Accelerating Higher Degree by Research (HDR) Mechanical Engineers' academic writing skills: an analysis of the development and initial outcomes of a novel visual-spatial, physical-tactile, integrated English language learning intervention, drawing on Engineering modes of cognition.

Aim

The aim of this on-going project is to mitigate the issue of the skills discrepancy between Engineering and Academic Language facility for English as an Acquired or Second Language or Dialect (EAL/D) Engineering Higher Degree by Research (EHDR) students through Participatory Action Research (PAR), using an intervention created after investigating EHDR modes of cognition, allied with pedagogies for gifted and talented students and a systemic functional linguistics (SFL) approach to language description and usage. Testing is currently underway to evaluate this intervention and measure its degree of efficacy on accelerated language learning.

Methodology

The purpose of this Participatory Action Research (PAR), as outlined by Cohen, Manion and Morrison (2011), is to create, implement and evaluate a novel visual-spatial, physical-tactile, English language learning intervention, designed to align with Engineering modes of cognition, to accelerate effective research writing practices critical to supporting Engineering publication. PAR is an active, dynamic research model that is aligned with this early research, which sets out to demonstrate both the need for remediation and a response framework, tested against small focus groups using selected groups of participants: the EAL/D, EHDRs, a group of academic linguists and a group of supervisors. It offers a cyclical pattern of responses (PAR *Spirals*) that both engages the participants actively in an egalitarian approach to teaching and learning and is constantly evaluative, giving dynamism to all elements of the process.

The project is designed to enable Engineers to increase their control of academic English in line with their Engineering skills, using an SFL model (ISFLA, n.d.), which acknowledges meaning-making as a *social practice*, aligned with Engineering modes of cognition. The system will work well with native speakers of English but should have particular value for EAL/D, EHDR students who need to accelerate their learning of academic English in order to achieve effectively in their studies. The International English Language Testing System (IELTS) (IELTS, n.d.) itself acknowledges that a) postgraduates showed a lower rate of improvement in mastery of English than undergraduates and b) that the impact of language contact outside the university had a stronger impact than that within it. Furthermore, Writing

induced the lowest average improvement of all the four elements: Reading, Writing, Speaking and Listening (IELTS, n.d.). Thus it is vital that HDRs who need to complete milestones, publish (particularly for those attempting a thesis by publication) and are assessed primarily through the written word, be offered a tailored, visual-spatial, physical-tactile, positive model of English, aligned with familiar cognitive approaches to learning, rather than assuming that the most able will acquire sufficient English for their needs through established, traditional methods.

Context

The feeling of falling behind in English can also contribute to well-being issues amongst the EAL/D, EHDRs. Native speakers of English frequently suffer from anxiety-related tensions such as Imposter Syndrome, a form of chronic self doubt which can destroy students' chances of completion (Caltech Counselling n.d.): if the inability to connect quickly and easily, linguistically and culturally, with one's peers is added to the mix, the results can potentially be catastrophic due to the high level of isolation experienced. The apparent regression in learning felt by EAL/D, HDR students can be redressed through positive teaching of academic language skills in a familiar cognitive environment, thereby increasing the positive interactions of what Csíkszentmihályi (2008) identifies as the eight key mental states that operate during the learning process. Of these eight, *flow* is the optimal state wherein learners are fully immersed in the task, to the exclusion of all else. Where learners are working in an additional language of which they have yet to gain mastery, flow may well not be achieved, as anxiety will undermine the autotelic experience of flow, undermining deep learning.

Alongside this, from the perspective of Gifted Education, Gagné (2010) sets out four different domains of naturally occurring abilities that he terms 'giftedness'. Engineers will demonstrate at least two types of these abilities, falling into both "intellectual" and "sensori-motor" giftedness (Gagné 2010). For Gagné, the learning domains are separate and any individual's location on the continuum from giftedness to talent is not only fluid within a domain but, more significantly, across domains. The talent fields are the specific learning areas: if there is a fracture in the level of attainment between two dependent fields (Engineering and Academic Language skills in this case), this will affect the aptitude domains of intellectual, creative and socio-affective mastery, concomitant with flow or engagement (Gagné, 2010). Furthermore, the idea that Engineers think in a specific way, that is, they have visual-spatial, physical-tactile approaches to high level problem solving, is well established in the Engineering literature (Godfrey, Crick and Huang, 2014; Fordyce, 1988; Kellam, Maher and Peters, 2008) but not necessarily addressed in current Academic Writing courses which tend to teach *en*

bloc, where, in fact, the different Schools/Faculties and paradigms require subtly different foci which are facilitated by variant favoured forms of cognition. It is, therefore, crucial to find a compatible way of teaching and learning writing skills for Engineers in order to accelerate academic language proficiency.

To teach English appropriately may well help to alleviate the high attrition rate amongst HDR students (for example, the University of Arizona put their attrition rate at 36%, whilst a study of the cohort in the whole of the USA put the national attrition rate at 80%) (Kiley and Mullins, 2004), a matter of key economic import to universities worldwide, as well as increasing confidence, engagement and academic writing output.

The system under development also incorporates an understanding of the concept of *noise* (interruptions to learning and understanding) (Dowling, Carew and Hadcraft, 2013), evaluating learning in terms of converting noise into a positive, rather remaining a deficit element of the learning mode; thereby providing students with mechanisms for finding *coherence* in meaning-making. In the early Shannon-Weaver Mathematical Model (Dowling, Carew and Hadcraft, 2013), the transmission of knowledge process is linear, with noise as the intervention, preventing meaning-making. There is now a range of transmission models available: all the current models focus on the transmission of information; however, more recent models are less hierarchical in nature and locate the actant (the instigator of learning) and reactant (the learner) as being equal partners in meaning-making. Foulger (Dowling, Carew and Hadcraft, 2013) moves towards an acknowledgement of the social elements of meaning-making in his model. Maxwell's more recent model (Dowling, Carew and Hadcraft, 2013) shows the process of delivering a package of messages in an Engineering context and increases the acknowledgement of the nature and impact of noise on and within meaning-making. Contemporary models are increasingly sophisticated, acknowledging that the role of meaning-making does not purely reside with the initiator of the communication, or *information source* but also actively resides with the *receiver*, where the recipient is in a turn-taking position in each interaction. For Kress (Lock, 2010), it actively resides with the "receiver, or decoder", as, for him, language only has meaning at the point of use, rather than being inherent in the code. Kress suggests that there are five key areas of social context which impact on language development for learners: teacher and learner expectations; the need for communication for academic purposes; EAL/D language issues; scholarship and academic constraints; along with the modes of assessment of academic work. This new model seeks to address these issues in a visual-spatial, physical-tactile way that is aligned with Engineering modes of cognition.

The key difference between original and contemporary models of meaning-making lies in the perception that there are two critical elements of meaning-making: one is *understanding* and the other is *communication of understanding and resultant novel concepts and research*. It can be argued that for many Engineers, *understanding* comes from meaning-making from the range of mathematical, diagrammatic and visual signs used to describe and analyse practical experience. These understandings need not necessarily be mediated through technically accurate English. As soon as it is recognised that both the actant and the reactant (sender/receiver and receiver/sender) are fully engaged in the semiotic and social worlds of meaning-making, then the issue of hierarchy becomes irrelevant and a multi-directional or multi-modal model becomes vital. Even here, the notion of the *gatekeeper* (Dowling, Carew and Hadcraft, 2013) (the supervisor, Graduate Centre, external examiner and so forth) is a critical form of noise: the deadly hand of the examiner cannot be underestimated as a powerful, often unacknowledged, element of meaning-making for both the student and the supervisor.

In order to overcome these difficulties, coherence is required both linguistically in the communication and socially in the preparation of the communication. The issue of coherence is part of the hierarchy of noise at the core of academic learning, recognised primarily by the student whose engagement in meaning-making is perceived as unsuccessful by the establishment or hierarchy if they do not recognise critical rules through the veil of being the consumer of learning. Kress (Lock, 2010) argues that multimodality, as a reflection of practice at its most abstract, actually incorporates coherence through its abstract, conceptual nature, which echoes what he terms ‘social semiotics’ (the actions, forms and types of meaning-making), which may be understood to complete the domain of meaning. This reinforces the reconceptualization of language proposed in this research, as it is inherently multimodal in nature, with the PAR approach enabling coherence through activating the particular social semiotics of learning appropriate for EAL/D, EHDRs.

Purpose or Goal

The purpose of this project, using the PAR methodology outlined by Cohen, Manion and Morrison (2011), is to create, implement and evaluate a novel visual-spatial, physical-tactile, English language learning intervention, designed to align with Engineering modes of cognition, in order to accelerate effective research writing practices critical to supporting Engineering publication. PAR is an active, dynamic research model that is aligned with this early research, which sets out to demonstrate both the need for remediation and a basic response framework, tested against a small focus group by groups of participants: the EAL/D, HDRs, a group of academic linguists and a group of supervisors. It offers a cyclical

pattern of responses that engages the participants actively in an egalitarian approach to teaching and learning that is constantly evaluative, giving dynamism to all elements of the process.

This research will use a social constructivist paradigm, which articulates with the PAR approach. The participants will be acknowledged to be actants in their own learning throughout the research spirals, increasing their engagement in and ownership of the meaning-making process. The research is operating at the nexus of a community of inquiry and a community of practice, where the researcher, HDR participants and supervisors are equally engaged with practice and inquiry, though with varied levels of experience. This experience is shaped into meaning-making through the sharing of ideas and participation (inquiry) with the student participants, thereby enabling them to become actively engaged in becoming an independent researcher in their own right, by proposing both knowledge and inquiry as methodologies to achieve new skills. Through the novel use of the visual-spatial, physical-tactile intervention, coupled with a combination of systematic review, diagnostic surveys, interviews, focus groups and post-intervention testing, a framework has been created to test and develop this new system of language learning for EAL/D, EHDRs.

Whilst the applied portion of this research is still in its early stages, the student participants have already indicated a recognition of the value of the intervention through their willingness to engage with each level of the process, supported by the fact that its non hierarchal approach means that we are seeking positive goals across each group (EHDR student participants, Language academics and Engineering academics) in order to secure a research-driven, evidence-based academic English language learning program, designed specifically for Engineers (Hunter, Picard and Kestell, 2015).

In order to achieve this multimodal solution, this research will determine the writing needs of EAL/D, HDR students in Engineering by evaluating current language levels and then introducing new teaching through a specially designed and built, cognitive-mechanical 3D instrument, coupled with a set of teachings attached to Fuzzy Sets of questions about language in order to generate a more personalised set of answers from the questions that arise from the physical object. Each element of these Fuzzy Sets will be derived from the Workshops with each group of participants, the written assessments and the ideas from each group of participants, in order to achieve an Engineering-focused set of solutions to these key issues. The nature of PAR allows for two spirals of the intervention and learning process, which will allow the final outcome to be significantly enhanced through reflection as well as whole School input.

Discussion of Preliminary Results

Analysis of current accuracy, fluency and sophistication in technical writing is providing baseline language data about the EHDR students from which to build the PAR project and this data has already been gathered. (For example: “We need to have a space to learn English quickly without it being a criticism.” and “We want to have a ‘thing’ to play with: this is how we learn. We’re tired of *everything* being on computers.”) (Hunter, Picard and Kestell, 2015a). Key initial feedback is positive and the students have been willing to share their emotional distress at the complexity of academic English writing (“I am finding it hard to have my work returned consistently and told my English is not good”), the lack of suitable English Language teaching opportunities and their wish to succeed (“I want to become a professor but I don’t know how I’ll achieve this when my English isn’t good yet and I don’t know how to fix it.”) (Hunter, Picard and Kestell, 2015a), supporting the hypothesis that their Language issues are indeed impeding flow and that the nature of the English required is, in fact, a form of gatekeeping in itself. Delivery of the workshops is taking place in two sets of five, two-hour workshops, one set in 2015, and one in 2016, with review, evaluation and support being ongoing throughout the year. Already the students have been very clear that the visual-spatial, physical-tactile, approach is attractive (“We want something we can play with physically: that’s what we love”) (Hunter, Picard and Kestell, 2015) and the prototype language aids are currently with the workshop. They will be linked with multi-layered, on-line self-assessment tools, which will use Fuzzy Set theory as the navigation tool, a variant form of Hsueh and Huang’s (2014) assessment model where the Fuzzy Sets can be either self or supervisor assessed and the outcome is produced directly from the assessment model. Unlike Hsueh and Huang’s model, this model is formative and accessible by any party at any point in the review process. This form of integrated multimodality is a key conceptual element of the new pedagogy, enabling independence as well as offering a common set of terms of reference for students and supervisors.

Both socio-affective development and mastery of technical language are being evaluated throughout the PAR spirals, as a key purpose of this project is to enhance engagement, student ownership of learning and flow when engaging with Engineering issues and thinking within the framework of English. Thus the reviews of each element of the spirals focus equally on socio-affective growth, alongside language learning for each participant.

Once the spirals are complete, the intervention will be presented to the School as a whole as a structured writing programme that implements a visual-spatial, physical-tactile system in order to enhance practice and act as a foundation for a longitudinal study.

Conclusions to date and proposed future work

The insights mentioned above will inform the remainder of the PAR Spirals, during which work will continue to be undertaken with the research students and to evaluate the outcomes of the intervention. Thus far it is clear that the visual-spatial, physical-tactile approach is perceived as exciting by the Engineers in the study, there is buy-in from each group of participants in the PAR as the need for an accelerated language learning system for Engineers is fully recognised and documented by the School. The instrument itself has been designed and is already in production by School technicians, ready to be introduced to all participants shortly for observation, testing and amelioration.

This research is the dynamic foundation of a preliminary study after which a further study might involve a wider range of text types, Schools and greater numbers of students from as wide a set of cultural and linguistic backgrounds as possible. A subsequent longitudinal study is proposed to demonstrate the efficacy of the intervention under a wider set of conditions again, making use of the results of this initial research and the theoretical methodologies discussed above. Initial success with the deployment of this testing model, with the PAR students actively seeking more support through enhanced confidence, being more focused in their questions and showing great curiosity about the layers of the systems being set up to provide answers to their language learning needs, suggests that the current initial model would appear at this stage to be supportive of the hypothesis and enabling to the refinement of the outcomes of the initial research.

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