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Fostering interdisciplinary skills in doctoral students from across the disciplines on an English for Special Academic Purposes (ESAP) course

Jennifer Skipp[4]

ABSTRACT

Universities have increasingly placed interdisciplinarity at the heart of their mission statements (Bridle et al., 2013). Yet, despite its integration into postgraduate programmes, research projects, conferences and workshops, the realisation of the interdisciplinary agenda can be problematic (Murdoch, 1992). In part, this is due to the continued focus on disciplinary socialisation at the postgraduate level (Holley, 2017), meaning that doctoral students are often unaware of what other disciplines do; lack experience of working or communicating with those outside their field; and might have a reluctance or lack of confidence to do so. Additionally, while collaboration and communication across the disciplines are deemed central to interdisciplinary endeavour, there is little guidance on how this can be encouraged at the doctoral level. These issues are evident in the English for Special Academic Purposes (ESAP) classroom which often requires doctoral students from diverse disciplines to work together. To address these problems, this paper will describe a tool designed for use in the doctoral ESAP classroom at a European university. The tool adapted elements of Karl Maton's (2013) Legitimation Code Theory (LCT) to help raise awareness of how to communicate with those outside the student's own (narrow) field. The paper evaluates this tool through a quantitative and qualitative analysis of post-course evaluations. In doing so, it highlights how the tool helps students see how they can adapt their contextualised knowledge and specific disciplinary language to their audience. One key advantage of the tool is that it enables students to retain discipline identity whilst giving them a means to appreciate non-disciplinary perspectives (Lattuca et al., 2013) or find common ground (Repko, 2008) or discipline interdependencies (Ashby & Exter, 2019), competencies recognised as key for interdisciplinary success.

Keywords: interdisciplinarity, ESAP, doctoral students, interdisciplinary skills, Legitimation Code Theory

[4] Senior Lecturer (freelance), Language Centre, University of Luxembourg and Senior Lecturer, English Studies, Trier University, Germany. Email: skipp@uni-trier.de

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1 INTRODUCTION

Working collaboratively in groups where members have diverse but complimentary experiences and qualifications has become a cornerstone of global efforts to address the world's urgent challenges (Holley, 2017). Such approaches have and are being taken, for example, to tackle climate change and health crises. Higher education has both encouraged and responded to such imperatives by instituting inter-, trans-, multi- and cross-disciplinary programmes, research centres and conferences (Bridle et al., 2013; Murdoch, 1992; for a review of each of these terms see Ashby and Exter, 2019). It is possible to refer to these efforts of working across disciplinary borders collectively as interdisciplinarity.

Interdisciplinarity has become seen as 'a desirable element of higher education' (Ashby and Exter, 2019, p. 202). Additionally, many professional bodies have also placed emphasis on the need for their members to work across disciplines. The Institute of Medicine in 2003, for example, recommended that its members have the ability to work in interdisciplinary teams with an awareness of the roles and responsibilities of each team member to create more holistic healthcare (Doulougeri & Montgomery, 2019). Thus, the increasing predominance of working across disciplines at universities and in professional capacities suggests that interdisciplinary values and skills are important to students in general and those in the early stages of their academic careers, in particular.

Interdisciplinary competencies are diverse. They include recognising disciplinary limitations; evaluating each discipline's potential contribution; reflecting on biases; and integrating or synthesising discipline elements (Lattuca et al., 2013). However, they also include an appreciation of disciplinary as well as non-disciplinary perspectives (Lattuca et al. 2013); acknowledging discipline or topic interdependencies (Ashby & Exter, 2019) and finding common ground (Repko, 2008). This second set of skills relies on good collaborative and communication skills to both facilitate and articulate these competencies (Ashby and Exter, 2019; Holley, 2017). Yet, there is little practical advice on how these can be integrated into curricula. This is despite poor communication and failure to appreciate the perspective or role of others being frequently seen as a root cause of the failure of interdisciplinary collaboration (see for example Doyle 2008). As Murdoch notes: 'Interdisciplinary co-operation is often hampered by communication difficulties between specialists representing different fields. Special terminologies have often developed over long periods of time and are extremely useful in disciplinary discourse. To the outsider, however, they typically appear as secret languages' (p. 51). If, as Aldrich (2014) states, interdisciplinarity serves as a form of communication between disciplines, then it makes sense to offer doctoral students who are engaged in or are likely to become engaged in interdisciplinarity a systematic means of communicating beyond their discipline.

The English for Specific Academic Purposes (ESAP) classroom is a potential space that could address this deficit as efficacious communication and addressing a target audience lie at the heart of intended outcomes. ESAP has often been associated with delivering courses within discipline

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contexts to increase students' discipline literacy. However, it can also refer to learning about and using English for a specific purpose such as research writing or conference presentations. Indeed, it is a conference skills course that provides the context of the present study.

This paper precedes by discussing this context and the problems of students from across disciplines working together therein. It establishes this problem through the analysis of anonymous pre-course questionnaires completed by course participants. It then describes the tool developed to address this problem and explains how it drew on Legitimation Code Theory (LCT) in its design. The use of this tool in teaching is explained and evaluated. Evaluation is through a quantitative and qualitative analysis of anonymised post-courses questionnaires. Lastly, it reflects on the value of the tool.

2 CONTEXT

This paper is based on a conference skills course for doctoral students taught at a multilingual university. The course was taught in 3-hour blocks over six weeks; with the assessment in the final week. The non-graded assessment was a 10-minute presentation to the class followed by a Q&A, and had to show evidence of course learning. Feedback was provided by class peers and the instructor. The course content deals with the basics of preparing and delivering a conference presentation, including scope and depth of content; structure; slide design; presentation delivery and managing questions. The students work together closely, and the learning is highly interactive. To facilitate this interactivity and the productivity of the peer feedback, it is ideal if the students develop a rudimentary understanding of what others are working on. However, as the course is available university-wide, the cohort of 10 students was multidisciplinary.

Group heterogeneity, such as on this course, can be perceived to be a disadvantage, particularly by the students themselves. This is because, at this level, students have usually become well socialised in their discipline and perceive their discipline identity as key to academic success (Baker & Lattuca, 2010). This has been influenced by the prevailing belief that access to a research community happens through a novice 'aligning themselves with the socially shaped identities of their communities' (Hyland, 2002, p. 1091) by appropriating the norms, values, attitudes, knowledge, and skills of their discipline or research community in their work. In developing such an identity, postgraduate students can become socialised in a relatively narrow manner (Holley, 2017). Indeed, even those working in interdisciplinary fields, such as urban studies, have become socialised in a narrowed and specific context.

The immersion of students in the language and culture of their field can result in significant barriers when put together in multidisciplinary cohorts. Firstly, it may have been a considerable time since they have encountered students from other fields (Brodin & Avery, 2020). Secondly, socialisation, specifically the impetus to be conversant in the language of their field, means mastering highly specialised English which can be at the expense of the continued use and development of more general English (GE). This, in turn, can result in an inability to explain research without recourse to disciplinary specific terms, resulting in an insecurity to do this when confronted with non-specialists.

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There is evidence of these issues in the pre-course needs analysis questionnaire (N=10). In these surveys, half the participants said that they were not used to presenting to a non-specialist audience. This stands in contrast to the eight students who agreed or strongly agreed with the statement that they were required to present to a non-specialist or interdisciplinary audience as part of their studies. Thus, there is clearly a need for doctoral students to become more conversant in addressing diverse audiences. Half stated that they agreed or strongly agreed that they lacked confidence when talking to people from different fields, and four that they had difficulty expressing themselves in general terms. A chief concern of over half the class (N=7) was the idea that non-specialists would not understand them. This suggests that students do not think their disciplinary language translates to those from outside their field and that they have not been trained in how this can be done. It points to a lack of awareness of how language can be used to simplify communication of complex research ideas. There is a belief that those outside the student's field would not understand their research context and vice versa, as supported by the 8/10 students who agreed or strongly agreed that a lack of knowledge about what other disciplines do makes it difficult to communicate with those outside their field. In short, the two key problems are that:

1) Doctoral students lack knowledge about the working practices of other fields or the experience of working with them.
2) Doctoral students lack skills that could help them communicate their ideas to non-specialists.

The premise of this study, therefore, was to facilitate multidiscipline doctoral students in working together by providing ways for them to communicate their specialised knowledge more efficiently and effectively to a non-specialist audience. It was important to design a tool that acknowledged the importance of disciplinary expertise required in postgraduate socialisation but opened opportunities to develop collaborative and communicative interdisciplinary competencies.

2.1 Developing the tool

Inspiration was drawn from the work on knowledge theory, Legitimation Code Theory (LCT) in particular. LCT is a sociological framework, developed by Karl Maton as a practical way to map thinking and knowledge practices. Whilst Maton developed numerous branches of LCT, the one which inspired the tool used here is that of semantic codes as it is the branch which is best suited to seeing the connection between knowledge and communicative language.

Maton's ideas are built upon those of Bernstein who classified everyday knowledge as 'horizontal discourse' and educational knowledge as 'vertical discourse' (in Martin et al., 2020, p. 157). Maton's concept of semantic codes includes the notions of semantic density and semantic gravity. Semantic density refers to how much meaning something contains or the number of meanings a word can have. Ingold and O'Sullivan describe this as the 'power' terms can have which strengthens as the simplistic is made more 'meaning-packed' (2017, p. 40), or specific and specialised. Semantic density becomes weaker when 'technical concepts' are 'unpacked' into

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simplified, everyday language (Martin et al., 2020, p. 22). Semantic gravity is the degree to which meaning relates to context and this becomes weaker when meaning is less dependent on context, and more generalised (Maton, 2013). Semantic gravity is stronger when meaning is more dependent on context, 'packing' knowledge into more concrete and localised examples. While LCT sees this as correlating with real-world contexts, it could be said that for postgraduates their local context is contingent on their narrowed and specific object of enquiry.

LCT is, however, not only theory, but has also been applied practically. For example, it has helped to inform curriculum design in a wide range of fields (see Tilakaratna et al., 2020 for an example from nursing), including interdisciplinary curriculums (Maton, 2018). It is also frequently applied in teacher-training programs, where semantic codes can be used as a principled approach to design lesson sequencing (for a recent report see Rusznyack, 2022). In addition to planning, it has been successfully implemented into the classroom context. Indeed, Maton intended LCT to be 'a toolkit' for educational practice (2014, p. 17) and semantic codes have been used effectively in the field of E(S)AP teaching. Ingold and O'Sullivan (2017) have noted the success of using LCT to help students visualise and organise their ideas in writing. Focusing on text composition, their use of the visual 'wave' which moves from the general and abstract to the specific and concrete, was a useful scaffolding tool for their learners. Others have used the tool as a useful way to bridge writing instruction with disciplinary knowledge building: Szenes et al. (2015) in business and social work; Kirk (2017) in anthropology and David Munn (2021) in international relations. Munn (2023) updated his approach to using LCT in his teaching to include a pyramid profile which assisted his learners to apply semantic gravity during the research phase of their writing. This aimed to ensure that students recognised general points during their reading, noting that these served as a basis for broad-based support, which in turn led to recognising specific and concrete case studies. Munn used this approach to demonstrate how each 'level' was necessary to achieve structural integrity of the pyramid, with the specific supported by the more abstract and general. This idea has been highly influential in the approach taken here.

There is, however, less research on using LCT and semantic codes to inform oral production and communication. One important study is that of Cranwell and Whiteside (2020) who analysed the spoken discourse of seven high-school and university teachers explaining a concept in chemistry. They found that at the university level, the concept was often presented with a lower level of semantic gravity more consistently. It was made more concrete, 'unpacked' or explained less often and to a lesser degree than when presented at school, remaining more abstract as instructors expected students to draw on their previous knowledge. These findings, whilst small-scale, have significant implications for expectations of how university students learn to communicate knowledge in their subject. It posits that due to less undulation between degrees of semantic gravity during instruction, university students, including graduates, are potentially less able to explain their own field or research through unpacking and repacking strategies.

Underlying all applications of LCT in an EAP context, is the understanding that the audience plays a central role in communication. Martin et al. (2020) classified 'knowers' using a triangle as a

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model to situate the 'ideal knower' or specialist audience at the apex and 'a range of novices', meaning general audiences and non-specialists, at the base (p. 17). As a central tenet of ES(A)P is adapting the purpose of communication to audience expectations, it is useful variable to build into the tool.

2.2 The tool

An intervention was designed to bring the useful ideas from knowledge theory outlined above to bear on the two key problems previously discussed. A pyramid-shaped model of communication was developed as a tool for application in class. The pyramid has four levels (Fig. 1). The base (1) represents a general audience who needs everyday language or General English (GE) applied to everyday contexts to process meaning. Level (2) represents an academic but non-specialist audience who still requires less specialised terms to make meaning but can process words that can be related to their experience of academic contexts (English for General Academic Purposes – EGAP). Level (3) represents discipline members who can understand those academic words in a more specialised context as they have experience of the field. Terms used here have disciplinary meaning and can be regarded as English for Special Academic Purposes (ESAP). In level (4) highly specialised words are made meaningful because of their narrow, highly specific context and can be used with an audience conversant with project specifics.

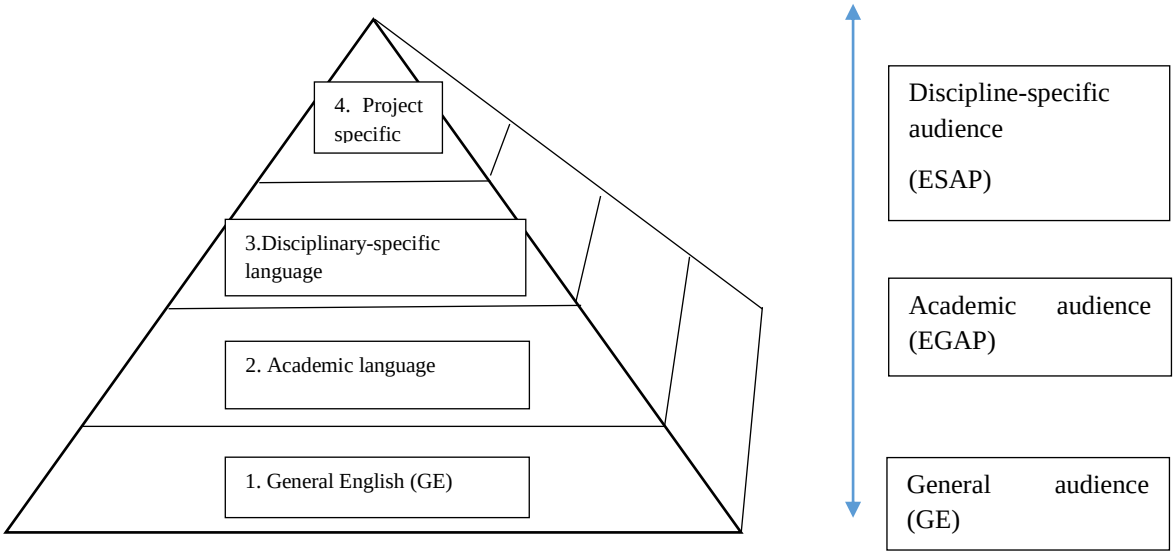

Figure 1. The Language Specificity Pyramid (LSP)

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The pyramid shape intends to demonstrate that highly specialised language (dense and contextualised) is built on the foundations of more everyday language and general academic language. Moving down the pyramid should help doctoral students to unpack the project and disciplinary language they have become accustomed to using into simplified language, applicable and understandable to those outside their field. This should therefore be beneficial to sharing knowledge and building understanding between them. However, the pyramid can also help students to realise that their language is made meaningful in a disciplinary or project-specific sense by adding terminological and contextual specificity as they move up the pyramid. Thus, packing or re-packing helps them to position themselves as a research-community member. The Language Specificity Pyramid or LSP thus incorporates gradations of general to specific audience, knowledge, context and language.

2.3 Classroom application of the tool

Table 1. Lesson plan indicating intended learning outcomes through the use of the LSP in classroom tasks

Lesson focus	**Intended Learning Outcome (ILO)**	**Task(s)**
Introduction of the LSP	Students use the LSP to explain research-specific ideas and terms by starting with everyday and more general academic language, then packing knowledge through project-specific details and language.	- Introduce your research to a general, non-specialist audience by explaining how three everyday words relate to your research project: important, difficult, change*. - First, explain how these words* relate to your research using words familiar to an academic audience (e.g. methods, data collection, variables, literature etc). - Explain this relationship further by adding discipline-specific vocabulary. - Explain further through adding project-specific details. Move back down the LSP when necessary. - Language of summary, description, explanation, comparison and analogy elicited/provided.
Presentation structure	Construct a macro- and micro- structure for a	- Introduce guidance on structure: macro-structure starts broad (introduction: the

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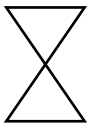
	conference presentation. 	how and why of the research:), becomes specific (body: methods, deliver and discuss findings) and ends broad (conclusions/implications). This also works at the micro level for the presentation of points and details (Alley, 2003). - Students use the double LSP to plot the main messages in each structural step. - Macro: Use GE and EGAP for clear messaging in the introduction and conclusion and more specialist terminology in the Methods, Results and Discussion - Micro: Points - levels: 1-3 → details - levels: 3 and 4
Answering questions	Answer questions appropriately	- First students identify types of questions that can be asked. - Use the pyramid structure to plot how to a) unpack technical questions to demonstrate depth of understanding and to assist non-specialist listeners, b) pack more general questions by moving up the pyramid with more complex and project-specific language use. - Students ask each other questions to practice.

The following reflects on each LSP task and how this required or exhibited competencies associated with interdisciplinary communicative competencies. In the session that introduced the tool, students were asked to verbally explain how the everyday words: change, important and difficult related to their PhD research. Before beginning, participants saw an example and co-constructed the language they thought would be needed to aid explanation at each level, for example, summary, description, explanation, comparison and analogy. Firstly, they could use EGAP, for example methods, data collection, variables, processes, literature etc., words familiar to an academic audience to explain the relevance of change, important and difficult to their research. Then, to explain more specifically why the EGAP word chosen is difficult, important or relates to change in their research they drew on more disciplinary-specific language. Finally, more project-specific terminology was added to their explanation. Students often needed to move back down the pyramid to unpack a term for their

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peers, but then moved back upwards to project specificity. Two examples of this task can be seen in Figure 2.

By scaffolding an explanation of their research upwards through the levels, they helped non-discipliners better understand specific terms than in a top-down pattern. This task also helped students to see that there are common grounds between elements of their research. Common ground was often experiential, meaning that it was something about the 'doing' of research that was difficult or important. Other interdependencies were linked to desired outcomes, often the attempt to convince policy makers of the need for change or institute societal change. Thus, common ground at levels 1 and 2 were acknowledged and divergence from this common ground demonstrated as they progressed up the pyramid (levels 3 and 4).

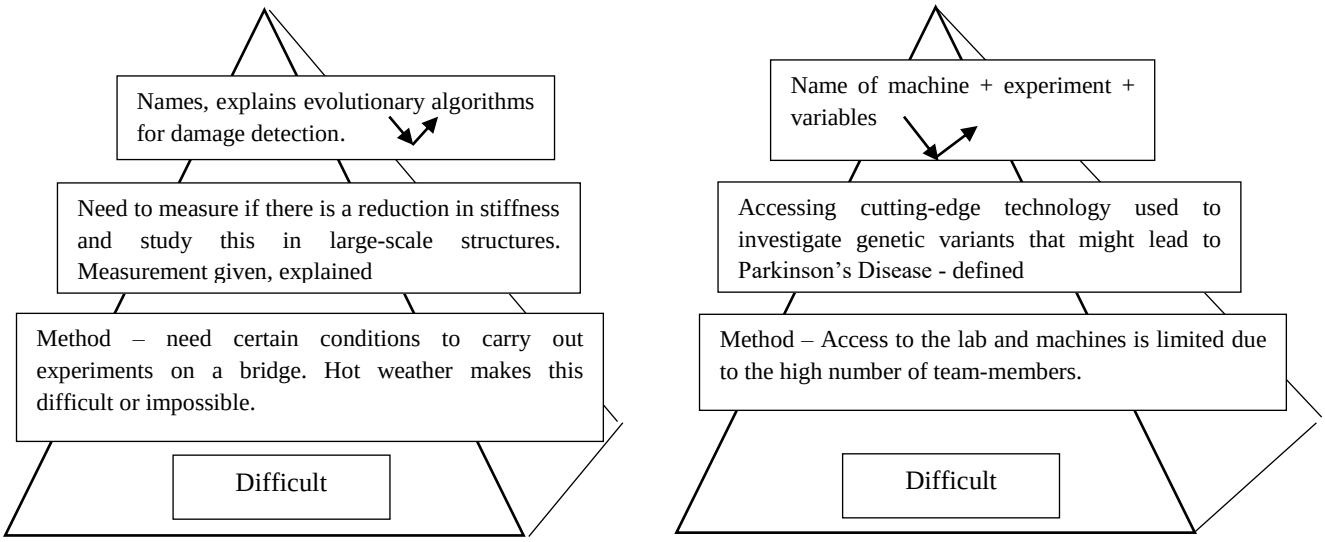

Figure 2: Building on everyday words with the Language Specificity Pyramid to reach project specificity: two examples.

In the session on presentation structure, the pyramid was inverted and joined to a second pyramid in an egg-timer shape. Students used this structure to present the key messages of each section, either with simpler language that made their messages clear, explicit and accessible in the introduction and conclusion, or using more concrete, project-specific terminology where meaning was more condensed and contextualised in methods, results and discussion. The tool was used to plot the macro-structure of their presentation as well as the micro-structure of point-details-analysis delivered in the main body of their presentation.

In the session on addressing questions, students were asked to use the pyramid to model responses to different question types. The task resulted in four different types of responses shown in Figure 3. Students identified questions which required the provision of more details: pattern (a). However, where these details were asked for by a non-specialist audience, response (c) would be required.

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Questions asking for clarification, particularly for a non-specialist audience would require response (b). However, with a specialist audience, this response should follow pattern (d) as the student repacks their explanation to demonstrate disciplinary and project-specificity. Visualising responses helped participants to see how they could balance addressing non-specialists and specialists and ensure their own credibility as a research-community member by re-packing their answer (d).

Response (a) Response (b) Response (c) Response (d)

Figure 3: Planned responses to anticipated questions using the LSP

3 METHODS

To determine how far the intervention addressed the problems previously discussed, a mixed methods approach to data collection was required. Angouri (2018) notes that meaningful combinations of methodologies can be useful for addressing practical problems raised in research questions. Newmann (in Johnson et al. 2007) concurs that a combination can reflect research questions better than either quantitative or qualitative could independently. Specifically, collecting both quantitative and qualitative data would not only provide an overview about whether the tool was useful through quantitative metrics, but would add detail and context about *how* students perceived it was useful through an analysis of the qualitative data. In this way, the quantitative analysis provides 'essential background to assist in the detailed qualitative interpretation' of the findings (Holmes and Meyerhoff, 2003, p. 15). Additionally, it may provide 'corroboration' of ideas expressed in responses to open-questions qualitatively analysed (Bryman, 2006, p. 105). The qualitative findings, in turn, provide 'illustration', 'elaboration' or 'clarification' of numerically-based responses (Green et al., 1989, p. 259 in Bryman, 2006, p. 105). Such between-method triangulation (Denzin in Johnson et al. 2007) allows a researcher to probe a data-set for meaning (Sechrest & Sidana, 1995) and provides a thicker and richer interpretation of the data that can increase the usefulness of the findings (Collins et al. 2006). This is key to assessing the efficacy of this intervention for this target group and its potential for future use.

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A quasi-experimental method was used, chosen because the group were known to me, thus not randomly selected, and, as there was only one cohort being taught at the time, no control group was available. Data was collected through an anonymised Qualtrics questionnaire. An anonymised questionnaire over, for example, interviews or a focus group, was preferable here because of the relationship between the instructor/researcher and participants. As Mallinson (2018) reminds us, expectations of and relationships between researchers and participants can 'raise complications' (68), including when the two are known to each other. Therefore, completion of the survey was on a voluntary basis and accessed via a link made available through our VLE (Moodle) immediately after the course. This self-administered questionnaire approach ensured that students could complete the survey away from the classroom and therefore removed from any associated pressures that may entail (Mallinson, 2018). Completion was not connected to an assessment or any credit points.

The questionnaire was comprised of 5-point Likert-scale questions, with 1 as not very useful, 3 as neutral and 5 as highly useful. It also contained open questions which specifically asked students to reflect and comment on the use of the tool. The methods followed the *Guidelines for Safeguarding Good Research Practice* of the German Research Foundation to ensure ethical compliance. While there was no obligation to answer the survey, all attendees responded (N=10). Thus, the sample was a multilingual, multidiscipline group of 10 doctoral students.

4 RESULTS AND DISCUSSION

All ten participants found the tool useful or very useful. In particular, they found the LSP useful for preparing the structure of a presentation for a mixed or non-specialist audience and for considering the language to use with these types of audiences (both 4.8 on average). This is supported by quotes from participants: 'I'll be presenting at an international conference that will gather people from the composite field but from many different disciplines. So I will present in front of a mixed audience. So this was useful.' Such responses suggest that the LSP can act as a useful guiding tool during conference preparation phases, especially when the target audience is non-specialist.

The utility of the tool for communicating with non-specialists is evident in the 9/10 students who answered that their ability to communicate with others outside their field had improved. This includes between the cohort themselves as all students strongly agreed that, by the end of the course, they could better communicate with those in the class. This was probably facilitated by tasks, such as Task 1 described above, as the LSP scored 4.5 on average for its usefulness in helping students to talk about their research in general terms. Being able to talk about academic endeavour more generally led to students appreciating the 'common ground' between them. Indeed, post-course, all participants agreed or strongly agreed with finding that they had more in common with their non-specialist peers than they had assumed. The appreciation of common ground can be seen as a key step to developing interdisciplinary practices in the future (Repko, 2008). Even for those students already working across disciplinary boundaries, the LSP was useful because it focused on communication in that process of collaboration. As one student reported: 'I'm working in a

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multidisciplinary project, so I'm always discussing my results to a mixed audience …where I have to adapt my speech in depth and scope to my audience. In this context, having in mind the language specificity pyramid helps me to communicate more efficiently'. The LSP can therefore help to place language at the centre of communicative efforts in interdisciplinary ventures.

Although experience with the tool might not have significantly increased the prospect of students purposefully choosing to present at non-specialist conferences (the likelihood was only 0.2 higher than pre-course), this quote reveals its advantage in this regard: 'I don't think the use of the pyramid influenced the likelihood of addressing one kind of audience or the other, but rather gave me the tools to address any of the two (specialist or non-specialist) more properly'.

Using the LSP to guide their presentation structure and to consider language specificity for a specialist audience were rated lower than for the non-specialists: 4.3 and 4.0 on average respectively. This lower rating is indicative of the fact that doctoral cohorts feel more comfortable addressing their research community in terms of the specialist language they can use and were perhaps less in need of guidance. Yet many found the LSP useful for reflecting on the reality of their 'specialist' audience at conferences already attended. For example, one student talked about expecting that conference attendees would be those who represented the apex of the LSP. However, attendees were primarily from levels 2 and some from 3, so that she was required to do much more unpacking of her research during the conference than anticipated during her preparation. Therefore, the LSP was useful for discussing how doctoral students have constructed and understood their discipline and how their research is significantly more specific and contextualised than many other discipline-members would have experience of, so a degree of medial movement is often still required even when addressing 'specialists'. Developing this skill is important as it is this medial movement where topic or discipline interdependencies (Ashby & Exter, 2019), key to interdisciplinary collaboration, might be identified. Participants did not consider that medial or baseline movement to simplify their specific and contextualised research compromised their disciplinary identity. While only two participants agreed that their disciplinary identity had strengthened by acting as a research community representative on the course, none said it had weakened. This suggests that disciplinary identity remains intact because the tool offers the possibility of moving back up to specificity of meaning and context.

All respondents said they could see themselves using the LSP in the future. One student said that they would use it 'as a tool to structure my talk'. Most comments on possible future use focused on its potential for pitching to the target audience: 'I think it is really useful to have a conceptual framework of what level of depth each audience needs, so I am sure that I will take this into account when preparing for future conferences'.

5 CONCLUSIONS

This study suggests that the LSP may be useful as a tool to guide communication, particularly between those from different research communities, and facilitate collaboration and meaningful interactions in the ESAP classroom and beyond. The tool offers a means to address the lack of

guidance about how to communicate effectively across disciplines which is being increasingly required in interdisciplinary academic and professional environments and can help to position its users as individuals who can communicate across borders. By using a pyramid, it is possible for students to see the efficacy of moving upwards and downwards for meaningful communication dependent on audience. It was apparent that this was required not only to consider language adaptation for a non-specialist audience but also to move medially to place highly specific details into more general disciplinary and academic terms (Holley, 2013). Using the pyramid structure to return to more specialised, disciplinary language through packing or re-packing, means that students do not undermine themselves as representatives of their discipline and their identity remains intact. This is key considering the disciplinary socialisation that doctoral students have undergone and the continued belief of its importance in joining research communities.

Bridle et al. (2013) found positive results from purposefully convened interdisciplinary workshops and Brodin and Avery (2020) noted greater collaborative tendencies and interdisciplinary thinking in doctoral students who were immersed in a well-designed interdisciplinary environment. This study also suggests that scenarios that bring together diverse disciplines can be beneficial and result in fostering interdisciplinary skills so desired by modern-day academia, professional practice and industry if they are supported by effective tools.

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