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The influence of psychological empowerment on the enhancement of chemistry laboratory demonstrators' perceived teaching self-image and behaviours as graduate teaching assistants

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Graduate students who fulfill teaching roles in the undergraduate laboratory play an important role in establishing a positive learning environment. A host of various graduate teacher training programmes have been developed, implemented and evaluated accordingly in order to enhance their teaching capability. In addition research has also documented the varied or sometimes complex factors that influence graduate students' teaching capability. This present study set out to explore graduate students' sense of psychological empowerment as an influencing factor on their perceived teaching self-image and behaviours. The Teaching as a Chemistry Laboratory Graduate Teaching Assistant (TCL-GTA) programme was developed to enhance the sense of psychological empowerment experienced by seven chemistry graduate students at an Irish University as a means of enhancing their perceived teaching self-image and behaviours. The data collected throughout this study involved both qualitative and quantitative forms through conducting interviews and administering questionnaires. The findings of this research suggest that the level of psychological empowerment experienced by graduate students lends considerable and positive contributions to their perceived teaching self-image and behaviours which are influenced by a number of contextual, training and personal factors. This research should interest those involved in teaching chemistry in higher education as well as those interested in empowerment of either teachers or postgraduate students undertaking teaching duties.

Introduction

Teaching in the undergraduate laboratory can be demanding for graduate students. As laboratory teachers, graduate students have several responsibilities that include grading, providing feedback, managing chemicals, developing undergraduate students' practical skills and conceptual understanding as well as offering them encouragement and support (Herrington and Nakhleh, 2003; Bond-Robinson and Rodriques, 2006). In seeking to fulfil and address all of these responsibilities, the experience can tax graduate students' own chemical knowledge and confidence (Bond-Robinson and Rodriques, 2006). Despite their efforts and even with training, many faculty do not rate graduate students' teaching capabilities highly, specifically in developing undergraduate students' conceptual understanding (Bond-Robinson and Rodriques, 2006). It is also known that graduate students do not receive significant feedback on their teaching capabilities or efforts from experienced staff or faculty (Luft *et al.*, 2004). Nevertheless, it remains uncontested that graduate students are the most influential factor affecting laboratory instruction (Lazarowitz and Tamir, 1994; Herrington and Nakhleh, 2003; Bond-Robinson and Rodriques, 2006). Given the significance of graduate students in their laboratory teaching roles, understanding what influences their teaching behaviours is important. A review of literature associated with the development of graduate students' teaching skills reveals that many contextual, training and personal factors influences their teaching behaviours. This research study set out to explore how contextual, training and personal influences can implicate the perceived teaching self-image and behaviours of graduate students during a process of psychological empowerment.

Contextual influences

The context in which graduate students teach can have a considerable influence on their teaching behaviours. It is argued that in the early stages of teaching induction, graduate students are propelled into a vortex of mystification as they attempt

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to decipher the values of faculty towards teaching, learning and research (Nyquist *et al.*, 1999). In many cases throughout higher education, teaching activities are secondary to research activities (Boyer, 1990; Nyquist *et al.*, 1999; Luft *et al.*, 2004). Deciphering faculty's values for teaching, learning and research whilst aligning their own expectations of their teaching role is thought to be an 'intense struggle' for graduate students (Nyquist *et al.*, 1999). Another example of a contextual influence on graduate students teaching behaviours is the pedagogic approach employed during undergraduate laboratory sessions. Problem-based learning or expository-based learning are examples of pedagogic approaches that can influence graduate students' self-image, which in turn influences their instructional decisions (Sandi-Urena and Gatlin, 2012, 2013). Aside from faculty's values for teaching, learning and research as well as the pedagogical approach employed during undergraduate laboratory sessions, more research is required to understand the other contextual factors that influences graduate students teaching behaviours.

Training influences

Teacher training and development experiences can also have a considerable influence on chemistry graduate students' teaching behaviours. Several research studies document the design and influence that teacher development programmes have on chemistry graduate students' instructional practices (Nurrenbern *et al.*, 1999; Kurdziel *et al.*, 2003; Hampton and Reiser, 2004; Bond-Robinson and Rodriques, 2006; Marbach-Ad *et al.*, 2012; Pentecost *et al.*, 2012; Richards-Babb *et al.*, 2014; Wheeler *et al.*, 2015, 2016). The way in which these teacher development programmes have influenced chemistry graduate students' instructional practices include enhancing their pedagogical chemical knowledge (Bond-Robinson and Rodriques, 2006), enhancing their ability to lead a pre-laboratory discussion before traditional laboratory sessions (Kurdziel *et al.*, 2003), enhancing their content knowledge to teach (Wheeler *et al.*, 2016), enhancing their confidence to teach (Richards-Babb *et al.*, 2014), and enhancing their ability to employ innovative teaching methods such as engaging students more, using questions to start a discussion rather than answering immediately, using visual-aids as well as written material, making eye contact with students, and communicating expectations (Marbach-Ad *et al.*, 2012). Undergraduate students taught by chemistry graduate students involved in teacher development programmes have positively rated their ability to lead undergraduate student-centred recitations (Pentecost *et al.*, 2012), their level of preparedness, understanding of material, clarity of explanation and encouragement to develop thinking and problem solving skills (Nurrenbern *et al.*, 1999) and their use of effective instructional strategies to include motivating, informing of objectives and prerequisites, presenting information and examples, providing practice and feedback and summarising lessons (Hampton and Reiser, 2004). However, most studies evaluating the instructional practices of graduate students in the laboratory rely upon "*intellectual gains related to content mastery, teaching ability and Graduate Teaching Assistants' satisfaction*" (Sandi-Urena *et al.*, 2011, p. 92). More research is required to investigate whether a teacher development programme can influence graduate students perceived self-image and behaviours as teachers.

Personal influences

Before graduate students even begin to teach in a particular context or participate in a teacher development programme, diverse experiences, role expectations and various epistemological beliefs regarding the nature of teaching, learning and of knowledge all cohere to influence their behaviour as teachers (Nurrenbern *et al.*, 1999; Nyquist *et al.*, 1999; Golde and Dore, 2001; Kurdziel *et al.*, 2003; Luft *et al.*, 2004; Bond-Robinson and Rodriques, 2006; Kinchin *et al.*, 2009; Sandi-Urena *et al.*, 2011; Hardré and Burris, 2012). Graduate students' prior teaching and learning experiences (Kinchin *et al.*, 2009; Hardré and Burris, 2012), particularly in an inquiry-based learning context affects their instructional decisions (Kurdziel *et al.*, 2003). Graduate students' epistemological beliefs on teaching and learning can influence their instructional decisions (Sandi-Urena *et al.*, 2011) but can also undermine undergraduates' level of understanding (Luft *et al.*, 2004). However, teaching experiences are thought to present graduate students with the opportunity to challenge their teaching and learning epistemological beliefs (Addy and Blanchard, 2010; Sandi-Urena *et al.*, 2011). The way graduate students recognise their self-image as teachers also influences their teaching behaviour (Sandi-Urena and Gatlin, 2013). The concept of self-image is concerned with how teachers descriptively typify themselves as teachers and can be distinguished from the concept of identity which gauges the static essence of a dynamic and biographical nature (Kelchtermans, 2009). Contributing factors to graduate students' self-image as teachers include their prior teaching and learning experiences, training, epistemological beliefs regarding teaching, learning and the nature of academic laboratory work along with their involvement in the laboratory as teachers (Sandi-Urena and Gatlin, 2013). Graduate students' self-image as teachers in the laboratory is inherently crucial since "*the fidelity of implementation of the learning environment is influenced by the Graduate Teaching Assistants' self-image*" (Sandi-Urena and Gatlin, 2013, p. 1308). Given the significance of graduate students' teaching self-image on the learning environment in the laboratory, more research is required to understand whether it can be enhanced and if so, how. This research study hypothesised that the sense of psychological empowerment experienced by graduate students could be a factor that influences their teaching self-image and behaviours. Therefore, the focus of this study was to gain insight into whether efforts to enhance graduate students' sense of psychological empowerment could result in the enhancement of their teaching self-image and concomitantly influence their teaching behaviours.

Teacher empowerment

Research on teacher empowerment is associated with a number of desirable outcomes for teachers such as heightened job satisfaction (Rinehart and Short, 1994; Wu and Short, 1996; Zembylas and Papanastasiou, 2005; Khany and Tazik, 2016), self-esteem (Lee and Nie, 2014), professional and organisational commitment (Wu and Short, 1996; Dee *et al.*, 2003;

Bogler and Somech, 2004) and reduced dysfunctional resistance (Vecchio *et al.*, 2010). Overall, the empowerment of teachers is associated with enhanced middle school effectiveness (Sweetland and Hoy, 2000) and positive climate (Lee and Nie, 2014). The empowerment of teachers at an institutional level is a "process whereby school participants develop the competence to take charge of their own growth and resolve their own problems" (Short, 1994, p. 488). On an individual level, Bogler and Somech (2004) conceptualise teacher empowerment as the "*individual's belief that they have the skills and knowledge to improve a situation in which they operate*" (2004, p. 278). According to Short (1994), the six dimensions of teacher empowerment include the provision of; (i) Decision Making, (ii) Teacher Impact, (iii) Teacher Status, (iv) Autonomy, (v) Opportunities for Professional Development and (vi) Teacher Self-efficacy. While teacher empowerment has many benefits for teachers, the research linking enhanced teacher empowerment to enhanced student performance is conflicting. One study carried out on the restructure of 24 schools promoting greater level of site-based management showed that there was no direct relationship between teacher empowerment and student academic achievement (Marks and Louis, 1997). However, another study evidenced that teacher empowerment was a significant independent predictor of student achievement in standardised proficiency tests in reading and mathematics (Sweetland and Hoy, 2000). Nevertheless, the study by Marks and Louis (1997) shows how teacher empowerment indirectly influences student academic achievement through the nurture of authentic pedagogy, influenced by professional community and collective responsibility (Marks and Louis, 1997). Making decisions on the basis of standards of intellectual quality rather than teaching techniques or processes as the central target of innovation posits authentic pedagogy (Newmann *et al.*, 1996). It requires teachers to: (a) be familiar with, respect, and actively use students' prior knowledge as they teach. (b) Realise that students are complex thinkers trying to make sense of the world. (c) Offer multiple opportunities for students to use conversation, writing, and other forms of expression to process information. (d) Become a coach, facilitator, guide, or mentor in a "cognitive apprenticeship" who inspires and nudges the student to do the active work of learning rather than an authoritative dispenser of information and truth. (e) Exemplify norms of collaboration, trust, and high expectations for intellectual accomplishment (Newmann *et al.*, 1996, p. 285). While authentic pedagogy can be attributed to both high and low levels of teacher empowerment, Marks and Louis (1997) shows how teacher empowerment affects authentic pedagogy indirectly through the tenets of professional community and collective responsibility for student learning among teachers. Professional community is an index of five measures; shared sense of purpose, focus on student learning, collaborative activity, deprivatised practice and reflective dialogue. Collective responsibility for student learning is operationalised through teachers' efficacy of instructing their students as well as how they expect their students will succeed (Marks and Louis, 1997). The study by Sweetland and Hoy (2000) also emphasised the importance of establishing professional teaching communities amongst teachers as it reports collegial leadership made significant independent contributions to teacher empowerment that in turn, was a significant independent predictor of student achievement. Teachers who are empowered in important teaching and learning decisions are more likely to set high, attainable goals, in which students respond positively to (Sweetland and Hoy, 2000). What appears to be necessary for teacher empowerment to have a positive influence on student performance is the affordance of decision making opportunities relating to teaching and learning decisions (Sweetland and Hoy, 2000) in a professional teaching community that has collective responsibility for student learning (Marks and Louis, 1997) (Fig. 1). However, it is noteworthy that most research on the topic of teacher empowerment and its influence on student achievement has been carried out on primary and secondary levels of education. Relatively less research investigates the empowerment of teachers in higher education and its influence on student achievement.

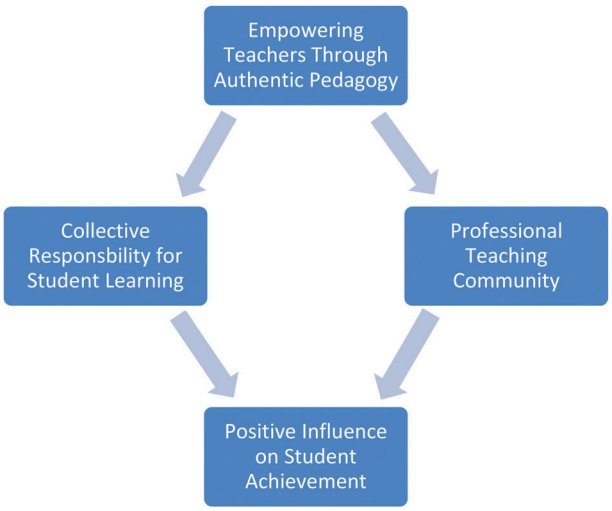

Fig. 1 How teacher empowerment can positively influence student achievement.

Psychological teacher empowerment

While individual teacher empowerment has been examined at length from the institutional level within the social structure of the school (Sweetland and Hoy, 2000), less focus has been placed on the individual, psychological component of the teacher empowerment process (Dee *et al.*, 2003; Lee and Nie, 2014). Further, there has been little, if any, research carried out on the individual and psychological empowerment of those who teach in higher education institutions. Recognising and embracing the individual is inherently important in the context of empowerment as Spreitzer (1995) claims that structurally empowering conditions cannot be fully realised unless the individual is psychologically receptive. Seminal works on the analysis and development of psychometric empowerment began with Conger and Kanungo (1988) who claimed that empowerment is a process of enhancing the self-efficacy of individuals. Thomas and Velthouse (1990) subsequently built on this theory to include belief systems, tasks and enactment processes as fundamental empowering elements that shapes individual's sense of impact,

Table 1 The intrinsic motivational cognitions of psychological empowerment and the dimensions of teacher empowerment

	Intrinsic motivational cognitions of psychological empowerment (Thomas and Velthouse, 1990)	Dimensions of teacher empowerment (Short, 1994)
Impact	The behaviour that an individual has to make a difference to influence strategic, administrative or operating outcomes	Teachers' perceptions that they have an influence on school life.
Competency	An individual's belief in his or her capability to perform activities with skill (Bandura, 1986; Gist, 1987)	The 'Self-efficacy' dimension of teacher empowerment refers to teachers' perceptions that they have the skills and ability to help students learn, to effect students' learning and are competent in developing curricula
Autonomy	Individual's sense of having choice in initiating and regulating actions (Deci *et al.*, 1989)	Teachers' beliefs that they can control certain aspects of their work such as instructional planning.
Meaningfulness	The value of a work goal or purpose, judged in relation to an individual's own ideals or standards	N/A

competence, meaningfulness and choice. These seminal works where then tested by Spreitzer (1995) that resulted in the development of the Psychological Empowerment theory. In validating the postulations of Conger and Kanungo (1988) and Thomas and Velthouse (1990), Spreitzer (1995) empirically validated psychological empowerment as a construct that manifests in four intrinsic motivational cognitions and active orientations to an individual's work: (i) *Impact*, (ii) *Competence*, (iii) *Autonomy* and (iv) *Meaningfulness* (Spreitzer, 1995). The definitions of each motivational cognition can be found in Table 1 along with a comparison of three of six corresponding dimensions of teacher empowerment as advocated by Short (1994). While the affordance of decision making and professional development opportunities along with the enhancement of teacher status are the other three dimensions of teacher empowerment (Short, 1994), it is noteworthy that the 'meaningfulness' cognition of psychological empowerment (Thomas and Velthouse, 1990) is not considered as a dimension of teacher empowerment (Short, 1994). Since the development of Spreitzer's Psychological Empowerment theory in 1995, two studies have since empirically supported the validation and reliability of the theory (Kraimer *et al.*, 1999; Uner and Turan, 2010).

Empowerment processes

A trend throughout the literature on the psychological empowerment of teachers is the focus on identifying and analysing features of school life that influence their sense of psychological empowerment (Dee *et al.*, 2003; Moye *et al.*, 2005; Lee and Nie, 2014; Khany and Tazik, 2016). The four motivational cognitions of psychological empowerment are found to mediate relationships between teachers' perceptions of immediate supervisors' empowering behaviours and their work-related outcomes such as job satisfaction, organisational commitment and professional commitment (Lee and Nie, 2014). However, the competence cognition did not mediate the relationship between teachers' perceptions of principals' empowering behaviours and such work-related outcomes (Lee and Nie, 2014). Elementary teachers who perceived higher levels of autonomy, meaningfulness and impact had higher levels of inter-personal trust in their principals and those who found their work to be more meaningful, to have more autonomy and who feel an influence on what happens in departments have higher levels of interpersonal trust (Moye *et al.*, 2005). Elementary teachers working together with similar disciplinary backgrounds or interest in similar educational issues has a strongly positive influence on their sense of autonomy, impact and meaningfulness but it has no significant influence on their competence which is a function of teachers' education level and years of teaching experience (Dee *et al.*, 2003). Elsewhere, psychological empowerment directly relates to secondary school teachers' job satisfaction however, the trust teachers have in their principals, colleagues, students and parents is indirectly related to job satisfaction through psychological empowerment (Khany and Tazik, 2016). Two trends emerge from this research on the psychological empowerment of teachers. Firstly, the majority of this research is carried out with elementary (Dee *et al.*, 2003; Moye *et al.*, 2005) and secondary (Khany and Tazik, 2016) school teachers. Secondly, quantitative research methods predominate these educational studies on psychological empowerment, but quantitative measures also predominate other studies on psychological empowerment in other fields (Kennedy *et al.*, 2015). This may have been influenced through the empirical validation of the psychological empowerment construct to manifest in four separate intrinsic motivational cognitions (Spreitzer, 1995). Another theme throughout the aforementioned educational studies on psychological empowerment is the tendency to focus on identifying and analysing features of school life that influences teachers' sense of psychological empowerment. Less research has investigated processes that result in the enhancement of teachers' sense of psychological empowerment (Kennedy *et al.*, 2015). A search of the literature found one programme that resulted in enhanced levels of psychological empowerment and decreased levels of burnout in oncology nurses (Özbaş and Tel, 2016). The programme that facilitated the enhancement of their psychological empowerment levels included discussions about group contract, coping with stress and cognitive distortion, relaxation techniques, problem solving, self-recognition, empathy, dispute resolution, assertiveness training and reflecting on their previous empowering experiences (Özbaş and Tel, 2016). Nevertheless, it goes uncontested that empowerment is a developmental process (Kieffer, 1984; Rappaport, 1987; Conger and Kanungo, 1988; Foster-Fishman *et al.*, 1998; McWhirter, 1998; Laverack and Wallerstein, 2001; Cattaneo and Chapman, 2010). Specifically, the process of psychologically empowering individuals is orientated towards the generation of "*beliefs that goals can be achieved, awareness about resources and factors that hinder or enhance one's efforts to achieve those gaols,*

and efforts to fulfil the goals" (Zimmerman, 1995, p. 582). Early works on describing the empowerment process suggests that it can be conceptualised in five stages: (i) diagnosing conditions that are responsible for feelings of powerlessness among subordinates, (ii) employing managerial strategies and techniques to address such powerlessness, (iii) providing self-efficacy information, (iv) nurturing empowering experiences for subordinates and (v) observing the behavioural effects of empowerment (Conger and Kanungo, 1988). Personal evaluation and cognitive structuring along with the revaluation of a problem to form a new perspective and adopt a new approach are two factors that are figured to be conducive in empowering individuals (Quinn and Spreitzer, 1997). More recently, Cattaneo and Chapman (2010) suggest that empowerment is an iterative process, involving personally meaningful and power-orientated goals, self-efficacy, knowledge, competence, action and impact. The essence of this process involves individuals setting goals, carrying out actions towards the achievement of their goals, observing and reflecting on the impact of their actions in relation to their goals (Cattaneo and Chapman, 2010). Although existing research evidences the factors that influence the empowerment of teachers in primary and secondary levels of education and their influence on student performance, little is known of the empowerment of higher education teachers, specifically, the empowerment of graduate students who teach in higher education Institutions. Further, it is not known whether the factors that influence the empowerment of teachers in primary and secondary levels of education can influence the empowerment of graduate students who teach in higher education institutions.

Purpose

The purpose of this study was to develop a teacher development programme that featured a process of psychological empowerment for graduate students. Firstly, it was necessary to explore how the sense of psychological empowerment experienced by graduate students influenced their teaching self-image and behaviours through the use of semi-structured interviews and a validated psychological empowerment questionnaire (Spreitzer, 1995). Secondly, a graduate teacher development programme to promote enhanced levels of psychological empowerment among graduate students was developed and implemented. Features of teacher empowerment that link to the enhancement of learning experiences for students were also taken into account throughout the programme. Finally, the influence that this programme had on the sense of psychological empowerment experienced by participating graduate students and how it influenced their teaching self-image and behaviours was then explored through the use of semi-structured interviews and the redeployment of the psychological empowerment questionnaire.

Methodology

This research is situated within a constructivist research paradigm (Guba and Lincoln, 1994). It is argued that research in the social setting is necessary which gives due recognition to sociocultural perspectives (Gergen, 1985; Cobb, 1994; Driver, 1995; Beck and Kosnik, 2006; Mertens, 2014). As such, the socio-constructivism paradigm adopted for this research is underpinned by the assumption that the construction of knowledge is an experiential and social process that involves all aspects of a person in inclusive and equitable learning communities (Beck and Kosnik, 2006). Regarding the affordances of adopting a constructivist paradigm when undertaking empowerment-based research, the constructivist paradigm is "*well positioned to capture empowerment's complexity and is highly sensitive to empowerment theory's assumptions and ongoing practices*" (Foster-Fishman *et al.*, 1998, p. 508).

Participants and context

In the institution that hosted this research, graduate students were referred to as '*Laboratory Demonstrators*' prior to the commencement of this study. In order to recruit participants in this research, the principal researcher made a presentation of the research objectives to ten graduate students who assisted in the delivery of general chemistry laboratory sessions. Four female and three male graduate students agreed to participate in the research on a voluntary basis. Ranging in age from 23 to 34, the graduate students were all pursuing laboratory-based chemistry PhD research programmes in fields including crystal engineering, material sciences, biochemistry and pharmaceutical sciences. Four of the graduate students spoke English as their native language whilst Telugu, Hungarian and Spanish were the native languages of the remaining three graduate students. Three graduate students reported to have previously fulfilled one-to-one tutoring roles with undergraduate students. However, no graduate student had completed any form of teacher development or training before this research. As per their postgraduate contract with the institution where the research was carried out, graduate students fulfilled six hours of laboratory demonstration duties per week. Since general chemistry laboratory sessions occurred every two weeks, the graduate students fulfilled demonstration duties in other types of chemistry undergraduate laboratory sessions during the intervening weeks of general chemistry laboratory sessions. All of the participating graduate students in this study had at least one year of experience as a laboratory demonstrator in the general chemistry laboratory. Before commencing their demonstrating duties, laboratory technical officers briefed the graduate students on various laboratory safety precautions and course leaders then briefed the graduate students on the procedural aspects of various laboratory sessions. General chemistry laboratory sessions occurred on a fortnightly basis. A traditional pedagogical approach to teaching these laboratory sessions involved the general chemistry course leader giving undergraduate students a pre-laboratory lecture on the background content knowledge and the procedure for each laboratory practical. Undergraduate students then followed a number of sequential procedural steps explicitly described in a laboratory manual. A typical laboratory session consisted of 40 to 50 undergraduate students, of mixed ability and who worked in pairs to complete the laboratory tasks. Four to five demonstrators were usually in attendance in each laboratory session. Traditionally, the graduate students' demonstrator role involved supervising undergraduate students and ensuring the maintenance of safety standards in the laboratory. However, during the pre-laboratory lectures, it was common for undergraduate

students to be informed by their course leader that the graduate students, as demonstrators were on hand to answer any question they may have about the practical. Before attending the laboratory, undergraduate students were required to write out a copy of the procedure, which was subsequently signed by the graduate students in order for admittance into the laboratory. When the laboratory work and accompanying report was completed, graduate students signed their reports as a means of granting the undergraduate students with permission to leave the laboratory. All laboratory reports were assessed by the course leaders and not by the graduate students at the end of every laboratory session. Graduate students were not paid for their demonstrating duties.

Design research

The nature of this research is characterised as design research which is defined as a "*series of approaches, with the intent of producing new theories, artefacts, and practices that account for and potentially impact learning and teaching in naturalistic settings*" (Barab and Squire, 2004, p. 2). One of the motives that underpins this approach to research is that it offers researchers with a practically relevant means of addressing a specific problem that is generalizable to a specific context: "*By carefully studying progressive approximations of ideal interventions in their target settings, researchers and practitioners construct increasingly workable and effective interventions, with improved articulation of principles that underpin their impact* (Van den Akker *et al.*, 2006, p. 2). This approach to research was chosen as it afforded the researchers with the opportunity to develop a programme that was appropriate for the enhancement of demonstrators' sense of psychological empowerment following the outcomes of an initial assessment of their sense of psychological empowerment within the specific context in which this research took place.

The 'Teaching as a Chemistry Laboratory Graduate Teaching Assistant' (TCL-GTA) programme

The TCL-GTA programme, involved an opening seminar followed by a four consecutive two-hour workshops. Towards the enhancement of graduate students' sense of psychological empowerment as laboratory demonstrators, the primary aim of the TCL-GTA programme was to generate a space for the graduate students to develop the belief that they could as teachers, enhance undergraduate students' learning experiences.

Role titles

Before the implementation of the programme, an adaption was made to graduate students' '*Laboratory Demonstrator*' role title as the researchers felt that it did not appropriately acknowledge graduate students' status as teachers in the laboratory. Instead, the researchers addressed graduate students as '*Graduate Teaching Assistants*' for the remainder of the TCL-GTA programme in order to acknowledge the graduate students' capacity as '*Teachers*' and not as '*Demonstrators*'.

The opening seminar

According to Zimmerman, generating a belief in the possible attainment of goals, an awareness of factors that influence the attainment of such goals as well as individuals efforts to fulfil these goals are characteristic features of psychological empowerment (Zimmerman, 1995). Therefore, during the opening seminar of the TCL-GTA programme, the principal researcher introduced graduate students to three areas of chemical educational research. These three areas of chemical education focused on identifying a problem, as a function of undergraduate students' learning difficulties in the chemistry laboratory, setting a goal of establishing a meaningful learning environment in the laboratory and exploring literature documenting the potential impact that graduate students could have on students' laboratory learning experiences.

1. **The problem: multiple dimensions of chemistry.** The first area of chemical education research explored the problems and concerns that the science education community has regarding the efficacy of laboratory learning experiences in fostering the development of conceptual understanding (Bates, 1978; Blosser, 1980; Hofstein and Lunetta, 1982, 2004; Hodson, 1990; Hawkes, 2004; Lunetta *et al.*, 2007; Hofstein and Kind, 2012). Specifically, the multiple dimensions of chemistry were discussed using Johnstone's macro, sub-micro and symbolic triangle of chemical representation (Johnstone, 1991). Literature documenting the problems that undergraduate students can experience in fluidly interpreting and understanding observable macroscopic events on sub-microscopic and symbolic levels was also explored (Johnstone, 1982, 1993, 2000; Gabel, 1993, 1999; Kozma and Russell, 1997; Nelson, 2002; Treagust *et al.*, 2003; Bucat and Mocerino, 2009; Tsaparlis, 2009).

2. **The goal: meaningful learning.** The second area of chemical education research introduced was Novak's construct of meaningful learning. This theory of learning involves "*the constructive integration of thinking, feeling, and acting leading to human empowerment for commitment and responsibility*" (Novak, 2010, p. 18). The principal researcher encouraged graduate students to set a goal of establishing a meaningful learning environment in the laboratory since setting goals is reported to be a key factor in the process of empowering individuals (Zimmerman, 1995; Cattaneo and Chapman, 2010). The findings of recent chemical education research associated with Novak's theory of learning (Bretz, 2001; Bruck *et al.*, 2010; Brandriet *et al.*, 2013; Bretz *et al.*, 2013; Galloway and Bretz, 2015a, 2015b; Galloway *et al.*, 2015) as well as research reporting on the varying levels of anxiety, confidence and self-efficacy experienced by undergraduate students in the laboratory was discussed (Smist, 1993; Bowen, 1999; Eddy, 2000; Kurbanoglu and Akim, 2010; Winkelmann *et al.*, 2015). Particular attention was paid to a research study that reported how affective experiences can influence undergraduate students' cognitive and psychomotor learning experiences in the first year chemistry laboratory (Galloway *et al.*, 2015).

3. **The potential: relieving problems and achieving goals.** The final area of chemical education research introduced to graduate students documented the significance of their potential to enhance undergraduate students' laboratory learning experiences (Gorham, 1988; Pickering, 1988; Lazarowitz and Tamir, 1994; Rodríguez *et al.*, 1996; Kher *et al.*, 1999; Herrington and Nakhleh, 2003; Ellis, 2004; Bond-Robinson and Rodriques, 2006; Nicklow *et al.*, 2007; Frisby and Martin, 2010; Ryan, 2014). Research articles that referred to graduate students who teach in the undergraduate laboratory as "*powerful tools to increase the effectiveness of chemistry*

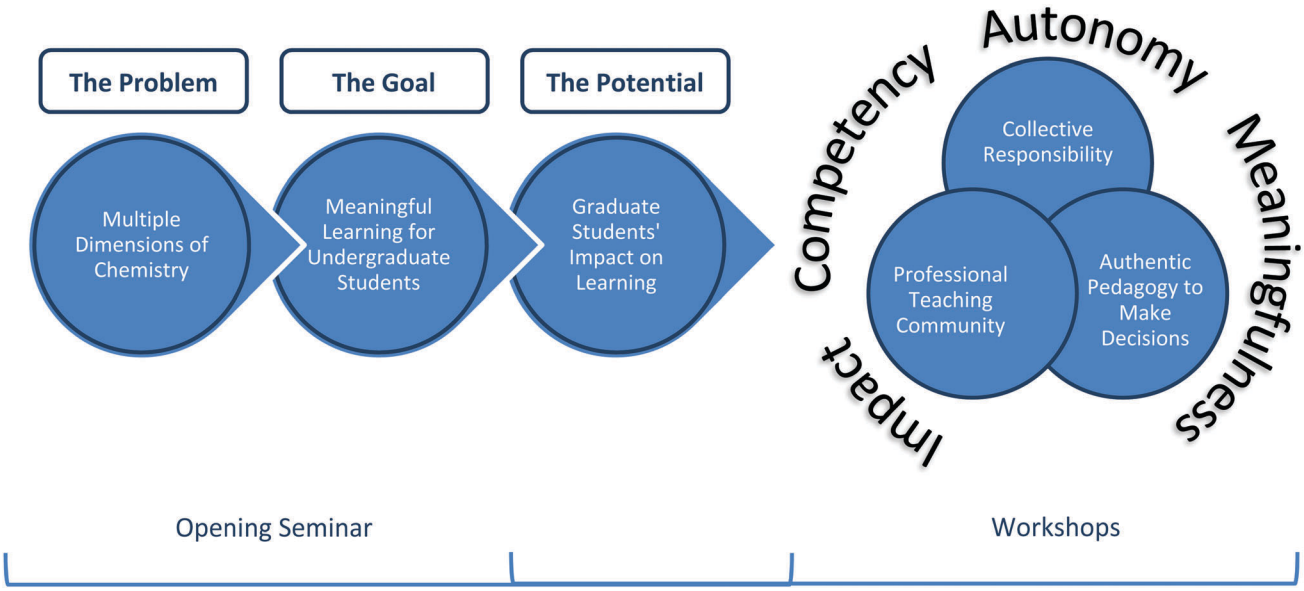

Fig. 2 Process of enhancing graduate students' sense of psychological empowerment during the TCL-GTA programme opening seminar and workshops.

learning" (Bond-Robinson and Rodriques, 2006, p. 322), "*the first line of defence*" (Nicklow *et al.*, 2007, p. 89), and "*critical colleagues*" (Ryan, 2014, p. 1) were relayed.

The sequential processes of identifying a problem, setting a goal and drawing attention to graduate students' potential to remedy this problem sought to enhance the graduate students' sense of impact, autonomy, competency and meaningfulness as the four motivational cognitions of psychological empowerment (Fig. 2). However, in order to limit undue influence on the research, the researchers never explicitly referred to such motivational cognitions during the TCL-GTA programme.

The workshops

Following the opening seminar, four consecutive two-hour workshops took place during the intervening weeks between the fortnightly general chemistry laboratory sessions, which also aimed to enhance graduate students' sense of impact, autonomy, competency and meaningfulness. While a more detailed description of the specific activities that graduate students engaged in during every workshop is explained in another article associated with this research (Flaherty *et al.*, 2017), the researchers sought to establish the conditions for which teacher empowerment links to enhanced student performance (Marks and Louis, 1997; Sweetland and Hoy, 2000). For teacher empowerment to have a positive influence on student performance, the affordance of decision making opportunities relating to teaching and learning decisions (Sweetland and Hoy, 2000) in a professional teaching community that has collective responsibility for student learning is necessary (Marks and Louis, 1997) (Fig. 1).

Authentic pedagogy to make decisions

Having the opportunity to make decisions and the knowledge that their decisions make a difference are features of empowered teachers (Sweetland and Hoy, 2000). In line with the concept of authentic pedagogy, focusing on intellectual standards to inform teaching and learning as opposed to reflecting on teaching techniques or processes as the central target of innovation (Newmann *et al.*, 1996; Marks and Louis, 1997), the TCL-GTA programme did not prescribe graduate students to adopt a specific teaching technique or process. Instead, the programme set out nurture authentic pedagogy by developing a learning outcome framework for graduate students to decide on what they felt undergraduate students should learn in respect to their affective, cognitive and psychomotor learning domains (Flaherty *et al.*, 2017). During the workshops, graduate students were encouraged to reflect, discuss and decide on learning outcomes for undergraduate students' pertaining to specific general chemistry laboratory sessions. Each graduate student had a different opinion on nature of such learning outcomes based on their own diverse prior learning experiences and areas of research expertise. Differences in such opinions where respected by the programme facilitator and by the other graduate students during the workshops. For example, one graduate student emphasised the importance for students to be able to understand the difference between the concepts of heat and temperature during an investigation on the heats of reaction. Another graduate student emphasised the importance for students to be able to understand the difference between the concepts of endothermic and exothermic reactions. Despite differences in opinions, graduate students were encouraged to guide students to achieve the learning outcomes that they felt were most important within their own ideals. It was anticipated that respecting the individual views of each graduate student would promote their willingness to guide students to achieve the learning outcomes that they felt were most important within their own ideals. It was also emphasised to graduate students that every undergraduate student is inherently unique with respect to their prior experiences and abilities. As such, the learning outcomes that graduate students devise for undergraduate students will change in light of such diversity. However, there were inherent limitations to the extent that such decisions made by the graduate students could be meaningful in light of the traditional pedagogic approach employed throughout

general chemistry laboratory sessions at the university that hosted this research. The traditional pedagogic approach placed considerable reliance on the laboratory manual as a means of describing the procedure and background content knowledge for undergraduate students. Regardless of prevalence of the laboratory manual, the TCL-GTA programme emphasised to the graduate students that they have the inherent decision to initiate an interaction with an undergraduate student with the intention of enhancing their learning experiences.

Professional teaching community

Professional community is an index of five measures; shared sense of purpose, focus on student learning, collaborative activity, deprivatised practice and reflective dialogue (Marks and Louis, 1997). The TCL-GTA programme set out to establish a professional teaching community amongst the graduate students by firstly acknowledging their chemical experience, knowledge and technical expertise along with their first-hand experience of working with undergraduate students during general chemistry laboratory sessions (Sykes, 1990). During the workshops, with a shared focus on enhancing undergraduate students' learning experience, graduate students sat around a round table and were encouraged to reflect on their past experiences as demonstrators as well as their own experiences as undergraduate students. The graduate students were then encouraged to consider these reflections when discussing and deciding upon affective, cognitive and psychomotor learning outcomes for undergraduate students. The graduate students where then encouraged to voice their opinions and ideas about how they felt they could contribute to the learning environment as teachers in achieving the learning outcomes they decided upon.

Collective responsibility

It is argued that preparing chemistry graduate students to teach requires them to become acquainted with a teaching responsibility that they may not have signed up for when they decided to become scientists (Sandi-Urena and Gatlin, 2012). The nature of a collective responsibility for student learning is operationalised through teachers' efficacy of instructing their students as well as how they expect their students will succeed (Marks and Louis, 1997). If teaching lore is to be transformed into meaningful professional standards, it is argued that teachers need to discuss and take responsibility for resolving immediate, concrete problems of teaching practice (Darling-Hammond, 1988). The TCL-GTA programme set out to develop collective responsibility amongst the graduate students for the enhancement of undergraduate students' learning experiences in two ways. Firstly, the graduate students explored the barriers to positive affective, cognitive and psychomotor learning experiences that undergraduate students face in the laboratory according to relevant chemical educational research. Secondly, in light of the prevalence of such barriers, graduate students' potential to relieve some of these barriers was emphasised. The graduate students were encouraged to realise that their chemical experience, knowledge and technical expertise made their interactions with individual undergraduate students acutely significant. As such, it was highlighted that if anyone in the laboratory had the power to enhance individual undergraduate students' learning experiences, it would be the graduate students.

Undergraduate student feedback

In an effort to assess the impact of teacher development programmes for chemistry graduate students, many have documented positive feedback from undergraduate student on the performance of participating graduate students in their teaching roles (Nurrenbern *et al.*, 1999; Hampton and Reiser, 2004; Marbach-Ad *et al.*, 2012; Pentecost *et al.*, 2012). However, these studies have not explored the impact that such feedback has on graduate students themselves. Further, the extent to which science graduate students receive significant feedback from experienced staff or faculty on their instructional practices is minimal (Luft *et al.*, 2004). While the primary aim of the TCL-GTA programme was to generate a space for the graduate students to develop the belief that they could enhance undergraduate students' learning experiences, the researchers assumed that this would challenge the graduate students' pre-existing self-efficacy beliefs of their capabilities to achieve this. However, any development or change in personal efficacy would "*require explicit compelling feedback that forcefully disputes the pre-existing belief in one's capability*" (Bandura, 1997, p. 82). Therefore, towards the enhancement of graduate students' sense of competency and efficacy, feedback from undergraduate students on the impact that the graduate students had on their learning experiences was obtained. It is important to note that this feedback was not being analysed to assess whether the TCL-GTA programme had an indirect impact on undergraduate students' learning experiences. Rather, this feedback was being used as part of the empowerment process, to evidence to the graduate students, their efficacy as teachers from the perspective of their undergraduate students. The feedback was collected at the end of the last general chemistry laboratory session of the year which was the last laboratory session running in parallel to the TCL-GTA programme workshops. It was voluntary for undergraduate students to complete the feedback form that consisted of three open-ended questions on a sheet of paper before they left the laboratory. Given that the undergraduate students still referred to the graduate students as lab demonstrators, the three questions asked:

(1) Did the lab demonstrators have an impact on your understanding of chemistry concepts during General Chemistry laboratory sessions? If so, how?

(2) Did the lab demonstrators have an impact on your laboratory skills during General Chemistry laboratory sessions? If so, how?

(3) Did the lab demonstrators have an impact on how you feel about General Chemistry laboratory sessions? If so, how?

Data collection

While the process of empowerment is considered to be an iterative process (Cattaneo and Chapman, 2010), the construct of empowerment is believed to be both a theoretical (Zimmerman, 2000) and empirical construct (Spreitzer, 1995). In line with the nature of design research, a pragmatic sequential mixed methods approach (Creswell, 2009; Teddlie and Tashakkori, 2009; Mertens, 2014) was adopted for the collection of both quantitative and qualitative

forms of data. Quantitative data was collected through the distribution and completion of a validated Likert style psychological empowerment questionnaire (Spreitzer, 1995). This quantitative data then facilitated the collection of qualitative data through interviews with individual graduate students. The collection of both quantitative and qualitative data occurred at two points in the research study. The first round of data collection occurred before the implementation of the TCL-GTA programme and the second round of data collection occurred after the completion of the TCL-GTA programme. In order to promote content validity (Haynes *et al.*, 1995), three science education experts and an experienced graduate student who was not participating in this research project reviewed the data collection instruments.

Quantitative data collection

The psychological empowerment questionnaire involves participants rating their responses to twelve Likert-scale statements (Spreitzer, 1995). The twelve statements are divided in sets of four whereby each set targets one of the four intrinsic motivational cognitions of psychological empowerment (Table 2). The researchers developed a separate version of the questionnaire for the two separate rounds of data collection involved in the study. The first version of the questionnaire aimed to measure graduate students' sense of psychological empowerment as laboratory demonstrators before their participation in the TCL-GTA programme (see Appendix 1). Therefore, the stem of each questionnaire statement reflected graduate students' capacity as laboratory demonstrators. The second version of the questionnaire aimed to measure graduate students' sense of psychological empowerment as graduate teaching assistants after the completion of the TCL-GTA programme (see Appendix 2). Therefore, the stem of each questionnaire statement reflected graduate students' capacity as graduate teaching assistants. Before completing the questionnaires, it was emphasised to graduate students that their responses would not act as an assessment of their performance in the laboratory before or during the TCL-GTA programme.

Qualitative data collection

After completing each questionnaire, the graduate students were interviewed in order to gain further insight into their sense of psychological empowerment both before and after the implementation of the TCL-GTA programme. Prior to the implementation of the TCL-GTA programme, the principal researcher carried out the interviews with the individual graduate students. At this stage, the principal researcher had never met the graduate students before. In order to reduce bias, a science education expert with more than 30 years' experience in the field and who had no involvement in the development or implementation of the TCL-GTA programme was recruited to conduct the post TCL-GTA programme interviews with graduate students (Patton, 1990). Each interview took the form of a semi-structured interview that featured the interviewer hearing participant's talk about the relevant particular life experiences (Willig, 2013). The interview agendas investigated the four intrinsic motivational cognitions of the graduate students' sense of psychological empowerment in their roles as demonstrators and as graduate teaching assistants respectively (see Appendix 3). The interviews lasted on average between 20 to 30 minutes and inquired as to whether graduate students felt they had an impact on what undergraduate students learn in the laboratory (impact), whether they felt competent (competency), whether they felt that they could decide what undergraduate students learn in the laboratory (autonomy) and whether they felt their job was important to them (meaningfulness).

Data analysis

By employing a mixed methods approach to the collection of data (Creswell, 2009; Teddlie and Tashakkori, 2009; Mertens, 2014), it enabled the researchers to triangulate the data (Jick, 1979). Triangulating the data allows not only for the examination of a phenomenon, such as psychological empowerment in this research study from multiple perspectives but it also allows for new and deeper dimensions to emerge (Jick, 1979).

Quantitative data analysis

Both versions of the psychological empowerment questionnaire required the graduate students to rank their response to each statement using a five-point scale ranging from 1 = Strongly Agree to 5 = Strongly Disagree. The responses were analysed using the Software Package for Social Sciences (SPSS v. 21). A Kolmogorov-Smirnov test revealed that the data from both questionnaires was normal. A paired *t*-test then compared graduate students' responses before and after the TCL-GTA programme in their respective capacities as demonstrators and as graduate teaching assistants. Since quantitative research methods on small sample sizes tend to have large effect sizes (Vogt, 2011), an alpha value of 0.01 was chosen to indicate significant differences (Petersen and Osborne, 2008) in the agreement of graduate students' to each statement in both questionnaires. The mean, median, standard deviation and p values of the graduate students' responses to the pre and post TCL-GTA questionnaires are shown in Table 2.

Qualitative data analysis

Thematic analysis was used to analyse the graduate students' responses to the interview questions (Braun and Clarke, 2006; Patton, 2015). This form of analysis involves searching "*for themes that emerge as being important to the description of the phenomenon*" (Fereday and Muir-Cochrane, 2006). A five step method of conducting thematic analysis (Braun and Clarke, 2006) involves: (i) familiarisation with the data, (ii) generation of initial codes, (iii) search of themes, (iv) review of themes and (v) definition and naming themes. Thematic analysis may be carried out in either a data-driven inductive approach whereby the emerging themes are visible and obvious to the researcher (Boyatzis, 1998) or it can be carried out using an *a priori* template of codes as a deductive approach of analysis (Crabtree and Miller, 1992). For this research study, *a priori* template of codes that characterised the four intrinsic motivational cognitions of graduate students' psychological empowerment was used to search for themes pertaining to each cognition throughout their responses. The themes which emerged were treated as semantic themes which are "*identified within the explicit or surface meanings of the data, and the analyst is not looking for anything beyond what a participant has said or what has been*

written'' (Braun and Clarke, 2006). Out of the 40 undergraduate students in attendance in the last general chemistry laboratory session that was running in parallel to the TCL-GTA programme, 27 voluntarily completed feedback forms on the impact that the graduate students had on their learning experiences before they left the laboratory. Given the role of the feedback forms in acting as a feature of the empowerment of graduate students in their teaching roles, the nature of the undergraduate students' responses were not thematically analysed to assess whether the TCL-GTA programme had an indirect impact on undergraduate students' learning experiences. However, the graduate students' reactions to the nature of the undergraduate students' responses during the post TCL-GTA programme interviews were to be thematically analysed (Braun and Clarke, 2006).

Ethical considerations

In upholding high ethical standards, Taber (2014) reminds that enthusiasm for chemical education research should not get ahead of the responsibilities we owe to those who gift us with data on teaching and learning. Therefore, towards the integrity and ethical preservation of those involved in this research, a number of considerations were taken into account. The anonymity of all participants involved in this research was ensured through the use of pseudonyms and all of the data collected was made confidential. All of the graduate and undergraduate students involved signed consent forms after being presented with information sheets detailing the nature of this research. Participation in this research was voluntary and both graduate students and undergraduate students were given the opportunity to cease their participation in the research at any stage. This research study was granted ethical approval from the institutions ethics committee.

Results

Both the quantitative and qualitative findings of this research indicate that the level of psychological empowerment experienced by the graduate students was enhanced post participation in the TCL-GTA programme (Table 2). Before the TCL-GTA programme, the graduate students neither agreed nor disagreed in their sense of psychological empowerment as laboratory demonstrators (m = 2.95, M = 3.00 (1.07)). After the TCL-GTA programme, the graduate students indicated an overall moderate agreement to their sense of psychological empowerment as graduate teaching assistants. The graduate students expressed significantly greater agreement to 8 of the 12 statements on the psychological empowerment questionnaire at the end of the TCL-GTA programme. There was no significant difference in their agreement to statements pertaining to their sense of mastery over the skills necessary to do their job, their sense of opportunity for independence and freedom in determining what undergraduate students learn in the laboratory and that their job activities are personally meaningful to them before or after the TCL-GTA programme.

Impact

Before the TCL-GTA programme and in their demonstrator capacity, graduate students neither agreed nor disagreed towards their sense of having a large impact (M: 3.00), a sense of control (M: 3.00) or influence (M: 3.00) over what undergraduate students learn in their laboratories. Their sense of impact on learning as demonstrators was concentrated at a psychomotor level by helping undergraduate students with the procedural aspects of experiments and some acknowledged how it was dependant on the traits and characteristics of individual undergraduate students

Table 2 Mean (m), median (M) and standard deviation (SD) values for graduate students' (N = 7) responses the psychological empowerment questionnaire

	As LDs			As GTAs					
	m	M	(SD)	m	M	(SD)	t	df	p
Impact									
My impact on what undergraduate students learn in the laboratory is large	3.00	3.00	(1.00)	1.14	1.00	(0.38)	5.461	6	**0.002**
I have a great deal of control over what undergraduate students learn	3.14	3.00	(1.36)	1.57	2.00	(0.76)	3.667	6	**0.010**
I have significant influence over what undergraduate students learn	3.28	3.00	(0.76)	1.85	2.00	(0.38)	7.071	6	**<0.000**
Competency									
I am confident about my ability to do my job	2.71	3.00	(1.11)	1.42	1.00	(0.53)	4.500	6	**0.004**
I am self-assured about my capabilities to perform my work activities	3.14	3.00	(0.90)	1.71	2.00	(0.53)	4.804	6	**0.003**
I have mastered the skills necessary for my job	2.00	2.00	(1.15)	1.43	1.00	(0.53)	1.333	6	0.231
Autonomy									
I have significant autonomy in determining what undergraduate students learn	3.57	4.00	(1.27)	2.00	2.00	(0.49)	3.667	6	**0.010**
I can decide on my own what undergraduate students learn	3.29	3.00	(0.76)	1.71	2.00	(0.82)	7.778	6	**<0.000**
I have considerable opportunity for independence and freedom in determining what undergraduate students learn	2.71	2.00	(1.25)	1.71	2.00	(0.90)	2.291	6	0.062
Meaningfulness									
The work I do is very important to me	3.29	3.00	(1.11)	1.85	2.00	(0.49)	2.500	6	0.047
The job activities I do are personally meaningful to me	2.14	2.00	(0.90)	1.43	1.00	(0.76)	1.698	6	0.140
The work I do is personally meaningful to me	3.14	3.00	(0.70)	1.14	1.00	(0.50)	9.165	6	**<0.000**
Total Level of Psychological Empowerment	**2.95**	**3.00**	**(1.07)**	**1.58**	**2.00**	**(0.59)**			

LD: Laboratory demonstrator (Pre TCL-GTA Programme), GTA: Graduate Teaching Assistant (Post TCL-GTA Programme). 1= Strongly Agree to 5 = Strongly Disagree.

and demonstrators. For example, Alana disagreed that demonstrators have an impact on learning, explaining that demonstrators are not there to teach scientific concepts rather, that they were primarily responsible for helping to set up experiments:

"[Demonstrators] *are not actually dealing with the concepts, as I said, we are just there to help set up the experiments that are already set.*"

Alana, Pre TCL-GTA

Ava explained how having an impact on learning was dependent on the level of engagement exhibited by individual undergraduate students:

"*Yeah, I think with the* [undergraduate students] *that are engaged that, I would say that* [demonstrators] *do, sometimes you would get students come up and ask for feedback on their lab reports before they leave…that's based on the student…It's just off their own back if they come to you with a question. You can kind of have a bit of impact in that sense.*"

Ava, Pre TCL-GTA.

Sean and Abby believed that demonstrators' previous experiences and teaching skills determined the extent of impact that they could have on undergraduate students' learning:

"*Most of* [demonstrators] *do give an impact actually, but I feel like, to be a demonstrator… everyone comes from a different background or different University… so, what kind of degree they have got… what kind of teaching and how to interact with students or how to interact with their supervisors, that's different for each of them.*"

Sean, Pre TCL-GTA

"*If* [a demonstrator] *knows how to ask good questions and how to show* [undergraduate students] *how to think, that's very useful.*"

Abby, Pre TCL-GTA

When asked to comment on whether they believed demonstrators could have an impact on undergraduate students' learning in the laboratory, all of the graduate students agreed that they could potentially have a much greater impact on learning. The believed they could have an impact in relation to promoting undergraduate students' confidence in the laboratory along with assisting them to develop their practical skills.

At the completion of the TCL-GTA programme and in their graduate teaching assistant capacities, the graduate students expressed a significantly greater agreement towards their sense of impact (M: 1.00, $p < 0.002$), control (M: 2.00, $p < 0.010$) and influence (M: 2.00, $p < 0.000$) on learning in the laboratory. Having a greater impact on learning was evident through how they perceived changes in undergraduate students' behaviour towards them:

"*…[Undergraduate students] were asking more questions, so they were setting up the experiment and the time which they actually gossip with each other, they are using that time to ask us a few questions*"

Noah, Post TCL-GTA

"[The undergraduate students] *were much more motivated. I, for the first time could see students who were not interested in being there, didn't want to be there, actually changed their view in the lab*"

Ava, Post TCL-GTA

"*I feel we had some kind of impact, when we started asking questions, they were trying to answer if they knew… Previously, they will say 'ok' and they will just move around in the lab and go to some other place. Now at least they talk to us.*"

Sean, Post TCL-GTA

"*In both cases* [as demonstrators and as graduate teaching assistants], *I think we have an impact but I think at the beginning* [as demonstrators], *we didn't ask questions and now* [undergraduate students] *feel confident to ask us questions… they seem to like more, what they are doing, so they think about what they are doing and they ask questions.*"

Mia, Post TCL-GTA

Competency

Before the TCL-GTA programme and in their demonstrator capacity, the graduate students neither agreed nor disagreed in their sense of confidence in their abilities to do their job (M: 3.00) and their sense of self-assurance in their capabilities to perform their work activities (M: 3.00). Moderate agreement was expressed in their sense of mastery of the skills required to perform their work activities (M: 2.00). Aspects that impeded their sense of competency included a lack of perceived ability to teach and a lack of experience.

"*I don't think so, I mean* [demonstrators] *kind of try to teach what we know, but I don't feel that we know how to teach, or at least, me.*"

Abby, Pre TCL-GTA

"*…Most of the demonstrators, they're not able to convey their message…most of them don't know what they are doing… few of them are not able to teach. Few of them just come for the sake of doing so.*"

Sean, Pre TCL-GTA

"*Hopefully, yes. After two years of experience. My first semester, I was not confident enough, you are in a new situation, handling 60 people for the first time… at the time I was learning the subject being taught here.*"

Noah, Pre TCL-GTA

The graduate students emphasised the constraints and factors which they felt, influenced their competency as demonstrators. These included a lack of appropriate preparation to teach, alignment of their own research fields to the particular laboratory content that they were assigned to demonstrate, time with undergraduate students, confidence, alignment in perceptions of the role of the demonstrator, feedback on their performance, the prevalence of a language barrier and high student expectations for demonstrators to teach.

At the completion of the TCL-GTA programme and in their graduate teaching assistant capacities, graduate students expressed significantly greater agreement towards their sense of confidence (M: 1.00, $p < 0.004$) and self-assurance in their capabilities (M: 2.00, $p < 0.003$). Graduate students claimed to have developed an enhanced sense of competency due to having developed a number of different teaching skills:

"*…I feel I can actually get through to students now, I feel I have developed the skills to actually identify what I feel they should be learning… and the skills of figuring out the questions to ask them, so that they are learning as well, so that they can come around to the question.*"

Ava, Post TCL-GTA

"*I think I got more knowledge about helping the students in the lab, because before, I didn't know exactly how to deal with the students or*

how to talk to them, and now I know what to do. I have to be patient, ask questions, get them to think… At the beginning I was shy and I didn't think I had the knowledge to help them… I didn't feel confident but now I think I can try to ask them questions and get them to think."

Mia, Post TCL-GTA

A change in their beliefs regarding the nature of their teaching role was a factor in enhancing their sense of competency.

"…*if I'm a Lab Demonstrator, I'm just demonstrating how it is to be done, as a Graduate Teaching Assistant, I would feel I'm teaching why it has to be done rather than how it has to be done…*"

Alana, Post TCL-GTA

"[As a demonstrator] *I thought that I was just there for three hours, it was kind of going from equipment set up is ready, that students are doing the experiment and that you have nothing to do really. We ignored in fact 90% of the population but* [Being a graduate teaching assistant]…*we have to go ask them questions, it was good, I think it was more significant*"

Noah, Post TCL-GTA

Although graduate students' sense of mastery of the skills required to do their job increased by the end of the TCL-GTA, the increase was not significant compared to their pre-TCL-GTA programme responses (M: 1, $p < 0.231$). Sean and Abby still acknowledged a desire for more teacher development opportunities:

"*We also need some more kind of workshops… at the moment, if a student approaches me for something, I might teach him, I will definitely teach him, I don't know whether I might convince him in all three domains* [Learning Domains (Bloom *et al.*, 1956)] *or convince him in just one domain, so, I still need to go a long way to understand those things.*"

Sean, Post TCL-GTA

"*I think it was a good experience, and the training helped a lot, I feel that I need more training that there is something to improve.*"

Abby, Post TCL-GTA

Autonomy

Before the TCL-GTA programme and in their demonstrator capacity, the graduate students expressed moderate disagreement that they had a sense of autonomy (M: 4.00), no agreement or disagreement in their decision-making ability (M: 3.00) and moderate agreement towards their independence and freedom over what undergraduate students learn (M: 2.00). They described the factors that implicated their sense of autonomy that included a lack of clarity of their role duties and responsibilities, their lack of participation in the planning laboratory sessions and being unaware of their teaching boundaries:

"… *I don't feel, no one really told me that I can, need to teach them what is going on during the experiment*"

Abby, Pre TCL-GTA

"*No. no, no, we're there, the lab is already set up and designed. So it's, no, not what the topics they design… Not even what aspects…Not even what aspects of the lab, I don't think we even get to decide that at all*"

Ava, Pre TCL-GTA

"…*You don't want to interfere with what a professor has taught. Well, if we're given the freedom, then yes, most of us can do it because we are doing our PhD…so you know the basic stuff,*"

Noah, Pre TCL-GTA

However, they expressed a desire to assume more autonomy:

"…*being a Demonstrator, you also need more freedom and liberty, if you are running an experiment and you just don't want to be a mere technician, helping the students to set up an apparatus or flask.*"

Noah, Pre TCL-GTA

"*Yeah… It's our research, I feel we know the things, how to handle or what's going to happen if they do this reaction… We know the answers… I think, I can teach them, no problem…*"

Colin, Pre TCL-GTA

At the completion of the TCL-GTA programme and in their graduate teaching assistant capacities, the graduate students expressed a significantly greater agreement in their sense of autonomy (M: 2.00, $p < 0.010$) and decision-making ability over what undergraduate students learn (M: 2.00, $p < 0.000$). There was no significant change in graduate students' agreement towards their sense of independence and freedom in determining what undergraduate students learn (M: 2.00, $p < 0.062$).

"…*we initially thought* [As LDs], *we cannot decide what to do and what not to do so our main purpose was to go and teach them how to use the instruments safely, ensure that everything goes fine and then just sign them off… now [As a GTA] I have been teaching them something new, sometimes I go out of the way like 'ok, can you tell me why this experiment is not working?' and then I can take them to some other stuff which might be useful and helpful to them*"

Noah, Post TCL-GTA

"[The TCL-GTA], *teaches you that, no you can teach them, you can interact with them, you can really own this time and help them to know the questions that they should know the answers to…I have the permission to talk to them, to annoy them, to ask them the questions*"

Ava, Post TCL-GTA

"*Oh, of course…we have some boundaries…we can chose whether I want to teach them how the indicator works or whether I want to teach them what is a pH*"

Abby, Post TCL-GTA

"*Yeah, I think, of course we don't get to determine what experiments they're doing… still we can help them to understand the concepts behind them*"

Alana, Post TCL-GTA

Meaningfulness

Before the TCL-GTA programme and in their demonstrator capacity, graduate students neither agreed nor disagreed that their role was important to them (M: 3.00) and that their work was personally meaningful to them (M: 3.00). An aspect that impeded the demonstrator experience for Colin and Mia was the time it took from their PhD research activities:

"*Well, I think it is something I have to do, I don't hate it, I don't like it…. I spend a lot of time as a Lab Demonstrator, so I cannot work in the lab and do my own research.*"

Mia, Pre TCL-GTA

"*I feel it is disturbing my regular research work… you need to do it so I am doing it*"

Colin, Pre TCL-GTA

However, the graduate students moderately agreed that their demonstrator job activities are personally meaningful to them

(M: 2.00). They perceived the experience as being beneficial in developing their science communication skills and understanding of basic chemical concepts:

"*Demonstration is a good thing because you know how to communicate, how to sell the science, how to share your ideas, how to get new ideas from the same experiment*"

Noah, Pre TCL-GTA

"...[Demonstrating is] *kind of a plus point too for researchers, because it helps you to tell a person who doesn't know about your research.*"

Sean, Pre TCL-GTA

"[Being an LD] *kind of helps... sometimes the labs I'm given would be, somethings which I did just after school... it's kind of like brushing up some of the basics*"

Alana, Pre TCL-GTA

At the completion of the TCL-GTA programme and in their graduate teaching assistant capacities, the graduate students expressed significantly greater agreement that their work as graduate teaching assistants is personally meaningful to them (M: 1.00, $p < 0.000$). Having the ability to influence how undergraduate students felt in the laboratory enhanced their sense of meaningfulness according to Sean, Alana and Ava claimed:

"*To be of value, means that I should have an ability to make a change in someone else. To make them confident*. [The graduate teaching assistant role is] *a lot more important to me, now I have lots of responsibilities as a GTA, not as a lab demonstrator...*"

Sean, Post TCL-GTA

"*We kind of feel the satisfaction from students... it kind of makes us feel happy that we did something to them, we made them confident enough in doing what they are doing... it boosts our own morale, we are actually capable of doing something.*"

Alana, Post TCL-GTA

"*I come out of the labs and I'm so happy because their responses are so positive, they're always thanking you... They felt they could approach me a bit more and that makes me feel really competent and really happy in what I'm doing and stuff.*"

Ava, Post TCL-GTA

Realising the significance of his teaching role contributed to how meaningful Sean experienced his GTA role to be:

"[Being a graduate teaching assistant] *is very important... if I am not willing to teach, I don't think any student will learn. It's up to me....*"

Sean, Post TCL-GTA

The prestige associated with having an emphasis on their teaching capacity in her new GTA title also contributed to Ava's sense of meaningfulness:

'Lab Demonstrator' does not look as good as 'Graduate Teaching Assistant'

Ava, Post TCL-GTA

However, there was no significant change in graduate students' agreement that their work is important to them (M: 2.00, $p < 0.047$) or that their job activities are personally meaningful to them as graduate teaching assistants (M: 2.00, $p < 0.140$).

Undergraduate student feedback

All of the feedback forms that undergraduate students voluntarily completed contained positive and complimentary towards the graduates students' impact on their laboratory learning experiences. Some of their responses included:

"*Any questions I had they explained why you do something instead of just telling you without actually learning anything.*"

"*They made the labs more enjoyable as I usually get very anxious. They were very friendly.*"

"*They showed me the proper way to measure and little tricks to get quicker and more accurate readings.*"

"*They made it more enjoyable than any other of my labs.*"

Graduate students' reactions to undergraduate student feedback

Prior to the post TCL-GTA programme interviews, the graduate students were presented with the student feedback forms. During the interviews, they were asked how they felt about the feedback. The positive nature of the feedback came as a surprise to them. Evidencing undergraduate students' value and appreciation towards their efforts to improve their learning experiences promoted feelings of competence and meaningfulness:

"*I never expected it. It was one hundred percent positive, I thought that at least, at least ten percent negative, but that was a surprise, we went through all of them like, 'that's not possible!'*"

Noah

"*They were actually really nice! I thought that they would write a negative thought, but everyone wrote perfectly fine and they actually literally wrote a few lines about us... they understand what we taught... That gives us like a feeling that we can do something much better as a graduate teaching assistant. Previously, if we were kind of just as a lab demonstrator, half of them might have just written, yes, no, and most have them have written like, no, no, no. So as a graduate teaching assistant, they might have got a different perspective of us and we also got a different perspective of them... it gives us a feeling that, you can, as well teach,*"

Sean

"*Yeah, it personally makes it more meaningful to me what I do, it makes, ok, like, I'm helping out, it makes me feel satisfactory and happy.*"

Alana

Discussion

The sense of psychological empowerment experienced by the graduate students before and after the TCL-GTA programme, in their respective capacities as laboratory demonstrators and as graduate teaching assistants influenced their self-image as teachers and their perceived teaching behaviours. As lab demonstrators, graduate students did not see themselves as teachers and thus, they did not engage in typical teaching behaviours. However, by the end of the TCL-GTA programme, the graduate students developed an enhanced sense of psychological empowerment as they became acquainted with the impact they could have on undergraduate

students' learning experiences provided they assume a more pronounced self-image as teachers.

Impact

As demonstrators, the graduate students did not perceive themselves to have a considerable impact on undergraduate students' conceptual learning in the laboratory because they did not see themselves as teachers responsible for enhancing this type of understanding. As such, they refrained from engaging with undergraduate students in conceptual-based discussions. Having participated in the TCL-GTA programme, the graduate students developed a more pronounced self-image as teachers. Perceiving changes in the way undergraduate students behaved towards them indicated that they were having a greater impact on learning as graduate teaching assistants. In line with changes in undergraduate students' behaviour, the graduate students perceived to have also changed their behaviour as they began to ask undergraduate students more questions. students' behaviour can influence their teachers, to the extent whereby increased levels of students' verbal and non-verbal responsiveness is correlated with enhanced perceptions of job satisfaction and self-efficacy experienced by teachers (Mottet *et al.*, 2004). The graduate students in this study suggested that the behaviour of the undergraduate students towards them influenced their sense of impact on learning. A lack of confidence, chemical knowledge and clarity from faculty regarding their role duties and expectations are some of the factors that limit graduate students from engaging undergraduate students in conceptual discussions (Bond-Robinson and Rodriques, 2006). The findings of this study also suggest that how undergraduate students interact with graduate students in the laboratory can influence graduate students' teaching self-image and behaviours. Therefore, it is important that graduate students and undergraduate students establish positive rapport towards the enhancement of graduate students' sense of impact on learning, their self-image and behaviours as teachers.

Competency

The titles used to address the graduate students influenced their sense of competency. As demonstrators, the graduate students claimed to be somewhat competent in *demonstrating* the practical aspects of laboratory sessions. However, by the end of the TCL-GTA programme, the graduate students reported to have developed an enhanced sense of confidence and self-assurance in their skills to do their job in line with how they began to realise their status as '*teachers*' as opposed to practical '*demonstrators*'. In an effort to enhance graduate students' sense of competency, the TCL-GTA programme did not focus on developing graduate students' understanding of explicit teaching techniques or processes, unlike various other graduate teacher development programmes that integrate literature on various approaches to learning such as inquiry-based, rote and meaningful learning (Bond-Robinson and Rodriques, 2006; Marbach-Ad *et al.*, 2012; Pentecost *et al.*, 2012; Wheeler *et al.*, 2015; Wheeler *et al.*, 2016). Instead, the significance of graduate students' status as teachers was emphasised. As one of the six dimensions of teacher empowerment, teacher status refers to how teachers feel their knowledge and expertise is respected (Short, 1994). By acknowledging their chemical experience and knowledge, technical expertise and their first-hand experience of working with undergraduate students during general chemistry laboratory sessions (Sykes, 1990), the graduate students were encouraged to voice their opinions on what and how undergraduate students should learn in the laboratory. As the TCL-GTA programme proceeded, the graduate students became more vocal and opinionated during the workshops. They began to assume a greater responsibility to teach what they felt needed to be taught. Towards the nurture of authentic pedagogy (Newmann *et al.*, 1996; Marks and Louis, 1997), and within their own capabilities, graduate students developed their own unique teaching approach that was sufficient for undergraduate students to achieve the learning outcomes they had decided upon in the TCL-GTA workshops. This required some graduate students to develop their questioning skills while others were required to boost their confidence levels. By the end of the programme, the graduate students saw themselves as facilitators of learning as opposed to being demonstrators that provided undergraduate students with practical assistance. The feedback from the undergraduate students was an important feature in the empowerment process as it affirmed the graduate students' beliefs in their capabilities to teach. Graduate students' interview responses provided further insight into why there was no significant change in their sense of skill mastery. As demonstrators, the graduate students agreed that they had mastered the skills needs to demonstrate the practical aspects of laboratory sessions. However, by the end of the TCL-GTA programme, the graduate students did not feel to have enhanced their sense of mastery. This was due to their new self-image as teachers. Graduate students now saw themselves as teachers and as a consequence, they realised that they had yet to master the skills that are required to be fully fledged teachers. As such, Sean and Abby acknowledged their desire for further teacher-development experience. A number of science education research studies that have been carried out in Ireland (Kelly and Finlayson, 2007; O'Sullivan, 2008; Robinson *et al.*, 2012; Ryan, 2015), the UK (Wood, 1990; Johnstone *et al.*, 1994; Lewis, 2002; Overton, 2003; Beaton *et al.*, 2013; Seery *et al.*, 2017) and in Australia (Panizzon *et al.*, 1999; Read and Kable, 2007; Teakle, 2008; Rice *et al.*, 2009; Sarukkalige *et al.*, 2010; O'Toole *et al.*, 2012; Braun and Kirkup, 2015; Kirkup *et al.*, 2015, 2016) have made reference to graduate students as laboratory demonstrators. However, the findings from this study suggest that the terms used to address graduate students in the laboratory can influence how they see themselves as competent teachers.

Autonomy

'*Mere Technician*', was the term used by Noah to describe how he saw himself in his demonstrator role. This term provides insight into his perceived lack of autonomy over what and how undergraduate students learnt in the laboratory. Noah's views were similar to those of the other participating graduate students as they did not see themselves as contributors in the design or

delivery of laboratory sessions. They were hesitant to perceive a sense of autonomy as demonstrators because they were unaware of whether it was within the intentions of course leaders for them to do so. Such ambivalence substantiates the postulation that graduate students are propelled into vortex of mystification during their efforts of deciphering the values of faculty towards teaching, learning and research (Nyquist *et al.*, 1999). Graduate students in this study were not aware that they could, or should teach undergraduate students which ultimately caused them to refrain from interacting with undergraduate students. By the end of the TCL-GTA programme, the graduate students indicated an enhanced sense of autonomy as they began to see themselves as teachers, with the '*permission*' and capability to teach. Developing an awareness of their teaching opportunities, an appreciation of the significance of their teaching efforts as well as actively deciding on learning outcomes during the TCL-GTA workshops contributed to their enhanced sense of autonomy. However, there was no significant change in graduate students' sense of opportunity for independence and freedom in determining what undergraduate students learn in the laboratory. Interview responses reveal that the prevalence of the laboratory manual and its role in underpinning the traditional pedagogic approach employed throughout the laboratory sessions will continue to limit their sense of opportunity for independence and freedom in determining what undergraduate students learn. This finding supports the contention that graduate students' behaviour, as a precursor of their teacher self-image can be linked to the pedagogical approach employed in the laboratory (Sandi-Urena and Gatlin, 2013). Nevertheless, the graduate students in this study still acknowledged a newfound awareness of their ability to make a decision to teach undergraduate students something other than the contents of the laboratory manual that underpinned a traditional pedagogical approach. Faculty need to promote clarity with regard to graduate students' role as teachers both in the laboratory as well as during decision-making processes associated with teaching and learning aspects of undergraduate laboratory sessions. Since graduate students assume important teaching responsibilities, considering to involve them in deciding on various teaching and learning aspects of laboratory learning could be significant since the deprivation of decision-making opportunities can lead to a decline in teachers' job satisfaction and desired level of involvement in school life (Rice and Schneider, 1994). Increasing the level of decision-making opportunities for teachers links to enhanced feelings of empowerment and satisfaction (Rinehart and Short, 1994) as it is figured to break down the isolation that keeps teachers separate through fostering collegiality (Maeroff, 1988). If graduate students are to be recognised and embraced as teachers in having a responsibility to promote a positive learning environment, involving them in various teaching and learning decisions could be a way of enhancing their sense of autonomy towards the development of their teaching self-image and behaviours. For example, course leaders could involve graduate students in devising learning outcomes associated with undergraduate students' affective, cognitive and psychomotor learning domains for undergraduate laboratory sessions. Alternatively, course leaders could involve graduate students in designing and employing new pedagogical approaches during undergraduate laboratory sessions.

Meaningfulness

The graduate students indicated a sense of meaningfulness in both their demonstrator and graduate teaching assistant roles, however their sense of meaningfulness changed as their self-image changed from being a demonstrator to a graduate teaching assistant. The reasons they felt their demonstrator role was meaningful were associated with how they saw themselves as researchers. Here, they described how the demonstrator experience facilitated the development of their science communication skills and their revision of basic chemical concepts. This substantiates previous research that suggests how the fulfilment of a teaching role can contribute to the development of graduate students' research capacities, namely, in developing their research skills (French and Russell, 2002) and promoting their epistemological and metacognitive development (Sandi-Urena *et al.*, 2011). However, the graduate students acknowledged that their work was significantly more personally meaningful to them as graduate teaching assistants. They attributed this to how they perceived to have promoted understanding as well as feelings of happiness and confidence in the undergraduate students they worked with. According to Fuller's stage model of teacher development, the concerns of novice teachers extend outwards, beginning from having concerns about self, to having concerns about tasks and situations, to finally having concerns about their impact on students (Fuller and Bown, 1975). This concern transition mapped the graduate students' journey towards becoming a graduate teaching assistant from their original demonstrator role. While their sense of meaningfulness in their demonstrator roles was initially concerned with their self-image as researchers, they derived an enhanced sense of meaningfulness from how they saw themselves as teachers, capable of influencing how undergraduates felt and learnt in the laboratory. There was no significant difference in graduate students' perceptions of how personally meaningful their job activities were to them or how important their work was to them. However, it was clear that the aspect that made the experience personally meaningful for them was the work they did to promote a positive learning environment and less so, the specific activities they did as teachers such as asking questions, answering questions and giving explanations. Highlighting and embracing the significance of graduate students' self-image as important teachers both within departments and in undergraduate students' learning experiences are key to improving their sense of meaningfulness as well as promoting the establishment of a positive laboratory learning environment.

Summary

To summarise, Fig. 3 illustrates the various contextual, training and personal factors that this study has identified as factors that influence graduate students' teaching self-image and behaviours. Regarding the influence of contextual factors, the behaviour of undergraduate students, faculty expectation and encouragement

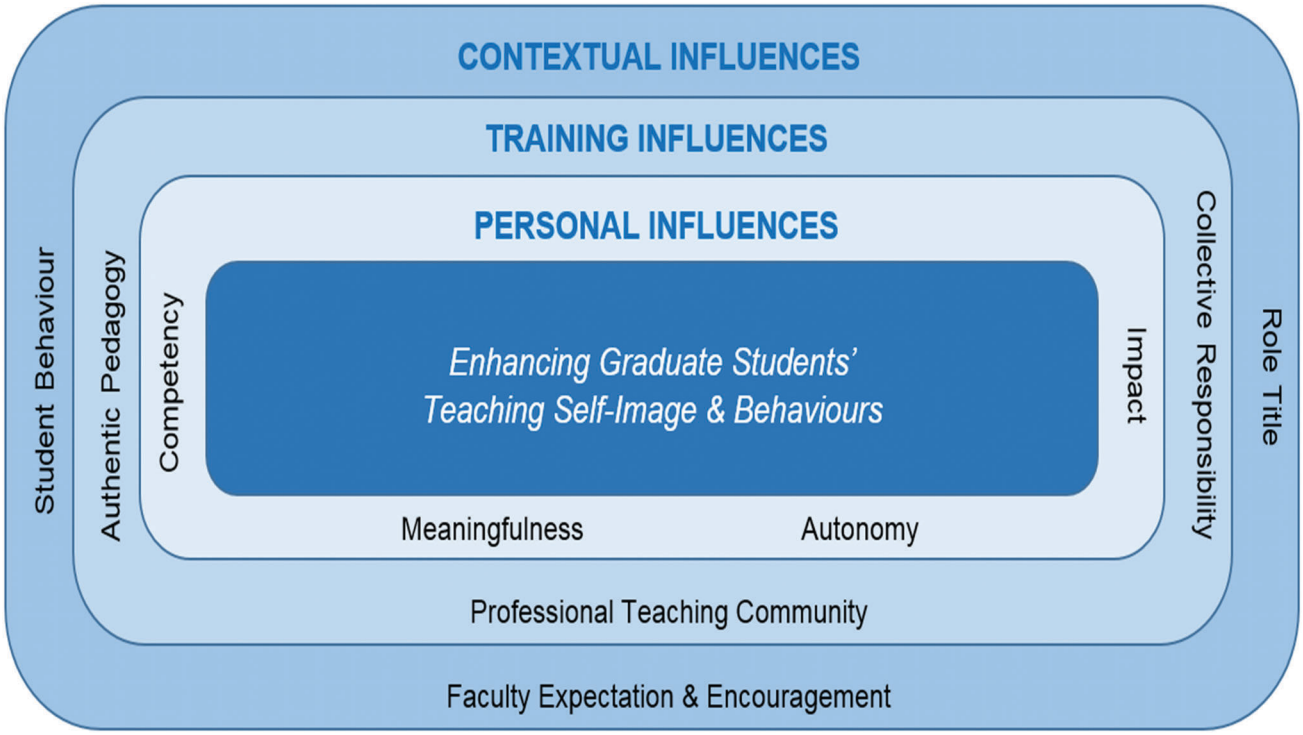

Fig. 3 Contextual, training and personal factors that influence graduate students' teaching self-image.

and the titles used to address graduate students who teach in the laboratory are factors that influences graduate students' teaching self-image and behaviours. Regarding the influence of training factors, the establishment of authentic pedagogy through developing a professional teaching community among graduate students that had a collective responsibility for undergraduate students' learning promoted the enhancement of graduate students' teaching self-image and behaviours. Finally, emphasising and encouraging graduate students' sense of impact, competency, autonomy and meaningfulness in their roles as laboratory teachers also promoted the enhancement of graduate students' teaching self-image and behaviours.

Considerations and limitations

The researchers encourage readers to take into consideration the following factors when interpreting the findings of this study. Firstly, it is acknowledged "*that psychology's emphasis on the cognitive processes of the individual leads us to study individual's sense of empowerment rather than actual increases in power, thereby making the political personal*" (Riger, 1993). The purpose of this study was not to develop or assess graduate students' *actual* impact, autonomy, competency or meaningfulness as precursors of their teaching behaviours or capabilities. Rather, the purpose of this study was to explore and enhance their *sense* of impact, autonomy, competency and meaningfulness towards the development of their teaching behaviours or capabilities. The researchers are currently analysing the impact that the TCL-GTA programme had on their teaching behaviours or capabilities through an analysis of their verbal interactions with undergraduate students after each TCL-GTA workshop. A second factor to consider is that the TCL-GTA programme involved just seven graduate students. More research is required into investigate whether the TCL-GTA programme or the construct of psychological empowerment can lead to the enhancement of the teaching self-image of greater cohorts of graduate students or wider teaching populations. With regard to the validity and reliability of employing design research as a research methodology, it is argued that "*if a researcher is intimately involved in the conceptualisation, design, development, implementation, an researching of a pedagogical approach, then ensuring that researchers can make credible and trustworthy assertions is a challenge*" (Barab and Squire, 2004). Finally, this research was carried out with a self-selected sample of graduate students. Inevitably, self-selected groups may be susceptible to bias as in this case, those who voluntarily participated in this research may be representative of a portion of graduate students with a heightened motivation to teach. As well as inherent difficulties in generalising findings from qualitative research, more comprehensive and robust research needs to validate other modes of empowering graduate students who teach aside from those purported in this article.

Implications for research

This research study provided insight into the how the sense of psychological empowerment experienced by graduate students in their laboratory teaching roles can be enhanced to result in the development of more pronounced teaching self-images and behaviours. However, some questions remain unanswered. While a

number of factors can contribute to graduate students' self-image as teachers (Sandi-Urena and Gatlin, 2013), relatively little is known about how their teaching self-image can be enhanced. This study evidenced the efficacy of the psychological empowerment construct in levering the enhancement of graduate students' teaching self-image. However, further research is needed to gain insight into whether there are other constructs and methods that are capable of achieving similar results. Building on Fuller's model of teacher development that purports the journey of a novice teacher to extend outwards from concerns about self, to tasks and to students, novice teachers also embark on a journey inwards as they grow as a teacher and a person (Conway and Clark, 2003). Here, novice teachers also grow inwards as they develop hopes and aspirations for their '*self-as-teacher*'. While the graduate students involved in the TCL-GTA programme developed a heightened sense of meaningfulness in their teaching roles from extending their concerns outwards, potential exists for further research to explore whether graduate students also develop hopes and aspirations during a teacher development programmes for not only their '*self-as-teacher*' but also for their '*self-as-researcher*'. Finally, while the TCL-GTA prioritised graduate students' sense of psychological empowerment as a means of enhancing their teaching self-image, our current research agenda is exploring how this actually influences their teaching behaviour towards undergraduate students. A recent research study suggested that the instructional practices of chemistry graduate teaching assistants can be classified as one of four types: the '*waiters*', '*busy bees*', '*observers*' and the '*guides on the sides*' which all are indicative of the level of interaction between the graduate students and undergraduates (Velasco *et al.*, 2016). Research is needed to understand whether the particular type of instructional practice that an individual graduate student is assigned to is fixed or whether the '*waiters*', '*busy bees*' and '*observers*' can all be guided to evolve as '*guides on the sides*'.

Implications for practice

The findings of this research presents a number of implications in developing the teaching capabilities of novice higher education teachers, particularly graduate students who assist in the delivery of undergraduate courses. Embarking on a higher education teaching career, either as a new lecturer or as a GTA is undoubtedly, a demanding task. In light of the number of contextual, training and personal factors that influence novice teachers' perceived self-image, it can be easy to forget that teaching is ultimately an emotional practice of passionate beings who connect with their students and fill their work and their classes with pleasure, creativity, challenge and joy (Hargreaves, 1998). Prior to the TCL-GTA programme, the graduate students' did not exude a sense of passion for their roles in the undergraduate laboratory because they didn't see themselves as teachers, capable of having an impact on students' learning. However, in developing a broader conceptualisation of the impact that they could have provided they assume more pronounced teaching roles, the graduate students were reinvigorated and rejuvenated in their roles. Those responsible for developing the teaching capability of novice higher education teachers must strive to attune to and nurture their emotional domains. For example, it may come as a recommendation to hold an induction seminar that generates a space for novice higher education teachers to embrace their role as teachers, and were necessary, a space that grants them the opportunity to reconceptualise their roles as teachers, as distinct from their roles as researchers. Emphasising the significance of their individual roles to potentially transform the learning experiences of individual undergraduate students may promote novice higher education teachers sense of belonging as a teacher, their commitment to the successful progression of undergraduate students and ultimately, their teaching presence.

While the primary aim of the TCL-GTA programme was to generate a space for the graduate students to develop the belief that they could enhance undergraduate students' learning experiences, perhaps the most significant contributing factor to the achievement of their aim was sharing the undergraduate student feedback with the graduate students. Just as the process of teachers providing students with feedback is important, the process of students providing teachers with feedback can be of equal importance. Ideally, within the context of developing the teaching capabilities of novice higher education teachers, providing them with positive, constructive and formative feedback from undergraduate students may promote their sense of self-efficacy and satisfaction.

Conclusion

This research builds on prior research that explores the factors that influences graduate students' teaching capability. As laboratory demonstrators, the graduate students in this study did not perceive a considerable sense of psychological empowerment that ultimately implicated the extent to which they saw and perceived themselves as effective teachers. In order to address this, the TCL-GTA programme underpinned an empowerment process that focused on identifying a problem, as a function of undergraduate students' learning difficulties in the chemistry laboratory, setting a goal of establishing a meaningful learning environment in the laboratory and exploring literature documenting the potential impact that graduate students could have on students' laboratory learning experiences. For the empowerment process to also have a positive influence on student performance, the affordance of decision making opportunities relating to teaching and learning decisions (Sweetland and Hoy, 2000) in a professional teaching community that had a collective responsibility for student learning was nurtured (Marks and Louis, 1997). By the end of the TCL-GTA programme, the graduate students developed an enhanced sense of psychological empowerment that positively contributed to enhancing the extent to which they saw themselves and acted as teachers in the laboratory. The findings of this research indicate the significance of graduate students' teaching self-image in influencing their behaviours as teachers in the laboratory. Further, the sense of psychological empowerment experienced by graduate students in their teaching roles is an effective tool in evaluating and enhancing graduate students' teaching self-image and behaviours.

Appendix 1

A questionnaire to be completed by Postgraduate Laboratory Demonstrators involved in the programme:

Teaching as a

Chemistry Laboratory Graduate Teaching Assistant.

Gender: Female ☐ Male ☐ Age _____

Native Language: _____

Details of Current Postgraduate Studies:

Year of current postgraduate study: _____

Area of postgraduate research: _____

Type of postgraduate research: Laboratory Desk ☐ Field ☐ ☐

How much experience have you of demonstrating in first year, undergraduate chemistry laboratory sessions? (Please Tick).

None ☐ 0-1 Year ☐ 2 Years ☐ 3 Years ☐ More than 4 Years ☐

Have you fulfilled the role of a tutor (Tutorials / Support Tutorials / Science Learning Centre) during your time at the University of Limerick? Yes No ☐ ☐

Have you ever undertaken training for the development of your teaching skills? If so, please describe briefly:

_____

_____

_____

Details of Previous Undergraduate Studies:

Please briefly describe the subject area of your Undergraduate studies.

_____

_____

Did you teach as part of your Undergraduate studies (Tutor / Laboratory Demonstrator)?

_____

_____

_____

Instructions

The questionnaire is being used to understand what it means to you to be a laboratory demonstrator. It consists of 12 statements which look like this:

EXAMPLE: Toyota cars are the best built cars in the world

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

Based on your level of agreement, tick the box which corresponds to the extent of your agreement with the aforementioned statement

1. I have significant influence over what undergraduate students learn as a Laboratory Demonstrator.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

2. I have mastered the skills necessary for my job as a Laboratory Demonstrator.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

3. I have significant autonomy in determining what undergraduate students learn as a Laboratory Demonstrator.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

4. The work I do as a Laboratory Demonstrator is personally meaningful to me

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

5. I have a great deal of control over what undergraduate students learn as a Laboratory Demonstrator.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

6. I am confident about my ability to do my job as a Laboratory Demonstrator.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

7. I can decide on my own what undergraduate students learn as a Laboratory Demonstrator.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

8. The work I do as a Laboratory Demonstrator is very important to me

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

9. The job activities I do as a Laboratory Demonstrator are personally meaningful to me

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

10. I have considerable opportunity for independence and freedom in determining what undergraduate students learn as a Laboratory Demonstrator.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

11. I am self-assured about my capabilities to perform my work activities as a Laboratory Demonstrator.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

12. My impact on what undergraduate students learn in the laboratory is large as Laboratory Demonstrator.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

Appendix 2

A questionnaire to be completed by Graduate Teaching Assistants involved in the

Teaching as a

Chemistry Laboratory Graduate Teaching Assistant.

Instructions

The questionnaire is being used to understand what it means to you to be a ***chemistry laboratory Graduate Teaching Assistant***. It consists of 12 statements which look like this:

EXAMPLE: Toyota cars are the best built cars in the world

Strongly Agree	Moderately Agree	Neutral	Moderately Disagree	Strongly Disagree
○	○	○	○	○

Based on your level of agreement, tick the box which corresponds to the extent of your agreement with the aforementioned statement

1. I have significant influence over what undergraduate students learn as a Graduate Teaching Assistant.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

2. I have mastered the skills necessary for my job as a Graduate Teaching Assistant.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

3. I have significant autonomy in determining what undergraduate students learn as a Graduate Teaching Assistant.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

4. The work I do as a Graduate Teaching Assistant is personally meaningful to me.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

5. I have a great deal of control over what undergraduate students learn as a Graduate Teaching Assistant.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

6. I am confident about my ability to do my job as a Graduate Teaching Assistant.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

7. I can decide on my own what undergraduate students learn as a Graduate Teaching Assistant.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

8. The work I do as a Graduate Teaching Assistant is very important to me.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

9. The job activities I do as a Graduate Teaching Assistant are personally meaningful to me.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

10. I have considerable opportunity for independence and freedom in determining what undergraduate students learn as a Graduate Teaching Assistant.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

11. I am self-assured about my capabilities to perform my work activities as a Graduate Teaching Assistant.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

12. My impact on what undergraduate students learn in the laboratory is large as a Graduate Teaching Assistant.

Strongly agree	Moderately agree	Neutral	Moderately disagree	Strongly disagree
○	○	○	○	○

Appendix 3

Interview Questions: Pre TCL-GTA Programme

Impact

1. Do you feel as if you have an impact/influence on what students learn in the laboratory as a demonstrator?
a. Why?

Competency

2. Are you confident in your skills/ability as a demonstrator?
a. Why?

Autonomy

3. Do you think you can make decisions about what students learn as a demonstrator?
a. Why?

Meaningfulness

4. Is your graduate teaching assistant role meaningful/important to you?
a. Why?
5. What does it mean to you to be a laboratory demonstrator?

Interview Questions: Post TCL-GTA Programme

Impact

1. Do you feel as if you have an impact/influence on what students learn in the laboratory as a graduate teaching assistant?
a. Why?

Competency

2. Are you confident in your skills/ability as a graduate teaching assistant?
a. Why?

Autonomy

3. Do you think you can make decisions about what students learn as a graduate teaching assistant?
a. Why?

Meaningfulness

4. Is your graduate teaching assistant role meaningful/important to you?
a. Why?
5. What does it mean to you to be a graduate teaching assistant?

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