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Innovating Pedagogy, Space And Technology In A South African Engineering Classroom

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ABSTRACT

The rapidly changing technological context of higher education has led researchers to reconsider the learning environment – both physical and digital. Current advances in information and communication technologies (ICTs) might enable new learning spaces and support a more effective pedagogy. Furthermore, the engineering curriculum should undergo change in order to be in line with industry requirements and, as a result, teaching and learning should also change. While ICT offers many opportunities, the challenge is to ensure that teaching and learning adapts to and utilizes new techniques and tools in pedagogically meaningful ways. The aim of this study is to discuss how academic learning spaces transform teaching practice, by investigating one lecturer's perceptions of a "future-fit" classroom and how such classrooms impact the lecturer's approaches to teaching and learning. "Future-fit" classrooms are technologically advanced and flexible learning spaces in which innovative and multimodal teaching approaches can be implemented. This research

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focuses on an engineering module in which a blended teaching and learning approach was used, combining ICT–mediated and web-based activities, the learning management system platform, face-to-face collaborative tasks and teacher-directed instruction. We observed classes in three formats (hybrid, online and face-to-face) and conducted two reflective interviews with the academic involved. The findings reveal three important themes: the design principles of learning spaces must be carefully considered; in order to create rich, engaging learning experiences pedagogical modes/practices must match learning spaces; and finally, technology can have a transformative impact on teaching and learning in higher education institutions (HEI).

1. INTRODUCTION

The use of technology has become ubiquitous in higher education; however, many university teachers, particularly in the global South, are not confident with using technology when teaching. As a result, engineering curricula often maintain the predominance of “chalk and talk” modes of pedagogy, which often leave students disengaged from what they are learning. Technology offers access to new modes of teaching and learning, but needs to be used in pedagogically meaningful ways. Lecturers are required to teach in innovative ways, using innovative technologies, but are required to do so in classrooms designed and built many decades ago. This is problematic because the spaces we operate in lock us into traditional ways of teaching and learning. There is growing recognition that the classroom environment is a central ingredient in determining pedagogical choices and student engagement, as “spaces are themselves agents for change” (Oblinger 2006, 12). Engineering students need to be prepared for a complex world and engineering teachers need to be better capacitated to educate engineers for a sustainable future by adapting their pedagogy towards more innovative teaching methods.

This study focuses on academic learning spaces. Drawing on observations, interactive interviews and researcher reflections, the study sought to explore how innovative academic learning spaces (ALSs) transform teaching practices in an engineering classroom. An understanding of how lecturers utilise space and teach within the spaces they inhabit will enable the higher education (HE) sector to actively harness and enhance those spaces for independent and co-learning opportunities and design better learning spaces – and pedagogies – in the future.

2. LITERATURE REVIEW

Cox and Marshall (2007, 59) list five reasons for knowing more about the impact of information and communication technologies (ICTs) on pedagogical practice and student learning, namely: (a) informing government policies; (b) directing teacher education programmes; (c) advancing national curricula; (d) designing or reforming classroom implementation and (e) analysing costs and benefits. These functions cannot be addressed if engineering educators are not capacitated to focus on new ways of teaching and learning. In an age where information is readily available everywhere and the role of the educator is undergoing great change, it is important for educators to remain key actors in facilitating students’ transitions to sustainable ways of life. In order to guide and empower students, educators need to be empowered and equipped with the knowledge, skills, values and behaviours that are required for this transition. Educators need to ensure that the learning environment is a safe space and should enhance this space by reducing barriers to participation and permitting students to explore new ideas and complex issues. Various studies have observed that the learning environment influences human behavior and has both direct and indirect consequences on learning and teaching performances.

The study of the design of learning spaces is a cross-disciplinary field with roots in education, architecture, design, and human-computer interaction (Boddington and

Boys 2011). Ellis and Goodyear (2016) identify two main domains within the research literature on learning spaces in higher education: physical and virtual learning spaces. They explain how research in physical learning spaces mainly tends to come from architecture (concerned with built space), environmental psychology (concerned with space design issues) and the learning sciences (concerned with pedagogy and curriculum design issues). The desired learning outcome should inform the selection or configuration of the learning space (Ellis and Goodyear, referring to Brooks 2011, 18). Ellis and Goodyear (2016) highlight the relational nature of different aspects of the learning environment. They emphasise that "the design, management and use of learning space should be a shared concern for all members of a university: a collective responsibility, the discharge of which can benefit all participants" (Ellis and Goodyear 2016, 2).

Spaces should be specifically designed to meet teaching and learning needs and the flexibililty of learning spaces is a priority. They should also be able to adapt to changing student demands, new pedagogies and technological advances. The literature (Boys, 2011; Mulcahy, Cleveland and Aberton, 2015) shows that space and its occupation are interlocked and dynamically inform and influence each other. This shows that it is not a cause/effect relationship, but rather a constant and dynamic interplay where each part affects the other (Ellis and Goodyear, 2016). The relationship between space and practice has always been complex as they endlessly inform and influence each other, but altering space does not necessarily change practice (Boys, 2011). The structure of space alone is insufficient to achieve changes in participants' interactions in that space (Landsdale, Parkin, Austin and Baguley 2011); rather, a shift in how we think about learning spaces and pedagogy is required, as a learning space is more than a physical building in which learning takes place. Space and practice are interdependent rather than just reflective of one another.

By improving knowledge of the relationship between space and practice, teachers take control of the space and deliberately change it to support pedagogical enhancement (Martin 2002). Cleveland (2016) and Martin (2002) also emphasise that the appropriation of space depends on the users and their environmental competence, so users must have the ability to actively use and re-design their physical environment to fit their pedagogical practices.

The PSTU (Pedagogy-Space-Technology-User) framework shows the links between space, teaching and learning (Radcliffe, Wilson, Powell and Tibbetts 2008; Manciaracina 2019), as depicted in Figure 1. Manciaracina (2022) explores the critical relationship between space, pedagogy, technology and the user, with a specific focus on the latter since it is the connecting element that relates to all contexts. Technology facilitates the use of space and enhances pedagogy. Space that embeds technology encourages certain pedagogies, while pedagogy is enabled by space and enlarged by technology. The user is positioned at the centre of the framework, which shows its significance and linkages to other elements in a complex innovative environment.

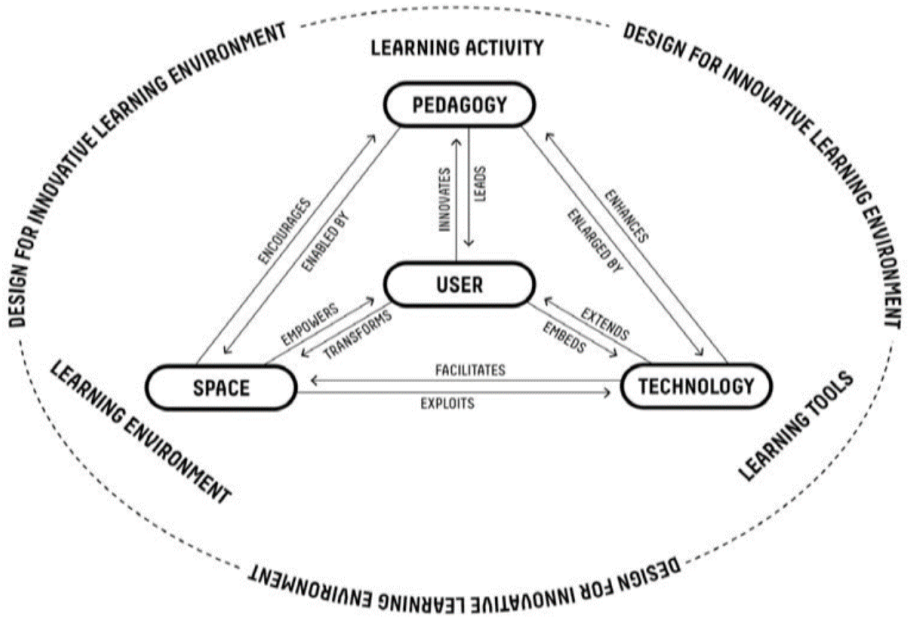

Figure 1: PSTU model based on Radcliffe et al.'s PST framework and updated by Manciaracina (2019)

3. RESEARCH DESIGN AND METHODOLOGY: PROJECT OVERVIEW AND EDUCATIONAL CONTEXT

The research presented here originated from a broader PhD study which focuses on how academic learning spaces can transform teaching practices. The broader research project involves five lecturers from varying disciplines in the university. A design-based research (DBR) study was carried out with a focus on collecting and analysing qualitative data. The teaching spaces used for this research included a technology-enhanced classroom, a traditional lecture hall and an online teaching space (see Table 1 that presents the spatial and technological features of these spaces). The technology-enhanced teaching space has collaborative tools, and is called a *future-fit* classroom. The teaching space blends Blackboard's *Collaborate* technology within the classroom, reducing transactional distance and providing students with the opportunity to use devices for collaboration. The lecture hall is a traditional teaching space, and Blackboard *Collaborate* was used for the online space. Data were collected in Semester 2 (June – November) of the 2022 academic year. This was an uncertain time post-pandemic as university campuses were cautiously opening doors to face-to-face teaching. While some classes remained online, others were face-to-face and others still were hybrid and blended. This 'liminal' state allowed for new realities as well as transitions in the teaching and learning space.

CLASSROOM ACTIVITY	SPACE	TECHNOLOGY USED BY THE STUDENTS AND INSTRUCTOR
Small group discussion	Future-fit Classroom • 20 single tables combined for group discussion • Portable group white boards • Wall mounted whiteboards • White desks that can be written on	• Ceiling mounted projector • Each group (4 groups) had one laptop per group • Glass writing walls • Wall-mounted display technologies for students
	Traditional lecture halls • Ordinary lecture hall • D-Shaped lecture hall	• Each student brings their own device (BYOD) to class • One projector screen at the front of the room • Instructor site is at the front left hand side
Class wide discussion	Future-fit classroom: • Instructor's station at the centre	• LCD monitors • Glass writing walls • Collaborate document cameras • Speakers • Control pads • Wirelss microphone and keyboards • Interactive pens

Table 1: Spatial and technological features of the academic learning spaces in our study

This paper reports on data collected from one lecturer, Dr O. The module she teaches is a first-year core module offered to electrical engineering students. The aim of the module is to develop students' professional and technical communication techniques, both oral and written. The module introduces students to basic engineering project investigation principles, such as conducting experiments, finding solutions and professionally reporting on results and conclusions. Qualitative data was collected in the form of interviews with Dr O, observation of her classes conducted in different formats (including recording of online, face-to-face and hybrid classes) and responses to open-ended questions sent to the lecturer via email. The lead author observed two lectures presented in the traditional lecture hall; the students then completed two assessment tasks which the lecturer marked. The lecturer suggested that before the major assessment task (a research report) for this course was due she would like to teach a class in the future-fit venue. She did a practice run in front of the lead author, a research assistant and some staff from the academic development unit of the university. The lead author then observed two hybrid classes taught in this venue. All these sessions were video recorded. The hybrid classes were 90 minutes each and the face-to-face class was 45 minutes.

The lead author then conducted reflective interviews after each hybrid class. Each interview lasted around 45 minutes. Permission was obtained from all the students to record the classes including their participation. We did not specifically interview students as the focus of this research was on the pedagogical strategies used in the different spaces.

The PSTU framework structured our analysis of the qualitative data collected. Each dataset was reviewed and organized based on the PSTU framework. Thereafter, codes were generated related to the four PSTU categories as well as the interaction between them. An internal reliability check was conducted by checking around 10% of the qualitative data, selected based on their significance to the findings. Themes and sub-themes were generated in order to generate a rich story and valid claims.

4. FINDINGS

Engineering educators must be prepared to work across different spaces to prepare students for sustainable futures. Three themes emerged from this study: the design of academic learning spaces must be aligned with teaching and learning developments; pedagogical practices must match academic learning spaces; and in order for technology to be relevant, it must be transformative.

4.1 Design of academic learning spaces and teaching and learning development

"Spaces are themselves agents of change. Changed spaces will change practice." (Oblinger 2006, 12). The design of learning spaces is an important resource that needs to be managed as an integral part of teaching and learning activities. Discussion with the lecturer showed how teaching in the future-fit classroom encouraged and promoted active learning. In Figure 2, the position of the teacher shows that she can actively engage with the learners in the classroom and promote active learning. The lecturer referred to how the design of the ALS is able to transform her teaching practices and encouraged her to adopt a more "*active teaching approach*", in order to "*actively engage*" her students in the learning process. In her view, the future-fit classroom gives a more *"engaging and immersive learning experience for students".* Yet, this approach does require practice and more support from the university's technical experts. In the first class held in the future-fit venue, there were many technical issues and in the interview the lecturer referred to how the university could better improve the classrooms to make teaching "*seamless in the future-fit classroom".*

She also referred to the help of her tutor: *"without the help of a tutor it's very hard to manage on your own. You have to have that support. Yeah. Otherwise it becomes very hard to manage it"*. The future-fit classroom also aided the tutor in assisting the lecturer, who highly valued the role of the tutors to "*equip them with using the technology when teaching".* When teaching in innovative spaces, a more engaging and immersive learning experience can be created for students, but this requires in-depth preparation on the teacher's part, which was not done for the first smart class, as this was the first time the instructor was teaching in the smart class while students

were present. In the second smart class there was a significant change as the lecturer was better able to manage the learning space and the different technologies available. She was also better able to engage students both in the face-to-face environment as well as in the online space. The future-fit classroom aimed to introduce innovative technologies and pedagogies in the classroom. The lecturer mentioned this in her reflective interview:

> *as educators we need to accept the reality that if we think of technology and if we think of research, some companies and industries are … even far more ahead of the curve than research, and so academic researchers must follow*.

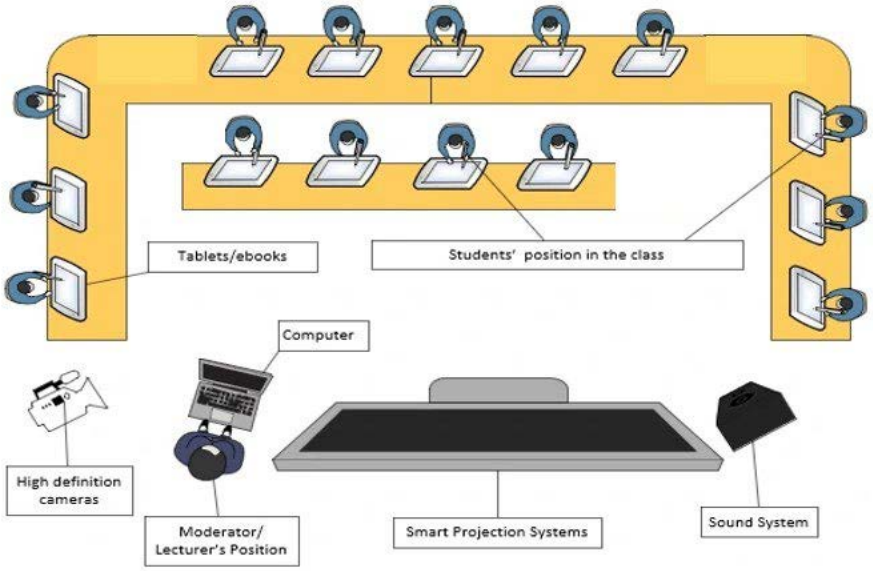

Fig 2: Layout of the experimental future-fit classroom

The lecturer also discussed how these spaces are able to support personalized learning as they provide students with a range of technologies that support different learning styles and preferences. Discussion with the lecturer showed how the design of the space can be better aligned with teaching and learning developments. The lecturer talked about how far ahead industry is and questions the validity of the type of education higher education institutions are providing:

> *the only thing going on for us, is how we [provide] the degree certificate, but the day another [cheaper, more viable] institution, such as, Coursera or another company offers the same, why won't our students go for the cheaper option.*

The lecturer argues here that there is a need to improve the space as well as the pedagogy, which leads to the second theme: that hybrid learning spaces (future-fit classrooms) need to be designed in a supportive, bold, creative and people-centred focus, as this can energise and inspire both lecturers and students.

4.2 Pedagogical practices must match learning space design

A conscious effort on the part of teachers is required to simultaneously engage students both online and face-to-face. According to the lecturer, one of the biggest problems faced by her (and, she feels, other lecturers) is the lack of engagement in the traditional classroom. The lecturer argued that she found the most engagement in fully online classes. In her reflective interview, she specifically mentioned that "*the switch between powerpoint and the whiteboard and show them how to solve the problem"* was easy for her and it was also useful because she was able to help students solve a problem, rather than teaching from a slide. Prior to collecting the data, the lecturer spoke about how important it was to create a rich learning experience for students and how teachers should focus on building and nurturing relationships. The lecturer argued that:

> *that is the whole part of exactly engaging students again, getting them to participate. You switch between the powerpoint and the whiteboard and use it [the whiteboard] to solve the problem. Yeah, it also tells the students the lecturer knows what they're talking about, not just showing me from a slide.*

The fact that the lecturer is concerned about the students being aware that she knows what she is talking about, is indicative of the fact that new technologies have helped to democratize knowledge, transforming when, where and how learning takes place. The key to aligning academic learning spaces to pedagogical practices is to create environments that allow for flexibility, that are adaptable and student-centred. In this way they can foster active, collaborative and authentic learning experiences. Therefore, understanding learning space design and creating efficient spaces can potentially improve pedagogical design.

4.3 Transformative technology

In future-fit learning spaces, students and teachers are better able to communicate with one another since they have more tools available at their disposal. Students may feel more comfortable asking questions and sharing their perspectives. As the lecturer mentions, "*in the future fit classroom, I feel they were participating more than those online*". The lecturer also praised the use of the future-fit venue as showing how technology can be a powerful tool for transforming learning. However, what was an important aspect for the lecturer was that sufficient training and practice was required: "*in the [future-fit classroom], I was able to access the whiteboard from my laptop and use it effectively. But I definitely needed practice*". In order to realize the full benefits of technology, educators need to use technology effectively in their practice. As she argued:

> *I used the technology to make an illustration. I can switch between the boards easily. I feel the practice we had during the pandemic helped, in fact …you need to prepare yourself mentally when teaching online.*

In order for technology to be transformative, educators need to have the knowledge and skills to take full advantage of technology-rich learning environments. The

pandemic forced teachers to learn to teach with technology, but with little preparation. In order for technology to be transformative, a holistic approach that considers a wide range of factors, including pedagogy, technology and learning space design must be aligned.

5. CONCLUSION

“One of the most important aspects of technology in education is its ability to level the field of opportunity for students” (King 2017). The use of technology in education has always impacted both the content and delivery of lessons but, more recently, technologies like artificial intelligence are reshaping how we learn. Technology in higher education is a powerful tool for transforming learning. The term ‘future-fit classroom’ refers to an innovative approach to teaching and learning using technological tools that help students grow in their thinking, knowledge, and literacy. In other words, a future-fit classroom is a traditional classroom that has been upgraded to include advanced instructional technologies and educational resources. In this setting, students can engage in formal education in ways that go beyond what is achievable in a conventional classroom. So-called future-fit venues are becoming increasingly important academic learning spaces in universities and they play an important role in pedagogical innovation. Pedagogy needs to be interactive and learner-centred. In this type of pedagogy, the teacher acts as a facilitator, rather than a knowledge provider. The student needs to be active and responsible and spaces like the one discussed in this research allow for this.

Our aim in this article was to examine how academic learning spaces transform teaching practice and our data suggested that focused learning needs to take place amongst lecturers so that education itself can be sustainable, transformative and appropriate to our times. Dr O’s case study provided insight into the importance of aligning learning space design and pedagogical practices, because learning spaces are constantly evolving and so pedagogical practices need to be studied and aligned to them. Envisioning this change and taking realizable, practical steps is the first step to transformative teaching practices.

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