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An oasis in the Laboratory Graduate Teaching Assistant (LGTA) garden: developing pedagogical skills for undergraduate scientific laboratories

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Abstract

Laboratory Graduate Teaching Assistants (LGTAs) are crucial to the smooth running of undergraduate teaching laboratories; however they are oftentimes exiled to superficial duties such as enforcing health and safety and procedural instruction. The aim of this intrinsic case study, carried out in an Irish higher education institution, was to characterise the support required by LGTAs to develop the key pedagogical skills that would assist them in effectively demonstrating undergraduate science teaching labs. Thematic analysis of the skills gap analysis undertaken indicated an overall shortcoming in LGTA support in developing appropriate pedagogical skills, characterised by a lack of LGTA confidence in their ability to effectively demonstrate. The under-supported pedagogical skills areas were mapped onto sub-themes of engagement, communication, grading and providing feedback. This provided a rationale to develop a bespoke training course to assist and underpin the LGTAs development as novice academics; to address pedagogical skills gaps and this was delivered following a socially constructed, 'just-in-time' pedagogy. Upon completion, the effectiveness of this model of LGTA pedagogical training to suitably support LGTAs in their pedagogical development was evaluated by stakeholder survey and discussion fora. Overall, it was noted that the training course had a very positive influence on the LGTAs; they developed a noticeable increase in confidence in their ability to demonstrate, they took on additional responsibilities in the lab and

developed their own community of practice. Based on the perceived improvement observed in this intrinsic case study, it is recommended that with continual training and appropriate support LGTAs can take a more central role in the STEM undergraduate teaching lab. An in-depth set of recommendations devised from this study is included and would be of particular value to novice educators in higher education and those the supervise, mentor and manage LGTAs.

Keywords: Graduate teaching assistant, 'Just-in-time' pedagogy, Pedagogical training, Pedagogical skills, Scientific demonstrating

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Introduction

Over a decade ago, Luft and colleagues (2004) described the environment in which Laboratory Graduate Teaching Assistants (LGTA) teach as akin to growing a garden in the absence of water. Quite simply, without the correct environment, and support, the LGTA would struggle to reach their teaching potential. The need to provide suitable support for those that teach in further and higher level education has been discussed at length (see Postareff & Nevgi, 2015 for a recent summary) and with LGTA support is most commonly provided by way of workshops and informal training programmes. More generally, it it has been noted that "*college teaching is the only profession requiring no formal training of its practitioners*" (Allen & Rueter, 1990, p.9). This is in comparison to other areas of teaching (Montessori, primary and second level). There is no absolute need to hold a teaching qualification to teach at third level; instead experience is often used to develop a teaching philosophy and personal style. This can lead to a divide in the educators at third level into experienced and novice academics (Hogan *et al.*, 2013). Novice academics are often not supported in their transition from a research-intensive path to a role that incorporates teaching duties. In the Sciences, one of the least supported groups of third level educators are the Laboratory Graduate Teaching Assistants (LGTAs); however, these are most often tasked with the challenging task of teaching practical skills to the larger, early year undergraduate classes (Park & Ramos, 2003).

A central aspect to undergraduate science education is the development of core lab skills appropriate for the future career of the student. Although discipline specific competencies are developed in later undergraduate years, the basic lab skills are often established in the early undergraduate years (Johnstone & Al-Shuaili, 2001). At the

most basic level those tasked with teaching lab skills will influence all aspects of lab learning including broader skills and competencies such as experimental design, data evaluation, accuracy and safety (White *et al*., 2013). The LGTA typically plays a pivotal role in structuring undergraduate lab learning; the LGTA often has more contact time with undergraduate students than full-time academic staff. For example, in some research-intensive universities almost all large undergraduate basic sciences lab instruction is provided by the LGTA, in some cases as high as 88% (chemistry) and 91% (biology; DeChenne, *et al*., 2012). Equipping the LGTA with the relevant skills to flourish in this teaching and learning environment would benefit all.

However, providing a LGTA pedagogical support structure raises several questions; including, how can the need to train LGTAs in the fundamentals of pedagogy align to the research ambitions of most PhD researchers? Most PhD researchers are in higher education institutes to conduct research on their topic of choice; teaching is a secondary focus that may result in an academic career path (McAlpine & Emmioğlu, 2014), although this path is not always easy to navigate (Larson *et al*., 2014). This seemingly contradictory scenario; the need to train in pedagogy to assure quality in their teaching duties during their research, but the non-universal requirement for direct pedagogical skills in their postdoctoral careers, can alienate PhD students and reduce their effectiveness as LGTAs in the undergraduate learning lab.

An alternative approach is where the LGTA, at the interface of educator and researcher, should be celebrated as being a member of '*distinctive tribe*' with much to offer (McKiggan-Fee, *et al*., 2013, p.171). The unique skill set offered by the LGTA should be harnessed and the LGTA centralised in undergraduate teaching, particularly

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in the lab. Sympathetic development, and execution, of appropriate support training with the core ethos of integrating the LGTA into an institutions teaching and learning community could achieve a more productive 'growing' environment for all. The research described here details how this approach can be achieved. A key output of this research was to design, deliver and evaluate a pedagogic training course to LGTAs with the specific aim of enhancing their teaching and learning skills for use in the undergraduate science lab.

Research Questions

This research aimed to address a key research question, underpinned by two aligned sub-questions.

RQ1: "How can the Laboratory Graduate Teaching Assistant be supported in developing pedagogical skills appropriate for undergraduate scientific laboratories?"

RQ2: "What are the appropriate pedagogical skills required by Laboratory Graduate Teaching Assistants teaching in undergraduate science laboratories?"

RQ3 "How might appropriate skills required by Laboratory Graduate Teaching Assistants teaching in undergraduate science laboratories be enhanced through suitable training?"

Research Design

Research Overview and Rationale

In order to deliver an appropriate training model a preliminary investigation, through stakeholder survey, identified the key roles and responsibilities of the postgraduate

demonstrator, as well as the current skills gaps in their pedagogical training. The initial training took place prior to the start of the LGTA demonstration duties and was followed up by targeted 'just-in-time' socially constructed workshops on specific, and timely, pedagogical skills. A fuller description of the training course implemented is available for re-use under a *Creative Commons* BY-NC-SA licence (Ryan, 2015). After the LGTAs received their training to close their skills gaps, they carried out their teaching and demonstrating duties for one semester (Semester One, 2014/2015 academic year). A post-semester survey, supplemented with targeted discussion fora, followed up with all the stakeholders that contributed to the preliminary investigation.

Researcher Background

The researcher is a research-active scientist whose scientific research is primarily positivist employing quantitative data. Concurrently, the researcher maintains an alternative research strand concentrating on a more social science, pedagogical research paradigm, with an anti-positivist perspective. In this study the researcher utilised a complementary combination of both qualitative and quantitative data to validate the emergent trends and improve the reflexivity of the research (Malterud, 2001).

This research project is based on a social constructivist ontological perspective and the epistemological basis is interpretivism (Denzin & Lincoln, 2000). These selections directly influenced the methodology and methods implemented and also affected the analysis and appreciation of the data and findings produced. The researchers personal background as a researcher and educator based in the hard sciences influenced and informed these positions.

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As the research is based on social constructivism and interpretivism, understanding was created by the researcher's interaction with the world and the research subjects. Aligned to this concept, that understanding of a research space is constructed by the researcher in conjunction with the research subjects, was the view that the research evidence is interpreted by the researcher to bring about further meaning and understanding (O'Donoghue, 2007).

Key Stakeholder Population

This intrinsic case study focussed on a medium sized group (n=27) of LGTAs who carried out teaching and demonstrating duties with undergraduate students. These LGTAs had previously completed a degree in a related scientific topic to which they taught or demonstrated. The majority of LGTAs were registered PhD students within the School of Food Science and Environmental Health (65%). Supplemental demonstrators were employed on an *ad-hoc* basis and these were generally postgraduate researchers from other Schools within the Institution, Dublin Institute of Technology, (25%), or other local universities (5%). Post-doctoral scientists were employed as demonstrators on rare and specific occasions (e.g. to demonstrate a specific set of advanced labs; 5%). Additional stakeholders that informed the study included undergraduate students, technical staff, academic staff and management (see Table 1 for a full breakdown of participant numbers).

Ethical Considerations

Participant ethical welfare was paramount at all times during this research project, In line with best practice, the participants were protected by the Institution's core principles of ethics in research including: voluntary participation, fully informed

consent, ability to withdraw, anonymity, to do no harm to the participant or researcher, privacy, confidentiality and security of data storage. Active informed consent was obtained from each participant prior to the start of each research element. As part of this informed consent the participants were provided with a detailed information sheet outlining the key aspects of the research along with information regarding data anonymization and storage, means of project dissemination and the voluntary nature of participation (BERA, 2013).

Methodology

The research questions, and sub-questions, limit the research boundary to a specific case and as such the methodology employed was an intrinsic case study (Noor, 2008). By following this methodology, the key pedagogical skills were identified and their classification and the effect of the proposed intervention (the postgraduate demonstrator training workshops) were explored in the context of the case it was developed for. This aligns with Cousins' (2005) case study categorization; in this research the intrinsic case study was deemed most appropriate as the researchers interest is in understanding the case at hand.

Methods

Quantitative and qualitative data were collected from five stakeholder groups; namely the LGTAs, academic staff, technical staff, school management and the undergraduate student cohort. Adapted versions of previously published surveys and discussion fora questions developed for this study were employed. Reflective writing from both the postgraduate population and the researcher were coded and themed (see Table 1).

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Data Interpretation

Quantitative data were compiled into *Microsoft Excel for Mac* spread sheets; one sheet per question set from each online survey (undergraduate, LGTA and Academic/Technical/Management stakeholders). Basic statistical calculations were carried out using the *Excel* default parameters. *Microsoft Excel for Mac* was also used to graph manipulated data, with resultant graphs exported faithfully to *Microsoft Word for Mac* for further analysis and discursive write-up.

Qualitative data were coded onto several key themes and sub-themes based on researcher interpretation influenced by Strauss and Corbin's (1990) Method of Constant Comparison and Braun and Clarke's (2006) Six Step Approach to Data Analysis. In brief, this entailed data familiarisation, initial code generation, initial theme identification, thematic review, theme definition and final reporting. Participant reflective blogs were similarly coded with the additional influence of Findlay and co-workers (2010) thematic analysis of reflective journals. All coding and thematic analysis was executed using *NVivo* (version 11). Data triangulation was utilised to ensure only valid themes were investigated and that the examples and findings cited were based on data from as broad a participant base as possible (Jick, 1979). Data saturation was observed, as per the qualitative coding method employed, and this indicated further iterative coding and thematic analysis was not required.

Limitations and Bias

In this study, the researcher adopted the role of an 'insider-researcher', based on previous experience and prior integration into the community of postgraduate laboratory demonstrating. The researcher had experience of lab demonstrating from an undergraduate perspective (4 years), a postgraduate outlook (3 years) and an

academic viewpoint (6 years). This varied experience gave the researcher an insider's view of three of the four key stakeholders within this case study; however, this intimate knowledge could lead to researcher bias. Appropriate methodology leading to data triangulation was used to circumvent this bias, with the benefit of the insider-researcher role deemed an advantage to this research (Chavez, 2008).

Cousin (2005, p.422) suggests that case studies should aim to achieve '*thick descriptive data'* capture and this was achieved through mixed data collection methods and validated by data triangulation. Both qualitative and quantitative data were used to determine the key pedagogical skills required by LGTAs and to gauge the effect of the subsequent pedagogical training. Furthermore, the *perceived* LGTA development of key pedagogical skills was investigated through semi-structured discussion fora. There was no comparison made to previous LGTA groups; however, experienced LGTAs were able to review prior training models in comparison to the current training approach.

One of the major limitations of this study is the small population sample that formed the basis of this research. Data collected from LGTAs based in one School, within a single higher education institution was central to this study. The number of LGTAs employed each year within the School is limited and typically based on registered undergraduate numbers. Additionally, LGTA participants were self-selected and volunteered to take part, which may have resulted in a bias toward motivated LGTAs. The effect of LGTA training was analysed by the key stakeholders after one semester of demonstration and recommendations for practice within the institution, and more generally, were extrapolated and detailed.

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Results and Discussion

Design and Development of Bespoke Training Course

The development of the bespoke training module was informed by survey of the key stakeholders; with each stakeholder group specifying key skills and attributes that the LGTA should possess.

The undergraduate stakeholders believed that the LGTA should be both technically and pedagogically trained. Additionally, the LGTA should have subject knowledge and be able to answer student questions. This aligns with Wood (1990) who noted that the role of the LGTA was to understand and show the technical aspects of lab work (and associated instrumentation), detail and explain any associated calculations and enforce the health and safety regulations. Further investigation of these stakeholders beliefs, based on Marshs' (1982) Student Evaluation of Educational Quality (SEEQ) survey and Hughes & Ellefson's (2013) Cognitive Learning Evaluation (CLE) survey, allowed the undergraduate voice on the roles of the LGTA to be characterised into four key themes; namely, learning, enthusiasm, interaction and rapport, which aligned to skills categorised by a Blooms-like Taxonomy (knowledge, comprehension, application, analysis, synthesis and evaluation; Bloom, *et al*., 1956).

An increasing trend in students' disagreement with the hypothesis that LGTAs assisted in skill development is noted moving across the taxonomy from knowledge to evaluation. This correlates with a decreasing trend in agreement to the hypothesis (see Figure 1). The data collected in this study contrasts with the Hughes & Ellefson (2013) original study whereby students were satisfied with the LGTA development of higher order thinking skills as part of the lab practical demonstration. A reason for

this contradiction may be that Hughes and Ellefson's study was based on an inquiry-based approach to lab learning; whereas an expository approach to lab-based learning was typical in this case study (Dunne & Ryan, 2012).

Academic staff, School Management, Technical Staff and LGTAs separately took part in discussion fora and an associated online survey to identify the key responsibilities and skills associated with demonstrating. Technical procedures, competence and ensuring student safety emerged as the key skills from these stakeholder groups. These responsibilities were coded based on emergent themes during the analysis of the examples provided by the online survey participants (n=10 participants supplying n=43 examples; see Figure 2).

Upon analysis it was evident that the LGTAs did not perceive assessment associated pedagogical responsibilities, such as grading or providing feedback, as their responsibility. However, this responsibility sub-set was further examined in the associated online survey, were the LGTA stakeholders were asked to provide adjectives to describe demonstrating roles and responsibilities (see Figure 3). The importance of their teaching responsibilities was evidenced through the interpretive coding of the respondents adjective words. Here, respondents pedagogical responsibilities; described by adjectives such as teaching, learning and facilitate, were primarily noted (95% of the adjectives were in this sub-category), with pedagogical responsibilities associated with assessment less so. The hierarchical order of adjective described responsibilities were also not aligned between academic and LGTA examples; LGTAs placed more emphasis on their engagement and interaction with the undergraduate students and less emphasis on knowledge content in comparison to

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the academic stakeholders perception. Further analysis of the online survey, based on DeChanne and co-workers (2012) research, sought to prioritise topics where training would be provided. Some aspects were assigned similar weighting by the academics and LGTAs groups; however, several topics varied greatly. For example, LGTAs put a higher priority on topics such as pedagogy, group work and grading and a lower priority on feedback (see Figure 4). This contradicted specific, explicit requests for training in feedback during the LGTA discussion forum.

An in-depth analysis of the stakeholders survey revealed that the LGTAs required additional support, with an emphasis on the specific pedagogical skills, communication skills and engagement (detailed in Table 2). These key skills aligned to the key skills required by demonstrators as noted in the literature (Cho *et al*., 2010; Gardner & Gail, 2011; Herrington & Nakhleh, 2003; Lockwood *et al*., 2014, Morrs & Murray, 2005). Skills required were rationalised based on the appropriateness of the desired skill to be enhanced through the proposed model of training and the overall suitability of the desired skill for the entire participant cohort (Goodlad, 1997). Technical skills and discipline knowledge, along with health and safety, were not deemed appropriate for this training model and were not included in the training plan. Socially constructed workshop-style sessions were delivered throughout the semester, to meet the LGTAs request for a 'just-in-time' approach to their skills development (Romiszowski, 1997).

Evaluation

Members of the Academic, Management and Technical staff (n=6) who had direct contact with the LGTAs who participated in the training evaluated the training

programme based on perceived LGTA change in teaching practice. The common emergent theme from this stakeholder group was a positive impression of LGTA development, specifically highlighting areas that were covered in the training courses (e.g. engagement, organisation and appropriate student interaction and guidance). The benefits noted here also echo previous research in the area of LGTA training for lab teaching. Jensen and co-workers (2005) noted that the primary development in LGTAs after suitable training was an enhanced understanding of *how* to teach in the lab and not just *what* to teach. In this intrinsic case study, this aligns to the LGTAs progression from simply instructional and practical demonstration towards adoption of different teaching approaches suitable for the different learners in the lab.

The LGTAs that participated in the training course were the primary evaluators of the effectiveness of the training model to enhance their lab pedagogical skills after the training course was delivered. A positive theme emerged during data analysis, and this was validated through saturated data triangulation. The LGTAs (n=4) noted how attending the course had benefits for all LGTAs regardless of their level of experience or lack of prior training. The provision of any form of training was appreciated by the LGTAs and this chimes with Sharpe's (2000, p.132) study where training, when introduced first, was seen as '*something for those thrown in the deep end* [of teaching]'. This appreciation turned into tangible personal development as the LGTA discussion forum participants remarked how they developed many of the skills that they felt they needed to develop, with the level of development exceeding their original expectations.

The 'just-in-time' model and method of training delivery were seen as an appropriate

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approach and the LGTA participants observed how they gained immediate value from the training course; noting that they were able to put the skills they developed in the workshops into immediate practice. The method of delivery was based on group participation, facilitated through group activities in each workshop and reflects Cassidy and colleagues (2014) finding that the LGTAs learn pedagogical skills very effectively through social constructivist approaches.

This trend was also evident in the participants reflective blogs (n=5). LGTA evaluators agreed on the benefits of reflection and reflective writing; however not all participants posted a reflective blog. Some participants commented that they preferred to 'lurk' in the online shadows and admitted to reading all the blogs posted and learning from them and this echoes with Preece and co-workers (2004) finding that lurking enhanced community based learning. Confidence in ones self, the perceived inability to write reflectively and the fear of posting to a community page were highlighted as reasons why most of the participants in the discussion forum did not post to the community reflective space. Learning within a community of practice can be beneficial to all participants as members of the group develop their understanding together. Sharing learning tools, establishing teaching 'norms' and expanding their use of the language of learning can pull the community together and simultaneously raise the communities standard (Brown *et al*., 1989). This moves away from the traditional '*teacher as individual*' approach to personal development, towards a social constructivist approach to learning and personal development which is particularly well suited to LGTA training and development (Dotger, 2011, p.158). Participants in the discussion forum commented on how they socially developed specific skills that they perceived as important. The skills mentioned encompassed all aspects of

pedagogy and aligned to the highest priority training theme (See Table 2). The skills developed included grading summative and formative components, contextualising lab skills for students, adapting to different learning styles in the lab and prioritising student supports.

An emergent trend from the discussion forum was the enhanced self-worth the participants felt after completing the training course and putting their new skills into practice. The LGTAs felt empowered and this was reflected in their more centralised role in the lab. They no longer saw themselves as an extra pair of hands, a health and safety enforcer or an unwilling participant in undergraduate learning. A noticeable change in LGTA confidence is observed in the LGTAs' overall confidence in their demonstrating ability (see Figure 5). This dramatic increase in confidence was noted due to a better understanding of teaching theory, a more defined skill set focussed on demonstrating or a combination of all the elements covered during the training course. Previous training courses in the biosciences for novice teachers have also reported increased self-confidence as a primary outcome of dedicated teacher training workshops (Gartland, 2013). A deeper examination of the data highlighted several areas of large opinion change after the training course; with the areas of greatest change noted in self-efficacy which aligned to topics discussed and developed in the training course (e.g. engagement, communication, grading and providing feedback). Improved self-efficacy in teaching has been linked to teaching practices such as designing better learning scenarios, seeking out engaging examples to contextualise the students learning, motivating students more, and being more resilient when faced with challenges in their teaching (Parker, 2014). Development of teaching efficacy is strongly influenced during the first exposure to teaching duties (Hoy, 2000) and for

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many STEM academics this takes place during their own time as postgraduate demonstrators. Developing a strong awareness and confidence in ones own teaching ability is crucial for LGTAs during their day-to-day demonstrating duties, but it will also form a strong foundation upon which to build their own academic career on.

Recommendations for Practice

Management

Align the LGTA to their core discipline

In this intrinsic case study LGTAs were often required to demonstrate outside their core discipline area. This reduces the effectiveness of the LGTA, as they are not experienced either in the technical, or the theoretical aspects of the required discipline. Aligning the LGTA to the their core discipline when demonstrating would allow the LGTA to be more comfortable in their demonstrating duties as they are subject experts in lab work in this discipline. This will add value to the undergraduate learning experience.

Reduce the LGTA to UG ratio

A major inhibitor to student learning, noted across all the stakeholders, was the ratio of LGTAs to undergraduates in labs. The typical ratio being 18 UGs to every LGTA. Recommendations to reduce this to 8 UGs to every LGTA would mean that in a typical lab within the School where this intrinsic case study took place one LGTA would demonstrate to one bench of students.

Lead Academics

Mentoring of academically novice staff

A culture of LGTA mentoring should be fostered and adopted. This could take the form of weekly meetings between the lead lab academic and the LGTAs demonstrating the lab. Feedback and feedforward on teaching roles could be provided during these meetings in term. Meetings before and after term could focus on incorporating the LGTA into the development of new labs or resources for current labs. Collaborative lab development should involve a two-way dialogue between the lead academic and LGTA (Bomotti, 1994).

Development of two-way, cross hierarchical feedback/forward channels

Enhancing the quantity and quality of feedback received by the LGTA will improve the LGTA development and lead to a superior learning experience. Feedback, and feedforward, should come from all the stakeholders, particularly the undergraduates, peer LGTAs and lead academics. One example of an appropriate feedback mechanism would be mid- and end of term guided reviews for undergraduate feedback. Here, undergraduate students review their learning experience, and how the LGTA impacted on it, through applied questionnaires and focus groups. Additionally, more discursive reflections with peer LGTAs (through a community of practice) and lead academics (through a defined mentoring programme; Luft *et al*., 2004 and Cox *et al.*, 2011) can further enhance LGTA teaching practice.

LGTAs

Support the development of a community of practice amongst LGTAs

A community of practice evolved holistically during this research; however, a greater and more structured emphasis on developing, enhancing and sustaining such a community would be beneficial to the participants. Such a community would allow

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the participants to support each other's personal development and, in conjunction, contextualise their learning within a socially constructed environment. Linking the face-to-face learning events with the online space associated with the module can allow the community of practice to grow and sustain itself.

Conclusions

This intrinsic case study examined the roles and responsibilities of LGTAs within an Irish third level institution, as defined by the key stakeholders in undergraduate lab teaching. A bespoke training course was developed to enhance the key pedagogical skills associated with undergraduate lab teaching and the effect of this training course was evaluated.

In this intrinsic case study the perceived roles and responsibilities of the LGTA varied depending on the stakeholder; however, a common thread is the requirement for LGTAs to be able to deliver a high standard of technical skills demonstration. The LGTAs and the Academic, Management and Technical stakeholders agreed that aspects such as engagement, lab safety and communication were all skills that were important in a LGTA. However, LGTAs placed a higher emphasis on pedagogical competency than the Academic, Management and Technical stakeholders. Indeed, the LGTAs placed pedagogical capability as the most important skill a LGTA should possess, yet the LGTAs in this intrinsic case study did not typically receive any training in this area. Additionally, LGTA stakeholders noted their lack of confidence in many basic demonstrating tasks, both technical and pedagogical. The first section of this research clearly indicated the need for LGTAs to receive training and support

in many aspects associated with demonstrating, including fundamental pedagogical training.

The provision of pedagogical training has been shown to have a positive effect on academics at all levels (Jensen, 2011; Postareff *et al*., 2008 and Gallego, 2014). In this case study a similar trend was evidenced. The LGTAs noted that following the bespoke pedagogical training course they had, in their opinion, a positive influence on their demonstrating and lab provision in general. Additionally, academic stakeholders also noted, from their perspective, the positive effect the training course had on the pedagogical roles carried out by LGTAs. LGTA training has previously been noted to focus on technical skills training, to the detriment of pedagogical training (Luft *et al*., 2004). However, in this study, pedagogical training formed the basis of the course, with no technical training. Aligned to Jensen and colleagues (2005) philosophy of focussing on how to teach, not what to teach; this training course developed the LGTAs' pedagogical skills across a number of key areas, as defined by the LGTAs themselves. A social constructivist model was adopted in the training course outlined in this study and this allowed a community of practice to grow between the LGTAs, both in the face-to-face workshops and the online reflective space. Ultimately, the LGTAs felt a greater sense of self-worth, increased confidence in their demonstrating abilities and they became a more central player in undergraduate lab learning.

With continual training and appropriate support LGTAs can continue to take a more central role in the undergraduate teaching lab. For example, roles outlined by Cassidy and co-workers (2014); such as lone instructor, mentor for new LGTAs, course developer, collaborator and scholar will come within the skill set of the LGTAs with

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continued training and development. The continued provision of this training course requires the support of the all the stakeholders outlined in this study. Additionally, creative and innovative approaches to the courses delivery and evolution, along with integration into the structured PhD model, will weave LGTA pedagogical training into the fabric of the Institution.

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Table 1: Summary of methods of data collection aligned to research questions. Pertinent references are also cited. The type, and number, of stakeholders contributing to each data collection method is noted along with the corresponding percentage of the total possible population this equated to.

Research Question	Data Collection Method	Type and Number of stakeholder participants	Reference
RQ1	Undergraduate Survey	Undergraduate students, n=66 (73%)	Hughes & Ellesfson (2013) Marbach-Ad *et al*. (2012); Marsh (1982)
RQ1	Postgraduate Survey	LGTA, n = 9 (33%)	Boman (2013)
RQ1	Academic, Management and Technical staff Survey	Academic, n= 8 (50%) Management, n= 1 (33%) Technical, n = 0 (0%)	DeChenne *et al*. (2012)
RQ1	Pre-training course Postgraduate Discussion Forum	LGTA, n = 21 (77%)	Luft *et al*. (2004)
RQ1	Pre-training course Academic, Management and Technical staff Discussion Forum	Academic, n= 5 (31%) Management, n= 1 (33%) Technical, n = 1 (25%)	Luft *et al*. (2004)
RQ2	Determination of "trainable" skills	N/A	This study
RQ3	Post-training course Academic, Management and Technical staff Survey	Academic, n= 8 (50%) Management, n= 1 (33%) Technical, n = 0 (0%)	This study
RQ3	Post-training course Postgraduate Discussion Forum	LGTA, n = 7 (27%)	This study
RQ3	Post-training course Postgraduate Survey	LGTA, n = 7 (27%)	Boman (2013)
RQ3	Participants reflective blogs	LGTA, n= 9 (33%)	Orland-Barak (2005)
RQ3	Researchers reflective diary	Researcher, n=1 (100%)	Nadin & Cassell (2004)

Table 2: Skills required by LGTAs, from all stakeholders (UG, Undergraduate; AMT, Academic, Management, Technical; LGTA, Postgraduate Demonstrator) were themed into three categories and prioritised based on quantity of skills per category. The Training Session (TS) where these skills would be developed are outlined also.

Group Theme	Pedagogy	
Priority	1	
Skill Requirement	**Stakeholder(s)**	**Training Session (TS)**
Add value to learning experience	UG	TS1, TS2, TS3
Problem solving skills	UG	TS1, TS2, TS3
Analytical skills	UG	TS1, TS2, TS3
Planning skills	UG	TS1, TS2, TS3
Evaluation skills	UG	TS1, TS2, TS3
Grading	AMT	TS2
Pedagogical	AMT / LGTA	TS1, TS2, TS3
Academic Processes	AMT	TS1
Feedback	AMT	TS2
Teaching Theory	AMT	TS1
Group Work	AMT / LGTA	TS1
Dealing with learning difficulties	AMT / LGTA	TS3
Feedback and Grading	LGTA	TS2, TS3
Generic Demonstrating Skills	LGTA	TS1, TS2, TS3
Final Year Projects	LGTA	TS3

Group Theme	Communication	
Priority	2	
Skill Requirement	**Stakeholder(s)**	**Training Session (TS)**
Provide clear explanations	UG	TS1
Discussion orientated	UG	TS1
Provide meaningful answers	UG	TS1
Organisation	AMT / LGTA	TS1, TS2, TS3
Discipline	AMT / LGTA	TS3
Communication	AMT / LGTA	TS1, TS2, TS3

Group Theme	Engagement	
Priority	3	
Skill Requirement	**Stakeholder(s)**	**Training Session (TS)**
Enthusiasm	UG	TS1
Motivation	AMT / LGTA	TS1, TS2, TS3
Engagement	AMT / LGTA	TS1, TS2, TS3

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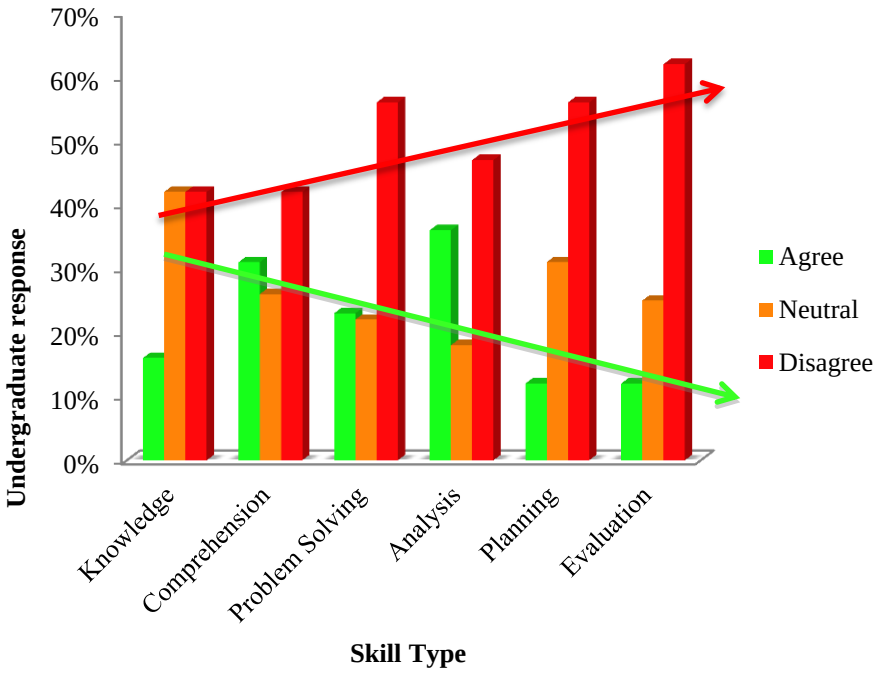

Figure 1: Graphical representation of the undergraduate students (n=66) perception of the higher order skills taught by the postgraduate demonstrator

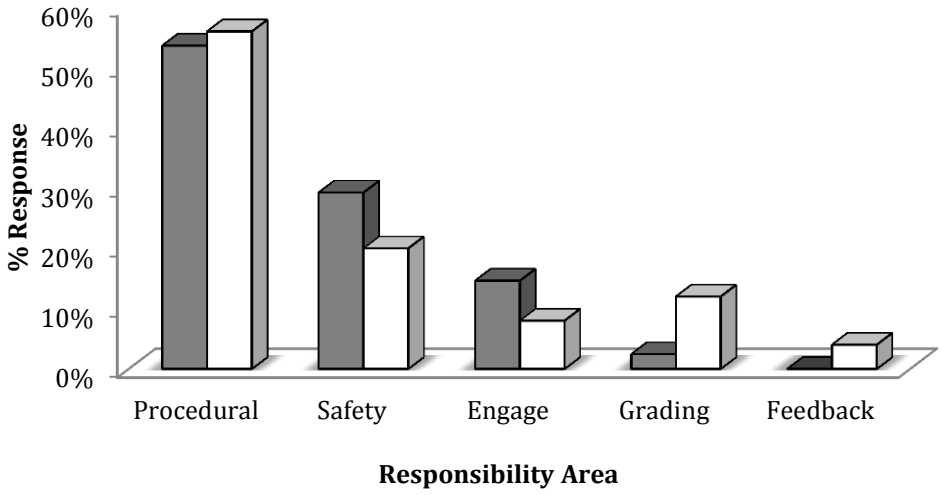

Figure 2: Schematic representation of the five emergent themes coded from LGTA (n=9, grey) provided examples of LGTA responsibility in the lab. The corresponding coded examples provided by the academics (n=9, white) are included for comparative purposes

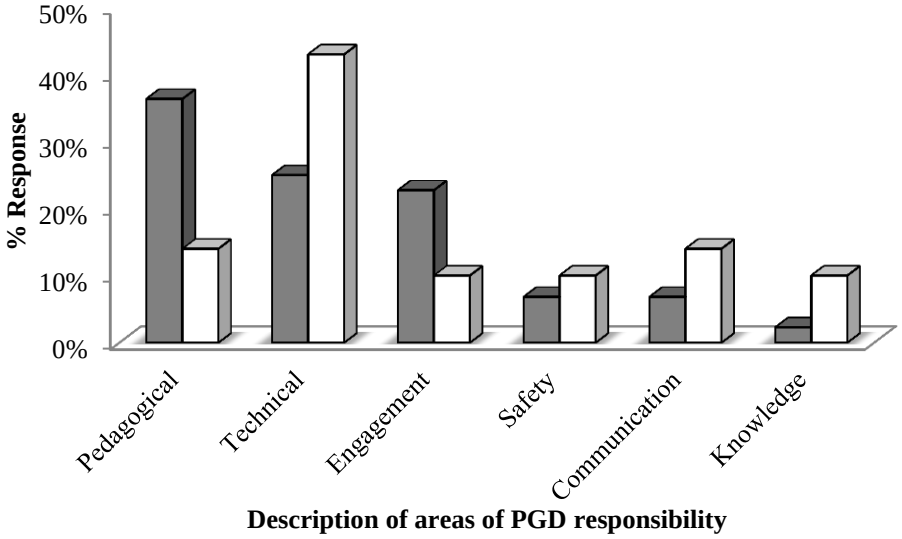

Figure 3: Schematic representation of the six emergent themes coded from LGTA (n= 9, grey) provided descriptive adjectives of a typical LGTA and their associated responsibilities. The corresponding coded adjectives provided by the academics (n=9, white) are included for comparative purposes

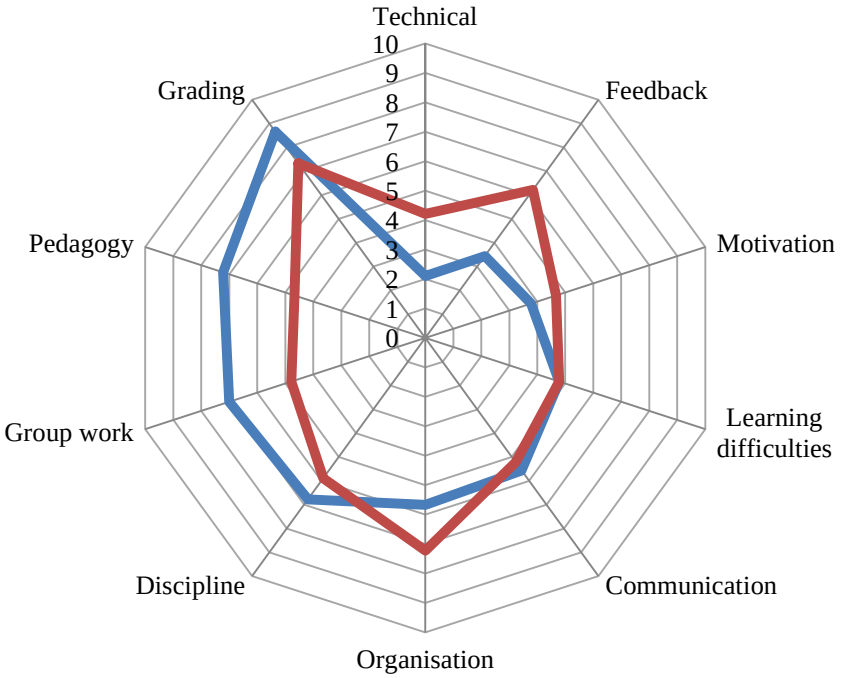

Figure 4: Schematic representation of the most important areas for LGTA training as assigned by LGTAs (n=9, blue line). The weighted rank was calculated as: (sum of (position * count) for each choice / total responses) + 1. Using this weighted ranking the lower the value, the higher the priority. The corresponding academic responses (n= 9) are detailed in red with the weightings calculated in using the same formula. Data presented collated based on online survey

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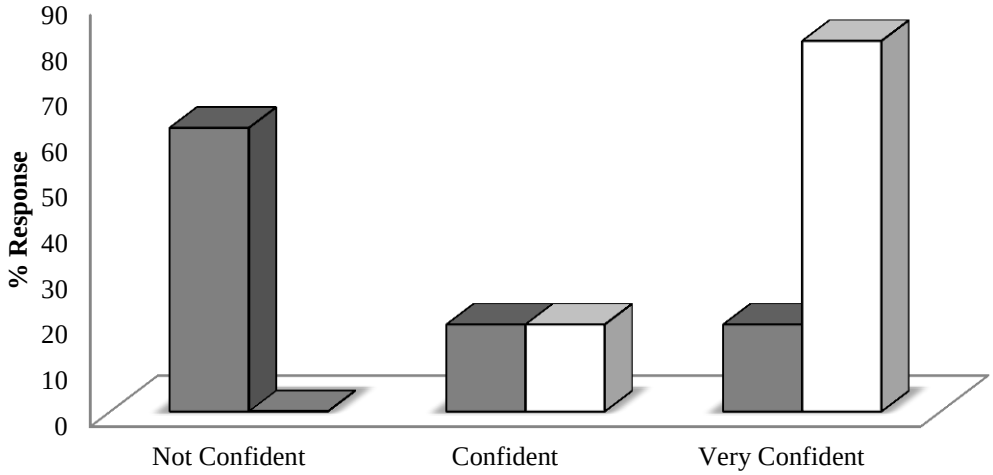

Figure 5: Overall summative analysis of Boman's (2013) modified Teaching Assistant Self Efficiency Scale. This teaching scale summary was based on the LGTA confidence rating before training (n=9, grey) and post training (n=7, white) in response to a twenty-one part survey