Empowering Teaching Assistants to Support Students: Impact of Training and Experience on Perceptions and Practices

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Abstract

Teaching assistants (TAs) have a major impact on the undergraduate science student experience, and therefore training TAs is critical to support engagement and learning. We ran a one-day TA training program for two years and found that participation in the program increased TAs' reflective practice and student-centered teaching over a semester of teaching. Open-ended pre-survey responses indicated that in addition to wanting to learn pedagogical approaches, TAs sought help managing challenging situations and student behaviour. Post-surveys confirmed that the program fulfilled most learning goals of TAs and they subsequently applied the new teaching approaches. Participants indicated high levels of empowerment within their teaching roles across the cognitions of impact, competence and meaningfulness, but low self-determination. All aspects of empowerment increased with experience.

Introduction

Teaching assistants, staff who do not have an on-going academic role, are vitally important to the undergraduate science learning experience. These staff take on roles including lecturing, tutoring, teaching discussion sections, writing and marking assessment tasks, supervising laboratory sessions, maintaining websites related to their units and facilitating interactive classrooms (Kurdziel, Turner, Luft, & Roehrig, 2003; Park, 2004). Descriptive titles such as "(laboratory) demonstrators", "graduate teaching assistants" (GTAs), as well as "contingent", "part time", "casual", "sessional" and "adjunct" are also used to describe the role. In this manuscript, we use the term "teaching assistants" (TAs), which includes staff who may not be involved in laboratory teaching, and may not be (post-)graduate students (Wald & Harland, 2020).

It is well established worldwide that in many university science units, students spend more time with TAs than with staff in on-going roles (Fong, Dillard, & Hatcher, 2019; Gardner & Jones, 2011; Luft, Kurdziel, Roehrig, & Turner, 2004; Prieto & Altmaier, 1994). This is also the situation in Australia (Grainger, Adie, & Weir, 2016; O'Toole, 2012), where TAs undertake an increasing proportion of teaching roles (Harvey, 2013; Hitch, Mahoney, & Macfarlane, 2018; Lama & Joullie, 2015), particularly in practical environments (O'Toole, 2012). The role of TAs in the laboratory or in the field work environment is complex, involving a mixture of teaching, assessment, interpersonal relations, safety considerations and time management, as well as responding on the spot to unexpected events (Bond-Robinson & Rodriques, 2006; Deacon, Hajek, & Schulz, 2017; Herrington & Nakhleh, 2003).

During the COVID-19 pandemic, all university teaching activities were forced online and many institutions have stated that they plan to retain online delivery for lectures (e.g. "Covid: Online teaching to stay", 2021 July 1; Bita, 2022 November 25). In-person science practical work returned to campus due to the need for specialist materials and equipment, resulting in some cases in TAs being the only in-person teachers that students see, and therefore even more critical to the undergraduate student experience.

TAs are typically post-graduate students (Park, 2004; Wald & Harland, 2020), but TA roles are also undertaken by people for whom this role is their primary occupation, termed here "professional TAs". Professional TAs are likely to have different orientations to teaching compared with TAs who concurrently undertake research (Ekiz-Kiran & Boz, 2020). Professional TAs are typically older, making them more credible to students (Semlak & Pearson, 2008). Further details about the employment context of TAs are provided in the Supplementary Material.

With increasing experience, TAs become more confident with the content and addressing student difficulties (Bond-Robinson & Rodriques, 2006; Fong, Dillard, et al., 2019; Lee, 2019). A detailed longitudinal study found fluctuations in self-efficacy over three years of TA practice (Chiu & Corrigan, 2019), with a decline followed by later increase. Nyquist and Sprague propose a useful model in which TAs move along a continuum from being senior learners to colleagues in training through to junior academic faculty colleagues (Nyquist & Sprague, 1998).

It is known that the preparation of TAs for their teaching role is highly variable (Gardner & Jones, 2011; Hitch et al., 2018; Mutambuki & Schwartz, 2018; Rushin et al., 1997), and many have no pedagogical training at all. There have been frequent calls for both general and discipline-specific pedagogical training for TAs (Deacon et al., 2017; Luft et al., 2004), to increase their skills in teaching inquiry-based laboratories (Kurdziel et al., 2003), to improve their ability to mark fairly and consistently (Grainger et al., 2016; Herridge, Tashiro, & Talanquer, 2021; Smith & Coombe, 2006), and to increase their confidence with students and mastery of the scientific content (Gardner & Jones, 2011; Mugivhisa, Mavimbela, & Olowoyo, 2020; Rushin et al., 1997). Gardner and Jones (2011) recommended that TA training programs should:

- be on-going,
- involve reflective practice,
- directly relate to science content, and
- build relationships among teaching staff.

A more recent review explored the efficacy of TA professional development in Australia (Hitch et al., 2018) and recommended increasing support to TAs through feedback, contact with academic staff and professional development. Comparing the impact of four different models of TA professional development on the self-perceptions of efficacy and attitudes of engineering TAs, Fong, Gilmore, Pinder-Grover, and Hatcher (2019) reported the timing of feedback was important. Mid-semester feedback from students had the greatest impact, while the impact was not different for TAs with different levels of experience.

In the past decade, several institutions have reported on various aspects of professional development for their science TAs, including science teaching pedagogy (Fong, Gilmore, et al., 2019; Lee, 2019), peer observation (Lang, Randles, & Jeffery, 2020) and peer pairing

(Wevill & Savage, 2020), practice-led training (Becker et al., 2017), and multiple chemistry-specific programs (Dragisich, Keller, & Zhao, 2016; Gallardo-Williams & Petrovich, 2017; Marbach-Ad et al., 2012; Pentecost, Langdon, Asirvatham, Robus, & Parson, 2012). Changes to the teaching practice of TAs following completion of professional development have been reported (Mutambuki & Schwartz, 2018; Pentecost et al., 2012; Ryan, 2015; Wheeler, Sturtevant, & Mumba, 2019).

Several recent studies have found that effective professional development needs to consider teacher empowerment when evaluating the professional development of TAs (Flaherty, O'Dwyer, Mannix-McNamara, & Leahy, 2017b) because it is a key factor in workplace commitment and satisfaction, and is likely to impact student achievement in direct and indirect ways (Marks & Louis, 1997). Workplace empowerment in professional development for TAs based on Spreitzer's model (1995) therefore forms the basis of this project.

In this study, we designed and implemented a one-day professional development program for TAs involved in multiple science disciplines in a large Australian university with large first year units (over 1000 students) and smaller upper-level units (20 – 200 students), with significant teaching by TAs into all units. Some units are offered on two or three campuses, with separate teaching and support staff on each campus but a common set of practical activities and assessment tasks

In this manuscript, we explored TAs' perceived levels of empowerment and how their perceptions changed over time. The research questions addressed by this study are:

1. Which aspects of TAs' workplace empowerment are most impacted by experience?
2. What are the key challenges faced by TAs, and how can these be managed through professional development?

Methodology

The design of the training program followed recommendations from Gardner and Jones (2011) as far as possible, using evidence-based teaching strategies. It included an introduction to cognitive load theory (Centre for Education Statistics and Evaluation, 2017; de Jong, 2010), training in active learning environments (Freeman et al., 2014) and providing feedback to students (Carless, 2020).

It was not possible to mandate attendance, and participants were paid to attend. We recognise that a single day program is not likely to lead to long term significant change to teaching practice (Fong, Gilmore, et al., 2019; Gardner & Jones, 2011), but financial constraints limited the program. However, because most TAs had regular meetings with staff to prepare for their teaching sessions (Mocerino, Yeo, & Zadnik, 2015), effectively training continued throughout the semester.

TAs evaluated the utility of the program via pre- and post-surveys on the day, and a follow-up survey after one semester. Details of the development and validation of the surveys are available in the Supplementary Material, along with sources for the 11 Likert items mapped to Spreitzer's four cognitions and the full instruments. Two Likert items did not map to components of empowerment, but explored TAs' role in safety (L8) and their identities within their roles (L11).

Chi-square tests were performed on relevant sets of Likert items, in order to compare between groups (experienced vs inexperienced TAs) and between time points (pre-post and follow-up). The data are tabulated in the Supplementary Material.

Open-ended questions at the end of each survey allowed participants to express their goals and responses to the training program, and the rewards and challenges of their roles. An explanation of the coding procedure is provided in the Supplementary Material, along with a table showing numbers of open-ended responses coded within each theme.

The program was run prior to the start of the academic year. Figure 1 illustrates the content and delivery over two years of the program. During the afternoons TAs could attend two discipline-specific sessions, through which TAs interacted directly with academic staff from their units across the campuses. A separate version of the introductory session was offered in 2020 for participants who had attended in 2019. Additions to the program were made in 2020 based on feedback as follows: (i) technical staff prepared and delivered a short session covering the specific expectations of TAs in the laboratory, and (ii) a video was shown role-playing a difficult situation, which was discussed in the broader context of the limits of TA responsibilities. The fieldwork session was not run in 2020 due to staff availability, while a biochemistry-specific session was added by academic staff from that discipline after they saw the usefulness of the program in other disciplines.

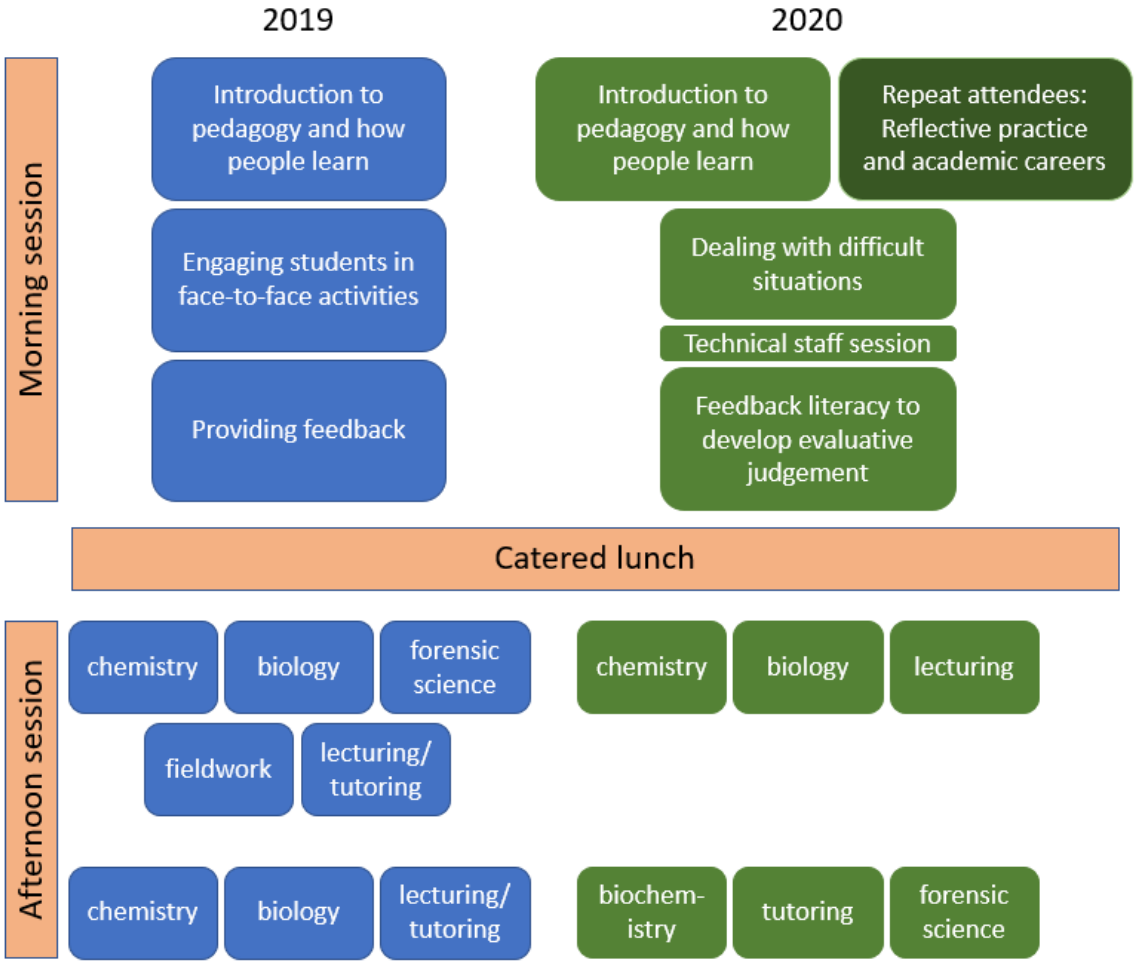


Figure 1. Structure of training program in 2019 and 2020.

We aimed to increase TA confidence by acknowledging that some student behaviour is due to extrinsic factors in students' lives and made TAs aware that having some disengaged students does not reflect poorly on TAs' teaching skills or mean that they have failed. We also explained that serious issues such as cheating should be transferred to academic staff, and we shared institutional resources. All sessions were run interactively, using polling and discussion activities to model active teaching behaviors and increase participant engagement.

A key feature of the program was that attendees were paid for their time (5 hours), and morning tea and lunch were provided, allowing participants to socialise and network throughout the day. It should be noted that previous work in this area has flagged the importance of paying TAs fairly for professional development (Hitch et al., 2018; O'Toole, 2012).

Institutional ethics approval for data collection was obtained prior to the commencement of the study (STEC-06-2019-SCHULTZ). Participants provided informed consent before responding to each survey.

Results and Discussion

Demographic data

A total of 110 participants attended the program in 2019, and 81 in 2020. Some attendees (18 in 2019, 13 in 2020) were academic or technical staff or from the learning and teaching division, and their responses to the surveys have been removed from the data. A total of 75 valid pre-survey responses were received in 2019 (82%) and 61 (90%) in 2020, of whom 28 (46% of the 2020 responses) stated that they had also attended in 2019. We did not exclude repeat attendees from the analysis for two reasons: unless they chose the same code, we had no way to identify survey responses that were provided by the same person, and their perceptions were likely to be different in each year as their experience increased, so they could be treated as separate cases.

Slightly fewer participants completed the post-survey (2019: 66 (72%) and 2020: 58 (85%)), and a smaller number (2019: 25 (27%) and 2020: 20 (29%)) completed the follow-up survey, which was distributed as a link within an email invitation. Responses to each survey from the two years were combined for all analyses, after checking that this made no differences in the observed trends.

Existing literature shows that experience has the most significant impact on TA perceptions and practice (Fong, Dillard, et al., 2019; Prieto & Altmaier, 1994). Therefore, for our analysis, we divided the participants into two groups: inexperienced (0 – 2 years) and experienced (more than 2 years in at least one TA role). As anticipated, we found that our TAs had diverse biographies. Figure 2 shows the breakdown of inexperienced and experienced attendees according to their current role.

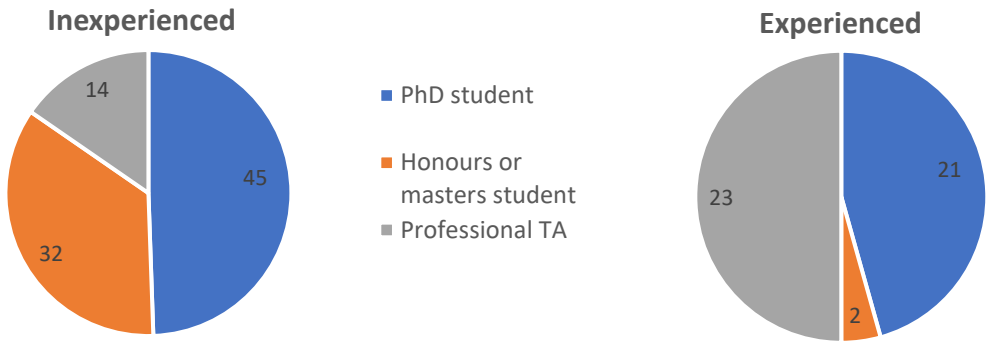


Figure 2. Current roles of inexperienced (left, N = 91) and experienced (right, N = 46) participants. Pre-survey N shown for each category.

It is important to note the large proportion of professional TAs (shaded grey in Figure 2), particularly among the experienced TAs, where they constituted half of respondents. These people are likely to have a different relationship to their role compared with PhD students, which will impact their interactions with undergraduate students. Many professional TAs have been in the role for multiple years and are older than graduate student TAs.

Participants were asked about what experience they had in their current roles, including laboratory demonstrating, field work, marking, seminars, lecturing and unit co-ordination. Teaching experience varied, ranging from those in their first year to several with more than 7 years of experience in multiple roles (Figure 3).

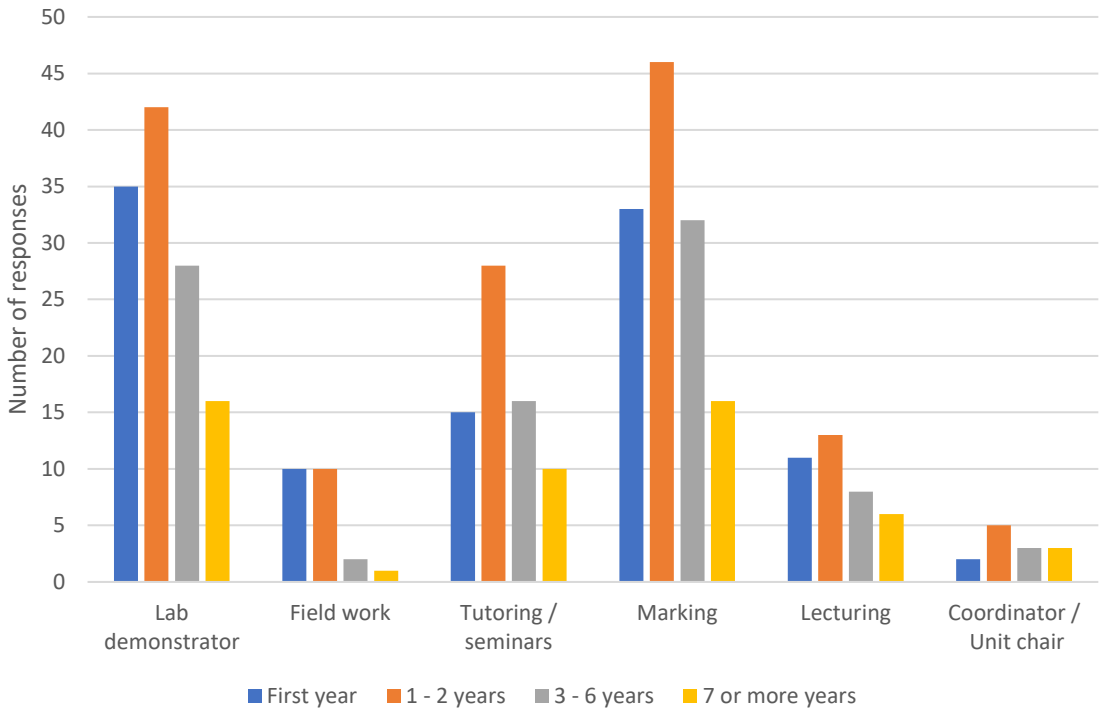


Figure 3. Number of years of experience workshop participants reported for each role that they expected to undertake in upcoming semester.

For every role except the most senior role of being a unit chair, over 60% of respondents had 2 years' experience or less. This is a natural consequence of the temporary nature of TA work, as students graduate and move into the workforce. Academic staff should be aware of this in their induction and training processes; information such as the availability of resources needs to be repeated every semester.

The level of prior training in teaching of most participants was low (Figure 4). This is consistent with literature findings that few TAs have significant training in teaching, and many have none at all (Gardner & Jones, 2011; Luft et al., 2004; Mutambuki & Schwartz, 2018; O'Toole, 2012).

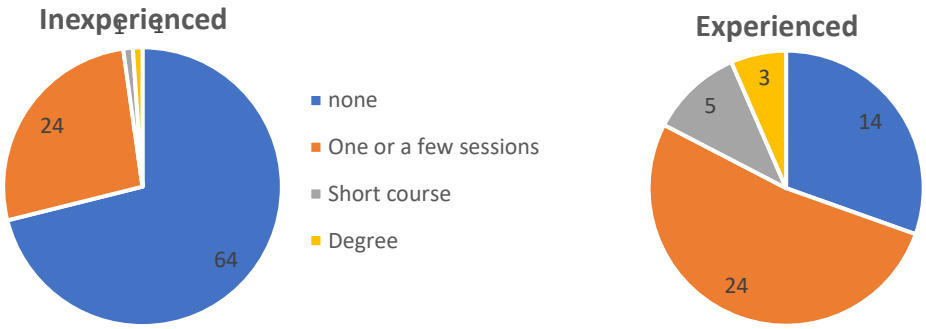


Figure 4. Training in teaching of inexperienced (left, N = 90) and experienced (right, N = 46) participants. Pre-survey N shown for each category.

Even among the experienced TAs, nearly one third had no formal training.

TA perceptions over time

It is important to note that for almost all Likert items, responses were overwhelmingly positive, and so the difference between "strongly agree" and "agree" is important. This likely relates to the fact that respondents were highly motivated, having chosen to seek TA roles, attend the program and complete the surveys.

Impact

Figure 5 shows the Likert data for item L1, which explored TA perceptions of their impact on student learning.

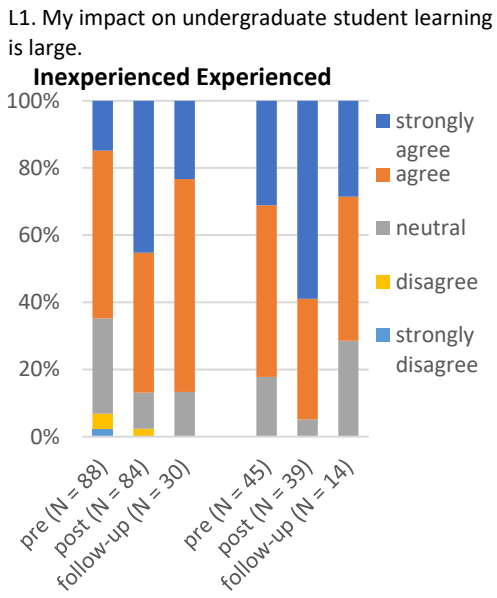


Figure 5. Comparison of inexperienced and experienced TAs' responses to L1 (impact on learning) immediately before (pre) and after (post) training program, and after one semester of teaching (follow-up).

Unsurprisingly, experienced respondents were more likely to strongly agree that they had a large impact on student learning at all time points; however, this difference was only significant for the pre-survey (χ^2 (1, N = 133) = 4.4, p = .35; Figure 5). Both groups strongly agreed that their impact increased significantly (inexperienced: χ^2 (1, N = 172) = 19.1, p < .001; experienced: χ^2 (1, N = 84) = 6.6, p = .01) immediately after the training program but dropped after a semester of teaching so there was no significant difference between pre- and follow-up in either group. Considering all agree responses, the inexperienced group maintained a significantly higher perception in both post (χ^2 (1, N = 172) = 11.4, p < .001) and follow-up (χ^2 (1, N = 118) = 5.1, p = .02) responses, while there were no significant changes at the three time points for the experienced group. In fact, a higher proportion of experienced participants neither agreed nor disagreed with the statement in the follow-up survey compared to the pre- and post-surveys. This indicates that the training program had an immediate impact on participants' sense of empowerment as they thought about their upcoming teaching. However, after a semester with students, they no longer felt as empowered. This presumably related to what they experienced during the semester: TAs likely develop a greater understanding of the work that goes into designing and scaffolding learning experiences, and therefore recognise that their own contribution is relatively smaller. They are also confronted with the limitations of their impact due to the realities of their students' lives.

Our TAs were initially more empowered in this cognition than those in the study by Flaherty et al. (2017b), which reported "neutral" prior to their training program. However, their responses moved to "strongly agree" in the post-survey, possibly reflecting the greater impact of a longer professional development program.

Competency

Five items, L2, L6, L7, L9 and L10, explored facets of teaching competency (self-efficacy for teaching) (Figure 6).

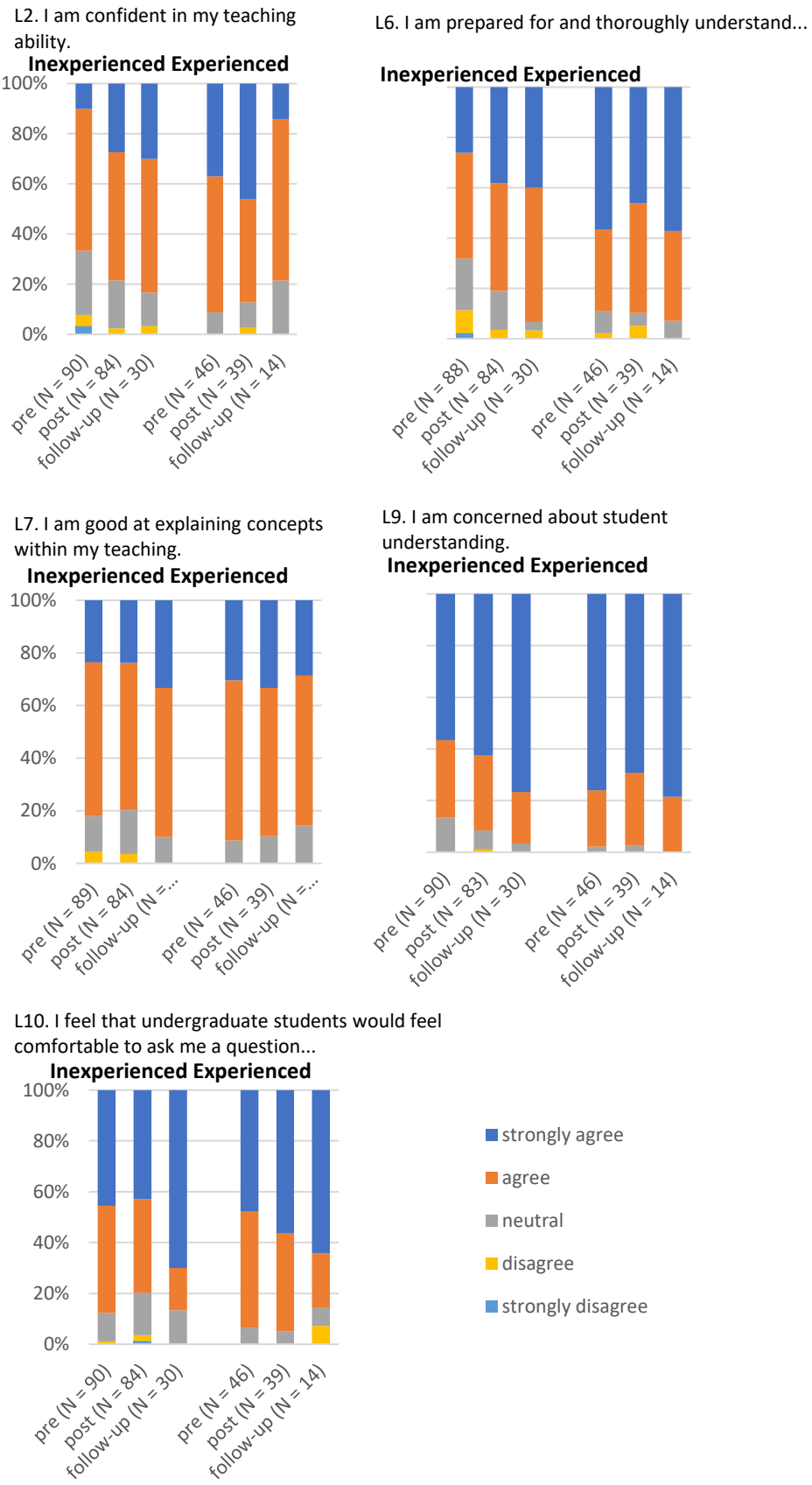


Figure 6. Comparison of inexperienced and experienced TAs' responses within the competency cognition to L2, L6, L7, L9 and L10 immediately before (pre) and after (post) training program, and after one semester of teaching (follow-up).

Differences were observed in both the values and the trends between inexperienced and experienced TAs within the competency cognition (Figure 6). Regarding confidence (L2), the inexperienced TAs showed a significant increase in confidence (strongly agree responses) immediately after the session that was maintained in the follow-up (post: χ^2 (1, N = 174) = 8.7, p = .003; follow-up: χ^2 (1, N = 120) = 7.1, p = .008). This group also showed significantly lower confidence in the pre-survey (χ^2 (1, N = 136) = 9.9, p = .002). Conversely, the experienced TAs demonstrated a non-significant drop in confidence after teaching.

Across all time points, experienced TAs perceived their understanding of the content (L6) to be higher than the inexperienced group; the difference was only significant in the pre-survey (χ^2 (1, N = 134) = 7.1, p = .008). The only significant change was for the inexperienced group, who increased the total agree responses between pre- and follow-up surveys (χ^2 (1, N = 118) = 7.5, p = .006).

Self-efficacy in conceptual explanations (L7) showed no significant differences between the groups, nor changes over time. Similarly, concern for student understanding (L9) was high and remained the same at each time point for each group, but there was a significant difference between the groups' responses in the pre-survey (χ^2 (1, N = 136) = 4.4, p = .04). The feeling that students would feel comfortable asking TAs a question (L10) differed significantly between the groups only in the post-survey, where the total agree responses were higher from experienced TAs (χ^2 (1, N = 123) = 4.7, p = .03). Between the time points, the only significant change was an increase in "strongly agree" responses within the inexperienced group between pre- follow-up surveys (χ^2 (1, N = 120) = 5.4, p = .02).

Overall within these areas of cognition, the perceived competency of the inexperienced TAs tended to increase at each time point, while the experienced TAs showed this trend only for L10.

This data is consistent with literature showing that experience is the main determinant of perceived teaching competence (Fong, Dillard, et al., 2019; Lee, 2019; Prieto & Altmaier, 1994). TAs' pedagogical content knowledge is expected to increase with experience (van Driel, Verloop, & de Vos, 1998), increasing their overall competence in their roles. Flaherty et al. (2017b) reported slightly lower empowerment data for the competency items in their pre-surveys; for L2, a shift from "neutral" to between "strongly agree" and "agree" was observed after the professional development. Items L6, L7, L9 and L10 were only asked in the pre-survey in their study, and for each of these items "agree" was recorded (Flaherty, O'Dwyer, Mannix-McNamara, & Leahy, 2017a), whereas we observed "strongly agree" except for L6 for inexperienced TAs and for L7 for both groups.

Self-determination

Because of the nature of their roles, we expected the perceptions of TAs regarding self-determination to be relatively weak. Responses to items L3 and L4 confirmed their lack of agency (Figure 7). Flaherty et al. (2017b) also found "neutral" for L3 in their pre-survey, which shifted to "agree" after their extensive professional development program.

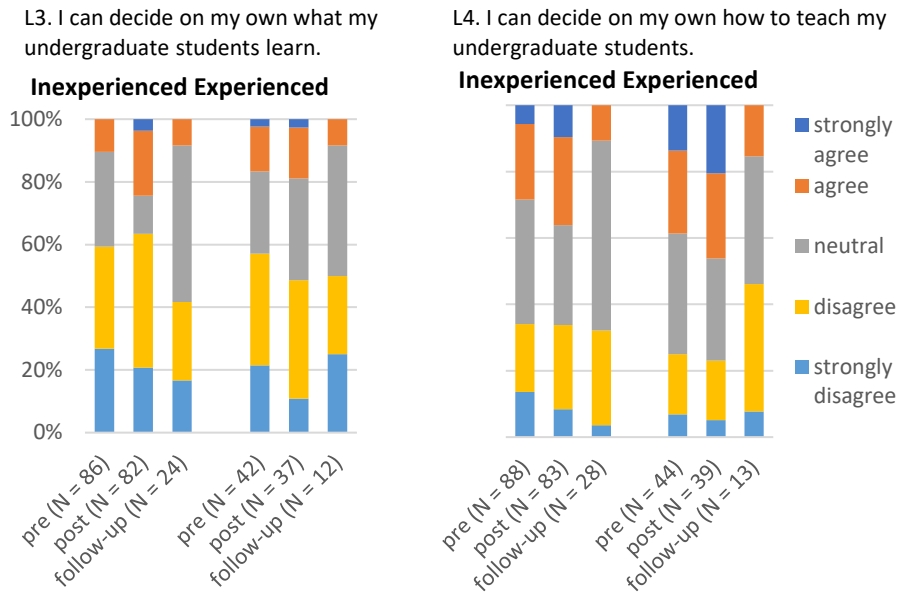


Figure 7. Comparison of inexperienced and experienced TAs' responses within the self-determination cognition to L3 and L4 immediately before (pre) and after (post) training program, and after one semester of teaching (follow-up).

Both groups of TAs indicated more control over method (L4) than content (L3) prior to teaching, with significant differences between within-group responses at all time points except experienced follow-up (inexperienced pre χ^2 (4, N = 174) = 15.6, p = .003; inexperienced post χ^2 (4, N = 165) = 44.7, p < .001; inexperienced follow=up χ^2 (4, N = 52) = 13.4, p = .009; experienced pre χ^2 (4, N = 86) = 27.0, p < .001; experienced post χ^2 (4, N = 76) = 44.7, p < .001) (Figure 7). A temporary significant impact of the training program was present in the post-responses of the inexperienced group to L3 (χ^2 (1, N = 168) = 5.7, p = .02), potentially reflecting an incorrect perception that they would have more decision-making power based on the program. The decrease in perceptions after the semester may indicate these TAs' recognition of the design by others that goes on prior to them teaching, similar to L1. There were no significant changes between any group or time point for L4.

Possible approaches to increase self-determination include asking TAs for suggestions to improve teaching, and adopting their feedback regarding teaching resources.

Meaningfulness

In marked contrast to the self-determination data, the TAs who attended this program found their teaching roles extremely meaningful. Item L5 had extremely positive responses in both groups (Figure 8), consistent with data reported by Flaherty et al. (2017b) for their post-survey.

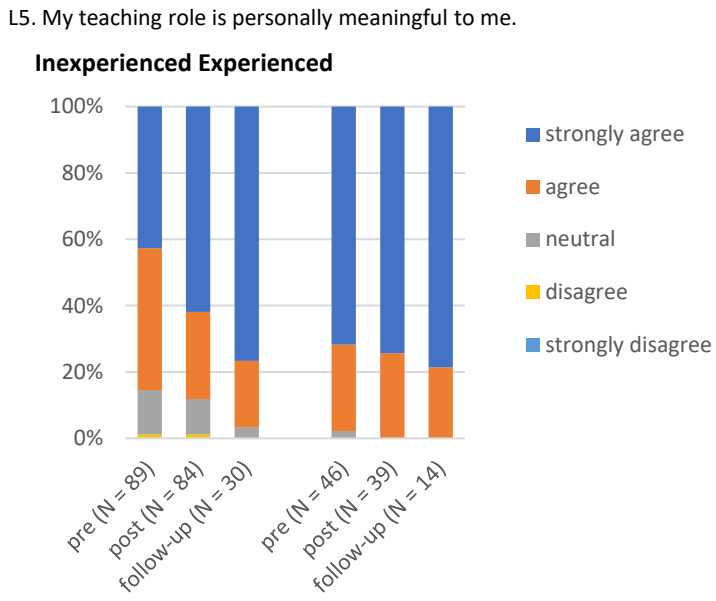


Figure 8. Comparison of inexperienced and experienced TAs' responses to L5 (meaningfulness) immediately before (pre) and after (post) training program, and after one semester of teaching (follow-up).

Supervisors need to be aware of this strong agreement of inexperienced TAs who are largely research students. Some supervisors treat teaching demands on postgraduate students' time as an inconvenience, taking them away from their research (Shortlidge & Eddy, 2018). However, few TAs will have a career in a research-only role, so the transferable skills and experience that they accumulate during their teaching are critical to their future working lives (Deloitte Access Economics, 2014).

There was a significant difference between the groups at the first two time points (pre: χ^2 (1, N = 135) = 5.0, p = .02; post: χ^2 (1, N = 123) = 5.05, p = .02) (Figure 8). For inexperienced TAs, the steady significant increase in agreement (post: χ^2 (1, N = 173) = 6.4, p = .01; follow-up: χ^2 (1, N = 119) = 10.4, p = .001) indicates that their teaching made it more meaningful to them, presumably through their interactions with students. Experienced TAs did not show any change on this item; their choice to continue to work in this role is likely motivated by this empowerment cognition.

Safety

Before analysing responses to item L8 we removed the few respondents who indicated that their role did not involve any laboratory or field work. The resulting data (Figure 9) agrees with Flaherty et al.'s (2017a) finding that chemistry TAs perceive that imparting safety awareness is important.

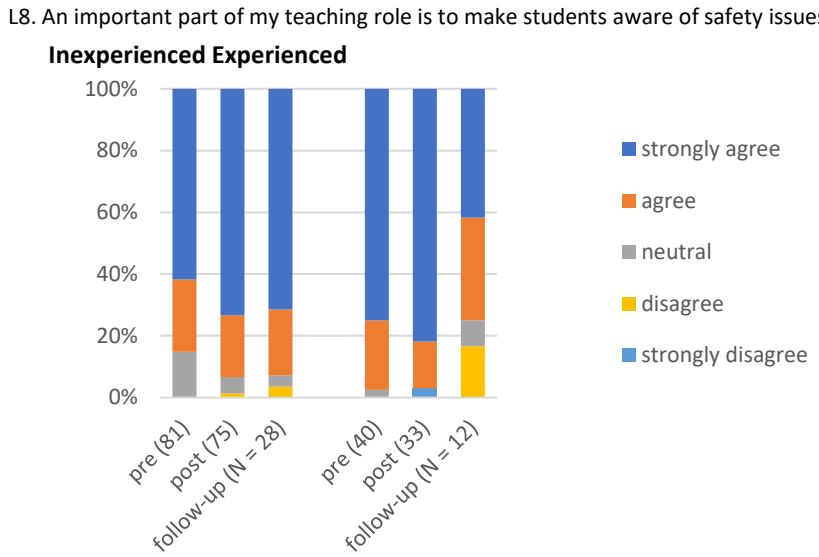


Figure 9. Comparison of inexperienced and experienced TAs' responses to L8 (safety) immediately before (pre) and after (post) training program, and after one semester of teaching (follow-up).

The follow-up responses of the experienced TAs showed a significant drop in agreement (χ^2 (1, N = 52) = 6.6, p = .01) (Figure 9). This was a small sample, but the result is still of concern. It is possible that it reflects the reduction of safety hazards in first year practical sessions through careful design of activities. Surprisingly, there was no difference in this data between 2019 and 2020, when most laboratory and field work was moved online.

Identity

TA development from senior researcher to junior colleague, explored through L11, was expected to correlate with the experience of the TAs, so we anticipated lower agreement with higher experience.

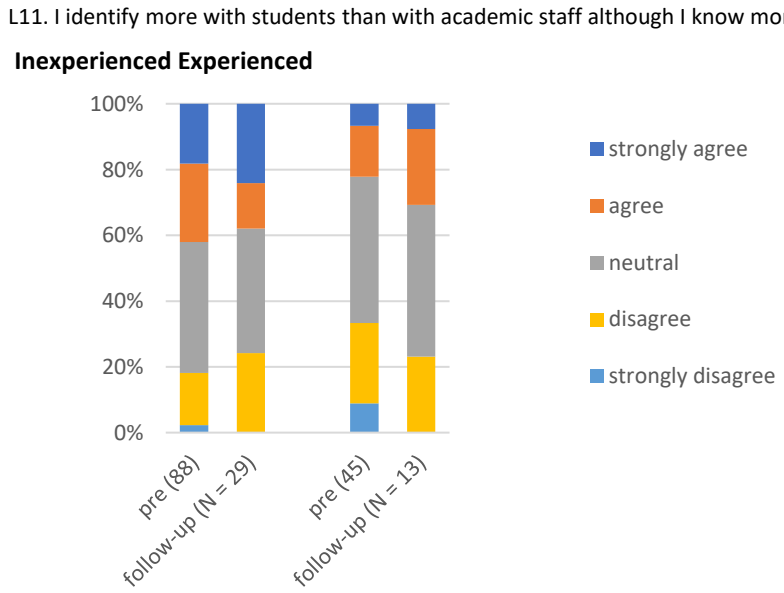


Figure 10. Comparison of inexperienced and experienced TAs' responses to L11 (identity) immediately before (pre) training program and after one semester of teaching (follow-up).

There was a statistically significant difference between the two groups in the pre-survey, with the experienced group having less agreement, as expected based on the question (χ^2 (1, N = 133) = 5.1, p = .02) (Figure 10). It is possible that some TAs interpreted the question to be asking whether they empathised more with students, which is likely to increase over the semester as they interacted with students.

Open ended comments

Pre-survey

The full set of themes can be found in the Supplementary Material; numbers in parentheses refer to the number of responses coded to each theme. The major theme of what participants hoped to gain from the session was teaching strategies and pedagogical tools (74). Minor themes were increased teaching confidence (12), information about expectations of their roles (11), student well-being (10) and networking with teaching teams (7). These themes were consistent across both new and repeat attendees. A representative quote from an inexperienced attendee was:

> *Learn strategies and bring knowledge and transferrable skills across and learn how to deal with groups of students being heterogeneous in skills, knowledge, motivation, cultural background etc*

When asked about situations they had previously encountered that they were not comfortable dealing with, 41 examples were given of students who sometimes behaved inappropriately during classes, such as by being passive or uncooperative. The same respondent as above gave some details of a typical challenge:

> *In prac: one student never engaged. Hardly talked with other students, didn't do the tasks (sometimes watched other students doing them). I tried to talk with him but he was very evasive. I feel like he needed help, but I could not get through to him.*

A more confronting response was received from a very experienced participant, who stated:

> *When a student physically threatened me demanding mark change.*

Additional specific challenges were mentioned, such as students insisting on being given answers or demanding extensions on tasks, which TAs are not authorised to approve.

Twenty-two responses indicated awareness of a lack of confidence or skill and 10 referred to behaviour of colleagues or the institution as causing difficulties. There were also multiple challenges (9) noted by TAs related to student diversity including language barriers and disabilities, as illustrated by the first quote above and the following quote from an experienced TA:

> *I feel a little unsure dealing with [disabled] students. I want to offer them support and understanding but don't want it to seem like favouritism or making a big deal out of their problems.*

Post survey

A range of responses was received for the most useful aspect of the program, with participants mentioning specific sessions: feedback (21), pedagogical theory (21), specific teaching strategies (18), aspects of their teaching context (16) and the opportunity to interact with other TAs (15). This broad range of responses supported our structure of offering a wide selection of sessions (Figure 1). The new session on dealing with difficult situations was mentioned in 12 post-survey responses in 2020 as the most useful part of the program, and a further four

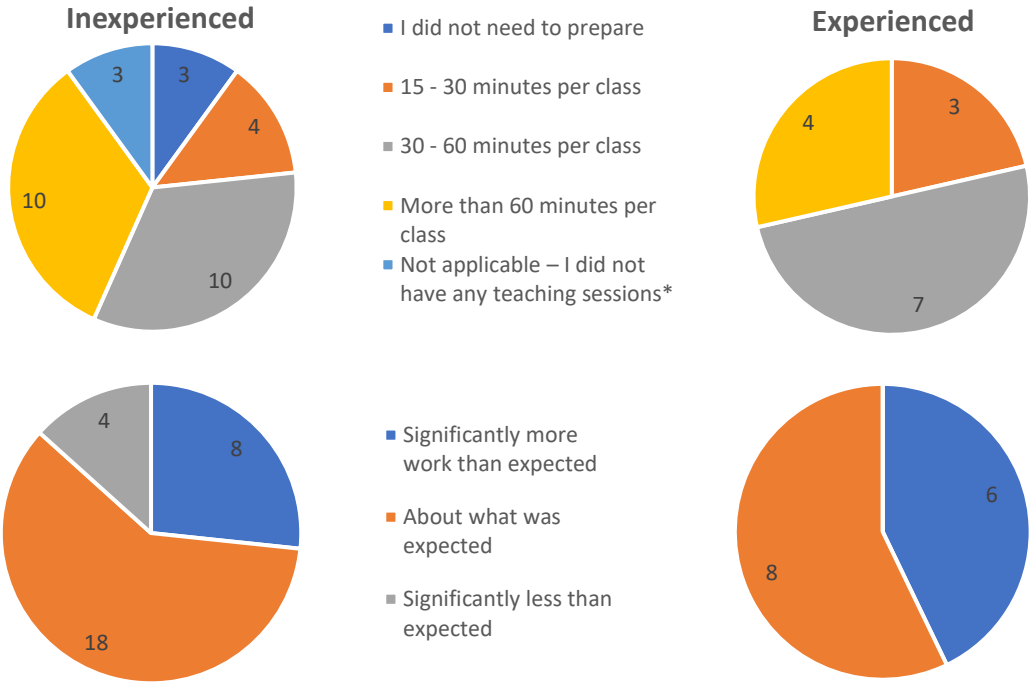
responses stated that the whole program was useful. This validated our inclusion of this specific session. Supporting the overall structure of the program, a 2020 participant stated:

> *The activities really made you to think about how students actually process the points you are trying to get across.*

The vast majority of respondents, 94% of inexperienced and 76% of experienced, anticipated modifying their teaching practice as a result of attending the program. TAs planned specific changes to their teaching practices with respect to: being aware of student needs (18), providing effective feedback (13), and new engagement (6) or pedagogical (6) approaches. Six respondents mentioned adjusting their interactions with colleagues. Even highly experienced participants expected to make changes to their teaching.

Follow-up survey

The follow-up survey asked respondents about the preparation time for their role, and how the workload matched their expectations. The data are presented in Figure 11; fewer responses were received compared to the pre- and post-surveys.



** These respondents were from 2020, when most face-to-face teaching was cancelled.*

Figure 11. Follow-up survey responses regarding preparation for teaching for inexperienced (left, N = 30) and experienced (right, N = 14) participants. Follow-up survey N shown for each category.

To our surprise, the experienced group did not have a better appreciation of the amount of work required, and most required a similar time to prepare as the inexperienced group. Possible explanation for this are that experienced TAs are more likely to teach in roles with greater responsibility, such as tutoring or supervising other TAs, where more preparation is needed, or move into teaching new courses, requiring intensive preparation each semester. There was no difference in these responses across the two years of the program. Although teaching was moved online in 2020, student numbers were unchanged.

After a semester of teaching, most (70% of inexperienced, 57% of experienced) respondents indicated that the program had impacted their practice, with five specifically stating that they gave more consideration to students' perspectives and addressing student concerns, four mentioning pedagogical approaches and three naming specific teaching strategies that had been implemented such as use of polling software to gain immediate feedback modelled in the program.

Two participants cited an increase in their confidence and gave examples of scenarios that they were able to manage after the training, such as the following quote from an inexperienced TA:

> *Due to the workshop, I was aware of the idea of helping the student build on their existing knowledge and skills instead of just rushing and giving them the answer. I therefore began by asking about whether the students had gone through the examples … …and stepped them through … If they were not on the right track, I redirected them to the information in the introduction presentation and gave them the time to think about then try again.*

The responses indicated that even though the program was one-off, it did make a difference to teaching practice, even for participants who had been in TA roles for 3 or more years. This shows the importance of even a short training program for TAs who may have had no prior training (as shown in Figure 4).

Respondents were asked about the most rewarding aspects of their roles, and eleven indicated that positive interactions with students were a highlight. A representative quote from an experienced TA shows that this does not get old:

> *Seeing students get excited about science in prac classes. Satisfaction of sharing my knowledge and skills.*

In 2020, multiple comments on the follow-up survey referred to different aspects of teaching online because of the COVID-19 pandemic. Their experiences are being further explored and those data will be reported separately.

Limitations of this study

A possible limitation to the interpretation of our results is that survey participation was self-selected (Bethlehem, 2010). It is likely that the choice to respond relates to participants' goodwill and personal relationship to their role. Response rates for the pre- and post- surveys were high, but the follow-up survey had low completion rates and therefore those responses cannot be considered representative. Also, those participants who completed surveys in both years have been treated as separate respondents. However, their responses were provided separately relating to their roles and perceptions in different years. Finally, the lack of pilot testing of the survey questions to ensure validity constitutes a significant limitation. These limitations do not invalidate our conclusions, which highlight issues that were raised by those who chose to respond (Chan, 2009).

Conclusions and implications for practice

The data collected in this study provide important insights into the lived experiences of TAs across science disciplines (Bryson, 2013), and the complex challenges that they face. A one-day training program designed following recommendations by Gardner and Jones (2011) was valuable even to experienced TAs, particularly the strategies to deal with difficult situations. A majority reported changing their teaching approaches in response to the program.

We found that all aspects of empowerment increased with experience. Among the empowerment cognitions, self-determination was expressed most weakly in the TA role. We recommend explicitly addressing educational design choices so that TAs are aware of the rationale and can adopt and support the chosen content and approaches. In addition, asking TAs for feedback on learning design and materials, and acting on this, should increase their self-determination. Meaningfulness was the most strongly expressed cognition and was also the most impacted by experience. Simply put, our TAs loved teaching and interacting with students. In the follow-up survey, this was reflected by the number of positive accounts TAs shared when asked what they found most rewarding about their role.

The key challenges for TAs were multiple facets of student behaviour, including students not participating, rejecting support and demanding answers, similar to issues faced by schoolteachers (Balson, 1992), but made more challenging in the higher education context because of the often smaller age differences and lack of hierarchy between TAs and their students. Effective training must incorporate recognition of the complexity of TA roles, and support TAs to manage the difficult situations that arise in their teaching environments, but also help them realise the limits of their responsibility.

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