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Evaluating teacher and student spatial transition from a traditional classroom to an innovative learning environment

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ABSTRACT

Proponents highlight the potential of flexible and technology-rich spaces, referred to as innovative learning environments (ILEs), to shape activities and behaviours able to affect a desired pedagogical change. With much of the attention on the design of the physical learning environment, there has been a limited interrogation of what happens in the transition from traditional spaces to ILEs. As a result, this study applied the Linking Pedagogy, Technology, and Space (LPTS) observational metric through a single subject research design (SSRD) to understand how teachers, and their students, transitioned from traditional spaces to occupy an ILE. The application of statistical and visual analysis ascertained the degree of short- and longer-term pedagogical changes made by individual teachers and correlated these to effects on learning experiences. Corroboration with the thematic analysis of teacher focus group presents an account of the spatial transition between and the pedagogical return of different learning spaces.

1. Introduction

The past decade has seen significant public funding directed to the creation of contemporary or 'innovative learning environments' (ILEs) in schools (Dovey & Fisher, 2014; Mulcahy, Cleveland, & Aberton, 2015). ILEs are characterised as multi-modal, technology-infused and flexible learning spaces that are responsive to evolving educational practices (OECD, 2015). Dumont, Istance, and Benavides (2010) described how the re-imagination of school spaces through the creation ILEs are a response by systems and schools to changes brought by the dynamic transition from industrial to knowledge economies. It is suggested the shift from conventional, traditional classrooms to ILEs can engender pedagogies that are thought to better support students to become lifelong and self-directed learners capable of navigating the complexities of a technology-mediated and knowledge-based society (Mulcahy et al., 2015; OECD, 2013).

Despite the current interest and investment in ILEs, there is a lack of empirical data to adequately evaluate the claims purported around their impact on both teachers and students (Blackmore, Bateman, O'Mara, & Loughlin, 2011; Brooks, 2011; Gislason, 2010). Brooks is critical of the overt theorising around these new spaces, with a "dearth of systematic, empirical research being conducted" on their impact on teaching and learning (p. 719). For Painter et al. (2013), this lack of evidence stems from the few methodologies and metrics able to isolate and then assess how different learning spaces affect both teachers and students. Besides a handful of recent studies (for examples see Alterator & Deed, 2013, 2016; Deed & Lesko, 2015) there remains little understanding if, or how, the transition from traditional classrooms to ILEs affects teacher practice and resulting student learning experiences (Blackmore et al., 2011).

This study aimed to discover what occurred when a group of teachers and their students transitioned between conventional or traditional classrooms, to an ILE. Over a two-year period, the study evaluated the immediate and longer-term impact of the occupation of these different learning spaces. The intent was to document what occurred when teachers and students navigated such a spatial transition. A time-series quasi-experimental approach facilitated by a Single Subject Research Design (SSRD), compared the activity and behaviour of the same teacher (n = 9) and classes (n = 12) through a repeated measures observational metric, and follow-up teacher focus groups. In a departure from more traditional techniques, the novel Linking Pedagogy, Technology, and Space (LPTS) observational metric recorded, compiled and produced a proportionate visual breakdown of the observed lesson across five domains: pedagogy, learning experiences, communities of learning, and student and teacher use of technology.

Longitudinal analysis of quantitative data from the LPTS metric enabled comparison of student and teacher activity and behaviour within a conventional or traditional classroom (baseline) and ILE

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(intervention). A combination of visual and nonparametric analysis identified those micro changes and trends, across the five domains, of individual teachers through and beyond the spatial transition. The subsequent thematic analysis of the follow-up teacher focus group evaluated the factors, spatial or other, that underlined those significant changes to the nature of teaching and learning in both spatial layouts. This multidimensional analysis presents a holistic teacher account of the pedagogical impact of different learning spaces.

The Drivers in the Investment in Innovative Learning Environments

The narrative around the need to prepare learners for the 21st century has seen learning spaces become a matter of policy in many countries (see MCEETYA, 2008; New Zeland Ministry of Education, 2014; OECD, 2013). The drivers of evolving educational policies and the integration of digital technologies altering the perceptions of what constitutes effective teaching and learning have prompted some to question the efficacy of the conventional or traditional cellular classroom model (i.e. Alterator & Deed, 2013; Benade, 2016; Dovey & Fisher, 2014). The traditional architectural view of the "classroom-as-container" model (Mulcahy, 2015, p. 500) with its fixed instruction settings (in groups or rows) is said to restrict teacher and student activity and behaviours (Fisher, 2006; Tanner, 2008; Upitis, 2004). Dovey and Fisher (2014) surmise that this inhibits the ability for teachers to easily enact a broader spectrum of pedagogies as dictated by current policies that favour a greater incidence of student-centric and technology-enhanced learning.

The rationale behind this critique is the assumption that the educational spaces are an 'active agent' in the teaching and learning process (Oblinger, 2006). More conventional, traditional spaces are said to be ideal for teacher-centric pedagogies that favour didactic, linear and standardised instruction (Dovey & Fisher, 2014; Dumont et al., 2010). These pedagogies support the dissemination of knowledge to students engaged in surface learning experiences that are typically focused on recall and memorisation of 'the basics' (Hattie & Donoghue, 2016; Theisens, Benavides, & Dumont, 2008). Benade (2016) and Dumont and Istance (2010) highlighted that the current narrative sees these pedagogies and learning experiences deemed inadequate to prepare today's students to be life-long learners of the future. Mulcahy (2015) suggested this misalignment as led some to postulate the potential benefits in the "re-consideration of learning and the spaces in which learning takes place" (p. 500).

The narrative around the reconsideration of the school learning spaces stems from the premise that ILEs are, somehow, able to facilitate a much wider range of pedagogical practices and learning modalities, than a traditional classroom (Dovey & Fisher, 2014; Lippman, 2010; Thomas, 2010). It is suggested that the affordances (digital and spatial technologies) of an ILE are aligned with a pedagogical orientation that sees teaching be a more active, collaborative, and responsive endeavour (Dumont & Istance, 2010; Theisens et al., 2008). Such an orientation is thought to facilitate those cognitive, metacognitive and collaborative experiences that are required for students to transition from surface to deep learning (Hattie & Donoghue, 2016; Theisens et al., 2008).

Empirical Evidence that Learning Spaces Make a Difference

There are authors that have considered the theoretical view that a learning space's affordances (those features that facilitate the actual use), its physical design, and associated technologies can enhance or hinder student learning by their effect on teacher pedagogical practice (Dovey & Fisher, 2014; Gislason, 2010; Halpin, 2007; Upitis, 2004; Woolner, Hall, Higgins, McCaughey, & Wall, 2007). In their literature reviews, Blackmore et al. (2011) and Painter et al. (2013) note the considerable contribution qualitative case studies and conceptual analysis have made in establishing this nascent field. However, both reviews, along with Brooks (2011), Gislason (2010) and Higgins, Hall, Wall, Woolner, and McCaughey, (2005), highlight a commensurate dearth of empirical, quantitative studies that rigorously evaluate the impact of different learning environments on teaching and learning.

A small number of empirical studies have measured the impact of different spatial layouts (exemplars include Author, 2017; Authors, 2014a, 2016c; Brooks, 2011; Tanner, 2008). The design of each has attempted to account for those intervening variables inherent in the school setting (such as the teacher, class composition, and cognitive ability). Collectively, these findings present a possible correlation between different classroom environments and student learning experiences and academic outcomes. However, due to their objective nature, these studies do not provide a deeper understanding of how and why the physical attributes of these different spaces supported or hindered the teaching and learning process to affect these measured outcomes (Blackmore et al., 2011; Gislason, 2010).

2. The study

2.1. Context

The study took place at a secondary boys' school, in an Australian city, that had engaged in a longitudinal evaluation of the impact of different learning environments on teaching and learning. Earlier studies at this site focused on understanding how and why different learning environments affect teaching and learning in a secondary schooling context. The process began with a modest refurbishment of a single classroom space and a sample of three teachers, to devise, trial and refine potential methodologies and methods to isolate and evaluate the effect of a spatial change (Authors, 2016c). In the following years, a series of studies, expanded regarding scope, sample size and statistical rigour, not only identified the design, materials, and technologies that worked (and those that did not), but also developed the knowledge and skills of the teachers. The transition from conventional or traditional classroom layouts to the occupation of ILEs corresponded with statistically significant improvements in student attitudes in the effective utilisation of technology, the incidence of more active and responsive learning experiences, and enhanced behavioural and cognitive engagement (Authors, 2014a, 2014b, 2016a, 2016b,). These changes correlated with statistically significant improvements in English and Mathematics academic achievement (average $g = +.53$). Furthermore, these studies found an average 9% variance in achievement attributed to the different learning environments (when various confounding variables were controlled) (Authors, 2014a), supporting the earlier findings of Tanner (2008). The resulting evidence base and corporate understanding informed the design, construction and occupation of the "Creative Precinct", which is the subject of this study.

The Creative Precinct was the school's first significant redefinition of what constitutes a responsive learning environment. It presented a major departure from previous spaces at the school, with its introduction expected to challenge many teachers perceptions of pedagogy (Gislason, 2010; Higgins et al., 2005). While the Creative Precinct was a design-oriented complex, its spatial construction followed the principles and practices common to many ILEs. Thus, its inhabitation offered a unique opportunity to evaluate what occurred during teacher and students' spatial transition.

Understanding how teachers navigate the transition process from traditional classrooms and evolve their practice in the inhabitation of ILEs is rarely articulated in the current narrative around school learning environments. Proponents of ILEs often highlight how the spatial transition will effect significant changes in pedagogies, but little explanation is forthcoming in exactly how, or the supports required for, this process to occur In their review, Blackmore et al. (2011) found very few studies that focused on understanding how both teachers and students navigate this process. The contributions of Alterator and Deed (2013); Alterator & Deed, 2016 and Deed and Lesko (2015) suggested that any pedagogical changes that accompany a spatial transition from traditional to ILEs are mediated by teachers' technical proficiency (subject-matter, curriculum and pedagogy), adaptability, and interpersonal knowledge. The mediating factor of a teacher's knowledge base and personal characteristics is echoed by both Lackney (2008) and

Steele (1980) in their work around the concept of 'environmental competencies'. For many, their existing environmental competencies, shaped by beliefs, existing pedagogies and previous experience, are often counter to the premise of ILEs.

The radically different layouts of ILEs challenge teacher environmental competency, when they are provided with little or no training or exposure to the operations of and ways of working within an ILE before occupation. It is no surprise that with a lack of teacher preparation for an understanding of the workings of ILE, they do not possess the inherent adaptability and capacity (technical proficiency) to evolve their practice easily during the occupation process. As a consequence, this causes many to often revert to default pedagogies at the expense of the desired pedagogical exploration and innovation. Thus, at the root of this research, is to understand better how the transition from conventional classrooms to an ILE affects teaching and learning, and if the envisioned pedagogical change can occur and under what circumstances.

2.2. Research questions

The study that is the subject of this article originated of a larger longitudinal evaluation of the impact of secondary school learning environments. This study explored the hypothesis that different spatial layouts would affect teacher behaviour and pedagogies and the learning experiences created. Hence, to understand this possible relationship further, what was of interest to this study was:

1 If a teacher and their students move from spaces that are described best as traditional in layout, to an ILE, how does this affect teacher behaviour through the types of pedagogies employed?
2 How do different spaces affect the types of learning experiences encountered by students?
3 How does the occupation of different spaces affect how teachers group students in various communities of learning (i.e. whole class, individual, small groups, mixed number groups and mixed class/year levels)?
4 How do different spaces affect how teachers and students use different digital (i.e. Tablet PC and data projector) and spatial technologies (i.e. furniture)?
5 What are the barriers and challenges associated when a teacher and their students move from spaces that are described best as traditional in layout, to an ILE?

2.3. The spaces

The study took place in two existing conjoined buildings, which housed the Creative Arts (Drama, Film, Television and Media and Visual Art) and Design and Technology (Design and Technology, Engineering and Technology studies) faculties. The original design of the buildings had specialist teachers in their specialist spaces (Fig. 1). These specialist cellular spaces were considered traditional in layout, with furniture arranged in a fixed setting that faced the front 'fireplace' teaching position (Reynard, 2009). A combination of a teacher desk, whiteboard and data projector screen delineated the front of the room. The use of these spaces was often teacher-oriented and subject-specific, with the classrooms, studios and workshops separated from each other. There were little or no inter-disciplinary overlaps in teaching or learning that occurred within either building.

In a collaboration between the school and The University of Melbourne's Learning Environment Applied Research Network (LEaRN), considerable teacher and key stakeholder consultation influenced the design of the Creative Precinct. Over a year, epistemological and pedagogical commonalities between the subjects were elicited through the School Spaces Evaluation Instrument (SSEI) (Cleveland & Soccio, 2015). The SSEI tool informed the consultative process of design and structured those interactions between key stakeholders that allowed them to explore the alignment of current and future teaching and learning within the proposed spatial layouts. The SSEI process highlighted the common elements of design, innovation and creation that all subject-areas shared. The consultation informed the architectural brief to create an assembly of spaces that could support each phase of the creative process (Fig. 2).

Fig. 1. Traditional General Learning Area (GLA) workshops prior to refurbishment.

The following design employed an *open-studio* approach centred around a common design thinking space. Teachers and students occupied and transitioned between and through Fisher (2006) spatial modalities (teacher-centred, student-centred, and informal). This dynamic occupation through teaching spaces, specialist technology-enabled workshop areas, and highly flexible inside and outside communal spaces acknowledged the fact that technology-mediated, creative learning occurred in a variety of settings and with a range of people (see Fig. 3).

3. Research design

This study employed a traditional SSRD to compare the activity and behaviour of the same teacher with the same class through a time-series quasi-experimental approach. Each teacher acted as his or her control, baseline and unit of analysis. The A (baseline)-B (intervention and same class)-C (intervention and different class) design measured the effect of a change in learning space (independent variable) on communities of learning, learning experiences, pedagogies and technology usage (dependent variables). The time-series evaluation through the repeated measures application of the LPTS observation metric produced quantitative data of a subject's (student and teacher) activity and behaviour. Follow-up thematic analysis of teacher focus groups presented their account of how the different spaces affected their pedagogies and the learning experiences that followed. It also provided an opportunity to clarify anomalies and trends from the analysis of observational data.

3.1. Sample

The initial sample of the A- and B-phases consisted of consenting teachers (n = 12) from the Creative Arts and Design and Technology. A stratified subject sample was achieved with fourteen classes the subject of the A- and B-phase observations. The sample consisted of teachers from the Graduate (n = 2); Proficient (n = 4); Highly Accomplished (n = 3); and Lead (n = 3) according to the career stages outlined in the Australian Professional Standards for Teachers (Australian Institute for Teaching & School Leadership, 2015). Each participating teacher had some level of professional experience in their field before their teaching degree.

The final teacher sample (n = 9), which was subject of the statistical

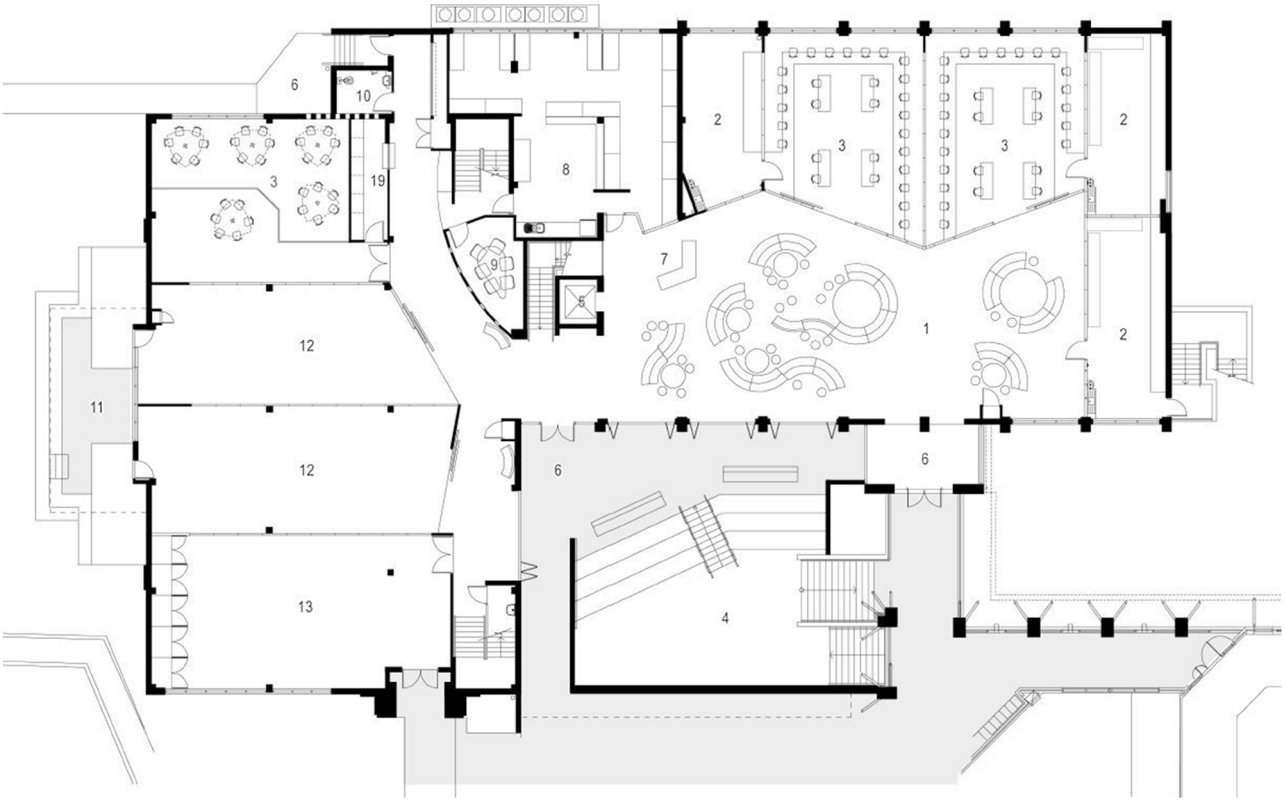

Fig. 2. Creative Precinct entry (level 2) floor plan.

Fig. 3. Open-studio workshops after refurbishment.

analysis, saw Teachers E, G and K omitted due to timetable changes in the second year (C-phase) of the study. These teachers did not teach the same subject and year-level combinations as in the first year of the study. Their inclusion would have introduced confounding variables of different assessment instruments and curriculum into the analysis, which would contradict aspects of the quasi-experiment design. The revised sample still represented a fair representation of the career levels in Australian Professional Standards for Teachers (Graduate $n = 2$; Proficient $n = 3$; Highly Accomplished $n = 2$; and Lead $n = 2$).

3.2. Methods

The LPTS observational metric tracks the frequency and duration of a broad range of observable teacher and student actions. The macro-enabled Microsoft Excel platform essentially uses a series of stop-watches to time student and teacher activity and behaviours across five domains (pedagogy, learning experiences, communities of learning, and student and teacher use of technology) (Fig. 4). For instance, the macro-enabled program can simultaneously log how long teachers engage in didactic instruction (i.e. lecture), or encourage whole class discussion, or question individuals or the entire class through a single observer interface. The interface allows a single observer to check the box that corresponds to a observed activity, which starts the associated stop-watch timer. When that activity concludes, the observer unchecks the box that stops the timer and duration is instantaneously calculated. A macro-enabled program then combines each observed instance of the activity, producing a cumulative time for each activity. The program then translates and organises these culminative times in such a fashion that it can produce instantaneous visual breakdown for each observation that can then be easily shared with the teacher (Fig. 5).

Pilot testing of the LPTS metric demonstrated adequate interrater reliability with Chi-square frequencies of the observations of six teachers by three observers on a total of twelve occasions not being statistically different ($p > .05$) (Bielefeldt, 2012). The use of time as the means to record activity, unlike traditional observational notes, reduced the influence of observer inference (Clarke et al., 2006). Furthermore, the application through a time-series design established controls of confounding variables (i.e. teaching and learning cycle and time of day) by the quasi-experimental design.

The three fortnightly observations for each teacher and class combination were completed in each phase of the study. A total sample of 123 observations was collected over the two-year period. Observations were conducted on the same day and time to moderate the influence of confounding variables outside the control of this study (i.e. time of the day). By collecting three observations in each phase (a total of three observations in Traditional spaces and six in the retrofitted ILE), this attempted to present a fair representation of the activity and behaviour of each teacher and class. Furthermore, by spreading the observations over a six-week period in each phase, this sought to negate issues of the lesson sequence within a unit's cycle and present a reasonable assessment of a teacher's practice.

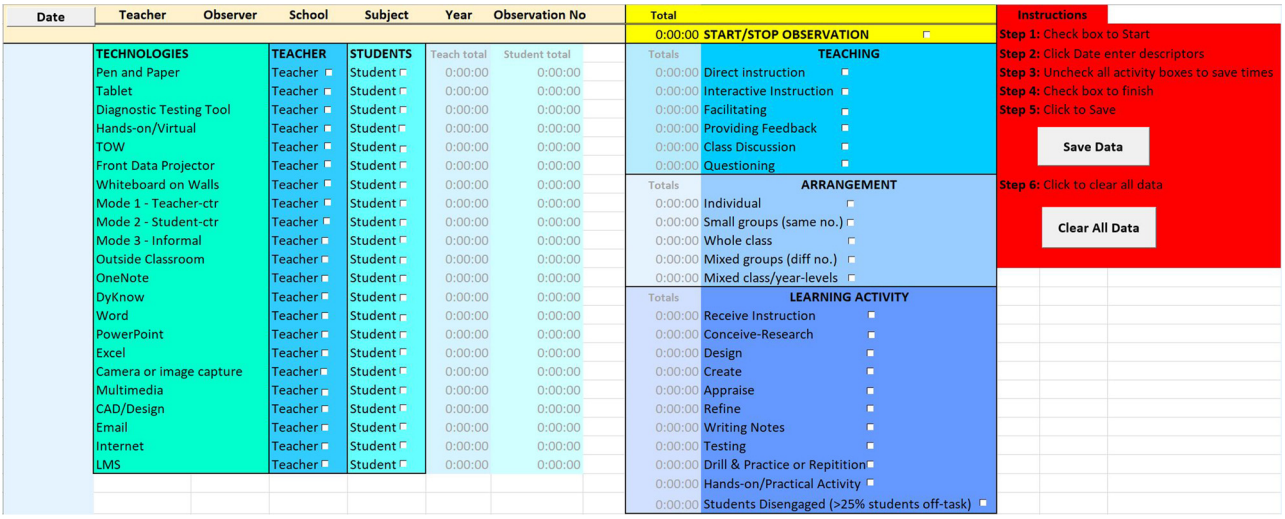

Fig. 4. Linking Technology, Pedagogy and Space (LPTS) metric observer interface.

3.3. Analysis

A combination of visual analysis and *Tau-U* calculations addressed research questions one to four through analysis of individual teacher data obtained from the LPTS metric. The visual and nonparametric (Tau-U) analysis identified those statistically significant (SS) changes in activities and behaviour between the three phases (A-B -C). The visual analysis criteria consisted of the level, trend, the immediacy of the effect, and variability.

The following application of Tau-U calculations provided a statistical process to justify the conclusions made in the visual analysis process. Tau-U calculations, based on the sampling distributions of Mann-Whitney U and Kendall's Rank Correlations, ascertained both the degree of non-overlap between the phases and controls for trending baseline/interventions phases (Rakap, 2015). The Tau-U calculations produced *p*-values that compared the A-B and A-C phases using the process suggested by Parker, Vannest, Davis, and Sauber, (2011).

The visual analysis and Tau-U calculations for observational data of Teacher A for the physical technologies domain of the LPTS metric are outlined in Fig. 6. The statistically significant change (SS) identified in the visual analysis (Teacher A) of the incidence of modes 1 and 3 and outside the classroom. The Tau-U for modes 1 and 3 corresponded to the Tau-U calculations of $p < .001$ (left panels). While the outside the classroom returned a Tau-U calculation of $p < .01$. The trend of data in the B- and C-phases resulted in a lower assessment of significance from the Tau-U process when compared to modes 1 and 3. On the other hand, the non-statistically significant change (NS) in the incidence of the student-centric modality (or mode 2) corresponded to the Tau-U calculation of $p = .758$ (top-right) panel. The overlap of data points between the three phases contravened the criteria for the visual analysis, with the Tau-U calculations reinforces the overlap of points and lack of difference in trend.

The thematic analysis focused on eliciting a teacher account of the relationship between the different classroom spaces and how these affected specific elements of teacher and student activities and behaviours. It afforded the ability to present context-specific and rich information to clarify and reflect upon anomalies and trends that emerged from the preliminary quantitative analysis. The results of the thematic analysis are woven into the discussion ensuing from the quantitative analysis of the LPTS metric. Finally, the discussion unexpectedly touched upon the barriers and challenges that occurred during the spatial transition, outlining the unexpected events and unforeseen circumstances and variables that impact on this process (Table 1).

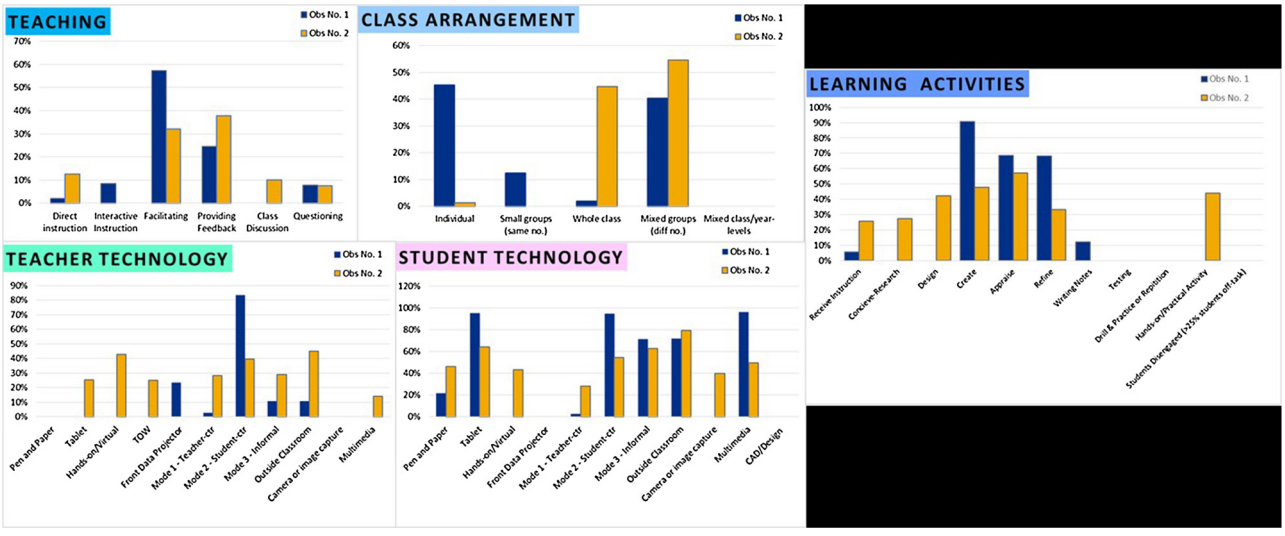

Fig. 5. Linking Pedagogy, Technology and Space (LPTS) metric visual output.

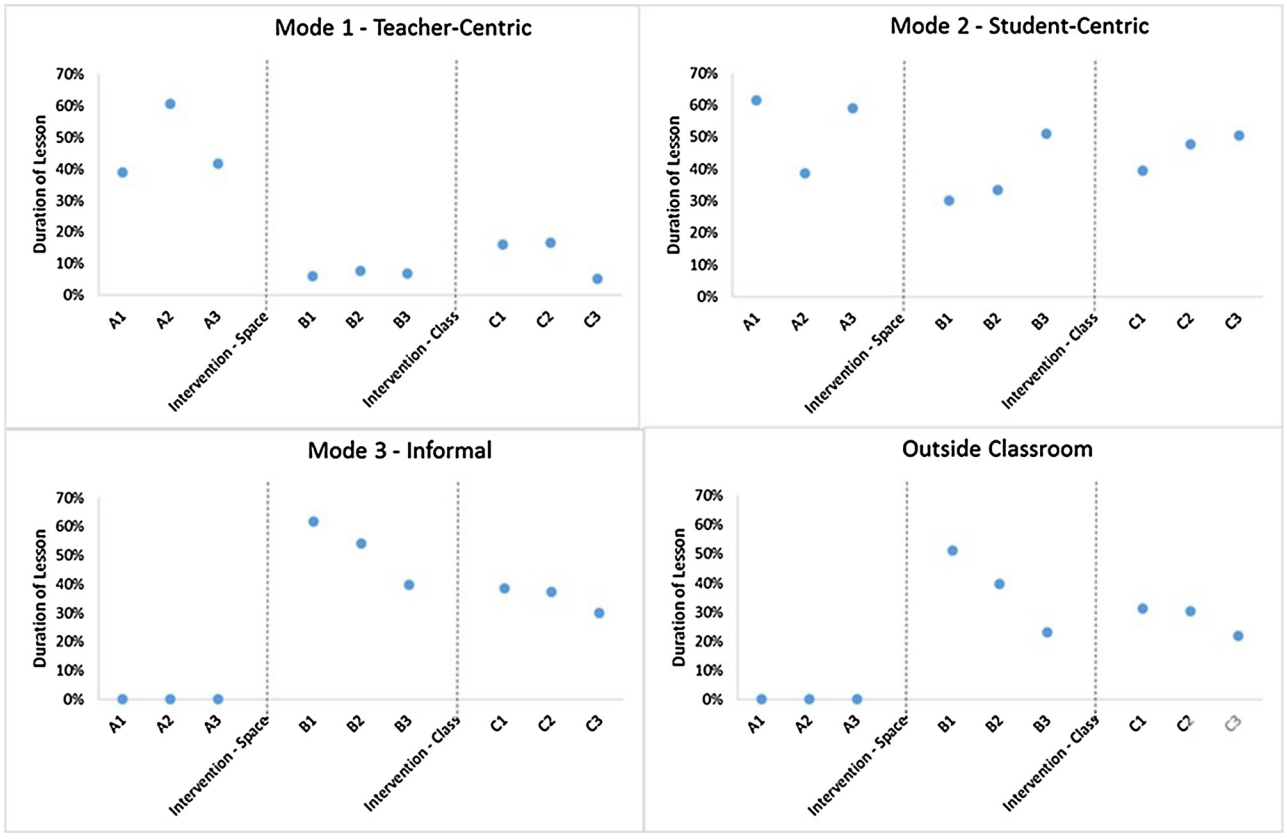

Fig. 6. Case of statistically significant (SS - left panel) and non-statistically significant (NS - right panel) change as determined by visual analysis criteria.

Table 1
Summary of the Initial Teacher Sample (n = 12) Demographics.

Teacher	Career Stage Level	Subject	Year/s
A	Proficient	Design Technology	8
B	Graduate	Drama	11
C	Proficient	Design Technology	7
D	Highly Accomplished	Engineering	11
F	Proficient	Design Technology	10
H	Lead	Visual Art	10 and 11
I	Lead	Film and Media	10 and 11
J	Graduate	Film and Media	9
L	Highly Accomplished	Visual Art	7 and 8

4. Results and discussion

4.1. Pedagogy

The pedagogy domain (Table 2) of the LPTS metric included the attributes of: didactic instruction, interactive instruction, facilitation, providing feedback, class discussion, and questioning. A key design intention of the Precinct, informed by the earlier studies at the site, was to de-emphasise the front fireplace teaching position as a means to effect more active and dynamic pedagogies. The visual analysis identified a significant decrease in the proportion of time spent by all teachers in a didactic instruction mode after the spatial transition. While the teacher sample still engaged in direct instruction in the B- and C-phases, it was no longer their dominant pedagogical model. Typically, teachers' use of didactic instruction became more focused, refined and responsive to student understanding determined through an increased incidence of questioning (in all teachers, except Teachers D and I).

The analysis of the LPTS data suggests that some change in pedagogies coincided with the spatial transition to the Creative Precinct. Analysis of the focus group conversation highlighted the changes made by teachers that underpinned the results of the visual analysis. Teacher B identified that the "change in space had a significant impact on my practice, I feel that the frequency of chalk and talk has substantially decreased, but its use is now more explicit and focused", which was corroborated by their visual analysis data. Teacher A, whose visual analysis indicated statistically significant changes in all attributes, indicated that the design "of the workshop spaces made it difficult to just to stand in front of a class and talk to them for an extended period." Teacher H expanded on this notion saying, "that the orientation of the spaces has challenged my lesson preparation and delivery, the lack of a front focal point challenges your mindset and existing approaches." These changes underpinned trends that saw a general shift away from a high prevalence of didactic instruction to a greater prevalence of feedback and engagement in questioning in the visual analysis of Teacher H.

This notion of how a changed spatial layout challenges teacher practice is often overlooked by both architects and school leaders. As Lackney (2008) and Steele (1980) highlighted, teacher environmental competency underpins a teacher's capacity not only to navigate a spatial change but to evolve their practices to appropriately utilise the affordances of the new space for pedagogical gain. These comments around how the new spatial layouts challenged teacher pedagogical practices warrant continued investigation. Often, this is an overlooked component of the current consultation and preparation process and support of teachers in the occupation of many ILEs.

4.2. Learning experiences

The learning experiences domain of the LPTS metric included the attributes: receive instruction, design, create, appraise, refine, hands-on, and students disengaged (a quarter of the observed class off-task). Comparisons between traditional (A-phase) and ILE (B- and C-phases) revealed a significant and sustained increase in the proportion of the

Table 2
Summary of Changes in Teacher Pedagogical Modes through the transition from Traditional Studios and Workshops (A-phase) to Creative Precinct (B- and C-phases).

Teacher	Class	Didactic Instruction	Interactive Instruction	Facilitation	Feedback	Discussion	Questioning
A	8 DT	*SS* [a] ***	*SS**	*SS**	*SS**	*SS**	*SS**
B	11 DR	*SS**	*NS* [b]	*NS*	*SS**	*SS**	*SS**
C	7 DT	*SS****	*SS****	*NS*	*SS**	*NS*	*SS**
D	11 EG	*SS**	*NS*	*SS***	*SS***	*NS*	*NS*
F	8 DT	*SS****	*NS*	*NS*	*SS**	*NS*	*SS**
H	11 VA	*SS**	*NS*	*NS*	*SS**	*NS*	*SS**
H	8 VA	*SS****	*SS**	*NS*	*NS*	*SS**	*SS**
I	11 FM	*SS****	*SS**	*NS*	*SS**	*NS*	*NS*
I	10 FM	*SS**	*SS**	*NS*	*SS**	*SS**	*SS**
J	9 FM	*SS**	*NS*	*NS*	*NS*	*NS*	*SS**
L	8 VA	*SS****	*NS*	*NS*	*SS**	*SS**	*SS****
L	7 VA	*SS**	*NS*	*NS*	*NS*	*NS*	*SS**

Note. [a] Statistically significant visual effect. [b] Non-statistically significant visual effect.
Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 3
Summary of Changes to the Types of Learning Experiences Observed in the Traditional Studios and Workshop (A-phase) to Creative Precinct (B- and C-phases).

Teacher	Class	Receive Instruction	Design	Create	Appraise	Refine	Hands-on/Practical	Students Disengaged
A	8 DT	*NS* [a]	*NS*	*NS*	*SS* [b] **	*SS**	*NS*	*SS****
B	11 DR	*NS*	*NS*	*NS*	*SS**	*SS****	*SS****	*SS**
C	7 DT	*NS*	*NS*	*SS**	*SS****	*SS**	*SS****	*SS****
D	11 EG	*NS*	*NS*	*NS*	*SS****	*NS*	*NS*	*SS***
F	8 DT	*NS*	*NS*	*SS**	*SS**	*SS**	*NS*	*SS****
H	11 VA	*NS*	*NS*	*NS*	*SS**	*NS*	*NS*	*SS***
H	8 VA	*NS*	*NS*	*NS*	*SS***	*SS***	*NS*	*SS****
I	11 FM	*SS**	*SS**	*NS*	*SS**	*SS***	*SS****	*SS****
I	10 FM	*NS*	*NS*	*SS**	*SS**	*NS*	*SS****	*SS****
J	9 FM	*NS*	*SS**	*NS*	*SS****	*SS**	*NS*	*SS****
L	8 VA	*SS**	*NS*	*SS**	*SS**	*SS**	*SS**	*SS****
L	7 VA	*NS*	*SS**	*NS*	*SS**	*SS**	*NS*	*SS**

Note. [a] Non-statistically significant visual effect. [b] Statistically significant visual effect.
Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

lesson that saw students engaged in those learning experiences that required a wider array of cognitive skills (Table 3). The most pronounced change between the different spaces related to how students engaged in activities that required them to both appraise and refine their work during the B- and C-phases. During the occupation of the ILE, students spent a greater proportion of the lesson engaged in the appraisal and subsequent refinement of their artefact or job. Typically, teachers prompted this process through the provision of feedback. However, as the study progressed through the B- and C-phases, there was a greater incidence of feedback from peers.

Trends from the visual analysis revealed a greater differentiation of student activity in an ILE compared to the traditional layout. In the traditional studios and workshops, a more defined and lock-step learning process was typical of all teachers in this sample. Teachers often structured a linear sequence of learning experiences that saw all students completing the same component or phase of the task at the same time (see Fig. 7). The rigid physical layout of the traditional spaces meant there was limited scope for activity differentiation.

The open studio design of the ILE spaces sought to remove these rigid spatial barriers. Visual analysis of the B- and C-phases of the study suggested that the majority of teachers made significant changes to their practice to facilitate a greater differentiation of student activity through the various stages of the creative process (see Fig. 8). Teacher C suggested that a reason for the significant increase in creation, appraise, refine and practical activity, were the spaces "enabling a greater differentiation of the learning activities in the different spaces." Teacher I agreed by saying that "the greater movement and the ability to let students go outside, supported more adaptive and flexible learning experiences to occur at the same time." Collectively, these comments suggest that the design was successful in allowing teachers and students

Fig. 7. Example of learning experiences in Visual Art before the retrofit.

to occupy different spaces, and at the same time, to change the types of learning modes. Here, the shift away from the dominance of whole class instruction in the traditional spaces was replaced with greater activity differentiation, and the increased incidence of feedback and questioning highlighted previously.

The visual analysis revealed a statistically significant decline in the time that students were disengaged or off-task. Teachers A, C and D highlighted how the spatial change affected student engagement. For example, Teacher A commented that their "students are aiming higher, they are doing more and are more ambitious in their designs. I noticed that my students' academic outcomes, confidence, and pride had all improved." The correlation between a spatial intervention and

Fig. 8. Example of learning experiences in Visual Art after the retrofit.

improvements to student engagement was evident in the earlier studies (see Authors, 2014a, 2016c). Also, Teachers A, D and F noted how the physical design of the open studio design aided their behaviour and classroom management. Here Teacher D found that having "no front in the room has forced me to increase my movement around the room, which I felt enabled me to keep my students on task." While, Teacher F found that the design of the spaces "meant that students could move freely about space, but I can easily monitor them in multiple spaces, which has increased student safety [in the use of workshop equipment]." These comments echoed those of the teacher sample from the earlier studies (see Authors, 2014a, 2016c), who associated removal of the front focal point with increased mobility about the space.

The collective findings across multiple studies at this site, do support the earlier assertions by Reynard (2009). The notion of a more responsive spatial layout has been shown to affect both student behaviour and engagement in learning. Here the removal of the front 'fireplace' teaching position, a construct that Reynard highlighted that acts as key monitorial/surveillance position and reinforces the authority of the teacher, improved teacher perceptions of their ability to manage student behaviour. Collectively, teachers across the various samples emphasise how the removal of the fireplace teaching position, forcing them to alter their behaviour and increase movement and proximity to students. Furthermore, such changes in behaviour are evident in the observed decrease in the proportion of lesson time focused on didactic instruction and greater incidence of class discussion, feedback and questioning. It is argued that together these behaviour changes to teacher practice aided by the spatial intervention underpinned these changes in student engagement in the class.

4.3. Communities of learning

The community of learning domain (Table 4) of the LPTS metric gathered data on the following attributes: learning in/as individual, small group (prescribed by the teacher), mixed groups (different numbers), whole class, and mixed classes. Across both faculties, there was a trend away from the individual and whole class arrangements (as exemplified in Fig. 7) to a more flexible and mixed grouping format (as exemplified in Fig. 8). Teacher A identified that "learning had become a much more social process" with the communal Design Lounge identified as the location that aided the process. Teacher F agreed that "the Design Lounge was invaluable, even though I did not use it to work with other classes, it enabled me to differentiate how I grouped my students." Teacher E agreed that the direct access to the Design Lounge "freed me up to try new things. It enabled me to differentiate the types of activities, as I had a second location that I could send different groups of students to work in." Confirming the trends observed in the domains outlined above, teachers spent less time orchestrating lock-step whole class instruction. Instead, they tended to simultaneously allow students to work in various sized or mixed groupings on different tasks in and outside the timetabled studio or workshop.

Table 4
Summary of Difference in the Communities of Learning in the Traditional Studios and Workshop (A-phase) to Creative Precinct (B- and C-phases).

Teacher	Class	Whole Class	Individual	Small Group	Mixed Groups	Mixed Classes
A	8 DT	*NS* [a]	*NS*	*NS*	*SS** [b]	*NS*
B	11 DR	*NS*	*NS*	*SS**	*SS**	*NS*
C	7 DT	*SS****	*SS****	*NS*	*SS****	*NS*
D	11 EG	*SS**	*SS**	*NS*	*SS****	*NS*
F	8 DT	*NS*	*NS*	*NS*	*SS****	*NS*
H	11 VA	*SS**	*SS**	*NS*	*SS****	*NS*
H	8 VA	*NS*	*NS*	*NS*	*SS****	*SS**
I	11 FM	*NS*	*NS*	*NS*	*SS****	*NS*
I	10 FM	*SS**	*SS**	*NS*	*SS**	*NS*
J	9 FM	*SS**	*SS**	*NS*	*SS**	*NS*
L	8 VA	*SS****	*SS****	*NS*	*SS**	*SS**
L	7 VA	*SS**	*SS**	*NS*	*SS**	*NS*

Note. [a] Non-statistically significant visual effect. [b] Statistically significant visual effect.
Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

An interesting trend was observed in the mixing of the Year 7 and 8 Visual Art classes. These were timetabled at the same time in three adjacent studio spaces. The responsive nature of the open studio design allowed teachers to easily separate the space into individual studios or open them into a single larger space. Visual analysis revealed that both participating Visual Art teachers took advantage of this spatial affordance to open their studios and mix their classes at times beneficial to their lesson intent. Throughout the B- and C-phases, these teachers used the affordance of a co-joined space to create a merged pedagogical space. Students could occupy different spaces and interact with their peers from the other class, while teachers coordinated how they occupied the spaces and the roles that they assumed. Interestingly, Teacher B identified that this process, aided by "the design of the spaces had improved my teaching, I now have greater access to work with my colleagues and the ability to observe them in action."

In comparison to the earlier studies conducted at this site, similar trends were observed about the nature of communities of learning in different spatial layouts. In a more rigid and static layout, teachers appeared to favour either the whole class or students working individually. On the other hand, a setting that was specifically designed for dynamic and fluid occupation removed those inherent spatial barriers that appeared to restrict more collaborative and mixed communities of learning. The comparable trends suggest that different spatial layouts can enable or hinder the opportunities for teachers to orchestrate various communities of learning during a lesson.

4.4. Student and teacher use of technology

The technology domain of the LPTS metric gathered data on the use of digital (i.e. data projectors and Tablet PCs) and spatial technologies (i.e. furniture). The visual analysis identified a significant change in the prevalence of Fisher's modalities of learning in the different layouts (Table 5). In a traditional design, teachers largely employed a combination of mode 1 (teacher-centric) and 2 (student-centric) learning modalities. In comparison, the open studio design of the Creative Precinct allowed the dynamic use of and transition between all three Fisher modalities in a single timetabled lesson. The visual analysis indicated that Teachers A, D, H and I took advantage of the 'outside' space of the Design Lounges, Gallery, and Meeting Rooms in addition to their timetabled studio or workshop. All teachers, expect Teachers B, H and J, made a consistent and sustained shift from a predominant teacher-centric orientation to a more dynamic informal (mode 3) teaching modality. Unlike in the traditional studios and workshops, teachers in the Creative Precinct appeared to utilise the affordances of additional

Table 5
Summary of Changes in Teacher Uses of Technologies Through the Spatial Transition from Traditional Studios and Workshop (A-phase) to Creative Precinct (B- and C-phases).

Teacher	Class	Tablet PC	Projector	Mode 1 [a]	Mode 2 [b]	Mode 3 [c]	Outside [d]
A	8 DT	*NS* [e]	*SS*[f]*	*SS***	*NS*	*SS***	*SS***
B	11 DR	*SS**	*SS**	*NS*	*SS**	*SS**	*NS*
C	7 DT	*SS****	*NS*	*SS**	*NS*	*SS**	*NS*
D	11 EG	*SS**	*SS**	*SS**	*NS*	*SS**	*SS**
F	8 DT	*NS*	*NS*	*SS**	*SS****	*SS****	*NS*
H	11 VA	*NS*	*NS*	*NS*	*NS*	*SS**	*SS**
H	8 VA	*NS*	*NS*	*SS**	*NS*	*SS**	*SS**
I	11 FM	*SS**	*SS***	*SS****	*NS*	*SS**	*SS**
I	10 FM	*SS**	*SS**	*SS****	*NS*	*SS**	*NS*
J	9 FM	*NS*	*NS*	*NS*	*NS*	*SS*	*NS*
L	8 VA	*NS*	*NS*	*NS*	*NS*	*SS****	*SS***
L	7 VA	*NS*	*NS*	*NS*	*NS*	*SS**	*SS**

Note. [a] Teacher-centric spatial mode. [b] Student-centric spatial mode. [c] Informal spatial mode. [d] Breakout Spaces (i.e. Design Lounge, Gallery, Meeting Room, and Workshop).
Note. [e] Non-statistically significant visual effect. [f] Statistically significant visual effect.
Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

spaces to differentiate instruction and learning activities.

The observed trends in the dynamic occupation of the physical learning environment were in keeping with the earlier studies at this site. The analysis of Authors (2016b) and Authors (2014a) demonstrated how many teachers utilised the design intent of an ILE to facilitate different communities of learning. Across all studies, teachers appeared to use the affordance of spaces (both traditional and ILE) as a pedagogical tool to facilitate pedagogies and learning experiences. A traditional classroom, by its design, was associated with a high incidence of teacher-centric pedagogies in a whole-class format. In comparison, the same teachers, teaching the same subject and class in an ILE, could exploit the affordance of multiple spaces and different technologies (digital and spatial) for pedagogical gain.

The occupation of ILEs correlated to a general reduction in teachers' use of digital technologies (Tablet PC and data projector). Supporting the reduction in time engaged in whole class and didactic-pedagogical modes, teachers typically spent less time disseminating information through the visual display of the data projector. Interestingly, this supported trends identified in earlier studies, which highlighted the tendency for teachers in the more traditional classroom layout to use digital technology as a primary means to disseminate content and information. This is a significant finding given that much of the conversation about digital technologies in education is its use as a means of connection and collaboration between teachers and students.

For students, it was observed there was a major change in their use of digital and spatial technologies (Table 6). Rather than being confined to the same space at the same time, as observed in the traditional studios and workshops, students occupied a greater range of spaces in ILEs. Teacher C (Visual Art) indicated that they had experienced various subjects not using their pre-determined space, as they on "several occasions" taken their "Visual Art class to the Drama studios to facilitate smaller group performance-based instruction." In addition to this example, during their time in the Creative Precinct, there was a tendency for students to be arranged in different sized groupings. Students transitions between Fisher (2006) three modalities of learning (teacher-centric, student-centric and informal) - a key facet of the Creative Precinct design. In these more fluid grouping and spatial arrangements, there was little change in the incidence of student use of their Tablet PC device. However, unlike their teachers, students spent a higher proportion of their time using their device as a means of creative endeavour.

4.5. Barriers and challenges associated with a spatial transition

The participants readily identified the challenges that occurred in the inhabitation and occupation of the Precinct. The challenges identified ranged from teething problems through to inherent structural barriers that restrict further innovation. Teacher F identified that "it took the students, and teachers, a period to get used to working in the new space." Teacher A agreed to say "that the ability for students to see each other through the glass walls was a short-term issue, as most got used to visibility pretty early in the piece." Teacher G identified that

Table 6
Summary of Changes in Student Uses of Digital and Physical Technologies Through the Spatial Transformation from Traditional Studios and Workshop (A-phase) to Creative Precinct (B- and C-phases).

Teacher	Class	Tablet PC	Equipment [a]	Mode 1 [b]	Mode 2 [c]	Mode 3 [d]	Outside [e]
A	8 DT	*NS* [e]	*NS*	*SS****	*NS*	*SS****	*SS****
B	11 DR	*NS*	*SS**	*NS*	*SS**	*SS**	*NS*
C	7 DT	*NS*	*SS***	*SS**	*NS*	*SS**	*NS*
D	11 EG	*SS**	*NS*	*SS**	*NS*	*SS**	*SS**
F	8 DT	*NS*	*NS*	*SS**	*SS****	*SS**	*NS*
H	11 VA	*NS*	*SS*	*NS*	*NS*	*SS**	*SS**
H	8 VA	*NS*	*NS*	*SS**	*NS*	*SS**	*SS**
I	11 FM	*NS*	*NS*	*SS****	*NS*	*SS**	*SS****
I	10 FM	*NS*	*NS*	*SS****	*NS*	*SS****	*SS*
J	9 FM	*NS*	*NS*	*NS*	*NS*	*SS**	*NS*
L	8 VA	*NS*	*NS*	*SS**	*NS*	*SS***	*SS****
L	7 VA	*NS*	*NS*	*NS*	*NS*	*SS****	*SS****

Note. [a] Subject-specific equipment. [b] Teacher-centric spatial mode. [c] Student-centric spatial mode. [d] Informal spatial mode. [e] Spaces (i.e. Design Lounge, Gallery, Meeting Room, and Workshop) outside timetabled location.
Note. [e] Non-statistically significant visual effect. [f] Statistically significant visual effect.

"the open spaces were more threatening to some students, but enabling to others." These comments do echo the work of Hildebrand (1999) around the influences of hegemonies. Hildebrand highlighted how it is not only teachers but also students, who experience challenge or discomfort with any form of educational change.

The conversation then shifted to the more structural or education-specific barriers that restricted further innovation. Teacher A identified that there "are mixed messages out there. There is a misalignment between our subjects driving innovation and change, with the significant emphasis on the results of the core or traditional subjects [i.e. English, Mathematics, and the Sciences]." Teacher D agreed to say "standardised testing and accountability to the board and parents are placing too much emphasis on English, Mathematics, and the Sciences. It was clear that this focus detracted from the supposed innovation culture that this building is trying to achieve." Teacher A agreed to say that the timetable, its constraints and design around the core subjects "is a massive impediment to further changes in the building." Teacher C identified that they felt "that the timetable and the constraints during its construction are key to support the changes that this building [Creative Precinct] is trying to achieve." Again, these points suggest the influence of Tyack and Tobin's grammar of schooling that inhibit change/s to the current schooling model. The comments outlined in this sample, suggest that the realities of everyday schooling do inhibit the function and intention of these more innovative spaces and the types of learning that they are designed to foster.

5. Conclusion

The premise driving the current interest in contemporary learning spaces is that they will facilitate a pedagogical change, one characterised by greater collaborative learning, critical thinking, communication amongst learners, and heightened creativity. However, there has been limited empirical evidence showing how these spaces have realised this envisioned change. This study attempted to illuminate how a spatial transformation, from traditional classrooms to ILE, affected both teacher and student activity and behaviour. The SSRD provided the means to articulate the pedagogical changes made by of Design and Technology and Visual Arts teachers through the spatial transition by the application of the novel LPTS real-time observation metric.

The visual analysis of the metric's quantitative data identified that the change in space did change elements of teacher pedagogical practice and student activity. There was a general trend away from a high proportion of didactic and teacher-centric (mode 1) whole class instruction. After the ILE intervention, this pedagogical model was still observed but was much shorter and more focused on its intent, which teachers noted improved its effectiveness. In its place was an increased prevalence of more active pedagogies facilitated in more informal (mode 3) arrangements. Teachers did utilise the affordances of multiple spaces to facilitate increased instances of student collaboration in mixed number groupings. How teachers plan for and employ these spatial affordances, in the longer term, warrants further exploration to determine the longer-term effects on the nature of student learning experiences.

The pedagogical shift did translate to the nature of and types of student learning experiences observed. In the traditional classroom, learning was overtly a passive and sequential activity directed by the teacher. In the ILE, there was a shift to more active pedagogies with greater levels of activity differentiation. The teachers spent more time providing focused instruction, feedback (appraisal) and suggesting future direction (refinement) to individuals and small groups of students. The open studio design of the Creative Precinct supported the effective and efficient movement of students through their activity in different spaces. Therefore, this observed change had a significant effect on reducing student distraction and off-task behaviours.

This study demonstrated how the affordances of different spaces, can shape the teacher and student activity and behaviour. These findings do suggest that the LPTS observation metric, analysed through an SSRD approach, has the potential to evaluate teacher and student experiences in a variety of learning spaces. However, to improve the generality and validity of both the approach and the LPTS metric, a longer-term evaluation of teacher changes and the effects of different contexts/spaces is required. Subsequent articles will focus on the longitudinal implications of a spatial transformation on teacher behaviour and pedagogies and how this affects student learning experiences and academic outcomes.

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