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Analysing mobile learning designs: A framework for transforming learning post-COVID

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Mobile learning is well established in literature and practice, but under-evolved from a rigorous learning design perspective. Activity theory presents a sophisticated way of mapping and understanding learning design, but for mobile learning this does not always translate into change in practice. The reported research addresses this by coupling a mobile learning specific approach to activity theory with a practice-based framework: the design for transformative mobile learning framework mapped to the pedagogy-andragogy-heutagogy continuum matrix (the DTML-PAH Matrix). Seven case studies are analysed using this approach and presented narratively along with framework informed analysis. Findings include that the DTML-PAH Matrix can be used to provide clearer implications and guidance for mobile learning practice, and that the DTML-PAH Matrix can also be guided by the practice over time. Implications for further research and practice are discussed.

Implications for practice or policy:

- Provide technological and pedagogical scaffolds to students.
- Learning designs should focus upon enabling elements of learner agency and creativity.
- To develop learning solutions to real world problems utilise a design-based research approach.
- Create authentic collaborative learning activities and tasks.
- Integrate mobile learning affordances in the design of the course and curriculum.

Keywords: mobile learning, activity theory, learner agency, post-COVID learning design, heutagogy

Introduction

Mobile learning is highly endorsed, but lags behind actual, self-regulated use of mobile technology that facilitates learner agency (Traxler, 2021). While this is of general concern, the impact of COVID has made this a far more critical gap that needs to be addressed. Doing so requires a systematic approach that embraces both a clear sense of activities and their relationship to each other, as well as the ways in which mobile learning may progress learners from recipients of learning to active partners and then to self-regulated or self-determined learners.

Established in 2016, the ASCILITE Mobile Learning Special Interest Group (MLSIG) facilitates a network of mobile learning researchers and practitioners across Australasia. The focus of the MLSIG has been upon the development of authentic mobile learning experiences that facilitate learner agency. The MLSIG has contributed to the field of mobile learning research and practice through guest-editing and publishing case studies in several special issues of technology-enhanced learning journals (Cochrane et al., 2020; Cochrane & Farley, 2017; Cochrane, Smart, & Narayan, 2018) as well as a variety of technology-enhanced learning conference contributions (Cochrane et al., 2016; Cochrane, Narayan et al., 2018; Narayan et al., 2019; Narayan et al., 2020). In response to the impact of COVID-19 on higher education, the MLSIG produced a series of mobile learning design case studies (Cochrane et al., 2021; Narayan et al., 2021).

In this discussion paper, we extend the introduction of seven mobile learning design case studies by analysing each mobile learning design case study through the lens of activity theory (AT; Engeström, 2001) and a matrix of two learning design frameworks: the design for transformative mobile learning framework (Cochrane et al., 2017) and the pedagogy-andragogy-heutagogy continuum (Luckin et al., 2010). We refer to this matrix as the design for transformative mobile learning framework mapped to the pedagogy-andragogy-heutagogy continuum matrix (DTML-PAH Matrix) and introduce the matrix in this paper as a framework for designing transformative mobile learning experiences.

Background and context

Smartphones are now powerful mobile computing devices with multiple sensors and high-quality audio-visual recording components enabling connectivity, communication, geolocation, health monitoring, personal identification and a gateway into the Internet of Things all within a user's pocket. Other types of mobile computing devices include mobile tablets, wearable technologies, drones and stand-alone augmented reality and virtual reality (VR) head-mounted displays. This array of mobile computing devices can be leveraged in education in many ways: for example, supporting education outside of the classroom (Eames & Aguayo, 2020), enabling learner agency (Blaschke et al., 2021) and forming the basis of bring your own device approaches to computing access (Ng, 2015). There are of course many negative aspects of the volume and ubiquity of mobile computing devices, notably the impact upon users' attention and social behaviour (Dyson et al., 2017; Murphy, 2019) and the ethics of the sustainable sourcing of the rare-earth components required to manufacture these devices in such scale. The United Nations (2016) has identified several sustainable development goals (SDGs), which are particularly relevant to mobile learning and require investigation and research to explore how the educational use of these devices impact the quality of education, infrastructure requirements and the reduction of inequalities. West and Vosloo (2013) identified 12 unique benefits of mobile learning: (i) equitable education, (ii) personalised learning, (iii) timely feedback, (iv) anytime, anywhere learning, (v) increased productivity, (vi) networking and access to communities, (vii) situated learning, (viii) enhanced seamless learning, (ix) encourages formal and informal learning, (x) provides stability (xi) opportunities for enhanced inclusive designs and (xii) cost efficiency.

However, Traxler critiqued the state of mobile learning research and implementation in 2021 as "It has failed to adapt to a world where mobile technologies are pervasive, ubiquitous and intrusive and where people and communities can now own their own learning" (Traxler, 2021, p. 1). Traxler's critique highlighted the lack of learner agency in mobile learning designs, a focus upon content delivery to mobile devices and inadequate addressing of the digital divide between the first world and the third world. This critique aligns with the United Nations SDGs 4, 9 and 10 (quality of education; industry, innovation and infrastructure; and reduced inequalities).

Pre-COVID recent mobile learning literature themes

In a review of studies in mobile language learning in Japan over 15 years, Forsythe (2021) found that studies focused on student perceptions revealing positive attitudes towards use of mobile learning on content creation, collaboration and interaction. Students tend to be more familiar with smartphone technology than computers. This might mean that smartphones can become a distraction as the personal use and academic use overlaps. Other important issues identified are privacy and ownership – using students' own phone for educational use can be problematic. The positive benefits of mobile learning for language learning are highlighted by a collection of case studies (Morgana & Kukulska-Hulme, 2021) and a systematic review of 54 articles since 2010 (Persson & Nouri, 2018). These benefits included:

- Real-world interaction increases language skills and performance.
- Mobile language learning improved vocabulary gains.
- Mobile language learning led to increased reading and speaking proficiency.
- Mobile language learning increased motivation while decreasing student anxiety.
- Mobile language learning increased social interaction through collaboration.

Post-COVID mobile learning literature themes

Contrary to small-scale and discipline-specific applications of mobile learning pre-COVID, utilisation post-COVID has been generic and widespread. Multiple recent studies from the field have reported significant impact on the adoption of mobile learning, particularly on learner remote access to education (Baldock et al., 2021; Dhar et al., 2021; Eutsler, 2021; Hartmann et al., 2021; Naciri et al., 2020; Perera & Gamage, 2021; Recke & Perna, 2021).

Theoretical framing

AT has been proposed as a framework for mobile learning design (Pachler et al., 2010; Sharples et al., 2005; Uden, 2007). In this context, AT (Engeström, 2001) has been utilised to provide a framework for considering the different entities and facets and the interplay between them as an ecology for designing for learning with mobile devices (Bozalek et al., 2014). AT delineates learning into several elements to understand and examine learner interactivity in sociocultural settings that are made of entities and artefacts in a space at a given time (Engeström, 2001; Rozario et al., 2016). As a result, learning in AT is viewed as an interplay between tools (mediating artefacts), subjects (actors), object(ive) (goals), rules (constraints and guidelines), community and division of labour (who controls it) – together forming the activity system (Engeström, 2001). The object of an activity system leads to the overall goal of the interactions, which in our perspective (Figure 1) are the learning outcomes achieved (developing learner agency) through the mediating affordances of mobile learning (enabling learner-generated content and learner-generated contexts). Though developed independently, our generic model of a mobile learning activity system shares many similarities to the adapted model proposed by Rozario et al. (2016).

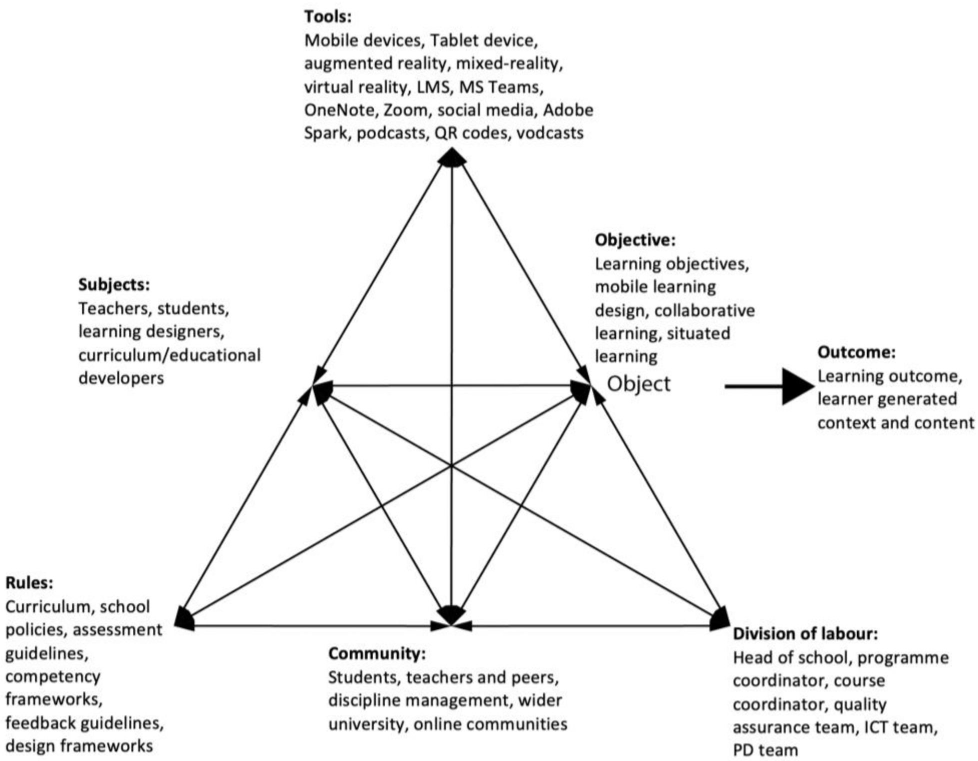

Figure 1. Generalised mapping of mobile learning design using AT

While AT is seen as useful for analysing relational aspects of mobile learning environments, it has been criticised for being difficult for mobile learning practitioners to translate this analysis into practice (Pachler et al., 2010).

The DTML framework (Cochrane et al., 2017) attempts to bridge this gap through providing a pragmatic mobile learning design framework. The framework has been iteratively developed from a variety of higher education contexts: Cochrane, 2020; Cochrane & Antonczak, 2014, 2015; Cochrane et al., 2014; Cochrane & Narayan, 2017. Kearney et al. (2020) summarised the focus and importance of the DTML framework:

> The Design for Transformative Mobile Learning framework, which, as the title makes clear, is focused explicitly on a radical, transformative agenda for education that goes far beyond making learning more efficient… In order for these transformations to occur, the Design for Transformative Mobile Learning framework advocates a shift from teacher-directed to student-directed pedagogies and frames m-learning as a context for the construction of authentic learning communities. (Kearney et al., 2020, p. 109)

Learner agency can be seen as a measure of quality education, where educational designs are focused upon developing learners' capacity to navigate the unknown (Blaschke & Hase, 2019; Hase & Blaschke, 2021). Transformative mobile learning designs implement strategies to facilitate a move from a focus upon teacher-directed content (pedagogy) towards student-determined learning or heutagogy (Blaschke & Hase, 2019; Hase & Kenyon, 2001, 2007; Moore, 2020). This involves applying the PAH continuum to mobile learning design (Blaschke, 2012; Kearney et al., 2020; Luckin et al., 2010) to facilitate learner agency. When put into a matrix, with DTML, PAH provides a mapping of how learners may transition into increasing self-regulation and learner agency across the eight mobile learning relevant areas or dimensions. The elements of the DTML-PAH Matrix are summarised and illustrated in Table 1.

Table 1
The DTML-PAH Matrix: A framework for designing transformative mobile learning, adapted from Cochrane et al. (2017, p. 27)

Design elements	Pedagogy	Andragogy	Heutagogy
Engagement types	Content delivery, digital assessment, teacher-delivered content and teacher-defined projects	Teacher as guide, digital identity, student-generated content and student-negotiated teams	Teacher as co-learner, digital presence, student-generated contexts and student-negotiated projects
Locus of control	Teacher	Student	Student
Cognition	Cognitive	Metacognitive	Epistemic
SAMR (Puentedura, 2006)	Substitution & Augmentation, for example, moving from a portfolio to an e-portfolio or using PowerPoint on iPad	Modification, for example, reflections as video cast and using Google Slides on an iPad	Redefinition, for example, reflections in situ and presentations as dialogue with source material
	Focus on productivity	New forms of collaboration	Community building
	Mobile device as personal digital assistant and consumption tool	Mobile device as content creation and curation tool	Mobile device as collaborative tool
Creativity (Sternberg et al., 2002)	Reproduction	Incrementation	Reinitiation
Knowledge production	Subject understanding: lecturers introduce and model the use of a range of mobile learning tools appropriate to the learning context	Process negotiation: students negotiate a choice of mobile learning tools to establish an e-portfolio based upon user-generated content	Context shaping: students create project teams that investigate and critique user-generated content within the context of their discipline. These are then shared, curated and peer-reviewed in an authentic community of practice
Ontological shift	Reconceptualising mobile learning: from a social to an educational domain	Reconceptualising the role of the teacher	Reconceptualising the role of the learner
Self-perception (Danvers, 2003)	Learning about	Learning to become	Active participation within a professional community

Taken together, AT and a DTML-PAH Matrix allow for a complementary understanding of learning activities, according to mobile learning-specific areas and in terms of three key stages of learner autonomy. The aim of this paper was, therefore, to use AT in combination with the DTML-PAH Matrix to better understand mobile learning and how it may be enacted for learning and curriculum design.

The research questions were:

(1) What can we learn from using AT to analyse mobile learning designs?
(2) How can the DTML-PAH Matrix extend AT analysis to practically inform mobile learning designs as a guide for quality education?

Methodology

We collected seven cases. We followed Yin's (2011) guidance on case studies, in that we began with exploring existing research and developing our theoretical framing. We then set research questions guided by existing research and framing. This then allowed us to delineate the scope and boundaries of cases, allowing for exploration of the research questions. Cases were mapped to AT analysis and the DTML-PAH Matrix frameworks to identify the mobile learning strengths and gaps and aid those that want to do something similar in the future.

How the case studies were selected

Seven case studies from the members of the MLSIG were purposively selected to create vignettes reflecting on the design of mobile learning experiences during 2021. These were shared in collaborative meetings with the members of the MLSIG. These members are affiliated with universities in Australia, New Zealand, Japan and the United Kingdom. The reflections were first shared in an MLSIG meeting, and the members were then invited to compose a vignette to be included in a concise paper and accompanying poster for the ASCILITE 2021 conference. Each of the seven case studies are extended for analysis in this paper.

Summary of interventions

As part of the ASCILITE 2021 conference, each case study was summarised with a video (Narayan et al., 2021; Cohrane et al., 2021). Rather than provide a textual description therefore, each of the example mobile learning case studies are introduced via this short overview or vignette (hyperlinked below):

- Paramedic clinical education in New Zealand (Aiello, 2021)
- Immersive virtual reality for social learning in Japan (Alizadeh, 2021)
- Architecture, engineering and construction site visits in Australia (Birt, 2020)
- Hybrid Model United Nations in Japan (Cowie, 2021)
- Virtual physiotherapy learning and assessment in New Zealand (Stretton, 2021)
- Designing for online, blended and synchronous learning for computing students in Australia (Worthington, 2021)
- Collaborative mobile learning in environmental science in Australia and Hong Kong (Bone, 2021).

Ethics

Each of the case studies is described and analysed from the perspective of the lecturers (who are also members of the MLSIG) as the designer of the mobile learning experience. As no student data is referenced in these design and analysis stages of each project, there is no need for ethics consent.

Case study analysis

We analysed seven mobile learning design case studies through the lens of AT (Engeström, 2001) and the DTML-PAH Matrix (Cochrane et al., 2017).

Each case study is introduced with a 250-word summary followed by an analysis using a shared Excel Spreadsheet for evaluation via the eight dimensions of the DTML-PAH Matrix via a 3-point scale to give a score out of 24 with a spider graph representation (Figure 2) and an AT diagram template (Figure 1) on which to map the goals, implementation and interactions of each case study.

We utilised Rozario et al.'s (2016) six-step model (adapted from Jonassen and Rohrer-Murphy, 1999) to map the activity system for each case study:

(1) Clarify the purpose of the activity
(2) Analyse the activity system
(3) Analyse the activity structure
(4) Analyse tools and mediators
(5) Analyse the context
(6) Analyse the activity system dynamics.

Case 1: Paramedic online clinical education

The transition from student to competent paramedic requires a hybrid educational approach for theory praxis development. The challenge during the pandemic period was to determine how the programme could help and support the learning within an online environment. Knowing that it is vital that the materials used by students are engaging and accessible, a flipped class approach was designed with options for a mixed modality presentation. The design gave the students both active and passive learning techniques whereby they could watch the video content in a traditional computer or iPad form or listen to the content via a mobile phone whilst in the car, gym or in any environment. The design was further complemented with subsequent synchronous online discussion forums. This in turn helped develop a sense of a learning community and promoted engagement and content reflection.

Student feedback described deeper cognitive thinking and reflection, and a community learning environment and the design resulted in an increased student grade average for the course. The learning design helped to establish a flipped class online community. The design helped shift the lecturer from one of delivering content (pedagogy) to one of now being an active member of the student community (ontological shift). The change in role led to the lecturer being able to guide discussion between the students that reflected the asynchronous online content (andragogy). Whilst the locus of control for the content delivery remained with the lecturer, the reproduction of the content towards the auditory learning lecture did offer a new approach to the online course material. The one main disadvantage of online education within the clinical space is that this approach is currently unable to provide haptic (hands-on) clinical skills practice.

An analysis of the case study using AT and the DTML-PAH Matrix is presented in Figures 2 and 3.

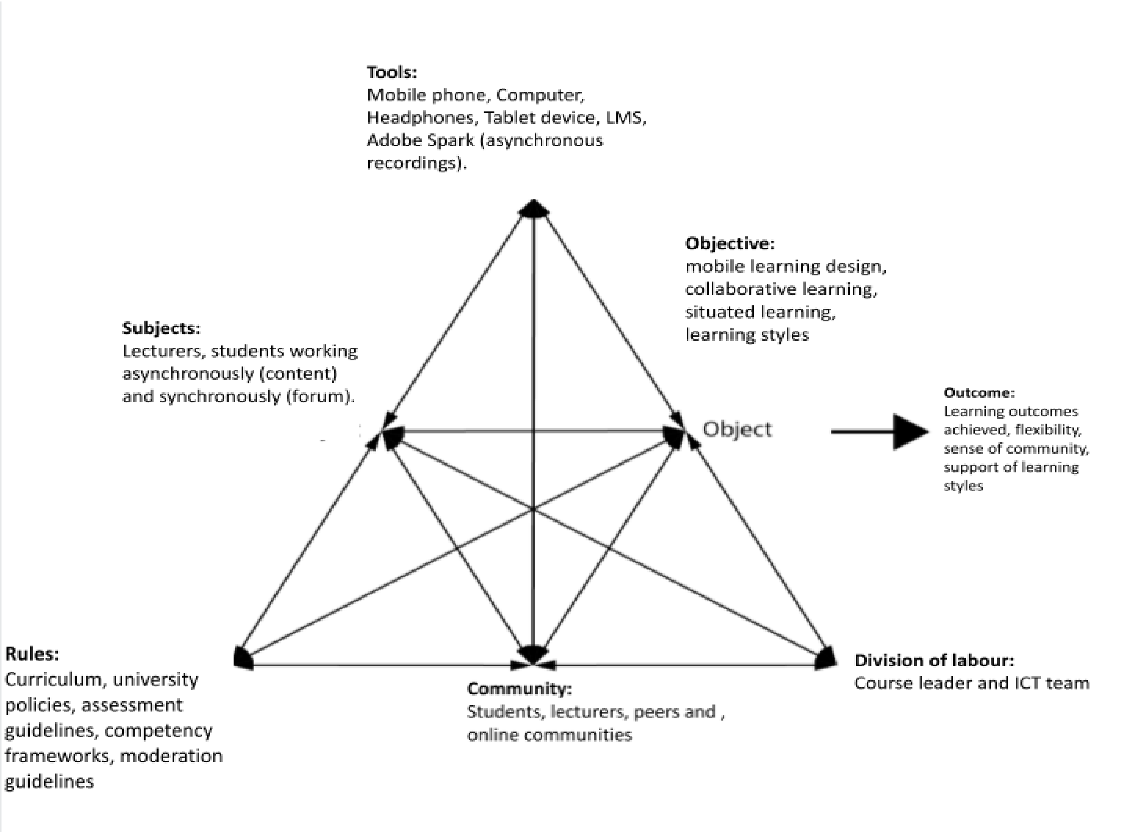

Figure 2. AT analysis (Case 1)

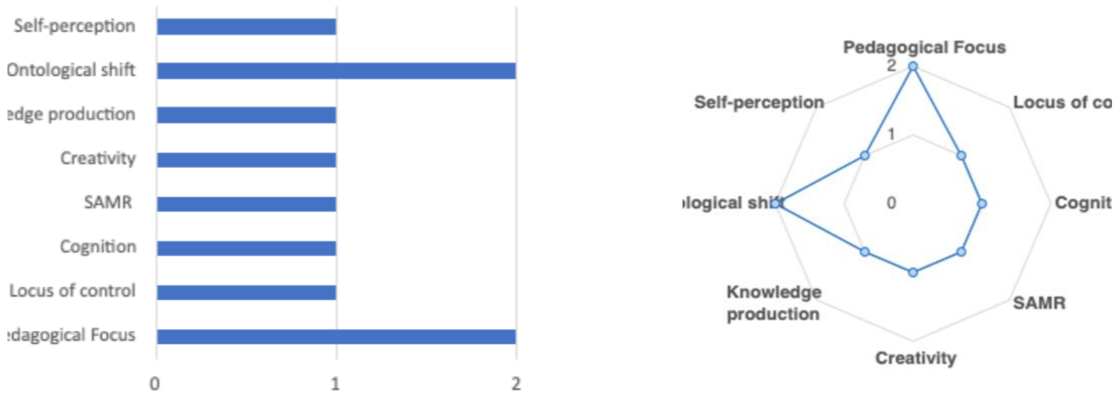

Figure 3. DTML-PAH Matrix analysis (DTML-PAH Matrix score = 10), Case 1

Case 2: Immersive VR for social learning

The pandemic forced many universities in Japan to transition to fully online or blended learning. To bridge the social distancing gap and to experiment with new ways of providing quality education in the post-pandemic era (SDG4: Quality of education; SDG9: Industry, innovation and infrastructure; United Nations, 2016), we examined the experiences and perceptions of a group of five students from varied ethnic and academic backgrounds (SDG10: Reduced inequalities; United Nations, 2016) regarding immersive learning to clarify the benefits and challenges of VR in social learning contexts (Figure 5). Following a student-centred design, five volunteer students were given Quest 2 headsets and asked to explore free VR apps for educational use. They presented their findings during remote weekly meetings held on Engage and documented their insights and reflections in an online survey. It was relatively easy for the students to find apps related to entertainment and social exchange; however, they found it more difficult to find apps that could be of educational use. In general, they had a positive attitude towards VR-powered immersive learning and considered it a fun and exciting experience. They mentioned sense of presence, focused attention and improved team bonding as other strengths of VR. Despite these benefits, most of the participants suffered from some degree of cybersickness (Rebenitsch & Owen, 2016) caused using head-mounted displays. To tackle these issues, the students were introduced to Mozilla Hubs, a WebVR platform, and were asked to create their own VR environments to showcase a project of their interest. The students viewed Hubs as a useful tool for virtual communication, but some of them experienced difficulties in terms of the amount of processing power that the platform requires. This case study shows that student-centred VR-based immersive learning has merits but also challenges that should be overcome to yield desired outcomes.

An analysis of the case study using AT and the DTML-PAH Matrix is presented in Figures 4 and 5.

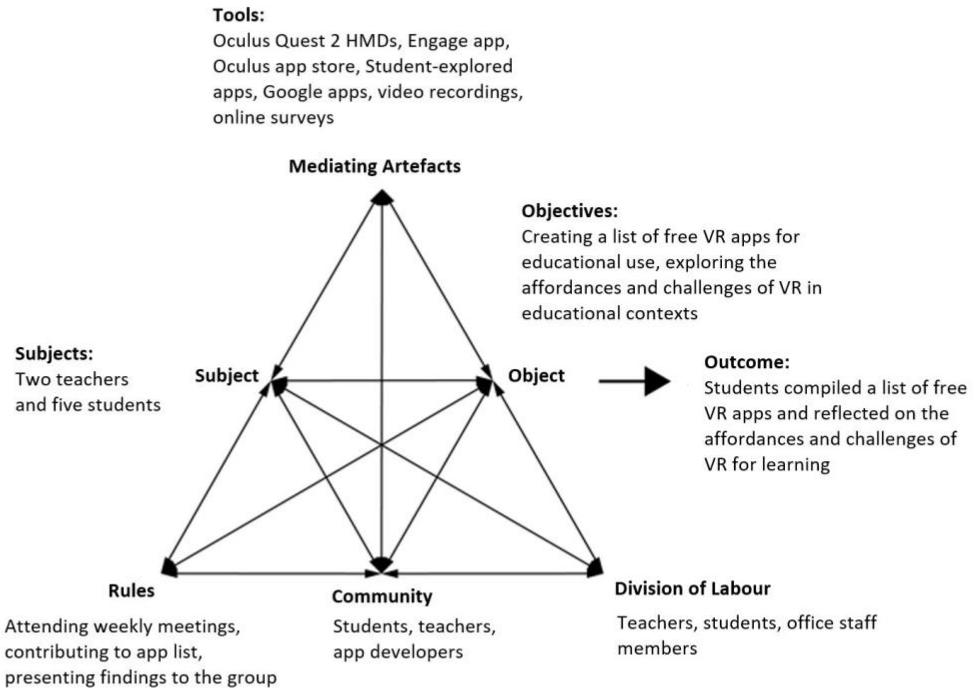

Figure 4. AT analysis (Case 2)

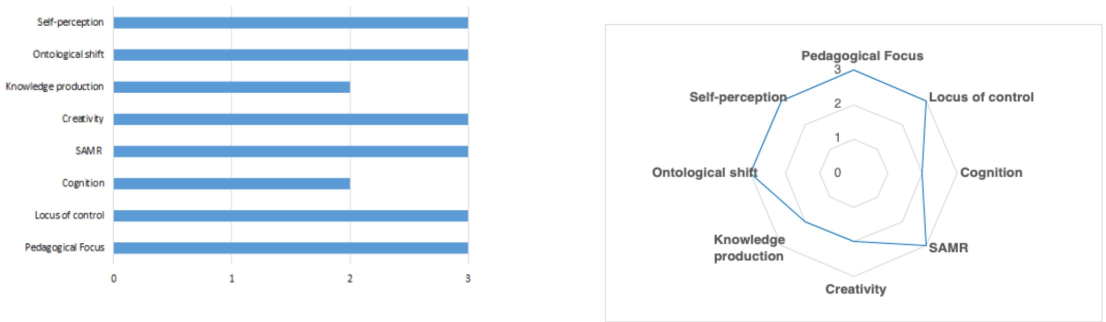

Figure 5. DTML-PAH Matrix analysis (DTML-PAH Matrix score = 22), Case 2

Case 3: Architecture, engineering and construction site visits

Bond University students have transitioned from physical site walkthroughs using 2D plan drawings and in situ augmented reality to a smartphone application, supporting in-home and classroom spatial learning. The application presents a human scale navigable building using a digital twin model, high fidelity 360-images and points of interest mapped to the 2D plan drawings. A total of 250 learners from construction and architecture attended a remote (May and September 2020) or hybrid (January, May and September 2021) workshop on bringing plans to life. Learners were asked to download the app prior to class with support videos on the learning management system. During the class, the teacher provided a lecture on technology enhancement in the industry through live demonstrations using VR and 3D models. Learners were then asked to follow the provided lesson plan and answer eight questions related to points of interest around the building, including identification of structure layers, capacity to map 2D drawings to 3D structures and their reflection of the task and technology. Learners identified the device and approach as pedagogically focused with the ability to switch between the views in real time. The theme of creativity emerged as learners could explore the building in ways they could not in the real world. This included options for scaling and navigating to points of interest such as the roof and structural footings. Students discussed enhanced communication with the teacher and peers by sharing screenshots from the app to the live video stream. Learners identified a greater understanding of the profession redefining their attitudes towards accessible technology use and content presentation.

An analysis of the case study using AT and the DTML-PAH Matrix is presented in Figures 6 and 7.

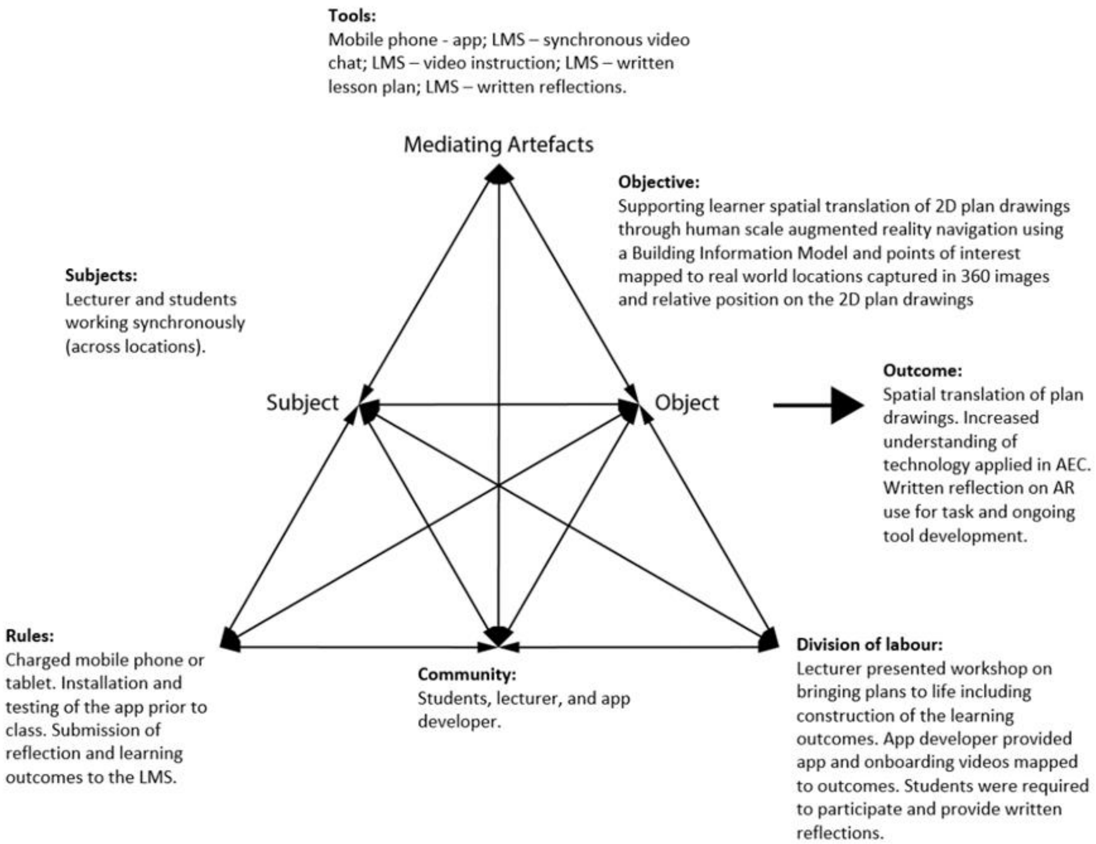

Figure 6. AT analysis (Case 3)

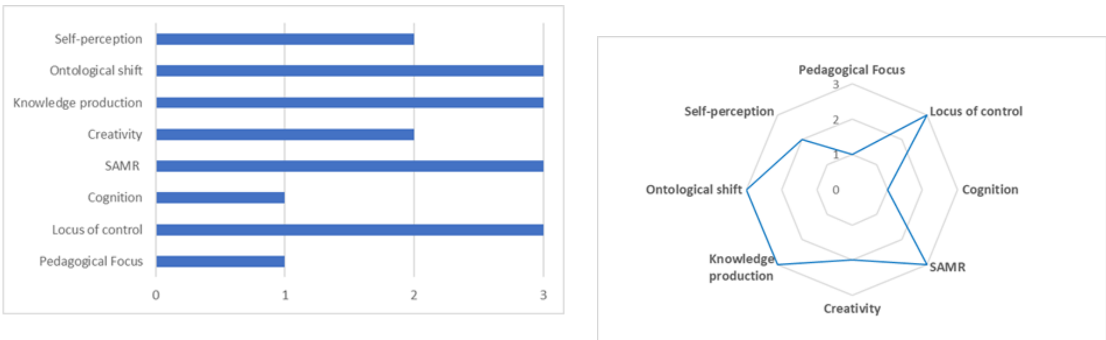

Figure 7. DTML-PAH Matrix analysis (DTML-PAH Matrix score = 18), Case 3

Case 4: Hybrid Model United Nations

From April to June 2021, a Model United Nations class at Okayama University in Japan was carried out in a hybrid manner to prepare students for an online event. The course consisted of eight 2-hour lessons. One teacher taught 14 Japanese students face-to-face in a classroom, whilst a second teacher was online with students from Spain and Taiwan who were unable to enter Japan because of the COVID-19 pandemic. The online teacher and students joined the classroom via Zoom and LINE as classroom-based students would open the applications on their phones. All students could access Moodle and Google Docs when carrying out research and writing action plans together. In addition, short speeches that used to be made face-to-face were recorded by the students on the Flipgrid application, which enabled both teachers and students to give feedback. There were three main implications of this experience for a more transformative learning design. Firstly, the pedagogical focus became more student-centred as students, especially through the LINE application, were able to generate their own learning goals and means of attaining them. Closely connected to this was the fact that as LINE was a student-chosen tool which the teachers did not have access to, knowledge of Model United Nations processes and procedures was partially gained through a student-only community of practice. Finally, the teacher's role, especially that of the online teacher, was transformed to one of collaborating with online students to jointly negotiate the new learning environment.

An analysis of the case study using AT and the DTML-PAH Matrix is presented in Figures 8 and 9.

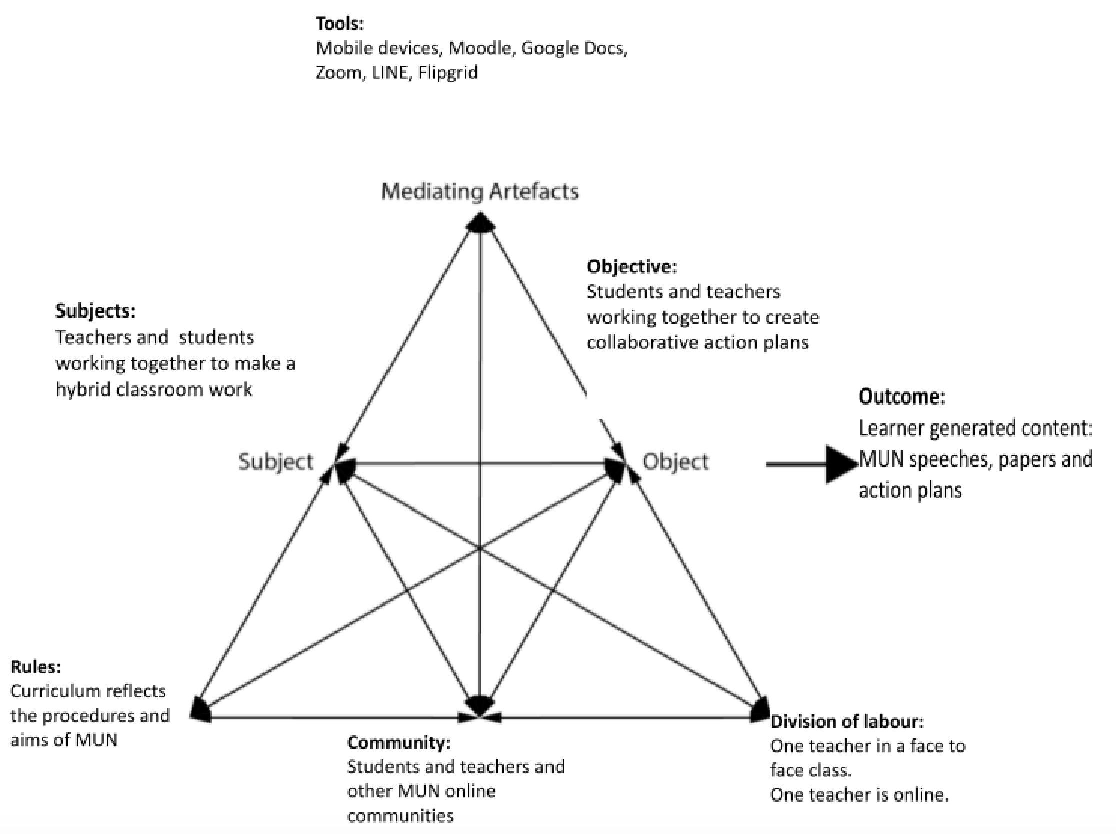

Figure 8. AT analysis (Case 4)

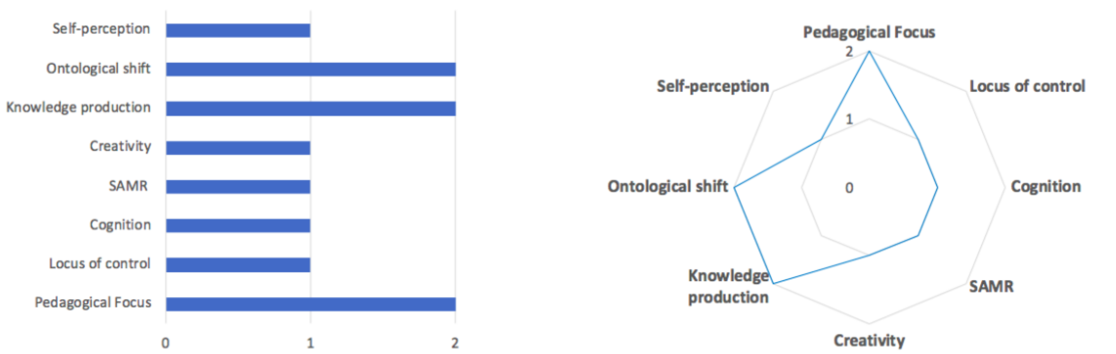

Figure 9. DTML-PAH Matrix analysis (DTML-PAH Matrix score = 11), Case 4

Case 5: Virtual physiotherapy learning and assessment

The physiotherapy department at Auckland University of Technology re-envisaged teaching and learning in response to COVID while being mindful of engagement, cognitive load and digital equity of students. In 2021, assessments were also redesigned in light of COVID with most conducted by synchronous verbal assessments using teleconferencing software. As proctoring was not available, an open-book approach was utilised without any significant differences when compared to previous year results. Practical assessments were also re-envisaged in response to either who was in the students' respective bubbles (social distancing small groups); or scenarios created to assess practical skills in isolation of others. We saw students learn through the practice-to-perfect their recordings and evidence of more thoughtful critical thinking skills. Students described being part of a community and remaining engaged with learning.

While the use of tools did not change remarkably, the reliance, connectivity, stability and digital equity of online resources was paramount. Establishing communities of practice was developed over time, as the value of collaborative and authentic learning provided connection and a sense of identity. Rules were adapted to enable flexibility of learning and the creation of artefacts that represented roles as physiotherapists. Learning during this time continued an andragogical focus with the locus of control still facilitated by the lecturer. There were some significant modifications of task and assessment design for physiotherapy, which required a reconceptualisation of the lecturer role with more peer-to-peer and lecturer-to-student co-creation. Students continued to have an active participation as teaching and learning strategies maintained an authentic learning experience.

An analysis of the case study using AT and the DTML-PAH Matrix is presented in Figures 10 and 11.

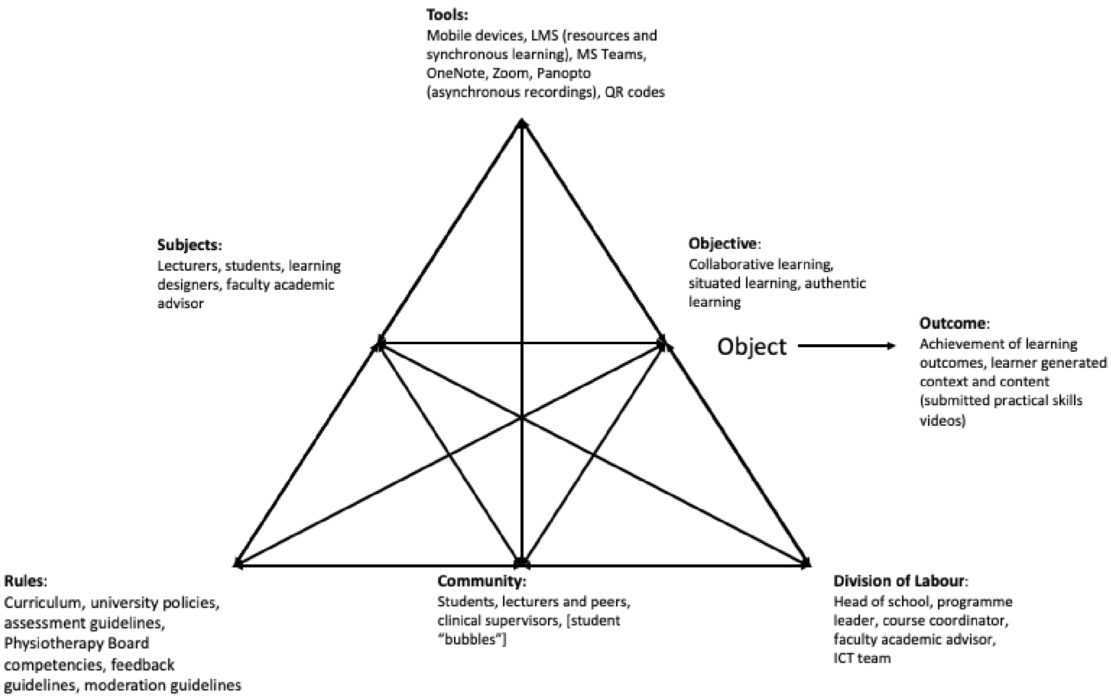

Figure 10. Virtual physiotherapy as applied to an AT framework (Case 5)

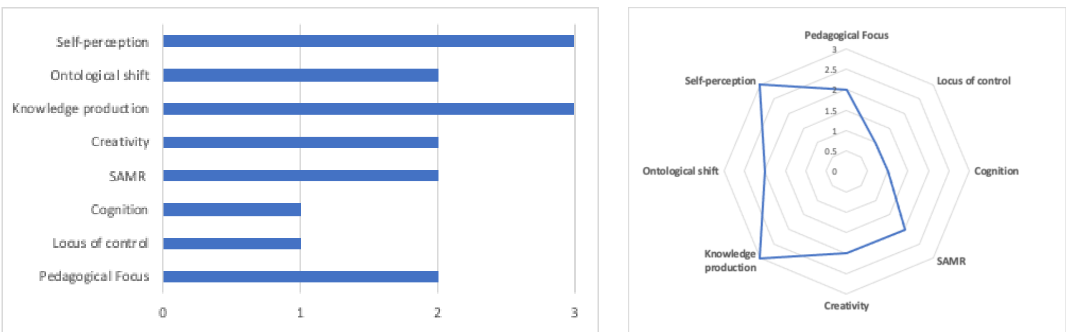

Figure 11. DTML-PAH Matrix analysis (DTML-PAH Matrix score = 16), Case 5

Case 6: Designing for online, blended and synchronous learning for computing students

For 2020, the computer project management course at the Australian National University switched from blended to pure e-learning (Worthington, 2019). The course consolidates learning at the end of a degree, with a reflective portfolio (Browne et al., 2020). The course was delivered twice in blended mode, just before the pandemic in 2019. In 2020, the workshops moved to Zoom and students undertook the same small-group activities in Zoom rooms. No changes were required to the learning objectives, course notes, assessment, or the Moodle learning management system. The materials had been prepared using accessible design, to allow for a mobile device. Short videos were generated using a text-to-speech tool, with closed captions for the deaf (SDG10: Reduced inequalities; United Nations, 2016). This resulted in videos suitable for low-speed wireless broadband links and mobile devices. Student engagement was encouraged through short online exercises and peer feedback with a few marks. No examinations were used, with teams of students working for a real client. This represents an andragogical approach, with each team of students responsible for planning their work, within a framework set by the course (see Figure 14). As online tools common in the computer industry were already in use, no changes were required to the roles of those involved: student, tutor, client, lecturer and careers counsellors, while there was increased use of online tools to replace face-to-face meetings (see Figure 12).

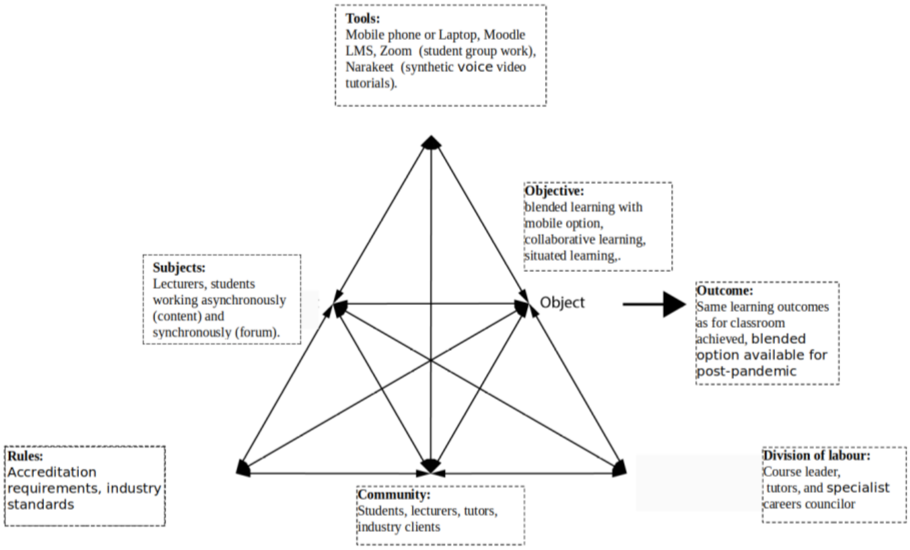

Figure 12. Online, blended and synchronous learning for computing students as applied to an AT framework (Case 6)

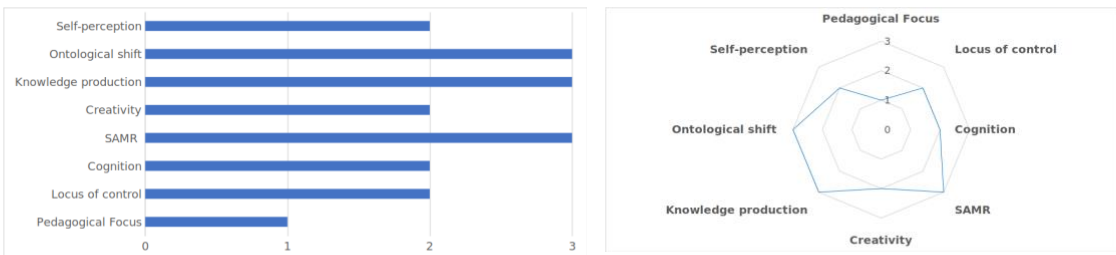

Figure 13. DTML-PAH Matrix analysis (DTML-PAH Matrix score = 18), Case 6

Case 7: Collaborative mobile learning in environmental science

Case 7 is an example of a case of intentional design. Whereas Cases 1–6 use AT and the DTML-PAH Matrix to analyse an enacted curriculum, Case 7 demonstrates the use of AT and the DTML-PAH Matrix in forward-facing design.

Authentic, place-based learning is essential for students of ecology and environmental science, assisting in building environmental literacy and an understanding of the effects of human impacts on natural systems. Mobile technologies have the potential to provide students with opportunities for flexible and collaborative learning opportunities and are increasingly attractive to field-based environmental science and ecology disciplines, enabling traditional data collection and collation to be done collaboratively and facilitating the sharing of data, analyses and student reflections. Our project in progress seeks to develop a digital learning ecosystem that will allow undergraduate students in coastal ecology to collect, collate, analyse and share field-based data and experiences, across institutions in Australia, Hong Kong and South Africa.

Central to the system is a custom-built mobile application, YourShore, developed by the FAIMS group (https://faims.edu.au/) (Ballsun-Stanton et al., 2018) to facilitate the collection of biodiversity and habitat data in near-shore environments. YourShore allows record annotation including image uploads, enables real-time data syncing across all users and offline data collection. It currently directs users to enter data for a pre-determined set of parameters at each location that include broad habitat characteristics and basic species information, representing an *augmentation* to traditional field data collection activities. Implemented as planned, the learning ecosystem will allow students to direct their own field-based learning, share experiences with peers at both their own and other institutions and contribute content to a growing shared database, developing their skills in collaboration, communication and self-regulated learning and allowing them a richer connection to the discipline.

A conceptual analysis of the case study using AT and the DTML-PAH Matrix is presented in Figures 14 and 15.

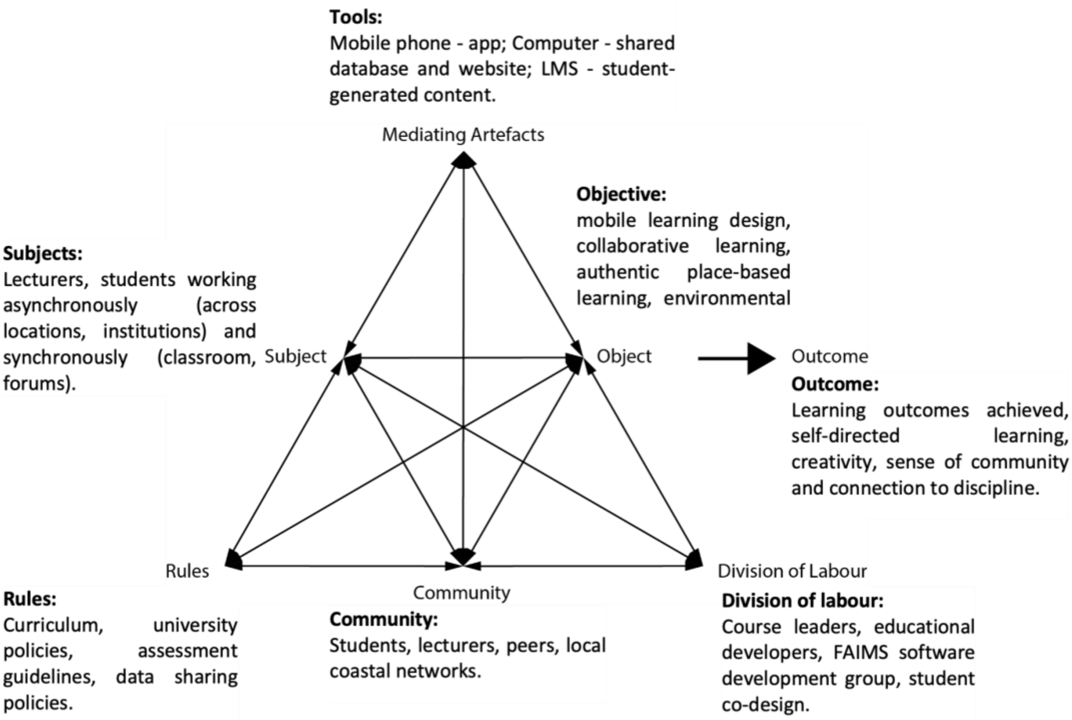

Figure 14. AT analysis (Case 7)

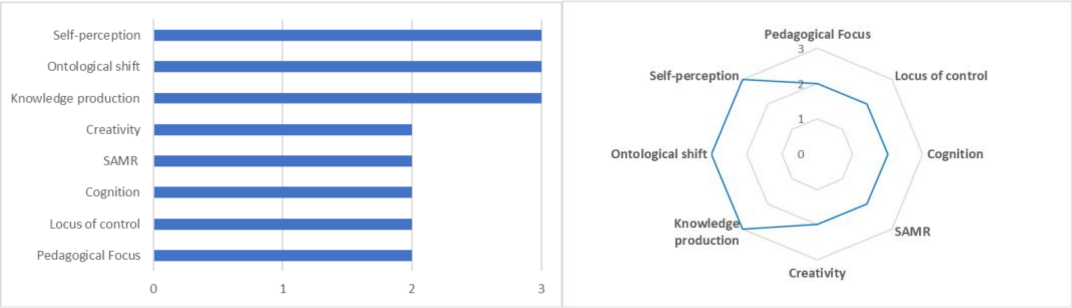

Figure 15. DTML-PAH Matrix analysis (DTML-PAH Matrix score = 19), Case 7

Summary of results

A summary of the DTML-PAH Matrix dimensions for all case studies is given below in Figure 16.

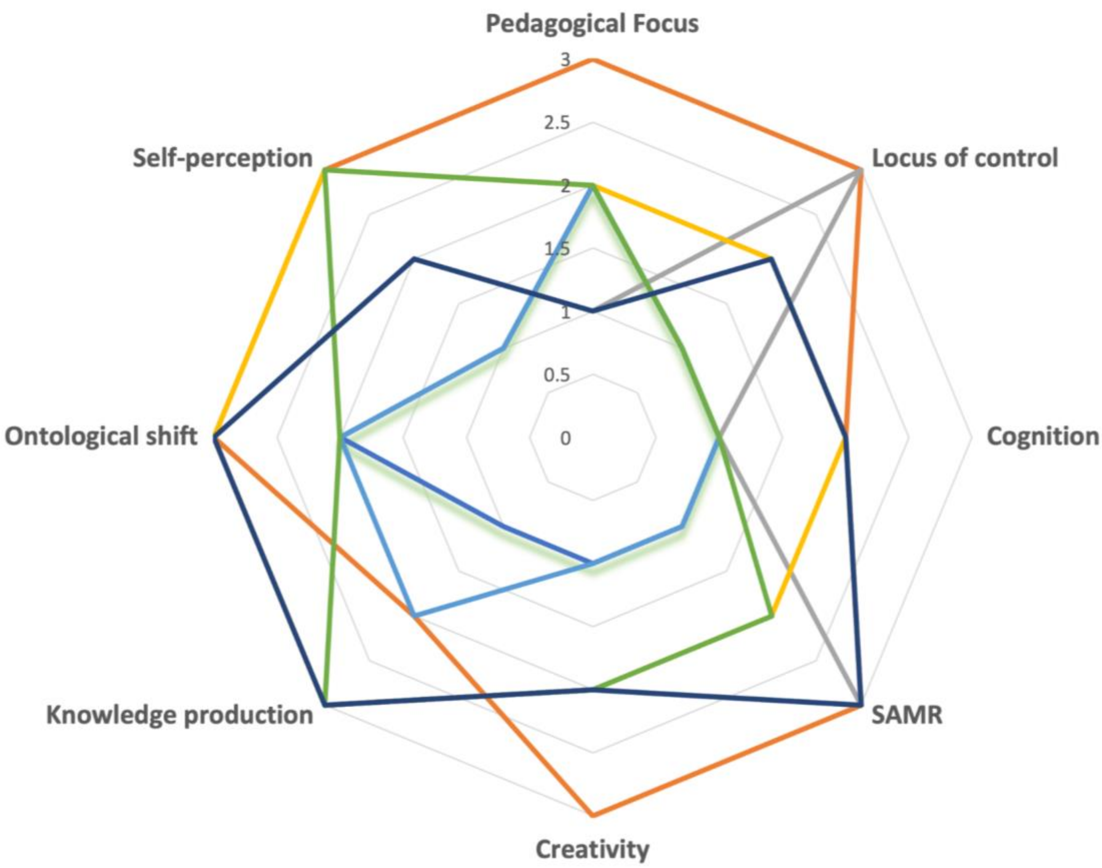

Figure 16. Comparative DTML-PAH Matrix dimensions score spider graph

Discussion

These results map different cases within a variety of disciplines. Clear relationships between cases may be seen, when PAH and DTML are used to understand the framing of cases and with AT as a lens. The use of the DTML-PAH Matrix provides a valuable tool to understand how mobile learning is progressing in relation to the perceived ubiquity of mobile devices in society (Traxler, 2021). One of the reasons for the gap between social use of mobile devices and educational use may be the challenges in conceptualising change in mobile learning, even when using well-regarded frameworks, such as AT (Pachler et al., 2010).

Combining the case results therefore gives insight into the answer to the research question: “What can we learn from using AT to analyse mobile learning designs?”. Specifically, when looking at a comparison of the DTML-PAH Matrix score analysis for the seven case studies (as shown in the combined spider graph Figure 17), it is clear that whilst all studies have a learner (pedagogy) focus (with this node being highest across cases), the specifics of how this pedagogy is delivered is still embryonic in many cases, with the cognition dimension of the DTML-PAH Matrix scoring the lowest, with none of the case studies reporting a focus upon the development of student epistemic understanding. Similarly, a focus upon creativity as reinitiation and a pedagogical focus upon heutagogy were only reported in one of the case studies (case study 2). This might be in support of the call from Blaschke et al., (2021) for a focus on more learning agency.

Yet despite this, it is clear from our results that the designers of these learning experiences are very conscious of the context of their learning environment. Knowledge production as context shaping was reported by 5 of the 7 case studies, reinforcing the affordance of mobile learning to facilitate authentic learning contexts. Facilitating ontological shifts as reconceptualising the role of the learner was reported by 5 case studies, and 4 case studies reported facilitating self-perception as active participation within a professional community, with these dimensions closely related to the design of authentic learning environments. This would suggest that whilst focus on learning characteristics is embryonic, the focus on learner agency is an important characteristic for those designers building these cases. In this way, our findings confirm existing research that emphasises learner agency as a measure of quality (Blaschke & Hase, 2019; Hase & Blaschke, 2021). Similarly, this also shows that our study confirmed research that found students held positive attitudes towards mobile learning (Forsythe, 2021).

Finally, looking at this work from the point of view of mobile device usage, results demonstrate a focus on this area, both in the DTML-PAH Matrix results as well as in the AT analysis. In the DTML-PAH Matrix results in particular, case study designers show a high focus on locus of control, as well as the SAMR framework (Puentedura, 2006). This would seem to confirm that context affects the learning (Gourlay, 2021) and justifies our desire in our research question to extend the research into differentiating and understanding some of these variations in terms of highly relevant and actionable areas.

Building on the use of the AT lens in the study helps us address the second research question: “How can the DTML-PAH Matrix extend AT analysis to practically inform mobile learning designs as a guide for quality education?” Our analysis suggests that mobile devices and platforms form the tools that mediate, facilitate and directly impact the objectives and outcomes of the activity system. These tools form connecting nodes between the different facets of AT. They act as a connecting agent that glues the elements together when creating a learner-centred mobile learning environment. The example activity systems of each case study hence attempt to map the unique or authentic affordances of mobile learning to developing learner agency through facilitating learner-generated content and contexts, with each case study illustrating this to varying degrees along the three-stage scale or continuum of the dimension of the DTML-PAH Matrix.

A comparison of the AT analysis for each case study identified a range of motivations and contradictions as themes that can be used to guide future quality education. Looking at the trend of mapping, there is a clear focus on both teaching staff and students as subjects of the work and as part of the learning community, indicating that learning is occurring at multiple levels in many cases. This is in direct contradiction to Traxler (2021) and suggests that addressing the lag in mobile learning relative to prevalence of self-regulated or determined use of mobile devices may be easier than anticipated, at least in terms of students’ endorsement of doing so.

As noted above, tools are also often mentioned, with a commonality of mobile and simplistic tools, very much in support of the bring your own device narrative (Ng, 2015). This suggests that continued endorsement of these simpler tools is valuable, especially in the context of mobile devices being taken up in developing and emerging countries as outlined by Manyeredzi and Mpofu (2022).

Finally, in support of Saikat et al. (2021), it is clear from these results that despite contextual differences, objectives and outcomes are often intended to be the same, with a focus on meeting learning outcomes and co-generated student content. This clear passion for co-created content across the cases could provide a starting point for more work in the space.

Limitations and further research

A limitation of this work is that each of these are a separate and unique case study but would perhaps be better reformed as a more holistic approach to design-based research. In this way, AT and DTML-PAH Matrix analysis of mobile learning designs forms a guide for the analysis and design phases of a design-based research approach to designing mobile learning environments. The evaluation and subsequent redesign phases of design-based research require participant (student) evaluation and feedback to measure the effectiveness of these designs. This is beyond the scope of this discussion paper and will be the focus of further research from the MLSIG. However, the efficacy of the DTML-PAH Matrix for improving student learning experiences has previously been evaluated in a variety of learning contexts (Cochrane & Antonczak, 2014, 2015; Cochrane et al., 2017; Cochrane & Narayan, 2017).

Recommendations

Based upon the outcomes of analysing seven mobile learning design case studies through the lens of the eight dimensions of the DTML-PAH Matrix we offer the following recommendations for the theme of this special issue of AJET – Achieving lasting education in the new digital learning world:

- Onboarding learners is important when introducing new technologies. This can be streamlined through using a flipped model, where prerecorded instructional content is made available asynchronously, while synchronous learning activities focus on the collaboration, group work and conversations that emerge during and after the activity.
- Learning design can move beyond substitution of practice with new technologies in the face of challenges, such as a pandemic, by starting with an asynchronous learning activity design core. Synchronous activities can then be added to the core, with the option of classroom based equivalents. This facilitates a redefinition of traditional learning environments.
- Designing the curriculum for authentic learning can be achieved through adopting a design-based research approach to consider the problem to be solved from both the technological and pedagogical aspects.
- Encouraging students to choose their own digital tools for communication can be central to student-negotiated projects and change the teacher role to that of co-learner. This can help move engagement from pedagogy to heutagogy.
- Mobile learning design can facilitate a community of practice that is flexible to the shift of situated learning between online, on-campus and clinical environments.
- Collaborative activities that encourage diverse sociocultural groups and co-design facilitate transformative learning experiences for a diverse population of students.
- Learning designs should focus upon enabling elements of learner agency and creativity, developing learners' capacity to navigate the unknown through authentic collaboration.

Conclusion

We began this article by summarising the application of AT to analysing mobile learning and the critique that AT fails to impact mobile learning practice. In response, we introduced the DTML-PAH Matrix and its eight pragmatic dimensions to transform mobile learning design towards enabling learner agency. We applied both AT analysis and the DTML-PAH Matrix to seven case studies guided by two research questions (see the Theoretical framing section).

Overall, this work provides some useful insight into the use of AT as a lens to understand the goals, implementation and interactions of each case study, and the analysis of the cases provide three useful practice guidelines for the use of the DTML-PAH Matrix in designing for mobile learning. Specifically, these case studies suggest a focus on holistic learning involving active participation from both teachers and students; a continued endorsement of simple tools; and a focus on meeting learning outcomes whilst also providing a co-creation experience. In this way, the work addresses the research questions, but also the broader central question of whether using a practice-based matrix with AT analysis can allow for clearer implications for mobile learning practice. It shows that the theory can be used in this way to provide clearer implications and guidance for practice and that the theory can also be guided by the practice over time.

Statement on open data, ethics and conflict of interest

Each of the case studies is described and analysed from the perspective of the lecturers as the designer of the mobile learning experience. As no student data is referenced in these design and analysis stages of each project, there is no need for ethics consent. All participants are named co-authors of the article.

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