to this particular context (chemistry department). This explanatory approach requires very different methodological features to those in inductive and deductive research (Blundel, 2007). In general, induction requires moving from a number of similar observations to empirical generalisations and theories, while deduction adopts a top-down approach that moves from general theories and existing variables to a conclusion about these variables' implications in repeated empirical observations.

Table 4.6: *Data analysis steps in relation to the levels of reality*

	Action	Level of reality	Generative outcomes/examples
Transcription	Verbatim	Empirical	Precise Content
Familiarity with the text	Reading	Empirical	Critical reflection
Labelling	Signification	Empirical	Critical reflection
Coding	Induction	Empirical	Lecturing Chemistry is hard
Categories	Deduction	Empirical	Pedagogy Discipline
Themes	Deduction	Actual	Teaching Approaches Teaching as a practice
Mechanisms	Retroduction	Real	Progressive agency In the face of a soft structure

Retrodiction

While the analysis and the findings did represent a significant insight into the adoption and enactment of teaching practices through the structure-agency lens, further work in needed. The aim was not to present not to seek a confirmatory approach to the conceptual framework synthesized in the literature. But rather to use it a preliminary guide scaffolding further depth. For example, the research did highlight some of the structures identified in the literature. But they are possibly more and the extent they are interrelated and impact on agency and hence practice is incommensurable. Agency (in all its forms) in the context of teaching practice is pivotal and understanding the complexities may not be possible in this single case study. Agency presented an opposing role than the one identified in the literature (e.g. ITTF vs. CCSF adoption). It was important to understand the interactions of the components "*because these mechanisms arise from various layers and the relations among components and layers, understanding the network of interactive parts is essential*" (Bygstad et al., 2016, p. 2).There

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were new elements not characterized in the literature. For example, recognizing teaching experience, agility (related to technology and change) and academic clout (role) were important. The contingent findings implying strong agency in face of soft structures is significant and vice versa does require further research. Moreover, the purpose of such research while methodologically robust is not to present a tightly conclusive rendering of acquiring knowledge; it is a foundational step into further understanding while being subject to debate. Figure 4 shows the components of agency and structure. While (table 5), provides a clearer descriptions and predictions based on the relevance of the mechanisms. The nature of teaching approaches made in the context of interactions of mechanism will be discussed in detail in chapter 7.

Table 4.7: *Data analysis steps in relation theoretical framework and redroductive analysis*

Code	Category	Theme	Theoretical framework reference	Retroduction Relevance	Teaching approach ITTF/CCSF (Retrodiction)
Interesting discipline Chemistry is hard Macro to micro Many sets of skills Many pockets of knowledge Some must be known	Troublesome	Structure (rules-resources)	Content	Low	ITTF
Did not have any pedagogical training Time to prepare my lectures Peer coaching I just prepare the lectures	Pedagogical competence	Agency	Adaptive agency	High	ITTF
How I was taught When I was undergraduate The same way	Epistemological essentialism	Structure (rules)	Rigid	High	ITTF
Time to do research Research expectations Contractual obligations Credit hours taught	Teaching-research nexus	Structure (rules-resources)	Rigid	High	ITTF
PhD able to teach Appraisal based on research	Institution	Structure (rules)	Rigid	High	ITTF

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Complete the syllabus Grade threshold Only 20% allowed not to complete					
Content familiarity I had to learn some of the concepts	SMK	Agency	Adaptive agency	Low	Varies
Student evaluation Service to the institution Certain things must be acquired by students	Self-efficacy	Agency	Functional agency	High	ITTF
Teaching induction Teaching excellence center Became better with time I introduced simulation	Professional development	Agency	Adaptive agency	High	Varies
More independent learning in years 3 and 4 Master students easier to teach Did not know how to deal with freshman students	Year level	Agency	Adaptive agency	High	Varies
Department does not interfere Different than maths or physics Chemists are quirky Was easy to get approval for the simulation software	Tribe and territories	Structure (rules)	Soft	Low	Varies
How the students want to learn I can only help the middle third The top will always learn Real life context Knowing my students I try different things	Perceptions of students	Agency	Progressive agency	High (New theme)	CCSF

Data validity

Creswell (2013) highlights the steps needed for the research to be valid and reduce researcher bias. In all, the research should manifest credibility, dependability, confirmability and trustworthiness and [reader] transferability inferences (Shenton, 2004; Denzin and Lincoln 2005) or content validity (Brédart et al., 2014; Creswell, 2014; Howard et al., 2016; Veronese et al., 2016), which then can be validated by research community (Delmar, 2010). Agreeably MacGibbon, and Morton (2001) suggested that trustworthiness or credibility (Wolcott, 1994) is the key element to maintaining the place of qualitative research in the academic world. Creswell (2014) defines these concepts concisely: "Qualitative validity means that the researcher checks for the accuracy of the findings by employing certain procedures, while qualitative reliability indicates that the researcher's approach is consistent across different researchers and different projects" (p. 201). While this is not strictly the case, interpretivist research all are essential for this research to attain credibility and validity except for transferability. The notion of transferability is not critical here as peculiarity of contextual knowing is the goal; some of its components might be relevant in similar or further research. Paradoxes, contradictions and "negative cases or outliers" also became rich sources for analysis (Bazeley, 2009). In qualitative research, negative case analysis enhances rigor and is used in the quest for verification (Padgett, 1998; Strauss & Corbin, 1990). An audit trail can be used to accomplish dependability and confirmability simultaneously (Lincoln & Guba, 1985; Padgett, 1998). Yin (1994) encouraged researchers to make every effort to produce an analysis of the highest quality. Triangulation is defined as "a means of cross-checking the relevance and significance of issues from different angles to generate and strengthen evidence in support of key claims" (Simons, 2009, p. 129). Triangulation refers to the use of multiple methods or data sources in qualitative research to develop a comprehensive understanding of phenomena (Patton, 1999). Triangulation first serves as clarification of meaning. Second, the researcher is interested in the diversity of perceptions. Effective triangulation showed that the analysis relied on all the relevant evidence and presenting balanced and comprehensive arguments by including all major rival interpretations in the analysis. In this study, the focus was on agency and structures in relation to the teaching approaches. The data and the subsequent analysis addressed this significant aspect of the study. I was synthesizing the analysis while remaining grounded in the contextual meanings of the findings .This is an important delicate aspect and of the analysis in which I used my prior, expert knowledge to further the analysis. The research paradigm used in the research cannot claim that knowledge uncovered is absolute and singular. It is nonetheless *relatively* true (also as in credible) because the process was scientifically designed and accurately reflects social experiences in that particular context. In search of better understanding, questions cannot have simple answer, nor was this the objective of the research. The aim is to gain knowledge to

understand more. This understanding becomes knowledge once validated. It is a constructivist process which is in constant flux. The emergent findings were synthesized following a robust design and analysis they remain contingent, debatable and present foundations for more research. The research questions themselves represented a challenge. They were investigated in small and particular setting which despite robustness claims remain contextual and desire to examine the findings in more contexts is still valid. Table 2 outlines the criteria used to ensure data quality and the approaches I used in the before, during and after research to provide the academic rigor and confidence in the findings. I have added also relevance, a criterion if recognized which will invite others to explore the quality of the research and perhaps induce more knowledge through support of rebuke. This in turn will make the researcher including myself to think carefully about the audience and present data and empirical findings accurately.

Table 4.8: *Ensuring Data Quality (based on Cope, 2014)*

Criterion	Similar terms or description	Approaches I used
Credibility (True value)	Believable Interpreted correctly	Precise and complete transcription Contextual interpretation and coding Triangulation-Saturation Accounting for outliers
Dependability (Trustworthiness)	Repeatable With similar results	Robust research design Recognition of potential
Confirmability (Neutrality)	No researcher bias	Ethical considerations Balanced arguments Recognition of difference
Transferability (Applicability)	Applicable in similar contexts	Proper design, analysis and findings Recognition of limitations
Authenticity	Readers relating emotionally and socially to the participants	Genuine context and participants Authentic reporting -Relatable setting Clear language Brief profile Description
Relevance	So what	Audience-Implications Deep and critical data analysis

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Table 4.9: *Triangulation and data analysis validity*

Source	Focus	Researcher Influence on knowledge-reality	Nature of discourse /data	Informs
Interview	Subject	Significant	Dialogue dynamic Subject focused	Reality Perceptions of practice-beliefs-agency-structures-Approaches Self-efficacy
Documents Artefacts	Materials	Insignificant	Innate researcher focused	(tacit) structures- agentic flexibly
Observation	Subject-material interaction	Insignificant	Innate researcher focused	Agency- (latent) structures-approaches
Reflective Recollection	Researcher	Significant	Subjective	Agency- (latent) structures-approaches

Further considerations

It is impossible for a researcher to approach the investigation without prior depictions of reality while inadvertently seeking to situate the data into the belief. Nonetheless, every attempt was made to ensure the realities presented in the data were analysed methodically where contingent knowledge was synthesised to provide neutral and factual evidence to support the findings to be discussed in later chapters. At the same time, due to richness and analytical depth of content and my personal observations related to the design (not necessarily because they complement the conceptual framework) they and research questions the content from some interviews may have been disproportionately compared to other used. The case here was comparing the responses from those interviews with the empirical realities I experienced while gaining their insight on the actual and perhaps the real. It would be of great value to knowledge and HEI to take this research further and use it to examine the agentic teaching approaches impact on student's learning. Furthermore, the aim here was not to prove or disprove anything. It was an active attempt to understand why, despite the same practice, teachers' approaches vary.

Summary

In this chapter, I examined knowledge concepts as social realist qualitative case data analysis. I provided detailed representation of the process and decisions made while reflecting carefully at each stage. The research must demonstrate validity and robustness. Originating in an in depth discourse analysis, construct established represented an institute theoretical framework. While this research is not built on a hypothesis, the literature review illuminated aspects which pushed me in the direction of empirically examining their validity. Therefore, the experimental findings from the research would ultimately represent an opportunity to align with the themes established.

Table 4.10: *Realities and associated conceptual and theoretical frameworks*

	Empirical	**Actual**	**Real**
Stratified (Layers) of reality	Observed Certain approaches to chemistry teaching practices	Teaching practices are generated by mechanisms	Mechanisms and structures with enduring properties
Example	Didactic- Lecturing	Perception of role-Utility – Pedagogical competence	Agency responding to structures
Existing Theory Reference	Social (Pedagogical) Practice (Competency- Material- Meaning)	Practice theory (Habitus-Field-Capital) TLR	Interplay of structures and agency
Conceptual framework	Literature review framework 1	Abduction Reconstituting the framework 1 in reference to the data into framework 2	Retroduction Reconstituting reality in reference to the framework 2

Chapter Five: Structures

The literature review identified certain "structures" significant to the choice of teaching approaches. This chapter examines how these and *other* structures may be deployed to predict tendencies to chemistry teaching approaches through their dialectical interplay with agency. I begin with descriptions of structures in reference to the literature and move into how they are characterized by the participants in this research. An important aim of this chapter is to provide answers and understandings related to the first research question in characterising structures and rationale which will be used to answer the third research question.

> *RQ1. How do structures inform teaching approaches and enacting the teaching practices? Realisations from research findings:*
>
> - *Certain structures exist*
> - *Material and cognitive*
> - *Human and nonhuman*
> - *Perceptions of structures vary*
> - *Structures are part of social peripheral field*
> - *Some are Permeable*
> - *Soft or rigid depending on the agency*
> - *Bourdieu's practice theory provides insights into structures*
> - *Meaning of practice conditioned by perceptions of existing and prior structures*
> - *Competency of practice enhanced through interactions with[some] structures*
> - *Material [and materiality of] structures*
> - *Agency contributes to changes in structures*
> - *Chemistry teaching approaches are often in relation to students and content as structures*

5 Structures

Table 5.1: *Example of using the questions to identify structures*

| RT nexus	Respondents	Considerations
Is it external and perceived to be real? Is it recognised by most/all respondents?	All	Contract- H-index-view of teaching
Represents a major consideration	Yes, All	Expectations- Interest-Promotion-
Does it influence practice/agency/ teaching approaches	Varies, most	Appraisal Time- Priority- field- Efficacy-utility-Student
Does it mandate certain approaches?	Varies , most	evaluations
Does it affect approaches and enactment?	Varies , most	

Thematic findings: Structures
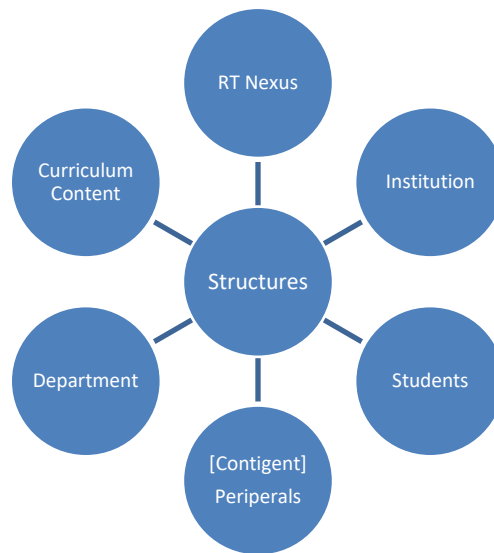
Figure 5.1: schematic of the data analysis step thematic finding synthesized from data
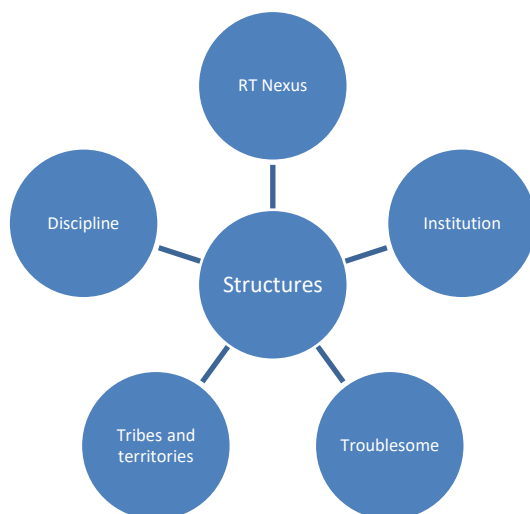
Figure 5.2: schematic of the data analysis step themes synthesized in the literature generated conceptual framework.

Teaching approaches and structures

Teaching chemistry is subject to the recognition and cognitive processing of structures which were identified earlier as rules and resources. Structure is dynamic, and not static, it is the continually evolved outcome or matrix of a process of social interaction (Sewell, 2006, p151). They often refer to the social forms and cultural systems that enable or constrain different projects from groups of agents (Ashwin, 2009). Although they cannot be viewed independent of the social world, in HEI, they can be concrete procedures and institutional arrangements which are implemented (Schön 1995, pp.27-28, Eikeland 2001, p.145) which Giddens (1984) describes as the specific sets of rules (or *schemas* according to Sewell, 2005) and resources (*or perceived ontological entities*) that either can constrain or enable agents. He also elaborates and insists on the duality of structures in both forms: human and nonhuman. In other words structures shape peoples practices but it is also people's practices which shape and reproduce structures. This is a contentious issue as Sewell (2005) argues that rules have resources in them and vice versa. For example, an implemented practice or tacit rule is to deliver lectures standing in front of a student audience which requires certain material and human resources for enactment. At the same time, laboratory equipment as educational resources is subject to rules. To gain a deeper understanding, the focus will be more precisely on these structures: rules (e.g.: belief, department, institution, and resources (e.g. textbook, technology, setting, PD). Despite the practicality of classifying structures, no structure is entirely rules or resources. Some structures are mostly rules with resources (e.g. teaching hours norms) and others are mostly resources with rules (e.g. use of laboratory). Often, academics in higher education are forced to negotiate these structures and make certain compromises related to teaching approaches. While some would argue for more diverse

approaches or combinations, the approaches to teaching being examined in this research are ITTF and CCSF. This can also be described as purposeful, essentialist, practical learning and learning with focus on innovation. From a realist perspective structures are ontologically recognized and often assumed to be immutable. This of course assumes uniform agencies and static social world. In reality they do change as agents and hence agencies at every interaction. For example, adherence to institutional rules and departmental expectations to "finish the syllabus" leads to a changed behaviour, teaching agency and hence approach, depth, focus. In this case, the immediate result will be to adopt more of ITTF due to time constraints.

Teaching as a Practice

Teaching as an activity in higher education can be viewed through different and compatible lenses. It is a *practice* as it signifies a repeated event with presumed enactment and trajectory and is more than disciplinary characteristics and situational factors (Richardson, 2005). Practices are, in fact, meaning-making, identity-forming, and order-producing activities (Chia and Holt 2008, Nicolini 2009b). *"There is no unified practice approach"* (Schatzki 2001, p. 2) so the prediction based on Bilgan's Soft/hard dichotomy is problematic to say the least. [Practice is] 'doing, but not just doing in and of itself. It is doing in historical and social context that gives structure and meaning to what people do and hence practice is always social practice' (Wenger 1998, p. 47) subject to complex considerations and forces which lead to certain enactments and realisations. In this research, there were marked variations in the responses pertaining to structural-agency, habitus-field-meaning, competency and practice trajectory through the discretionary deployment of capital against the changing field.

Soft-Rigid Structures: rules or resources?

As previously stated structures can be rules or resources. In the literature they were also identified as either soft or rigid. Furthermore, following the responses and how they characterized the influence of structures, it was important to draw a distinction between them. Deductive and retroductive analysis was used to make the distinction. The structure or sub-structures were classified as either soft or rigid. *Soft* structures were perceived to exist and are part of the teacher's consideration; however, they do not seem to constitute a considerable role. At the same time, some structures represented a significant consideration and thus are labelled *rigid*. This labelling may change with time and may be heavily dependent on agency (chapter 6). The structures (table 2) synthesized are grouped based on relationality and are different than the findings displayed in the conceptual framework. Here it is important to recognize that rigid does not necessarily mean confining pedagogically, similarly soft does not mean that it is empowering.

5 Structures

I used the following questions/ criteria to identify structures.

1. *Is it external and perceived to be real? Is it recognised by most/all respondents?*
2. *Does it represent a major external consideration?*
3. *Does it influence practice/agency/ teaching approaches?*
4. *Does it mandate certain approaches?*
5. *Does it affect enactment?*

Table 5.2: *Proposed characteristics of structures (soft-rigid)*

Soft	Rigid
e.g. departmental culture	e.g. teaching research nexus
Can be overcome by most agents	Cannot be easily overcome by most agents
Weak regulatory and normative role	Strong regulatory and normative role
Constitutes little consideration (Habitus-Field)	Constitutes significant consideration (Habitus-Field)
Has little impact on approach	Has significant impact on approach

In the next part, I will be relying on Giddens classification of structures as rules and resources to examine chemistry teaching practices. **Resources** refer to human and nonhuman enablers such as bodily competences, materials (Textbook, laboratory, and technology), language, time, and context (department, institution). **Rules** (or schemas) refer to mental, perceived, own, understood, tacit, recurring framework of practices (e.g. epistemological essentialism, RT nexus). A hybrid of both is proposed where a distinction is unclear. Table 5.3 provides some description of the categories and sub-categories of these structures with examples. Nonetheless, the purpose is not to provide a labelling of these structures as the boundaries are often marginal, but more significantly for educators and policymakers rather provide an authentic attempt at recognizing their existence and their interplay with agency.

Table 5.3: *Proposed chemistry teaching approaches structures in the context of rules-resources.*

Rules	Soft/ Hard	Agency	Examples	Resources	Soft/ Hard	Agency	Examples
Normative	Hard	Low	Essentialism RT nexus	**Allocative**	Hard	Low	Teaching load
Interpretative	Soft	High	Students Content	**Authoritative**	Hard	Low	Research Assessment

Rules or Resources, Does it Matter?
Curriculum: language, context, culture

Chemistry Essentialist Troublesomeness [Rigid]

The curriculum is both rules and resource. A common theme in the research finding is related to the *peculiarity* of teaching chemistry. There are elements of *memorizing*, *critical thinking*, *problem solving, different ways of thinking* and a genuine attempt to relate to real life. It was not perceived to be difficult in the purely cognitive sense but that chemistry requires different *skillsets, pluralistic ways of thinking, abstract,* and *multidisciplinary knowledge* in mathematics, and physic. Perhaps it is more fitting to situate this sub-structure within the general them related to chemistry as a discipline (table 2) because it is related directly to the nature of the content and cannot be treated independently . This represents a shift from the theoretical framework generated in the literature review. Nonetheless, this was in contrast to the views shared by the teachers who expressed active efforts to make the learning contextually authentic. Hence, peculiarity and pluralism of the disciplinary content may be perceived as "difficulty" and is related not only to the discipline but the interconnectedness of the content with other bodies of knowledge and skillsets required. From a SPT perspective the enactment of the practice is influenced by the inelastic complexity of the *material (content)*. As a result of this structure, the teachers (as agents) and hence the approaches are expected to accommodate this and make changes to enhance their teaching competency levels whilst having a heightened recognition of the meaning of the practice taking into account the students' perspective as well. At the same time, there are many types of chemistry. While generally described as hard, they can be pure and applied at the same time. The respondents were clear in their expectations from themselves and the students in each course at different *year levels*. Teaching chemistry does require students to master certain concepts and the constant shift from the **macro to micro** (Johnstone, 1991). This often makes Students find chemistry principles as alien to their everyday lives (Gabel, 1999) and alien of Ouasri (2017); Overton et al. (2013); Cartrette & Bodner (2010); and Salta & Tzougraki (2010) and allows for *adaptive* agency to build a connection between students and the content.

> So I always try to find ways to bring the theoretical concepts down to the practical side. So students can find a better link. Especially because **chemistry discipline is difficult** let's say to bring to students because they always think that it just leads to education, leads to limited jobs once they finish studying chemistry and they have difficulties trying to relate how practical chemistry is to their real life in general. [E]

> Largely, I think chemistry is one of those subjects where you need **different things**. You need a certain amount of **memory work** but at the same time you need to take in information from lots of different places   and put it together [A]

5 Structures

> It does not matter how they do it ....The most important thing in **HEI (emphasis mine)** is to **enthuse** the students and instill an interest in the subject after teaching well. But then I do not see how you can teach well if you are not enthusiastic about the subject. [A]

> I try to achieve **depending on the course** I am teaching for example for general chemistry I try to achieve literacy in chemistry. Students should be able to at the end of semester like **solve certain chemistry problems** so that is my approach, and also **analyze and evaluate daily life** or any situation in terms of chemistry. [D]

Students [*Dominant Field operator*]

Students by content and year [rigid] from essentialism to realism

There are guiding principles or rules which govern the interaction with students and how teaching should be enacted. Some of these rules are formative while others are interpretative. The latter allows for a significant margin of freedom for teachers to implement the practice they deem appropriate based on the interaction with students and content. At the same time, they are an important resource. Their numbers, academic backgrounds matter and access to material resources within the department also depend on their year level. While it was reasonable to consider this component as part of curriculum, the approach of *teaching* the content is directly related to students' most specifically for the socially attuned teachers. The findings of this research showed that teachers were well aware of the epistemic nature of the content and the cognition of the students' academic levels and reactions; making changes to the approach accordingly. There were also differences at the sub-disciplinary levels. Some sub-disciplines require substantial ability to comprehend spatial dimensions to be able to visualize reactions. Domain differences in epistemological beliefs seem to be related to differences between so-called 'hard' (e.g. mathematics and science) and 'soft' (e.g. social science and humanities) fields of study, with some studies indicating that students hold more naive epistemological beliefs in 'hard' fields. In addition, Biglan distinguishes between disciplines but there is little distinction within the discipline itself. For example, physical chemistry might have more in common with physics and mathematics than organic chemistry (often seen as softer and hence more likely to adopt a CCSF approach. Heavily, mathematical sub-disciplines or specialisms (e.g. physical chemistry) were more likely to assume ITTF approach rather than a CCSF.

> I feel like organic chemistry is closer to the students let's say to physical chemistry when you speak about orbitals or I don't know Schrodinger equation where it's all like ...... you know the student have need like needs their imagination and uh lots of numbers. Yes, the organic chemistry it's nicer it's **softer** than physical chemistry. [B]

5 Structures

> Some content is ***very mathematical***. You know when I taught first year chemistry, it was very mathematical. You calculate moles. You are calculating, voltage in a cell, that kind of stuff ... there is a lot of math in it, right? It is very different than organic chemistry where it is very structure, 3D structures, the properties they have, the kind of reaction they can undergo because of these properties. There is not a lot of maths in organic chemistry compared to regular chemistry that I taught in first year. [F]

> Organic requires a lot of ***memorization*** but I think I would always bring that, the critical thinking and the analytical thinking that I teach in analytical chemistry to the course itself to allow them where there are concepts where they might use the critical thinking to be able to use it. [E]

> Teaching it, it involves other ***connections with some other disciplines***. So you need to show students how central it is and how it can be utilized to serve the other disciplines. And teaching chemistry does not only require just learning the concepts, it is also learning other set of skills like solving problems like critical thinking and I think some other disciplines may be require these set of skills to be developed but may be not as much as in chemistry. [C]

> In terms of teaching practices, as I said, it varies ***from one course to another***. It some courses, it is delivering lectures and using hand notes and doing problem solving in class. In other courses, there are some modules where the students are expected to give reports and present certain topic that they have researched about throughout the semester as an assignment or something. So the rationale is to help students not only become independent by the time they graduate with bachelors but also be able to utilize their skills do either upper studies or even join the industry. That is the primary role. [E]

> I would approach (chemistry) 101 differently I would prefer to **stick to the book** to make it fair to everyone to every other section. [I]

The work of Biglan (1973) and Becher (1989) establishing hard-soft whereby teachers from 'hard' disciplines such as chemistry were more likely to report a more teacher focused approach to teaching, and those teaching 'soft' disciplines were more student-focused (Sari Lindblom-Ylännea, Keith Trigwell, Anne Nevgia and Paul Ashwin, 2006) falls short in dissecting the nuances which exist within the discipline. There is perhaps a missing account of disciplinary specialism and changes in the pedagogical terrain, technological advances and changes in the students' psyche. The identified structures representing general cognition may be attributed directly to the teachers' notion of habitus and contextual field perceptions. Some are not permanent, others might exist subconsciously and are difficult for the teachers to recognize and articulate their existence let alone role. This will require further and detailed research perhaps a longitudinal case study. For example, most importantly students *as resource, highlighting* the significance of learner emotions (Ritchie, S. M., 2018) whereby the teacher will adjust the approach depending on the reactions of the students. Teaching students

who are expected to be future engineers with strong epistemic positivism is perhaps different than those who are pure chemistry majors. The difference not only will transcend the approach but perhaps depth and scope. This structure might also be viewed as theatre audience seen as an external single entity (is the feedback good?) Furthermore, the year level played a significant (and hence rigid) role in the approach adopted. Once the essential skills and the required body of knowledge, the respondents were more likely to adopt CCSF approach in beyond year two. It could be that certain cognitive maturity also is achieved and certain degrees of independence should ensue. It follows that the academic discipline can be seen as a form of specific and rigorous scientific training that will turn out practitioners who have been 'disciplined by their discipline' for their own good. A clear sentiment in the findings is the significance of students as human and subsequent use of material structural resources critical to understanding teaching agency.

"I think the point of lecture is *not simply information transfer*. It is information transfer and defining the kinds of skills students should be picking up as they go through, defining the kinds of knowledge but also trying to inspire students and make sure that they get switched on to chemistry. So by making it trying to make it relevant to their lives...trying to give them real examples of the concepts you are talking about in lecture are used in their everyday life" [A]

If you are interacting with student a lot, you can see if something is digested or not, so the way you are teaching…. So basically, you have to get the *feedback from students*. [D]

Usually, it is, I like to have mutual *interaction with the students* and I have seen my in teaching chemistry approach evolving throughout the years. It is not fixed. I have gained some knowledge from my mentors during my PhD and from the training experience that I had post my PhD and also from interacting with other professors here and also the I think the interaction with the students had changed the way how I deliver teaching chemistry.[E]

Mostly it is the students. What they are like. What is the way that they prefer to **consume** knowledge? [F]

I became less selfish, focusing on what the **students need**. [H]

I am always to put myself inside the *students' shoes*, how they feel because I am coming from the same places as they are from secondary, high school university so how I was feeling when I was learning so I am trying to emulate my previous situation during my learning process that shaped my teaching chemistry. For example, if you are teaching like some abstract concepts you have to concrete examples, you have to models you have to use daily life examples for example. So I am using these frequently these techniques in my lectures. I try to use like technology plus normal experiments any kind of **tools** that I can concretely and visually explain the chemistry so that is my approach that helped basically what I am trying to do right now. [D]

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That approach would depend a ***lot on the students***, on the region, the level of the students. So for example, if I teach first year students they are surely different from second year. There is a huge difference. Sometimes, I think wow. That is really huge, and if you go to the third year, you will see that is more and if you go to the masters and compare it to the bachelor it is also different. [C]

I would say that this is a challenge I deal with in every class. You have ***3 kinds of students*** really. You have students who are super switched on, super into this and you might be going to slow for them. They are like **sponges,** they take everything you give them and they want to know more. And that is a small majority at the top. Most other students are at the level where they are supposed to be and they are there because they want to get their degree. Then there is like the worst is like… you have students who are there, maybe either they are not supposed to be there because maybe in our **culture** people are pushed towards engineering and science. Maybe that is not your thing but you are there because our culture says this is what you have to learn or maybe you are just not motivated for various socioeconomic reasons. [F]

I think it is a question that if you think about HEI, the ***top third of students*** will be successful whatever is taught to them and however is taught, the bottom third will struggle whatever the teaches in front of the class do. I think good teaching makes a difference to the **middle third** that you can improver them. [A]

But when I have the opportunities I try to push the limits of course I don't have the time to do hands on activities inside class especially for higher level courses because you expect higher level course to be a little bit tough, less dependency if you want at ***higher level (3rd and 4th year)***. [E]

So may be around the ***4th year mark*** I would say that students develop maturity and may be the one who you cannot motivate have dropped out at that point. But I don't think there is a big difference between 1st and 2nd year. [F]

I prefer to teach sophomore students because usually the ***first year students***, you know, they need to learn lots of techniques like learning strategies and learning techniques. Coming from school, most of their techniques are based on memorizing. [B]

So that is one big difference in my case when I approach ***higher level students***. [C]

For example in lower level course I use **visual aids** like model, like solid model, or computer software, modelling software, plus much more experiments. When you go to ***higher level courses*** basically you can deal with much more theoretical aspects, detailed aspect of the courses… and it is student oriented. [D]

''I try different methods to present the idea. I teach the way I learn. When I think of ***myself as a student***, I think about the best way to teach''. [D]

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Department *(the term department [chemistry] is used to refer to teaching norms]*

Academic Discipline: tribes, territories [Soft]

Again the department is both rules and resource. While the existence of normative rules was not quite evident in the responses, certain epistemic and resource (allocative- authoritative) considerations were significant. Studies into academic identity and disciplinary location reveal that the level of socialization within 'disciplinary tribes' is significant in shaping how individual academics see and engage in the world (Becher & Trowler, 2001). In simplistic sense the academic discipline from a regulatory perspective tribal/territorial has constituted *little* role in guiding or directing teaching approaches and practice. Yet, similar to the rendering of Prosser *& Trigwell, 1999, p.159: [University teachers] 'enter teaching and learning contexts with a range of prior experiences of teaching and learning and ways of conceiving teaching and learning. The context itself evokes certain kinds of prior experiences which then situate the university teachers in those contexts'.* The findings suggest a strong reference to the learning experiences by teachers as students. Some respondents reflected on their approaches in relation to "*how they were taught*"; either as a positive model or a negative model (meaning they disliked it and sought to be different). Furthermore, the participants did not express significant normative controls by the department either in the expectations related to specific approaches. Nonetheless, the discipline as a natural science situated in factual epistemic and essentialist knowledge presented more emphasis towards ITTF with clear emphasis on skillset acquisition and distinctions of approaches based on year level. The department in tribal sense presented its role in the *unsystematic* pedagogical knowledge gained *from others* while studying and as teachers. Thus, from departmental perspective, certain ways of *''doing''* were inherently perceived to be expected or the norm and not necessarily mandated. This is perhaps due to the fact that the department is still in early stages of formation and has not had enough time to develop certain pedagogical characteristics (allocative- authoritative); thus allowing for significant agency.   While no respondent expressed any influence from the **newly formed** (*which could explain why departmental identity has not surfaced*) department to teach in a certain manner within the department, the notion of teacher centred approach remained dominant. At the same time, there were many logistical and administrative concerns e.g. '*'finishing the syllabus which often places more focus on ITTF approaches in an attempt to check box completed content''* and ''accreditation'' and notions of "identity predisposition. Shifting away from this may not lead to being cast away, but may hinder the expected the conjuring of competencies, skillsets and pre-requisite knowledge. Yet there are embedded disciplinary characteristics related to teaching approaches evident when the respondents expressed deep concerns about their pedagogical ability to teach in other departments (e.g. physics, English or Maths). But

strikingly related to the notion of disciplinary tribalism, few responses seemed to view it in terms of operational traits rather than epistemological difference.

> It is not like something related to the chemistry department itself as much as something related to the **culture of the university or the country**. But **nothing particularly for the chemistry department**, except of course the safety rules in the lab that they don't exist in other departments like maths or English or communications, that we need to respect and follow.[B]

> The **department does not interfere** (emphasis mine) in the teaching practices. [D]

> I think if you are going to get into a certain subject, you are **predisposed** to be there. [F]

> Not at all (*referring to the role of the department*). [H]

> I think part of the problem here is that you are asking a difficult question, because you are asking about the role of the department, but the **department is actually the collection of individuals**. [A]

> Our department is still **very young in terms of chemistry department**. I think we have not reached, we are about, we are striving to reach a position where we can say that we are giving distinguish teaching practices compared to other departments. [E]

> I think, again, going back to the other questions, teaching **chemistry is different** than the other disciplines, for example if I compare it to maths, it is more interactive and engaging. You know, chemistry, as you know, you are a chemist yourself, it is like a central science where it is connected to physics, you need maths, really the central science, so I think without, in our meeting, departmental meeting, we don't discuss much the approach or the teaching method. But I think from the nature of chemistry as a science, we, I think if I have to move to another department, I am sure I will suffer because sometimes for example in maths it is about numbers, it is a different teaching approach, yes. **Every department or discipline has a different approach**. [B]

> **Teaching is teaching** but I think for chemistry is there's a lot more technical detail I'm sure there's still some techniques in art but there's lots of technical details and lots of principles that build on top of each other that the student needs to learn and understand um to become a successful chemist so there's I mean when you come in there's a lot of things that you need to learn. [H]

Epistemological essentialism

Ideally, chemistry should be taught in reverse manner: practical to theoretical or at least in very close alignment. The over emphasis on theoretical positivist knowledge (or normative rules) at the introductory level course often resulted in ITTF approaches. There was a clear evidence of scientific

epistemic essentialist focus on ITTF approaches to teaching with regards to the core competencies **students must know (non-negotiable, established ideas)** possess particularly in the first two years. This is perhaps related to the structures of knowledge and the social structures within the discipline Becher (1989) which pre-determines the specific bodies of knowledge and skillsets. Trowler (2008b) argues that much of the work on the disciplinary knowledge practices has been informed by 'epistemological essentialism', the notion that disciplinary knowledge practices determine teaching–learning processes (see Trowler and Wareham 2007 for a review of the different positions developed in relation to the impact of disciplinary knowledge practices on teaching–learning processes). ITTF was more related to *utility (and purpose to obtain a certain desired level of competency or common core knowledge)* and other constraints which I may refer to as competency epistemic essentialism as it relates to the skillsets acquisition. With increasing year levels, this structure became more liberal (softer) in terms of approaches. What makes this structure rigid is the degree of flexibility granted to the teachers who were often focused on outcomes. Here it is a case of implementing "tribal" approaches to concept building through means of memorizing '' body of knowledge'' and intense practice questions. However, while the epistemological essentialist research has been criticised for presenting an overly structuralist account of the disciplines that underestimates the scope for academic agency in shaping TLA (Mathieson, 2011) is significant in preparing students for higher level grade as they progress in their degrees. At the same time, not all students are chemistry major students as seen later in ''peripherals''. The issue with attributing tribal characteristics to a department is assuming that while on the surface they might share a common goal. The specialties are so defined they, the bounty is not necessarily distributed for the welfare of everyone. Tribes have specific duties for everyone which while compartmentalized combine to achieve goals related to survival, prevalence, dominance and perhaps expansion.

> Chemistry is very ***different*** than the other ones for sure. I think that chemistry is an interesting discipline because it intersects physical and life science together. [F]

> ''There are certain things that the ***students must know***. It is not something open for debate. They need to know the basis before they can be introduced to other ideas.''[E]

> It is not like there are new ideas there. We are teaching ***established ideas***. We just have to find a way of communicating it to the students in a way they can get it. It is not like we are reinventing the wheel or anything, right? [F]

> Largely, I think chemistry is one of those subjects where ***you need different things***. You need a certain amount of memory work but at the same time you need to take in information from lots of different places and put it together

so if you are planning a chemical synthesis you need to be able to take lots of different reactions and put them together to make your target. [A]

As you go on students know more and more so you can use more and more *refined models*. [A]

It is not a *negotiable content*. But as you progress from freshmen chemistry 1 to 2 it depends on the instructor how he brings the information to the students. [E]

But you know when you join HEI there are established **norms**, you generally follow. But nobody tells you have to teach this way or you have to follow this way. Generally it is a balance between the existing culture and your previous experience and knowledge. [D]

Even within the department, there are *no set rules* on how you do things. You are given a lot of freedom, as long as you deliver this content within a certain timeframe, then you can deliver it however you want. I don't think that is really an issue. I think the **issue is why the content is fixed** the way it is fixed... why do we have to keep doing the same things over and over when technology is changing so much. Not so much the knowledge, it is moving at a certain rate. [F]

Teaching Research Nexus [Rigid]

The line between rules and resources is also blurry in this structure. The incompatibilities or misalignment of agency between research and teaching the teaching research nexus (Trowler and Wareham, 2007a, Jones, 2011, Blackmore, 2016) surfaced quite clearly in the responses with term such as *"hard'', "difficult'', "time", "balance" "appraisal" "research focus'', 'teaching as a chore''* representing a significant consideration but varies at individual levels. Of particular importance is the *''appraisal''* process and hopes for *''tribal prominence''* which was often related to research performance to measure value (Henard & Leprince Ringuet, 2008, p. 5) rather than teaching excellence. Perhaps this represents a significant structural domain depicted in the respondents' reflections influencing not only the approaches to teaching practices but the notion of self-efficacy. In general, 'hard' natural sciences such as chemistry would be more research respected. Natural scientists would be more focused on producing journal articles and would enjoy a greater degree of social connectedness in their specialist field. In contrast, the 'soft' sciences would be less respected; their practitioners would be more focused on teaching and publishing articles and would be far more loosely connected. The strain generated as a result of research expectations often casts shadow on the ability of teachers to modify content and hence approach, introduce teaching innovations (resource limitations and priorities) and shift the focus more towards student centred learning. There is also the issue than all respondents were trained to do research but not exactly trained to teach. So here we

have a case whereby an individual is expected to do two tasks and equally succeed at both whilst an emphasis is preferentially placed on one and no real training to do the other. While it may be a common concern for most, there is discrepancy in the agents' interplay with this structure which can be attributed to position and seniority of teachers. For example, evident in the responses, assistant professors in their early careers attempting to move up the ranks will have a harder time trying to manage between the two. This is also made more complicated by the contingency of having a heavy teaching load or teaching   course and where either the research interest in the content is low or non-existent (e.g. a biochemist teaching chemistry 101). While established senior professors may find it easier to manage due to lesser teaching loads and reduced pressure on ''*producing papers*''. This is of course not factoring in individual agency (chapter 6). This is of significant concern to the institution. Trowler and Wareham (2007) further argue for addressing the need for defining the level of specificity in this nexus in terms of the extent and significance of [other] causal effects. This will undoubtedly enhance our understanding of the mechanisms of the enactments of teaching chemistry practices.

> ''But if I **increase the teaching the research will go down** for sure. It is at the end a 24-hour day.'' [C]

> You know finding a balance between teaching and research is **not easy** but what I think, I need to put more efforts to, I am trying, is doing research on improving the education and teaching style in the classroom room. [E]

> Not very well (referring to the balance between teaching and research). [H]

> Ok, now, remember at university, you don't have a heavy teaching load, as you know, especially when you are **doing research, you are relieved of the teaching duties**. But mainly to be honest with you, I am to make research progress during the teaching semester but luckily we have time especially at the end of the spring semester to perform. That is where I can see and progress with my research. [B]

> ''It is **challenging** but you know it is a choice if you want to go this way you have to take it if you don't want to go this way you don't have to take it. So it is a choice basically but the quality of research is affected this way. … [D]

> You have two different types of professors. You have professors who are very focused on research and for them they view **teaching as a chore** that they have to do. [F]

As a result this structural dimension represents a considerable strain on the agentic enactment and therefore might be considered to be rigid and highly correlational. At the same time, generalizations are never appropriate as Rowland (2000, p. 1) quite appropriately put in a clear exemplification of the different realities when operating within the teaching-research nexus and the role of agency: *"some of*

the most inspiring teachers are able researchers, but not all; that some prominent researchers are good teachers, but not all'.

Institution [Soft]

In HEI context, Trowler (2008) aptly describes the Teaching and Learning Regime or TLR consisting of eleven elements; some of which are structural. These elements (*power relations- implicit theories of teaching and learning- conventions of appropriateness- recurrent practices- tacit assumptions- codes of signification- discursive repertoires-subjectivities in interaction- materiality in interaction-backstories in process-regimes in interaction)* often determine the nature of the TL environment including teaching approaches and how they are manifested and embodied in reality. For example, *recurrent practices, tacit assumptions (about teaching, learning and role) and implicit theories of teaching and learning* seem to guide the approaches particularly for the new teachers or those who do not possess strong pedagogical background and limited agency. At the same time, an example of power relations can manifest itself in the changes to the assessment which can ultimately influence the approach. It is easy to regard this structure as either rules, resource or equally both. This perhaps is dependent on the individual agent. The respondents highlighted the role of "appraisals" (a strong institutional normative and perhaps coercive rule); curriculum review related to accreditation, teaching future engineers, syllabus completion, assessment guidelines and the little role teaching has in the process. This perhaps has indirectly encouraged the respondents to make more gains in research and often at the expense of teaching. Trowler (1999, p190) rightly *reaffirms:* "*Induction practices in HEI to date have been founded on a theory of the acquisition of knowledge, understandings and practices which has not been made explicit or evaluated".* Similarly, the findings suggest a lack of **pedagogic induction** or training (deficiency seen as softness) and has positioned greater agency on the individual. This is to the assumption that content knowledge alone is sufficient for practice *competency.* There were also issues with availability of allocative resources and professional development opportunities and heighted expectations from the respondents. While not directly and clearly identified but inherent in the appraisal process (publications), student evaluation, grade threshold's the institution's ambitious rank improvement plan also placed a significant less visible constraint on the respondents. This ideally should make this structure rigid. However, I still consider it to be soft because teaching approaches still largely depend on the agent. But it is not quite so simple. Trowler (2005, 29) also reports "*Cultures are extremely tenacious both at a national, macro level and at the meso level.* Trowler (1998, p.28) explains the complexity for enactment as *"Organizational cultures operate differently at different levels in the organization*" and reflects on the inability of the individual to embody change independent of the group, and hence the institution, but of course to certain limitations (Trowler, 2008, p.19-20).

Abrahamson, & Rosenkopf, 1993; Gerwal, 2002; Jan, et al, 2012) suggest relying on *mimetic* thrust to promote implementation. It can also explain some of the behavioural discrepancies based on habitus and the changing *global* field in an "*increasingly globalized or globalizing education policy field*" (Lingard, 2009).

> I think there is not a lot of… for the institution they give you ***rules that are fixed,*** right… But there nothing really that inhibits how you do it. [F]

> ***Anyone with a PhD can teach*** and everybody with a PhD is left to work out their best way of teaching. And it is done from a fairly, controversial, but I will say it anyway, from an amateurish point of view. Most of us are rank armatures; very few of us have actually **teaching qualifications**. [A]

> But you know when you join HEI there are ***established norms***, you generally follow. But nobody tells you have to teach this way or you have to follow this way. [D]

> I think it played a role when ***they introduced ALEKS*** (adaptive learning system for chemistry). [H]

> I ***fought for the concept*** to have this datasheet or kind of open note because as I said before like memorizing when a student tells you organic chemistry is all based on memorizing, this hurts. So I don't want them to come to a chemistry course thinking it is all about memorizing. [B]

Contingent peripheral (new rules or resources)   [Rigid/Soft]

Here, once again these can be either rules or resources. For example, this can be a new normative rule such as the reduction of the examination content, the introduction of a digital resource or both such as in the case of the sudden shift to remote learning where technology represented an additional structure. But the interpretation of this novel structure provided ample opportunities for individual agency. While in some regard, it can be treated as part of individual agency, it more aptly treated as a structure because of social, institutional and departmental expectations. For example, using simulations or event virtual lecturing adds an additional consideration for the teachers and appropriateness of approaches used. This domain requires detailed exploration. Here, again the agent's sense of habitus in relation to the changing field is important in characterizing the nature of the structure. For example, moving entirely to a remote learning mode can be a rigid structure even with great sense of self efficacy when the agent lack certain digital competences thus impacting enactment.

> So this was a little bit challenging for the faculty because it was during the summer, during COVID where people are ***not mentally prepared***. But other than that we are provided with all the support. You know in chemistry, the head of department fought for organic chemistry to have like very good software called ChemDraw I don't know if you know about it, for our chemistry students so they can use it to draw and to calculate the energy. So I think

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being 100% prepared, maybe it is too optimistic but maybe we had enough ammunition *to cope with the changes.* [B]

We had also recently transited from one e-learning platform to another, so also adjusting to new technologies, e-learning technologies, which *affected our teaching style*. [E]

I feel it's my **strong point like teaching distance learning** for me right now is like what I love to do just because I have gadgets right like I have both screens open. [G]

Table 5.4: *Data identified key components of structures driving teaching practices*

Structure	Teaching Research Nexus	Institution	Department	Students	Curriculum	Contingent peripherals
Nature	**Rigid**	**Soft**	**Soft**	**Rigid**	**Rigid**	**Rigid/soft**
Social Practice Theory Reference (Material - Field)	**Research efficacy**	Normative controls Student Evaluation	Normative practices Appraisal	**Background Interaction and reaction Year level**	Content/ Essentialism	**Digital Resources (ALS) Remote Learning Global disruptions**

Table 5.5: *Identified and reconstituted structures and their elements*

Curriculum [rigid]	Department [soft]	Students [rigid]	Research [rigid]	Institution [soft]	Contingent Peripherals [Rigid/soft]
Rules	**Rules**	**Resources**	**Rules**	**Rules**	**Rules/Resources**
Content Peculiarity	Meetings	Academic background	Publications	Job description	Technology platforms
Syllabus	Positivism	Studying for the test	Time	Appraisal	Global issues
Learning Objectives	Deliverables	Reaction	Review board	Title	Remote Learning
Assessment	Accreditation	Types	Significance	Service	Class size
Textbook	Colleagues	Language	Conferences	Ranking	Setting
Authentic Context	Departmental Objectives	High school discrepancy	H-Index	Perceptions of Professors	Teaching out of specialism
Lecture notes and PowerPoint	Good practices	Learning skills	Prominence	Centre for excellence in teaching	
Practical	Appraisal	Year level		Promotion	
Resources	Interdisciplinary	Grade		Institutional	

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		expectations		Review	
Breadth	Multi-section	Major		Content coverage	
Skillsets	Teacher evaluation	Motivation		Service	
Deadlines	View of knowledge	Dispelling myths			
Scope and sequence	Normalized Practices				
Inherit knowledge	Assessment approaches				
Essentialism	Connection to other courses				
	Linking the parts				

Summary

Structures exist at many levels, layers; rules and resources. They can be the set of norms and rules which guide and in some cases dedicate the enactment of a practice. In a teaching context in higher education, teachers often view their teaching practice through those structures. Elements such as the department, discipline and academic tribe, institution, academic labour, teaching-research nexus constitute considerations in the enactment of the practice. In particular situating ''students'' and ''content'' as rigid structures provided better understanding of the teaching approaches and enactment. While some strong indicators exist which show that some of these structures contributing a greater role (rigid) than others (soft) on the practice, this is not universal and cannot be generalized. To simply conclude that [chemistry] teachers adopt certain pedagogical approaches as a result of the existence of one or more of these forces without a proper account of the role of the agent and hence teaching agency will be an understatement. Gaining a better perspective of the practice will require further examination of the agency (chapter 6) and how it together with structures forms a conjoined dynamics (chapter 7) leading to a certain enactment.

Chapter Six: Agency

This chapter examines the findings underpinning agency in the enactment of chemistry teaching practice related to approaches. The literature review highlighted components of agency. Synthesis of the findings will be utilized to answer the second research questions and draw knowledge to answer the third research question related to the interplay of structures and agency (action to produce certain effect) in predicting tendencies of enactment. Using Bourdieu's practice theory (Habitus-Field-Capital) three types of contextual agencies were identified: *functional, adaptive and progressive*. Characterizing their features were significant to better understand how teaching as a practice is enacted at the agentic level and in relation to structures.

Realisations from findings:

- *Teaching practice is not clearly defined from agent's perspective*
- *Individual agency is complex*
- *Agency related to two different tasks (Research and Teaching) of different significance*
- *Agentic pedagogical enactment is the essence of practice*
- *Conditioning factors lead to certain agencies*
- *Different types of agencies arise contextually*
- *Agentic Self-efficacy and enactment competency are important considerations*

Thematic findings: Agency

Generally, the agents' recognition of the characteristic features of structures is similar. Their perceptions, processing and enactments are not. Hence, their responses to rules and resources structures varied. Data analysis revealed that contextual chemistry teaching agency can be divided into three types: *functional, adaptive, and progressive* (fig. 6.1). Each type will be discussed in detail in the next sections.
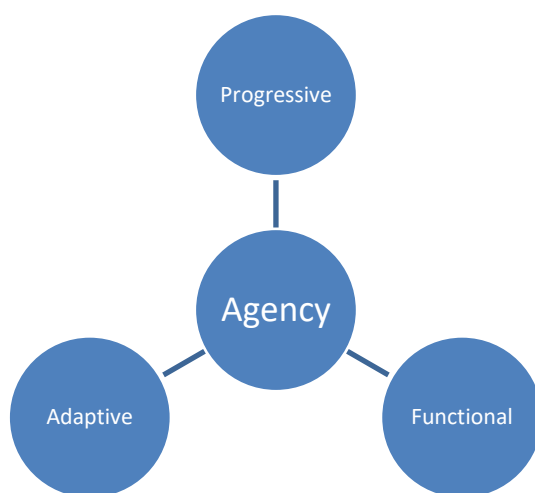

Figure 6.1: Updated and regrouped thematic finding synthesised from data

Agency and Practice

"*Agency is implied by the existence of structures … is formed by specific range of cultural schemas and resources available in a person's milieu*" (Sewell, 2005, p. 144). Chemistry teaching agency is no exception. The degree of agency, individual or collective (Hindess, 1986), and is subject to a host of factors which have shaped the personality of the agent, perceptions, belief, social and power status. For example, a head of department introducing certain teaching approaches faced less resistance than a novice lectures; thus highlighting power relations. At the same time, agentic teaching innovations in a chemistry department in institution A may influence other departments and the existing structures as well. Ball (2006) argues that social agents tend to align their actions with dominant discourses, which means that they try to gain power and legitimacy through normalising and embracing dominant ideologies and the structures that support them. Agency in social sciences is used to explain individuals' social action (Hollis, 1994). Martin (2004, p.136) defines agency as 'the capability of persons to make choices and act on these choices'. More precisely, in social science as in teaching practice, *pedagogical* agency (Veletsianos, G., & Russell, G., 2014) is understood as individuals' capability to engage in intentional, self-defined, meaningful, and autonomous action in circumstances constrained by power relations and structural, contextual factors (e.g., Archer and Archer, 2003; Foucault, 1975; Giddens, 1984). Bourdieu's field theory, especially the notion of habitus; Giddens's (1991) theory of structuration; and Archer's (2003) realist social theory and notions of agency and structure all aim to cross the divide between micro and macro views of agency and give space to the local and the specific (Ashwin, 2009; Fuchs, 2001). Akram and Hogan (2015) suggested that with Bourdieu's notion of habitus it is possible to achieve a more nuanced approach to agency, especially why it is difficult but not impossible to change our practices and why people are not able to control the process and rather prefer the status quo. Barman et al. (2016) examined teacher autonomy, which is often used in confluence with agency, in relation to educational reform; they illustrated how policies become meaningful for health teachers by reshaping local practice. Bourdieu (1974) termed habitus, a "*system of implicit and deeply interiorized values which …helps to define attitudes towards the cultural capital and educational institutions*" (p. 32). Habitus helps to link social power relations to individual decisions, experiences, and practices within education. Investigations of educational inequity that apply habitus attend to a critical yet underutilized element of Bourdieu's (1977b) theory of practice. From a basic SPT perspective agency requires competencies (utility of individual and external resources), recognition of meaning (rules), and operational artefacts (resources). A clear connection exists to Bourdieu's habitus, field, and capital triad. Isolating habitus as a single entity as seen in this research is erroneous. The habitus breaks with the debate between formalists versus substantivists,

structure versus agent, nurture versus nature, which has become more of ''*an obstacle instead of an inspiration*'' in the social sciences (Wilk and Cliggett, 2007, p. 4). Moreover, it is not a question of either or but a question of how is the dynamics changing the practice. The application of Bourdieu's scholarship to higher education is partly apt for several reasons but better examined in social realist lens treating habitus (in addition to field and capital) as precursors to certain enactments of agency. Related to this research, Bourdieu and Wacquant (1992, p. 15) suggest that when doing research on social reality and social change, instead of looking at dualistic 'things' like the collective or the individual, structure or agent, system or actor, we should look at relations. Thus, agency in curriculum work is approached here as a negotiation process and relationship within different structures that constrain or enable agency (Ashwin, 2009). To understand agency better, I will use my basic definition: *person doing an action for a particular effect, e.g. teaching presenting information through a PowerPoint presentation because it is expected, practical, visual, efficient, and purposeful or any other reason.* Thus, the agent and his or her agentic actions are at the core of the teaching practice. But not all agencies were the same and subsequently the interplay with structures.

> I really try to implement interactive style of teaching when I came to the UAE and it was much it was possible because of the smaller class sizes yeah it made things a bit easier. [H]
>
> *It depends on the instructors*. Instructors have a big role in making the let's say, subject approachable and as I told you, making that link to the real world, it think is important and trying to put yourself in the shoes of the student. This is another thing as instructors sometimes you need to understand or put yourself in that position try to understand what the students are facing or if they are having any difficulties. I think this is important. [E]
>
> ..*smaller cohorts* I can aim to work with weaker students to achieve 100% success and my second objective is to show them the real application at this stage of this chapter in careers in different careers .[I]

In the next section, building on the work of Campbell et. al. (2009), Biesta and Tedder's (2006, 2007), Fu and Clarke (2019), and Schwier, Campbell & Kenny (2007) in their classifications of agency, I used the data and findings in characterizing different types of agencies (table 6.1) focusing on the significant drivers in each.

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Table 6.1*: Data identified types of agency*

Practice	**Functional Agency (Transient)** **Low Habitus** **Low structure impact**	**Adaptive Agency (Transforming)**	**Progressive Agency (Transformative)** **High habitus** **High Structure impact**
Agency	Self-efficacy Managing nexus	Student knowledge	Strong Epistemological belief Confidence
Social Practice Theory reference *Meaning (* Mentalism, Textualism, Intersubjectivism) *Habitus* *Capital*	Perception of role	Content-Pedagogical development	Educational research Resources
	Pedagogical competence /Deficit	Self-reflection Experiences	Teaching culture
	Utility	Learning theories	Leadership /Passion
	Epistemological essentialism / Prior experiences	Peer coaching	Professional development Innovation
	Appraisal / Student evaluation	Strong structures	Soft skills Leverage
	Subject Material Knowledge SMK	Managing change	Entrepreneurship Non- conformity

Data analysis deductively revealed that the teachers exerted different levels of agencies. Each was characterized by certain understanding. Table 1 draws on findings related to the different types of agencies identified. In some cases, teaching *had to be* done as a function without competency and proper meaning while maintaining visibility in research. In such cases, agency is operational and is responding heavily to the externals (e.g. RT nexus-Institution). Deviations from this essentialist approach were seen when the respondents had prior exposures to situations of where CCSF were presented to them as students.

> I had a very good like… chemistry **teacher at school one especially one at school and one at university**, and believe it or not the university one was an organic chemist. So uh I was really like marked and influenced by both of them in my academic life and these two teachers or faculty where again they were really like they trying to simplify things and that and connect chemistry to everyday life. In addition to that I helped to do like between the

> bachelor and the PhD like a **teaching Diploma** where we studied a bit about like psychology of the students a little bit of like pedagogy   [B]

> I was **not prepared** when I began teaching….I took some course in the UK about University teaching. But it was late. [H]

Adaptive agency comes from more insightful understanding of students and deeper conceptualizing of the interplay with structures. The experience gave the teachers additional agentic force to conceptualize their teaching approaches more appropriately. Here while, the structures remained rigid, better situational and experiential reflection (heighted Habitus-Field) enhanced the competence of the teacher-agent to modify instructional design and approaches contextually (what has worked, what is going to work, what might work). The teachers as agents here have better sense of *practice trajectories* building on prior experiences and expected outcomes.

> I think when I started out, advice from colleagues. When I started out there was **no formal mentoring scheme or anything**. It was very much get on with it and do it. When I started again there were no formal training programs. It was just go and give some lectures on thermodynamics. So you did. So you develop things. You take advice from colleagues. I think the major thing is actually the students. As you have been in it for a few years, you tend to work out what works and what does not and over the course of 30 years certainly the students have changed as well. [A]

Progressive agency is a further level of agency where the teachers had deep knowledge of structures and confidence (competence component) not only to adapt their approaches but bring about changes to the structures within the field. This often came heighted sense of habitus-field resulting from seniority, position and deep rooted pedagogical passion and not necessary at the expense of research. Those are also more likely to engage in pedagogical development and educational research.

> I don't think they have the experience to teach directly I think they need some training probably to **build their confidence mostly their confidence.** [G]

Detailed discussion of the three types of agency will be discussed next.

6 Agency

Functional Agency : *Acting within the field (rules and resources)*

Self-efficacy

Sewell (2005) refers to agency as the ability to apply the knowledge of schemas (rules) to different contexts (p.143). The concept of a 'teaching approach' is used varyingly with some researchers seeing it as relatively stable (Kember & Kwan, 2000), while others agree that context affects teaching approaches (Fanghanel & Trowler, 2008; Prosser & Trigwell, 1999) and 'Pedagogic Device' (Bernstein 1990, 2000). The findings suggest that the perception of role and ability was often constrained by individual's understanding of self-efficacy and the considerations of the teachers in relation to the research and teaching nexus (RT). Finding the time to complete both tasks with equal dedication and effectiveness presented a ***challenge*** to the respondents. The RT nexus presented as a rigid structure in many cases, often limited the ability of the teachers to exercise agency and therefore represented a considerable factor in contextualizing agency as adaptive. This is especially important in cases where the teachers had significant research demands or they were research oriented and viewed teaching as a secondary activity. The teaching approaches initially adapted represent great limited notions of practical operational functionalism often falling back on how the teachers were taught or what students might want. Here the perceptions of habitus in relation to the field or perceived structures are foundational and primitive. These conceptualized 'mental' activities of understanding, knowing how and desiring are necessary elements and qualities of a practice in which the single individual participates, not qualities of the individual" (Reckwitz 2002b, 249, 250). This surfaced in more often when the teachers had little pedagogical knowledge, limited awareness of students, greater focus on research, or higher research demands with strong epistemological essentialist perspectives. This in turn increased the chances for more ITTF approaches. This is further complicated by emphasis on scientific research which often meant that approaches to teaching and pedagogy remained underdeveloped.

> Yes but it is ***challenging***. I tell you. It is ***not always 50/50***. Maybe on one day or a couple of days it is more geared towards research when I am not teaching. I think for me I still need a little bit more time to try to devote some of the research time to enhance the teaching style. [E]

> You know what you have to teach, right; the ***material that needs to be communicated***. [F]

> I just remember ***how we were taught*** this in undergraduate school. [D]

> ''It was ***very hard teaching freshmen*** students. They need a lot more effort ...whereas teaching seniors or grads was a lot easier...they already have acquired the learning skills and can handle independent work''
> "Maybe I am ***not the right person to answer these questions*** [*about teaching approaches*]" [F]

Adaptive agency: *Acting beyond the field*

Student-Content knowledge

A student-centred approach is consistently viewed as more sophisticated than a teacher-centred approach (Kember & Gow, 1994), and is considered to be necessary for the successful integration of Detach (Glassett & Schrum, 2009; Somekh, 2008). A significant consideration to the culturing of effective and appropriate teaching approaches was the knowledge of students and content. Teachers viewed the relationship between the as complimentary and their role was to demystify the peculiarities. They quite often referred to ''*students'', ''their reaction'', ''my performance'', ''active learning'', ''gauge'' ''learning from students'', ''different approaches'' and ''engagement''*. A strong indication of adaptive agency and enactment (perhaps leading to progressive agency) without the expected parameters was attributed to diagnosis of students and the nature of the content at every stage of curricular expectations down to the conceptual level. This is quite contrary to the model proposed by Biglan 1973 which wholesomely and enduringly treated chemistry as a hard discipline yielding ITTF approaches. Going further, the mechanism of agentic operation depends on situational awareness (habitus and field) and interactional dynamics with the social in the form of structures. Teachers made decisions on the appropriate approaches to interactively link students to content. Therefore, it is a complex process of cognitive transactions theoretically and enacted contextually. In other words, what is expected based on the presence of certain prerequisites for a certain practice might be realized differently on the ground. Thus, the results empirically confirm the relational origins of teachers' approach to teaching (Prosser & Trigwell, 1999). In other words, teachers who experience different contexts (year level, sub discipline, student groups) adopt OR *adapt to* (adaptive agency) different approaches to teaching in those different contexts. The strong negative correlations between the two change variables show that, when CCSF approaches are increased, the ITTF approaches are reduced, and vice versa.

> They are used to different things, they are used to ***different approaches*** coming from schools so you adapt that, you try things and if they work you keep them, if they don't… so I think actually learning from students is important as well as everything else. [A]

> It depends of what I am actually ***doing*** at the time. I think you need a mixture of labs, tutorials, smaller group and lectures. There is a body of knowledge that all students have to acquire. Some could acquire that by reading and independent work. Most acquire it by attending lectures. [A]

> For example, if you are teaching like some ***abstract concepts*** you have to concrete examples, you have to models you have to use daily life examples for example. So I am using these frequently these techniques in my lectures. I

> try to use like technology plus normal experiments any kind of tools that I can concretely and visually explain the chemistry so that is my approach that helped basically what I am trying to do right now. [D]

> So I like to have that ***interaction*** with students in class. I do not like to see passive students in class. [D]

> Mostly it is the students. What they are like. What is the way that they prefer to consume knowledge? Is it just a lecture? Do they prefer solving questions in the classroom together? You know every class is kind of different. I kind of ***gauge*** them. …. I pay a lot of attention to what students say. [F]

> There are ***different pedagogical considerations*** that you are trying to use with students and different ways of presenting the same material so they can appeal to different kind of learners. And I am not sure that somebody coming straight from a high level post-doc and being thrown into to teach freshmen chemistry or even later years chemistry. I am not sure. I think that is tough. I think that it is difficult. [A]

Meaningful learning involves both implicit and explicit learning processes (Vygotsky, 1986) and clear understanding of both. In this context, an inadequate pedagogical background often curtailed this goal whereby the lack of proper pedagogical training meant that teachers gained the experience while practicing. This interaction between the agent and the structures (rules and resources) strengthened with time and were able to make the decisions related to approaches based on utility and context. It is perplexing to assume that anyone solicited for a task may know subject content knowledge, yet quite often lack the know-how of how to implement. At the same time, strong and elevated sense of habitus and field enabled some to adapt and situate their practice appropriately by making greater agentic thrust to enact teaching through effective use of approach based on the context. Teachers, therefore in this context gradually created their *practice-based professional knowledge through a cognitive apprenticeship* (Y. Soysal and S. Radmard, 2016).

> As a feedback, I hope that they understand. I can tell, even myself, when I explain one topic, I feel it myself if my **performance** was good or not. So usually what I do after every lecture and look at my PowerPoint and it doesn't matter how many times I taught this particular concept and I try to add some notes and change here and there. I always go back and recreate my PowerPoint, to make sure that next time. My ***performance***, it is like a theatre, to make sure that my next performance would be better. And again, sit down and judge my performance in a particular topic and so on. [B]

> University professors are not really taught how to teach the way teachers in HS and other schools are taught. Like, we don't take courses in teaching. We ***don't learn the theory of teaching***. I feel like the style in which you teach like a university professor teaches kind of the way, almost the way they were taught to teach''. [F]

Progressive agency: *Acting changing the field (changing rules and enhancing resources)*

[Enhanced] epistemological beliefs

Personal experience and cultural context combine to influence individual educational practice (Brookfield 2017, p.2-3). Individuals such as teaching academics have to work out the dialectic between answering the questions, 'what do I want?' and 'how do I go about getting it?' (Archer 2007, p. 19). Similar to Chalmers (2007) *experience* matters. Personal epistemology, according to Hofer (2002), is the study of how individuals develop a conception of knowledge and its acquisition, and how they use that conception to understand the world. Through this process of constructing knowledge about their pedagogical practices, each lecturer advances beliefs about what knowledge is, and how it is constructed as a system of cognitions known as personal epistemology (Barger, Perez, Canelas, & Linnenbrink-Garcia, 2018) which in turn influences how it is *communicated* to students. According to Chan and Elliott (2000, p. 225), teachers' epistemological beliefs play crucial roles not only in their choice of teaching methods but also in making decisions, selecting teaching materials, focusing on the content, specifying how to *approach* students in the classroom, and how they manage students' behaviours (Erkan Dinç, 2017). In terms of teaching chemistry practice, there is a significant deficiency in competences. This was evident in the respondents' approaches to teaching and learning which gradually developed as the teachers gained more ***experience and confidence***. This is certainly dependent on how they ***perceived their teaching role*** in the first place. Although *''meaning''* of the practice is enriched through a better understanding of habitus in relation to the field *(mostly students and content interplay)*. Teachers learning by doing and determining the best way to ''teach'' is something developed through better understanding of meaning and hence competency. Here, progressive agency generated when the individual gained deeper understanding of habitus and field (understanding the full trajectory of rules and active utilization of resources) with a potential to exert influence on others by utilizing pedagogical capital. At the same time, of significant consideration also is the little role played by chemistry education research in driving change in pedagogical competence. This is also reiterated in the literature "*despite an increasing number of articles and books on teaching-scholarship published in recent years the notion of teaching-scholarship remains an elusive yet intriguing concept*" (Kreber, 1999, p. 323). Furthermore, the better conceptualizations of teaching practices are practice-based rather than theoretical. In other word, little role is played by chemistry education research and or educational research in general. It is perplexing, nonetheless, and perhaps highlights the secondary significance of teaching as a component of practitioner's role whereby teaching approaches are often contingent and utility-based.

6 Agency

I am sure that the majorities of chemistry *faculty do not read the journal of chemical education*, do not read chemistry education research and practice where as they probably do read chemical communications they do read the journal of American chemical society so I think it is important for people. [A]

Over the years, as I taught more, I began to realise the best ways to teach a particular concept. [G]

I actually, I sat and *I watched X teach a lecture, I watched Y*. I watched a bunch of people teach because I did not know how it is done or how or the level of these students. I did not even know. So I would say definitely it is a weak area. [F]

Yes, I fought for the concept to have this datasheet or kind of open note because as I said before like memorizing when a student tells you organic chemistry is all based on memorizing, this hurts. So I don't want them to come to a chemistry course thinking it is all about memorizing. So I tried to convince my colleagues, anything that has to do with memorising should be given to the students, because nowadays it all about learning and I think at least in organic chemistry *I managed to influence my colleagues*. [B]

I think it is a question that if you think about HE the top third of students will be successful whatever is taught to them and however is taught, the bottom third will struggle whatever the teaches in front of the class do. I think good teaching makes a difference to the *middle third that you can improver them*. [A]

I would think it is *experience.* This is the way that I see from one year to another year how the students interact with the course, how they learn, and the feedback of the students. [C]

Because it similar to other instructors, and seems that for most instructors that the teaching practices they have come up with are based on *personal experience* and figuring things out and trying to see what works and what doesn't work and building up on this experience every semester and every year. [C]

I like to have mutual interaction with the students and I have seen my teaching chemistry approach evolving throughout the years. It is not fixed. I have gained some knowledge from my mentors during my PhD and from the *training experience* that I had post my PhD and also from interacting with other professors here and also the I think the *interaction with the students* had changed the way how I deliver teaching chemistry. [E]

I cannot say that it changed over the years as much as *I gained more experience* and gained more confidence. I can reassure and I try to accumulate more day to day examples. But in terms of teaching.. I can say that teaching style, I remember when I taught back in the 90s, we did not have PowerPoint, so the style yes has changed, now we have PowerPoint, and we were using chalks, now we are using whiteboard, this is technical more than the content. But in terms of teaching style not much... I don't think. [B]

I would like *to introduce some educational type seminars* alongside our research seminars but this year as you can imagine has wiped lots of things and that was one of them. But I would like to think that people would be

receptive to those sorts of conversations. But again, it tends to be "it is another thing to do". Whatever people of academics we are usually pretty busy. [A]

Generally speaking, you kind of know the material. You know what you have to teach, right; the material that needs to be communicated. Usually there is like learning objectives that you have ahead of time. Kind of those in mind, you basically, I don't know… ***I am not pedagogically*** [has difficulty pronouncing the word], you know that word pedagogy; I don't have training like you guys have training when you go to teacher's college. So I am not sure that I am answering your questions properly. [B]

I think one of the other problems is in terms of ***faculty here anyway is that the majority of faculty have virtually no teaching background.*** So they are not introduced to any pedagogical theory so they do not. They fall back on their experience they fall back to what happened to them when they did their degrees. Because there is no formal training course for new faculty a lot of them do not have much experience of considering pedagogy and thinking about things should be taught and how things should best taught. So it is very much '' well it worked for me this is the ways I am going to do it" and lots of faculty have not been here very long, have not been teaching very long, some of them have, so they are still developing their teaching style.. I think without a theoretical framework to work from. So I would be surprised if any of them had been asked about the best way of teaching their particular subject or their particular bit of it. It is very content focused. A lot of people come to me and say I am running out of time , I have to cover such, such and such and I actually I am trying to encourage them to think about actually they don't have to cover things just because it is written down in the syllabus. It is better to cover a fewer things well and make those links and to encourage and enthuse the students that simply batch through a lot of material. [A]

Summary

Agency is multifaceted, contextual and can be viewed as a latent component of structures which do not exist without agents. It can be individual or collective (Sewell, 2005). Agents are active and contribute to enactment of repertoires, embody recurrent practices and drive change. A more appropriate perspective is to characterise [teaching] practice in terms of the dynamics between the agent and the social structures positioned in habitus-field-capital framework.   Here, there were realistic examples of the interconnectedness of agency and structures. The three types of agencies identified are a produce of interaction with structures. As a result of some structural disproportional influence, agents as teachers variations of meaning of the practice of teaching, pedagogical competencies and hence the use of material resources varied.   From a teaching approach to practice, they respond to structures, process contexts. The degree of freedom agents possess related to their approaches to teaching may be attributed to development of agentic drivers through experience based pedagogical belief and self-efficacy.

Chapter Seven: Agency-Structures dynamics

This chapter explores the dynamics of the structures and agency in the enactment of the approaches in teaching chemistry in this context. The aim is to provide better understandings related to research questions 3. Consistent with Giddens' structuration theory and the dialectic interplay between structure and agency, I further investigate how structure and agency engage in the subsequent enactment of approaches of chemistry teaching in this context.

3. What are the epistemological and pedagogical implications of better conceptualization of the role of agency in the structures-agentic context?

Teaching in the context of Agency-Structures dynamics
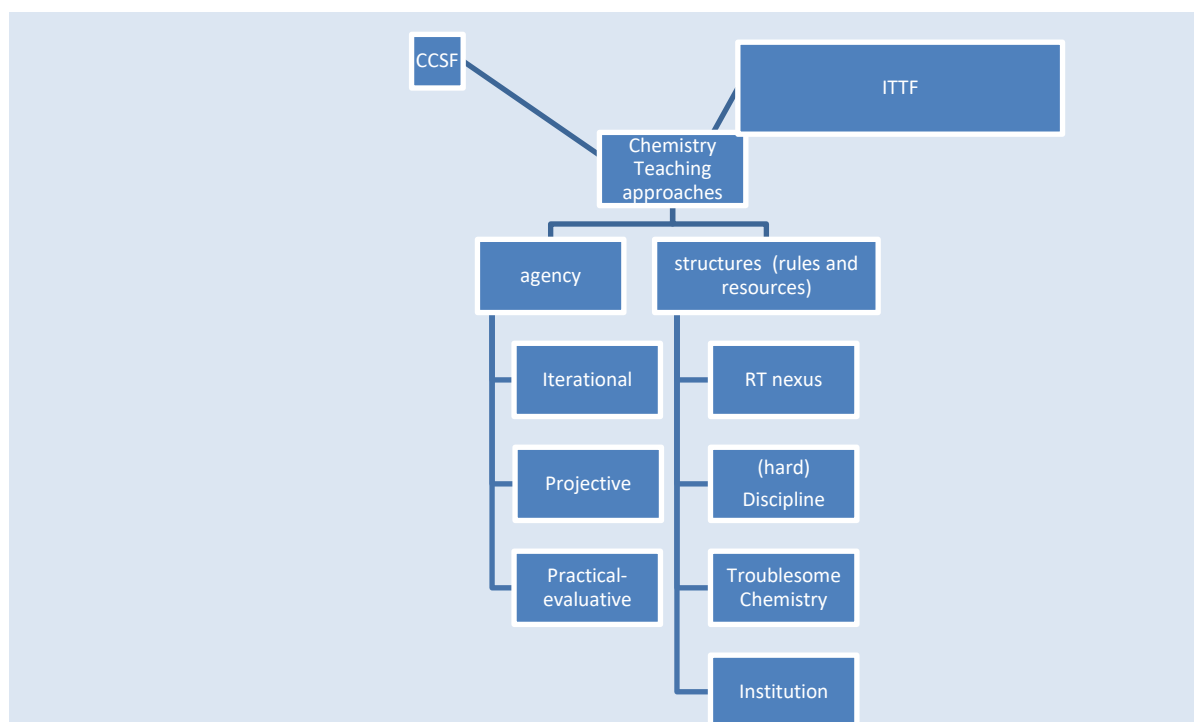

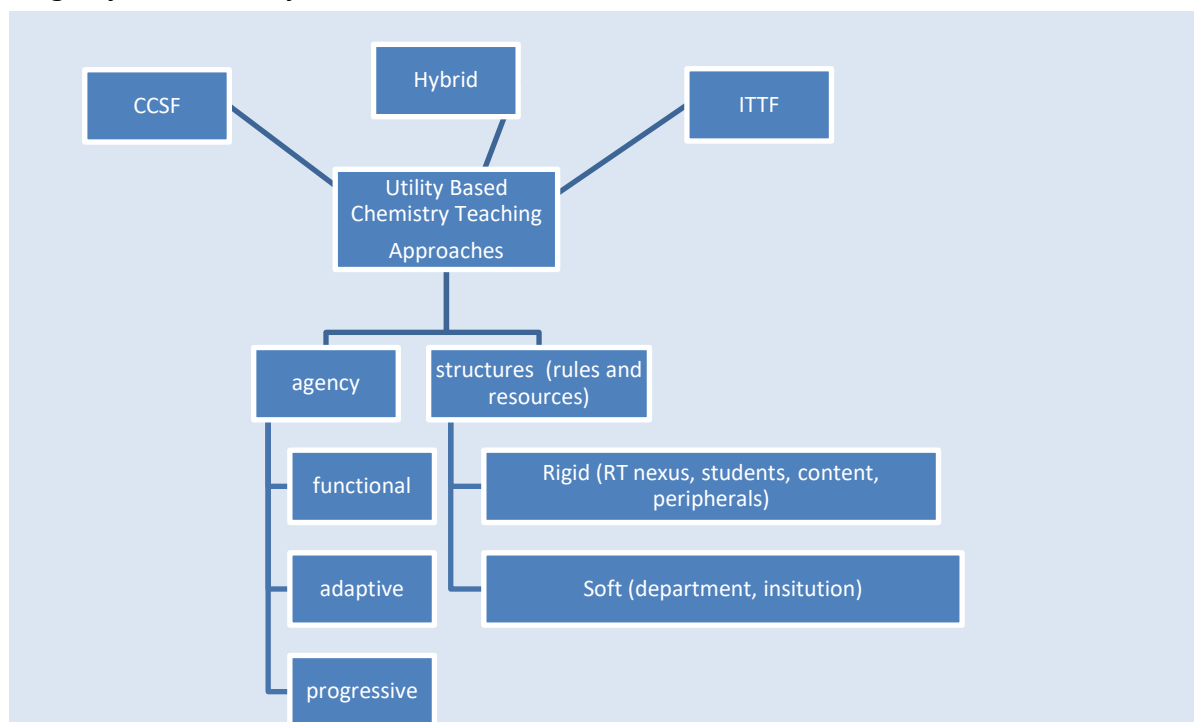*Figure 7.1: Literature synthesized theoretical framework*

Figure 7.2: Research synthesized theoretical framework for approaches to teaching chemistry.

Agency-Structures Processes

"Agents are empowered by structures both by the knowledge of cultural schemas that enable them to mobilize resources and by the access to resources that enable them to enact the schemas" (Sewell, 2005, p.151). In this regard, utility-based teaching approaches are based on contextual processes of assessing the interplay of all conjured agencies and utilization of resources, embodiment of perceived rules to enact certain approaches. It is the processing of all of those contextually based on perceived value for the teacher, students or both groups in varying benefit. For example, utilizing mostly ITTF approach (epistemic essentialist) for stoichiometry recognizes the nature of the (positivist) content (threshold concept) and the need for students to gain competency through excessive problem-solving and drills. The teacher is examining what is at stake when adopting certain approaches in terms always considering time, effort, value, efficacy deeply embedded in what is perceived to "work" and what is possible at those instances given all other structural components. I began examining teaching practice through a social realist lens focusing on agency in the context of structures and their interplay. The findings suggest agreement with Giddens' (1984) proposed structure-agency theory agency and structure operated in a dialectical relationship. Agency was defined not as the sum of discrete acts, but as flow of conduct. Further, agency resides not only in individuals, but also in institutions and things. Ashwin (2009) perhaps quite correctly uses the term 'structural-agentic processes to describe the co-existential and emphasises *that 'structure and agency are not different kinds of processes but different ways of grouping or conceptualising complex social processes'* (19). This includes chemistry teaching practices. They are forms of energy which go back and forth and influence each other. There are

varying degrees and layers of structure. Similarly, there are different levels of agency competency. In this research context, the different permutations and interactions between the two interconnected entities provided a situated teaching approach.

> ...gradual change and experimentally it shows me more positive outcome each time I try something new so it's a gradual change maybe if you ask me this question in 3 years, I would be answering it differently as well because it's human interaction. ***Teaching is a human interaction***. [I]

Teaching in the context of Agency-Structures: A utility Approach

An institutional policy gap is the lack of recognition of pedagogic competency. From the institutions perspective and similar to Boyer's (1990) exclamation "*teaching is often viewed as a routine function, tacked on, something almost anyone can do*" (p.23) clearly underestimating competency and meaningful transition into the practice. Quite rightly also, the repertoire of instructional practices that faculty draw upon is the result of a socialization process and interactions into a unique cultural group as in a disciplinary setting, a process that is not dissimilar to an individual's socialization into any social group (Amanda Oleson & Matthew T. Hora, 2013). In structural terms, this study focused on how particular sets of structural-agentic processes become situated in and shape teaching practices. For example, despite high epistemic essentialist considerations, having epistemological belief related to the needs of the students' mandated CCSF or best approach. At the same time, recognising students as a rigid structure also had a similar effect. While, teachers navigating the RT- nexus found it difficult to exercise progressive agency. This is quite fitting to the conceptualization of the teaching practice in the context of this research. Here, some forms of agencies according to Trowler and Cooper's (2010) teaching and learning regime or TLR refer recurrent practices or repertories in a close proximity to functional agency but still have the potential to expand further. This is in agreement with Ashwin, 2006) who states "*examining particular TLA interactions on the assumption that the relation between structure and agency shifts over time and between situations: that it is situationally contingent*" (p.6).

> There is basically degree of interaction for me particularly while teaching undergraduates I will try to break up the classes by introducing in class activities so that we will practice a concept in the class and so the students don't really get some understanding of what they're doing. I think in terms of ***postgraduate teaching is a little less prescribed*** so you're more of a facilitator of learning. [I]

Agent-Structures dynamics

There is sufficient evidence to support the role of various teaching agencies in the enactment of the teaching practice in chemistry as often the focus in the literature placed emphasis on structure. Sewell,

2005, p.125 points out: "What tends to get lost in the langue of structure is the efficacy of human action or "agency" for to use the currently favoured term". Similarly, Shanahan (2009) argued, identity studies in science education often emphasize "aspects related to the individual and especially to individual agency" (p. 44), rather than the dynamic interplay between structure and agency. Teaching enactments represent cases of orchestrated structured activities *dances* by agents as they are *coupling* with structures. Thus, I quite disagree with the notion of a clash between agency and structures (Jansen, 2013, p.12) as they exist symbiotically, perhaps Dutta's (2011, p.9) statement that structure [quite appropriately] refers to the recurrent patterned arrangements that influence or limit the choices and opportunities available to people best explains the enacted practice. In other words, certain structures do exist without those specific agents but the presence of those agents impacts them at least in the long term. While some structures may momentarily remain the same, their perceptions, significance, and nature vary and hence more elaborate representations of these activities become more pronounced when agency is empowered (adaptive and progressive). More aptly, and to a certain congruency with the current research, Stones (2005) succinctly summarized this concept: "*Social structures almost always either have agents within them and/or are the product of the past practices of agents. And agents, for their part, have social structures within them, not least in the guise of [individual understandings of the world]*" (p. 4). This duality is essential in understanding how teaching practices are manifested. In a wider view, it is an interaction between the agent and the surroundings (structures of all types). Here, in terms of dynamics, as I proposed in chapter 5, the terms soft and rigid are used to move away from this differentiation based on the descriptive and focus on functionality. Structures arguably exist independent of agency but their causal powers "are at the mercy of two open systems: the world and its contingencies and human agency's reflexive acuity, creativity and capacity for commitment" (Archer, 2003, p. 7). Moreover, it will be rather presumptuous to treat agency as a uniform depiction. Agency is dynamic and situational and embodies different levels of physical, mental, spiritual competencies. How it interacts with structures is everything. It governs how a teacher decides to make full use of a digital resource or interpret and implement assessment tasks (e.g. *for learning, as learning or even of learning*). Thus, teacher agency is about teachers' active contributions and an important dimension of teachers' professionalism [and practice] (Priestley et al., 2016) and how teaching based on approaches in recognition of structures is enacted. Furthermore, the classification of structures is useful for policy and enactment; enabling (soft, nurturing, and permeable hence greater agency e.g. allocative resources) and constrain action (rigid, confining and limiting e.g. research expectation guidelines and rules). Another example related to the findings is the clear emphasis on students' perceptions and *reactions i*s viewing the practice in the context of utility of rules and resources as structures. The capacity of teachers to independently develop this flow of conduct

was often shaped by rigid structures and the choices available to them to act as evidenced in the findings. But decisions for enactment were subjective related to adaptive and progressive agencies. From a teaching perspective there were many things to be considered to understand the practice. At the same time, the causal effects of structure on individuals are manifested in certain structured interests, resources, powers, constraints and predicaments that are built into each position by the web of relationships (Porpora 1998, p. 344). For example, there were varied teachers' responses to RT nexus, content peculiarity and student audience. This is *not quite holistic disciplinary approach generalizations as variations within the department materialized and hence treating all of chemistry as a hard discipline may not be quite accurate*. There were little considerations for disciplinary tribe situated in the mandated approaches. But there were considerations to academic tribal hierarchy as considerations of course evaluations, appraisal process and demands existed. At the same time, teaching agency requires competency and clear comprehension of the overarching structure (mostly students) which underpin the activities in the HEI. Competency is significant not only in reference to epistemological disciplinary and *troublesome chemistry* considerations referred to in the literature but also recognition of how to effectively transfer or *handle* its trajectory related to students as audience (in cased of elevated sense of habitus and field). Many studies have shown that one's own learning experiences can often inform future teaching decisions (Richardson, 1996; Phelps and Lee, 2003; Kensington-Miller et al., 2013; Cox, 2014; Oleson and Hora, 2014). For new teachers, their views of teaching are often to how they were taught at the undergrad level (with variations across year groups) and epistemic essentialism and hence adopted functional agency. They had varying embodiment of agencies than those established in the HEI or join from other HEIs bringing along substantial academic and pedagogical capital. Yet strong competency, content and student knowledge enabled others to assume adaptive and progressive agency. Here experience may have been downplayed if the sense of habitus and field were high to begin with transacted by discretionary use of capital. This might be evident in the forms of leverage exercise and ability to navigate the structures and act accordingly. For example introducing curriculum change (e.g. instructional design) or deviating from the norm does involve certain degrees of power or strong epistemological belief and character leadership. Those who are more willing to exercise greater amount of [progressive] agentic influence on the teaching practices and perhaps challenge the structures. Moreover, *established* (professionally validated) pedagogical identity was relevant to the selection of approach CCSF/ITTF or combination based on experience and heightened sense of habitus; therefore greater progressive agency. This agency has also the ability to modify, alter or minimize the structural constraints. It is poignant to clarify here that not all structures are limiting. For example better perception of students (and content) as a structure is enabling. There are also cases where the agent's ability to navigate the rigid structures as a result of

personal skills can sometimes be enabling as well. Progressive agency includes elements aligned with *enhanced* self-efficacy, in the form of, for example, educational goals and motives and the better utilization of capital based on lucid understanding of habitus and field. This of course cannot be considered independent of the structures without recognizing how dynamic this can be. Yet, the issue is highlighted as existentially problematic as there is no single case can deal with the complexity of teaching as a practice (Fitzmaurice, 2010, p.53). Nonetheless, a significant amount of understanding is contextually gained through the lens of structural-agentic interplay.

Table 7.1: *Interplay between agency and structures in conditioning teaching approaches*

	Established (student based) Pedagogical identity	Agentic-Structure Dominance	Filter (force/s)	Driving force
Professor (New)	Weak	Structure	Macro and Meso	Content Teaching-research External
Professor (New)	Strong	Agentic	Micro and Meso	Pedagogical beliefs Teaching-research
Professor (Ten)	Weak	Agentic	Micro	Content Teaching-research External
Professor (Ten)	Strong	Agentic	Micro	Pedagogical beliefs Teaching-research

Table 7.2: *Data identified characteristics of agency types and dominant strong structures*

Strong Field-Low Habitus   High Capital

	Functional Agency (Transient)	Adaptive Agency (Transforming)	Progressive Agency (Transformative)
Structural consideration	Content	Content-student	Students
Structure	Constraining	Enabling	Innovative
Agency	Operational	Situational awareness	Strong Validated Epistemological belief
Social Practice Theory	Routine	Agent changing	Agent driving change
	Utility	Utility	Utility
	Balance between	Agent dominates,	Agent dominates, structures

reference Meaning Habitus Capital	agent and structures	structures is maintained	are altered
	Low competency	Competent	High competency
	Prior (learning) Experience	Managing change	Leverage Soft skills
	Social Conditioning	Emancipation	Empowerment

ITTF-Utility Approaches   **Pedagogical Experience Best Approaches/ CCSF** ➤

Agent-Structures dynamics Model

Figure 7.2 highlights the relationship between the different types of agencies in relation to structures. When the structure is rigid and coupled with functional agency, the agent's action is often operational and outcome based. As the agency becomes stronger, it is ability to deal with rigid structures increases with a potential to influence the existing structure or even change some aspects of it. This is even more evident in the case of progressive agency. Taking students for example as a rigid structure, it can be reshaped whereby students (even at the introductory level courses) upon exposure to CCSF approach by a progressive agent who strongly believes in this approach are cognitively able to deal with the content in authentic context and create their knowledge accordingly. However, in the case of functional agency students seen passively can condition the promote ITTF approaches (e.g. when they are used to memorization / when the teacher has limited sense of Habitus and Field). The utility of this model is in its account that all practices are related to the dynamics of the individual (agent) and the periphery (social and structures). This dynamic dependent on its constituent elements and the forces within guides the nature of the practice. Structures can be strong as long the agent is weak i.e. functional and vice versa. For example, despite structural normative forces, teachers can deviate from this and adapt a more student centered teaching approach if there is a strong pedagogical belief in its utility. At the same time, strong emphasis on research productivity will impede the teachers' initiative in instructional design and technology. A close examination of this relationship is important to understanding how practices are manifested and hence enacted. The proposal here is that practices are negotiated out of the dialectical interplay between the agent and the structure. Both interconnected entities bring along their contingent conditions to the negotiating table. Temporary treaties are signed to enact a certain contextual teaching activity. The terms might change when constituents become more pronounced and hence breaches can happen which shift the equilibrium to either side (progressive agency drives practice despite rigid structures or if any agency if soft). This interplay generates a structural-agentic chemistry teaching ''dances'' which are enacted contextually through harmonizing the conditioning elements. The style and display of the dances depend on the

proportions of the different elements (agency-structures) utilized. To a great extent, this is in agreement with Sewell's (2005) assertion that "*If enough people or even a few people are powerful enough, act in innovative ways, their actions may have the consequence of transforming the very structures that gave them the capacity to act*" (p. 127).
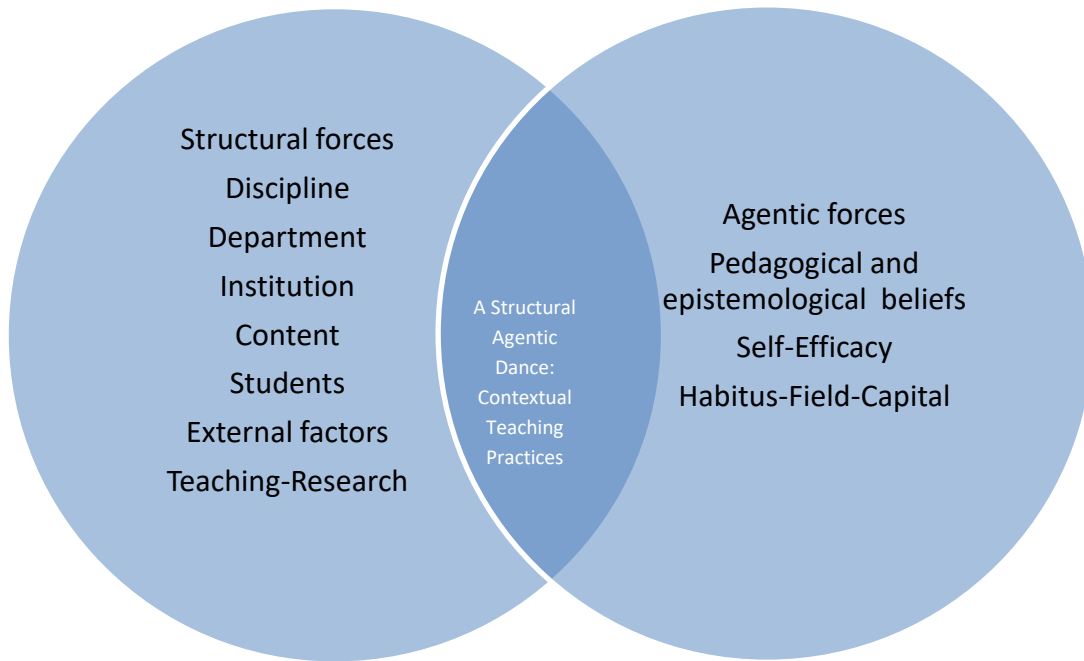

Figure 7.3: Schematic representation of teaching practices and approaches in the context of agency and structures
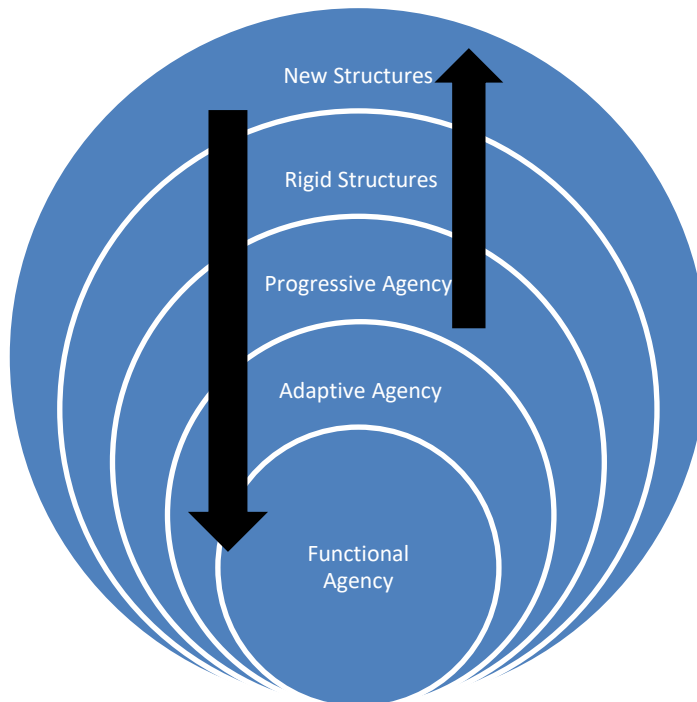

Figure 7.4: types of agency in reference to structures. Arrows refer to the influence exerted.

Conceptualize response to the RQ3

Epistemological implications

I have found Archer's (2003) social realist theory to be a useful framework. Archer's work identifies three interdependent strata of reality: structure (e.g., institutional systems, policies), culture (e.g., norms, ideas, beliefs), and agency (individual freedom to act). The interrelations between them occur over and vary over time. The power exercised here is systemic, referring to how agents are positioned (Ashwin, 2009, p. 22). Epistemologically, there is plenty to process when examining the practice through a realist lens: the empirical (enacted practice), actual (certain structures and agency exist) and the real practice (interplay between the structures and degrees of agency predict realizations). There were many gaps in the knowledge of the processes which take place at different levels from the macro to micro. For example, the HEI solicited ''teaching agents'' in the ability to perform teaching tasks failed or chose to not recognize the core pedagogic competencies required without providing an effective induction program .

Pedagogical implications

Teaching as a practice in higher education in this context presented a paradox when examined in a social practice theoretical (Meaning-Material-Competency) lens. Bourdieu's habits-field-capital approach provided better characterization. Examining the practice in a social realist paradigm provided greater depth. It signified the shifting role of habitus perhaps related directly to meaning and competency in understanding how the approaches are appropriated and enacted over time. The research highlighted the significance of the role pedagogical competency and agency in developing pedagogical skills whereby mastery of desired competence is something that often is acquired by experience. The findings clearly identified *''students''* as a crucial structural consideration in the enactment of the practice and its aspired trajectory. From a HEI perspective, it is critical to examine the findings and place more emphasis on RT nexus, curriculum design, unifying perceptions of rules, access to resources, pedagogical training and better understanding of students leading to a more appropriate agentic approach to teaching and hence more effective teaching.

Summary

The aim of the research was to provide some understanding of the teaching approaches of chemistry teachers in HEI context and the rational. Referring to teaching a practice, while focusing on agency and structures, demonstrated a potential for better understanding. The agentic-structural continuum shows dynamism, contingency and fluidity. It has also shown that it can explain the enactment of the practice through scoping the forces in action. Referring to the outcome of this dynamics as an indicator of the nature of the practice is equally beneficial. Agents acting in rigid structures will muster reduced role in the enactment of the practice. While those with strong agentic self-efficacy stemming from clear pedagogical belief might play a greater role. Chemistry as a hard discipline is characterized with an appreciation of facts and positivist perception of knowledge. This often impedes the role of the agent teacher in favour of structures. Yet, it does not prevent the teachers from exploring instructional designs and approaches which may deviate from this epistemological essentialist view. Policy-makers should be keen to understand this phenomenon and propose policy changes in view of this knowledge in alignment with the institution's vision while recognizing the changing terrain. Calls for incorporating pedagogy training for future academics might be quite apt. while other HEI have recognized this gap and opted for distinguishing themselves as teaching rather than research institutes. In other words, whether or not to invest in the agent's pedagogical competence and to what extent? This is definitely not easy to answer when considering the changing perceptions of knowledge, competency-based education, internationalization of education and pressures for status based on academic prowess.

Chapter Eight: Conclusions

The concluding remarks are positioned in a social realist lens used to capture the interplay of structures and agency and utility in providing improved understandings of approaches to teaching chemistry in a department in HEI through conceptualizing responses to the research questions:

Research Questions

RQ1. How do structures inform teaching approaches and enacting the teaching practices?

RQ2. How do teachers in a chemistry department in a HEI characterize their teaching approaches and practice and the role of teacher agency?

RQ3. What are the epistemological and pedagogical implications of better conceptualization of the role of agency in the structures-agentic context?

What is chemistry teaching?

Teaching (chemistry) situated as a social practice is subject to many considerations. The choices made by teachers are often related to the alignment between realism, chemistry and essentialist teaching approaches. This was often evident in the responses of the participants who often expressed essentialist approaches to teaching, learning and assessment. For many respondents, and based on the university's perspectives teaching came with the job and seen as a side activity to their main role as researchers. Paradoxically, the often the teaching load did not reflect this. Here, there were missing elements related to practice such as meaning and competency. For new teachers their habitus-field understanding was limited by this realisation. Perhaps, it is reasonable then to expect that this activity would garner less importance from the two parties: teachers and institution. This leaves a lot of freedom to act in an essentialist mode within what is perceived to be important existentially for the teachers; often focusing at the core competencies deemed critical for each course. The fact that the majority of students in many of the taught courses were not chemistry majors did not provide the teachers the liberty to expand beyond core competences and hence often ITTF approaches surfaced. But this was not always the case, whereby some teachers exercised pragmatic pedagogical agencies allowed for constructivist approaches to knowledge acquisition. The ability of the individual to exercise certain pedagogical agencies is often related to meaning of practice and notions of self-efficacy.

How do structures inform teaching approaches and enacting the teaching practices?

Structures are contingent

Better characterization of structures provided certain depth to understanding teaching practice. Examining teaching chemistry in a social realist lens gives a sense of the important conditioning structures which yield certain teaching approaches. Structures were identified as either rigid or soft related to basic functional agencies. Structures can also be related to competencies. For example, while students were identified as a rigid structure with significant consideration, teachers who possess high pedagogical competences and perhaps deep meaning of practice may not place the same significance. At the same time, teachers who have limited pedagogical experience may have seen the soft department with its generally liberal approach to TLA as rigid where conformity and isomorphic practices are required. In referring strictly to either approach, as either ITTF or CCSF, would not give a realistic characterization of the how the practice is realized. Furthermore, the insufficiency of only relating approaches to these structures undermines the role of agency which is seen to be a dominant force in the responses of the some of the participants. Here, while certain structures are rigid, this does not make them impermeable because of agency. One might even go beyond and refer to them as external considerations because using the term ''structure'' implies certain rigidity and firmness which is often not the case. This also downplays the argument of the existence of separate structure and agency entities and positions them in a dialectical relationship.

How do teachers in a chemistry department in a HEI characterize their teaching approaches and practice and the role of teacher agency?

Agency is important

Agency is complex and is connected to notions of habitus. Agentic *drivers* may depend on character and personality, age, background and many other social considerations. Yet, it was important to seek how teaching agency manifested itself in different context of time and space. Despite the clear essentialist approaches assumed in early year one and two, which represents certain challenges to students later on, it was not always simply a choice between information transfer teacher focus (ITTF) or conceptual change student focus (CCSF). There were often combinations and instances of adaptive and progressive agencies stemming from strong pedagogical beliefs, heightened notions of self-efficacy and deeper understanding of perceived structures. Cases of functional agencies were not only limited to new teachers but in cases where teachers viewed research as far more significant and rewarding whilst possessing essentialist approaches to teaching and learning. The agent who represents a sum of

all competencies, cognition, prior, current experiences and futures expectations is the *doer* of this practice. Agents function within the physical and the metaphysical fields. Perceptions of practice and subsequent enactment are influenced by the elements of Reckwitz's (2002) cultural social theory: mentalism, textualism and intersubjectivism, which are deeply related to structures. In this case, the *utility* of teaching as an activity to create core foundational and needed knowledge (for engineering students) often hinders innovations in teaching approaches and the implementation of CCSF approaches. These approaches should ultimately lead to newer knowledge. Yet this is perhaps difficult at the institutional level where teaching practices have remained stagnant for a long time. Teaching approaches and decisions are made at the individual level. Comparatively, those with strong sense of habitus and field (meaning), coupled with pedagogical competency are versatile in their teaching approaches and tend to make decisions based on better understanding of content and students. Certain progressive agencies might influence structures (e.g. assessment rules, content coverage). However, it is unclear how persistent and sustained they can be without a systematic and enabling structure of sharing practices and teaching innovation. This perhaps explains the resiliency of some of the teaching practices and the inability of the research in chemistry education to manifest itself authentically.

Different agencies and structures

What are the epistemological and pedagogical implications of better conceptualization of the role of agency in the structures-agentic context?

Practice varies

Teaching as a practice requires certain competences (Malmberg and Hagger, 2009; Schunk and Zimmerman, 2012). Teachers at the HEI level face numerous internal and external challenges related to the degree and nature of enactment. Enactment of the teaching practice and adopted approach depend on many variables whereby contextual *meaning* of what is to be achieved represented a significant consideration. Epistemic essentialism played a role where teaching competency was not high. Teaching as a practice in this context is often regarded as purposeful and secondary activity when compared to research. Often utility played a significant role in how this practice is enacted in relation to its aspired outcome considering the engineering focus of the institution and hence the department. The department represented a minor conditioning force as it is perhaps in its infancy and has not built certain characteristics leading to a recognizable identity. While many respondents exhibited certain flexibilities in the approaches adopted, they expressed realisations of the importance

of appealing to students. Furthermore, certain rigidity was seen in emphasising core competencies at the first and second year levels further constricted by institutional considerations. Assuming a social realist lens provided a greater opportunity to characterize social structures and classify them as rigid or soft based on the perceptions of the agents. Approaching this practice from a SPT perspective in highlighting how meaning and competencies manifest themselves in the enactment of practice and its trajectories provided an additional depth. Meaning of practice becomes more pronounced with time and or if teachers possess strong epistemological beliefs. While and academic background in the form of SMK is sought by the HEI, pedagogical competences are assumed to be acquired while on practice. Furthermore, the utility of Bourdieu's practice is highlighted in the activation of *habitus* in relation to the field and capital. Often, it was many considerations which provided modified understanding of the habitus, thus yielding contextual and different types of agencies.

Utility Based Practice: Not simply ITTF or CCSF

The research began highlighting the use of either ITTF or CCSF. While this classification is perhaps useful in depicting disciplinary differences, it is not simply a matter of both approaches constantly and wholesomely being used. ITTF assumes passive students where concepts are simply being relayed without internal processing or changes in the understanding of the concepts. This is not exactly correct. Students are part of the process in ITTF and conceptual understanding of content is being developed. At the same time, assuming that there is not information transfer (and or teacher focus) in CCSF is equally erroneous and undermines the work done by the teacher to achieve this goal. What is clear in the research is that the teachers are considering many issues when they assume and implement certain approaches where the utility to all stakeholders is perhaps at the maximum. Again, this is not uniform and does depend on the content and teaching agency. For example, in nomenclature (naming substances), where memorising is warranted, the teacher can be quite creative in coming up with ways for the students to acquire this body of knowledge but it should not be expected. How much is the teacher able to implement changes to the approaches depends on the agency and significance of this change and of course the peculiarities of the content. It follows then, if the content is a must-know, there is greater emphasis on ITTF approaches. But again this could be temporary until there is a certain level of expected understanding. Modification of approaches requires strong realizations of habitus and the field. For chemistry students, there are certain things that must be known: basic competences even at the sub-disciplinary levels. These are often not achieved without for a lack of a better term *information transfer.* This is often the problem that many teachers face at the first and second year level when there is a genuine effort to shift the focus away from certain teaching and

learning approaches at the high school levels. There are many important considerations for this contextual chemistry teaching practice from the perspectives of the teachers. There are elements of agency and social practice embedded in the components. Utility is related to the significance of the content, ability to modify, agentic and structural considerations discussed before. For example, dealing with a topic such as stoichiometry which is a relatively difficult *threshold* concept requires innovative teaching agency. Students often struggle; the content is important, teachers need to be creative in creating strong conceptual understanding. Here, self-efficacy and certain levels of adaptive and progressive agencies are needed. One way would be for the teacher (functional agency due to many reasons) to present the content in an information transfer mode with some examples and hope for the best. Alternatively, the teacher can use different approaches to ensure mastery of this content. This is of course subject to many agentic and structural considerations and time allocation. This reiterates Ball's (1994, p.10- 11 italics in original) description of practice as "sophisticated, contingent, complex and unstable...'created' in a trialectic of dominance, resistance and chaos/ freedom" amongst many other considerations. The question here is: *how much teaching agency (if possible, which includes changes to instructional design and approaches) is required and at what expense*? In other words: what is the best way to achieve this goal? This often depends on pedagogical experience as greater levels of habitus and field understandings are gained. The teacher is able to make decisions to modify, alter, support and reinforce based on gained practical competence. In some cases, teachers who have strong epistemological beliefs with genuine understanding of the students and content can achieve this even if their teaching experience is not very rich. Perhaps what makes chemistry unique is the fact that is often viewed as difficult and professional prominence at the HEI level is often not achieved though pedagogical excellence but rather research productivity. The inelasticity of assessment of learning (quizzes, midterm, final, practical) often hinders changes to teaching approaches as well. This often tends to undermine innovative approaches to teaching at least at the structural and not the agentic level. Legitimate questions such as how much different would the learning be if the approaches were different? Even for core concepts, what would be the result if learning is measured in terms of practical authentic or innovative applications of the concepts rather than standardized exams? How many students are being turned away from natural sciences such as chemistry because of the way that is presented? Why do institutions believe that anyone with an academic PhD can teach? Why chemistry education research is not altering the teaching approaches? Table 8.1 provides a better understanding of teaching chemistry as a social practice through highlighting the considerations and real (unseen) conditioning mechanisms which lead to certain enactments. For teachers to perform their teaching practice effectively (depending on their contextual notions of "effectively" if it is the goal) while

managing considerable constraint due to teaching and research expectations depends heavily on the degree of individual agency activated in reference to perceived structures and often is enacted based on utility.

- Content peculiarity
- Student knowledge
- Meaning of practice
- Interpretation of rules
- Use of resources

Table 8.1: *Characterizing chemistry teaching practices*

	Empirical	**Actual**	**Real**
Stratified (Layers) of reality	Observed Certain approaches to chemistry teaching practices	Teaching practices are generated by mechanisms	Mechanisms and structures with enduring properties
Example	Lecturing-Inquiry (ITTF)/CCSF/ Both/Other	Perception of role-Utility –Content- Competencies- Students Pedagogical competence	Agency functioning in relation to structures e.g. essentialist
Existing Theory Reference	Social (Pedagogical) Practice (Competency- Material- Meaning)	Practice theory (Habitus- Field-Capital) TLR	Social realism (Agency-structure interplay)

Implications for novice teachers

Chemistry as a discipline requires students to have the ability to conjure up different skill sets from other domains such as mathematics, other natural sciences, and problem solving and dealing with potential language, social, power, and cultural structures. The importance of teaching agency cannot be underestimated. The urgency of progress in research should not be at the expense of teaching. While it might be worth it to rely on some epistemic essentialist approaches at the introductory levels, it is equally critical to recognize the students and content as structural and deal with this interaction based on the aspired learning trajectories whilst instilling the foundations for deep learning. Seeking guidance and learning from other experienced instructors is also of paramount importance as the teacher is building the teaching identity. This might not always be simple as the novice teachers are attempting to make sense of the institutional culture, implement disciplinary epistemic rules and how utilize the resources given the limited power or authority they possess at that point which places them in *"functional agency"*. The aim is to reduce the time novice teacher dwell in this type of agency.

Implications for the research- oriented teacher

While this might represent a good proportion of professionals, it is critical to examine their priorities and how to prevent teaching from becoming a concern or vice versa. While I am not particularly in favour of a complete divorce of activities, many institutions are now offering separate tracks: teaching and research. Ideally, those who are research focused should be involved in teaching courses related to their research. Yet, certain institutional demands sometimes necessitate that some faculty might teach courses not considered as ''favourite'', they should still remain open to the idea. The eagerness to further their research profile should not come at the expense of teaching and other duties integral to the student's learning and experiences. Building teaching agency is also beneficial for research productivity through an enhanced ability to communicate concepts to others, while fully recognizing that self-efficacy in the context of teaching and research nexus is sometime difficult to maintain especially with the changing structural forces.

Implications for the head of department

Teaching experiences as a resource may not be fully utilized as there is plenty of substantial knowledge and experience within the department. Implicit or explicit rules can be enhanced to promote effective teaching agencies through better induction programs and establish a reasonable balance between teaching, and departmental objectives and institutional expectations.   A closer examination of curriculum design (*with an authentic effort to engage other departments to integrate interdisciplinary concepts and skills*) and the integration of the practical component are dually needed. For example, better coordination with the English department (e.g. English for engineers or sciences)

as students often have difficulty processing problem solving text because of language. Similarly, collaboration with the mathematics department could yield content (e.g. math for chemists) suitable for chemistry students. Furthermore, year level considerations and the appropriateness of teaching qualifications should be carefully examined. For example, what skillsets are needed to build the foundational knowledge in students in years one and two? How different is teaching in those years than teaching at the high school level?

Implications for institutions

Teaching or research? Institutions need to examine purpose, mission and vision. Teaching cannot be treated as an addendum. While there are efforts to develop teaching excellence, they often remain underdeveloped. Perhaps better effort is needed to make institutional rules more explicit and pedagogical resources more suitable and conducive for teaching innovations. At the same time, adding another structural constraint such as pedagogical training may complicate things further for teachers. Yet not placing significance to teaching agency and excellence may do far more harm. While research is vital for institutions, the notion that teaching is something that anyone with a PhD can do should be reassessed. There is also the issue of the practical undertaking of research in chemistry education which seem to have little influence on teaching practices.

Implications for students

Despite the tangibility of chemistry and presence in everything around us, students often perceive chemistry as difficult. This may not be an issue only pertaining to HEIs as it may have roots in society and becomes more pronounced at the high school level and the manner in which the content and concepts are presented. Students may not always realize that many sets of skills are needed to process chemistry concepts as well as the sub disciplinary differences (physical vs. organic). Students often at the HEI level witness a marked shift in teaching approaches, as they are not expected to become independent learners and decipher through the concepts. In this context, this was evident in the effort made by teachers to change the thinking from memorising to conceptual change and deep learning. However, this may not always be easy when there is great emphasis placed on the letter grade received through a traditional assessment scheme at the end of the course amongst other considerations.

Implications for my practice as a teacher

As a chemistry teacher, it was profoundly illuminating to see the complexity of teaching as a practice in the context of agency and structures. The varied teaching realities and practices were always born out of the certain contextual conditioning forces which facilitated certain agencies as they interacted with prior, existing or perceived future structures. Teaching chemistry and hence the adoption of certain

approaches were subject to complex mental processes in which the agent was making decisions based on perceived understanding of role, purpose, priorities and in alignment with expectations and external forces. The duality of teaching and research represented a complex problem in terms of practice and how both activities can be performed effectively. More pronounced teaching agency and its potential influence on existing structures surfaced when the agents processed deep understanding of the role and terrain. The role of structures (rules and resources) was apparent in conditioning the teacher [and students] in adopting certain practice and actions in accordance with the notions of what a chemistry teacher at a HEI should act like. A significant illumination of this thesis finding is to develop the mechanisms for enhanced chemistry teaching agencies through greater integration of pedagogical development program and genuine appreciation of the rigid structures which tend to curtail (e.g. RT nexus) this agency if the means are not available or if not characterized properly (e.g. content and students).

Implications for my role as a researcher

While highly informative, much of the pedagogical research in the TLA chemistry teaching practices remains heavily based on theoretical designs related to conventional teaching theories (behaviourism, cognitivist, constructivism, connectivism). They do not capture the nuances of chemistry teaching practices in HEIs and the enactors of these practices in relation to the social world. Researching chemistry TLA in a HEI context thorough a structural-agentic lens is illuminating, inspiring and informative. It captures well the different layers of realities resulting in the enactment of these practices. This improved understanding of the considerable mechanisms at play in enacting teaching practices is significant in terms of pedagogy and policy and practice (Burston, 2016, Harder et al. 2009). There are authentic implications for educators, policymakers and managers to use the findings and re-examine the policies and practices in place (e.g. teaching load, research expectations, institutional focus, pedagogical training, curriculum design and recognition of students). I am inspired to continue to examine the issue further with a focus on students.

Summary

Chemistry, a hard discipline, is peculiar and cannot be treated as one unit. Even within the sub-discipline, content importance, and approach can vary. Examining the practice in a social realist lens underscores the role of agency as it interacts with perceived contextual structures. Teaching as a social practice is subject to perceptions of materiality, meaning and competences. Chemistry teaching approaches are enacted by individuals with prior experience and positions on knowledge who exercise certain contextual agencies. Structures such as students and content, amongst others, play a critical role as their interplay with agents who possess contextualized understanding of role (meaning), interpretations of rules, self (competences) and secure access to resources (materials) through navigating power structures often determines the mode of enactment of the contextual teaching practice. The strong essentialist pedagogical position assumed by teachers often determines the approaches based on aspired trajectories. Teaching research nexus represents a significant consideration for many respondents in the current context. Furthermore, the institution positions the respondents in a paradoxical position in terms of expecting teaching and research excellence whilst heavily emphasizing the latter and not providing a pedagogical induction of the former. Despite the advances in chemistry educational research, there are little instances of its implementation and its influence on pedagogical innovation at the HEI. There are clear instances for HEI in general to examine the teaching and utility of current approaches in the advancement of knowledge and generation of students who perhaps can do more with their knowledge rather than be labelled as competent based on a questionable TLA regime. Further work should focus on the agency and the students' performance.

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Appendices

Appendix A: Removed to ensure anonymity

Appendix A: Removed to ensure anonymity

Appendices

Appendix B: Interview Consent Form

CONSENT FORM

Project Title**: *A case study* exploration of the utility of structures-agentic interplay in characterizing the role of agency in the adoption and enactment of teaching approaches in a chemistry department in a higher education institute**
Name of Researcher: Ziad Aoudi

Email: **z.aoudi@lancaster.ac.uk**

Please tick each box

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily	☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time during my participation in this study and withdraw from the study at any time before the focus group begins, but will not be able to withdraw their contribution to the discussion once recording has started.	☐
3. I understand that any information given by me may be used in future reports, academic articles, publications or presentations by the researcher/s, but my personal information will not be included and all reasonable steps will be taken to protect the anonymity of the participants involved in this project.	☐
4. I understand that my name/my organisation's name will not appear in any reports, articles or presentation without my consent.	☐
5. I understand that any interviews will be audio-recorded and transcribed and that data will be protected on encrypted devices and kept secure.	☐
6. I understand that data will be kept according to University guidelines for a minimum of 10 years after the end of the study.	☐
7. I agree to take part in the above study.	☐

_____   _____   _____
Name of Participant   Date   Signature

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Signature of Researcher /person taking the consent_____ **Date** _____   Day/month/year

One copy of this form will be given to the participant and the original kept in the files of the researcher at Lancaster University

Appendices

Appendix C: Participant information Sheet

Participant information sheet

Title: *A case study* **exploration of the utility of structures-agentic interplay in characterizing the role of agency in the adoption and enactment of teaching approaches in a chemistry department in a higher education institute**

I am a PhD student and this research is for my thesis on the PhD Educational Research programme with the Department of Educational Research at Lancaster University.

Please take time to read the following information carefully before you decide whether or not you wish to take part.

What is the study about?

The research is about the teaching approaches in a chemistry department in higher education and the role of teacher agency in adopting and enacting teaching approaches in relation to structures (e.g department, discipline, institution and research role)

Why have I been invited?
As chemistry academic in higher education working at a University in the UAE.

What will I be asked to do if I take part?

You will be interviewed for about 45 minutes. You will be asked
1. *How would you characterize your approach to teaching chemistry?*
2. *What influenced your approach to teaching chemistry?*
3. *Can you describe some of the factors which shaped your approach to teaching chemistry?*
4. *In your opinion, how does the subject and discipline affect how the ideas are taught?*
5. *Can you describe your teaching approach? How might you change your teaching style at a different content (organic/ physical) for example?*

6. *Can you describe how you deal/dealt with the challenges you face in teaching chemistry now? (if a veteran academic , I would ask about other institution where they worked before)*
7. *Do you teach differently depending on the course level? How?*
8. **''Teaching Chemistry is different than other disciplines''**. To what extent do you agree with this statement and how might it vary in different areas of chemistry?
9. Can you describe and explain the rationale of some of the teaching practices in your department and how you relate to them?
10. Can you please elaborate on how your approach to teaching is similar or different than your department's or institution's?
11. How do you balance between research and teaching duties?
12. How might your teaching style be different if say you are teaching English or Mathematics? Why?
13. How would you describe your role and any *considerations (evaluative steps)* when you think about changing the way you teach chemistry?
14. How does the departmental culture (and institutional) and existing practices or expectations guide or influence your approach to teaching?
15. Can you describe situations or factors that guided, challenged or led to changes in your teaching practices or those in your department?
16. How would you characterize your role and that of your department in changing teaching practices?

What are the possible benefits from taking part?

It is an attempt to better reflect on your role and practice of teaching chemistry in HE. Whether genuine tangible benefit will be immediately obtained is unknown. However, any gained knowledge will undoubtedly more insight into the field of teaching chemistry, practice and disciplinary cultures.

Do I have to take part?
No. If you do, you can also withdraw at any point.

What if I change my mind?

You can withdraw at any point. The data collected and recordings securely stored will be destroyed after the award of PhD. However, it is always advisable if you have any doubts to ensure that you are certain prior to the interview and recording. Collected, used and anonymized references in the research might be hard to exclude at later stages if they are used.

What are the possible disadvantages and risks of taking part?
The research does not pose any health or personal risk

Will my data be identifiable?
No. All identifiable details will be removed. The interview will be recorded, transcribed and safely stored with my as the only researcher with the only access.

How will we use the information you have shared with us and what will happen to the results of the research study?

The anonymized data will be used to answer the research questions and will be part of my PhD. They might also be used for other different types of publications, conferences and journals.

How my data will be stored
Your data will be stored in encrypted files (that is no-one other than me, the researcher will be able to access them) and on password-protected computers. I will store hard copies of any data securely in locked cabinets in my office. I will keep data that can identify you separately from non-personal information (e.g. your views on a specific topic). In accordance with University guidelines, I will keep the data securely for a minimum of ten years.

What if I have a question or concern?
You can always directly ask for clarification or have a question or concern at any point or contact myself or my supervisor at Lancaster University:

Ziad Aoudi, Principal/Lecturer, Abu Dhabi, UAE

z.aoudi@lancaster.ac.uk

or

Professor Paul Trowler, Director of Studies, Higher Education: Research, Evaluation and Enhancement, Department of Educational Research, County South, Lancaster University, Lancaster LA1 4YD. 01524 594443

p.trowler@lancaster.ac.uk

This study has been reviewed and approved by the Faculty of Arts and Social Sciences and Lancaster Management School's Research Ethics Committee.

Thank you for considering your participation in this project.