AGILE: ADRESSING VUCA AND AFFECTIVE FACTORS IN DESIGN & DESIGN ENGINEERING PROJECT BASED LEARNING

Stephen GREEN[1], **Suzan ORWELL**[1], **Freddie PAGE**[1], **Tiffany CHIU**[1] **and Ahmed PATEL**[2]
[1]Imperial College London
[2]Middlesex University and Imperial College London

ABSTRACT
The volatile, uncertain, complex and ambiguous (VUCA) global context, amplified by two years of COVID has a profound effect on the predominant project based learning approach within design and design engineering curricula. Project management and affective or emotional factors are evidenced as significant but often overlooked within this context. Linking literature on the topics with data from n=200 participants from 3 HEIs, three aspects of popular industry Agile project management approaches are shown to correlate directly with addressing the VUCA context together with a model as a basis for considering the alignment of the topics.

Keywords: Agile, project based learning, affective domain, VUCA

1 INTRODUCTION
With a 50 plus year history of design research, much of which has been focused on design process there has been more limited attention to two categories of factors which logically have a profound effect on the outcomes of design, engineering and innovation activities. These categories are identified here as: (i) affective factors and (ii) project management factors. These are extensively explored in other fields but represent significant gaps in the design research field. Studies of design and engineering education (D&DE), where a predominant strategy is Project Based Learning (PBL), have also tended to focus on process with limited attention to a comprehensive view of factors affecting learning and project outcomes. In an earlier study Green et al highlighted how Volatility, Uncertainty, Complexity and Ambiguity (VUCA) factors are impacting the affective or emotional domain of learning [1]. The recent global COVID context has amplified recognition of affective factors in learning. Considering project management and affective factors in combination leads to the primary motivation for this work: to explore how to better support student learning and to address affective learning challenges in design engineering subjects.

1.1 VUCA
The VUCA concept and acronym can be seen as an approach to 'black swan' events, originally 9/11, but now COVID. We can initially consider VUCA factors in relation to three nested spheres of influence: the global 'external' context, the pedagogical context and the student or student teams' 'internal' context [2]. As a direct result of the global COVID pandemic a number of scholars have referenced the VUCA model as a basis for exploring the 'forced' adjustments needed in teaching and learning practice and pressure on students' wellbeing [2,3]. As a foundation for considering these affective factors, the value of translating the VUCA terms in various contexts including education has been noted in a number of studies [1,2,4]:

- **Volatility** is associated with fluctuations and turbulence with acknowledgement that D&DE teaching is yet to fully embrace these dynamics, whether in shaping attitudes, transforming pedagogic delivery or predicting future professional roles.
- **Uncertainty** is defined as a psychosocial construct which can have positive and negative implications for how issues and events are managed considering levels of confidence and understanding. For example, in D&DE learning and the relationship between student risk aversion and creative thinking.

- **Complexity** is manifest in many contemporary contexts where multiple factors that interact with each other can lead to experiences of chaos and stress. However, Don Norman notably states: 'Design schools do not train students about … complex issues…'[5].
- **Ambiguity** is a lack of clarity about how to interpret situations with incomplete, contradicting, inaccurate or 'fuzzy' information. Pedagogy contexts require us, not just to consider ambiguity between context and process factors, but also the conscious and unconscious ambiguity in the psychosocial factors amongst students and faculty.

Our earlier paper [1] evidenced the link between the VUCA categorization and student emotions or affective factors, in particular within the uncertainty and ambiguity categories. Uncertainty in PBL was seen in the student data to directly influence anxiety, stress and confidence levels. Many students saw the time and effort required to deal with uncertainty as a negative in their learning. Ambiguity was typically viewed by students as a fault of tutors' teaching plans or materials, for example perceptions of ambiguity in assessment rubrics. Therefore, we can see that the VUCA concept has value for identification and decomposition of affective factors, but with considerable scope for more nuanced understanding and recommendations for mitigation.

1.2 Affective factors

Whilst affective factors have been a well-recognised part of Bloom's three domains of learning outcomes [6] it is increasingly recognised that the affective domain is under researched. The domain is seen as fundamental to the cognitive and psychomotor domains but has been marginalized due to the challenges of objective evaluation [7]. Organisations including OECD and UNESCO recognise the importance of resilience and social-emotional competencies as part of learning, but also that teachers are poorly prepared for supporting their students [2]. Studies show that stress in learning environments is 'contagious' and affecting both students and staff, and there is a need to address the balance between disciplinary knowledge and skills content with cultivating emotional resources and agency [2]. Bloom's affective domain has evolved into a low-to-high hierarchy of factors based on work by Krathwohl et al. [2]: Receiving (e.g., teaching and learning content & experiences), Responding, Valuing, Organising and Characterising (internalising and personalising a value system). Scholarly exploration of affective factors in the education field leans heavily on Bloom's work and typically discusses interventions following this hierarchal model.

The psychology field defines that emotions and motivation are determined by social-historical contexts. A further classification identifies three levels of consciousness in relation to emotions: i) total subconscious emersion, for example being consumed by anxiety, ii) students having awareness of their emotions, and iii) adding conscious actions in response to emotions or having the facility to regulate emotions [8]. Therefore, connecting the regulation of emotions to motivational factors and self-efficacy. Acknowledging the complexity of studies of affective factors, Figure 1 maps understanding and frameworks from psychology [8], through the educational field [2], to Agile applications in education [9].
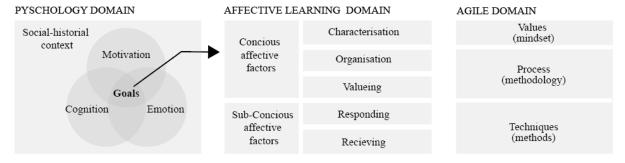

Figure 1. Mapping affective factors from psychology to Agile in education

1.3 Project Management, Agile and the HE context

Agile is a popular iterative project management approach used in industry since introduction in 2001 to manage software engineering projects and teams [10]. It emphasises clear communication, incremental delivery and empowerment of team members. The use of Agile in learning and teaching has been implemented for several years with some earlier research establishing the relationship and similarities between Agile principles in industry and education in general. For example, both domains focus on

planning, organising, frequency in assessing, appreciating feedback from different sources, monitoring quality and controlling success criteria [11]. The continued and embedded practice of feedback and reflection is an important element to consider in the higher education context as a basis for developing some of the necessary professional competencies, capabilities, and expertise for desirable graduate employability attributes. Agile methods may create positive influences on team collaboration and communication and improve the structure of PBL and team activities, leading to better collaboration, communication, self-efficacy and systematic thinking [12]. Parsons & MacCallum analysed Agile in teaching and learning at three levels: values, processes and techniques with the values level providing a foundation for promoting student agency with a focus on outcomes and improvement [9]. The processes level encompasses key concepts such as iterative and reflective learning and time boxed steps. The techniques level is synonymous with methods including, rapid prototyping, peer learning and 'stand-up's' (rapid presentation and reviews). Linking Agile values, processes and techniques to affective factors in PBL; time-related demands such as high workloads, deadlines and the challenges of self-organized learning are associated with stress but could be decreased with enhanced project management practices [9]. The outcomes focus of Agile values links with PBL and positive emotions. At the techniques level, time boxed steps support a sustainable pace of learning, with regular feedback and reflection on actual learning outcomes. Supporting students in self-managing this approach can help build confidence and alleviate uncertainty.

1.4 Emergent VUCA – PBL model

Considering affective factors (amplified by COVID), and the predominant PBL mode of teaching and learning in D&DE, leads to a development of a model (Figure 2) which shows a more nuanced alignment and influence of VUCA factors with students and projects in educational settings than our earlier work [1]. Starting at the middle of the model we can see that VUCA factors, especially Uncertainty (and associated emotions) have a direct internal influence on students and therefore their learning (indicated by an outward pointing arrow). The PBL context, or zone of influences, is often further complicated by group working. Students are working within a predominantly PBL context, which, to varying extents, is mediated or scaffolded by tutor input in what can be described as the zone of proximal development (ZPD) – the space between what students know and what they can potentially learn [12]. It has been pointed out in relation to reflection, as a higher level of learning, that; 'Teachers themselves may firstly have a zone of proximal development to negotiate' [13] and that Ambiguity for students (and associated emotions created in the PBL context) can be influenced by effective scaffolding. The PBL context is usually strongly aligned with and influenced by Volatility and Complexity in the external context. Therefore, this model serves as a useful reference for a further decomposition of research questions within the refined goal of: how to better support student learning and address affective learning challenges in the ZPD with Agile approaches?
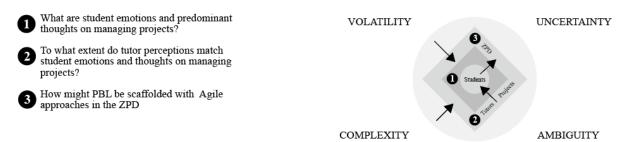

Figure 2. Alignment and influence of VUCA factors on students and projects

2 PRIMARY RESEARCH METHOD

A method to gather data to understand student and tutor perspectives in a time efficient way was developed for the study. This involved using an online interactive survey platform (Mentimeter) with a selection of students and tutors at institutions involved with undergraduate and postgraduate design, design engineering and innovation study. Overall student participants n=209. and tutors n=22 from three HEIs took part in the survey. A common format was used for students and tutors, with tutor questions adjusted to ask about their PBL plans for students and perceptions of student thoughts. The questions and related rational were as follows:

Q1 **Year of study** (1st year undergraduate to 4th year postgraduate level)? It was anticipated that student views and tutor strategies might evolve over the period of HE study and in turn may relate to levels of educational scaffolding.

Q2 **Size of project** (length and mode variables)? What is known as short-fat and long-thin modules, or projects of varying lengths are predominant features of D&DE programmes. This data is intended to reveal any overall factors in relation to year of study and levels of scaffolding.

Q3 Words associated with **managing D&DE projects**? Each participant was invited to provide up to 5 words. This was intended to provide an understanding of the predominant thoughts and therefore practice of the participants on their project. Correlations with tutor responses may indicate variations between student experience and practice and tutor strategy and perceptions.

Q4 Words associated with **emotions on D&DE projects**? (up to 5 words per participant) In this case the accompanying information encouraged providing words which might cover a range of emotions. This will allow for significant sentiments to be identified and the overall weighting of sentiments on different potential axes. Student – tutor variations may indicate different perceptions and areas of concern.

Each of the following questions had multiple choice answers on a 5 point Likert scale ranging from minimal to extensive activity. This format allows for both qualitative and quantitative analysis of the resulting data.

Q5 **What goals** do you set for yourself when working on a project? (students); To what extent do you define goals for students' projects? (tutors). This potentially links to Agile values and principles.

Q6 How much **project structure** do you independently define in your process? (students); How much structure or defined process do you provide for your students' projects? (tutors). This question links to Agile operation or structure.

Q7 To what extent do you **formally record-review-reflect** on your project process & decisions? (students); To what extent is student record keeping, reviewing and reflecting integral to your planning for student project work? (tutors). This is linked to Agile concepts of review and reflection.

Q8 How much of your own **decomposition and sensemaking** do you do in your projects (rather than what staff provide)? (students); How much of your own decomposition and sensemaking do you provide students & require them to follow? (tutors). This is relating to Agile decomposition for planning and workflow.

Finally, students were asked to provide short comments on the **relationship between project management activities and feelings** during project work, or for tutors, their understanding of their student's thoughts.

3   RESULTS

The qualitative data in the form of keywords and short statements provided a rich initial indication of perceptions of project management and affective factors. The complete dataset for the two keyword questions is considerable. In the form of word clouds (e.g., Figure 3) the data provides a clear overview of factors. For Q3 **project management** it is notable that theories and frameworks are largely absent, but there is clear recognition of time being the most significant factor. Specific tools or methods such as Miro or Gannt also feature strongly. One can also see that the sample can be strongly influenced by their immediate experience. For example, responses from a 2nd year group reflected the significance of communications in team working as part of project management. For Q4, asking for key words associated with **feelings or emotions,** there is a clear overall dichotomy between the excitement, motivation and student's inherent commitment to their subject area, contrasting with, at the negative end of the spectrum, words including: 'stress', 'anxiety', 'confusion', 'low confidence'. It is also interesting to see more nuanced factors such as: 'imposter syndrome,' 'feeling neglected,' 'overwhelmed' and others. For both questions there is clear evidence of correlations between project management and affective factors, for example students listing 'mental health,' 'stress' and 'anxiety' in the project management question, and 'team dynamics' and 'being lost'' in the feelings question.

Figure 3. Q4 Word map of feelings from one of the study HEIs

The quantitative data from Q5-Q8 provided limited basis for analysis and insight. The averages of the tutor responses (n=22) on the 5 point Likert scale broadly matched the overall student results, however individual responses also included tutors marking all questions at both the low and high end of the scale, suggesting highly individual views on the topics. The student responses across all 4 years and 3 HEIs were broadly in line, with some indication that 4th year students were more reflective and objective in their answers than lower years. There was a common profile of scores across year groups and the four questions. Q5 **Goal setting** had the highest ratings with >70% scoring in the 4-5 range. Q6 **Project structuring** scored lower with the majority >66% scoring in the 3-4 range. Scores shifted lower again for both Q7 **Recording-reviewing-reflecting** and Q8 **Decomposition & sensemaking** with a wider spread of results and a smaller majority, around 40% scoring at the midpoint of 3.

The short phrase responses to the final question, linking project management with feelings, provides the richest source for research insights. From an overall *n*106 detailed comments an initial coding exercise reveals a number of predominant themes ordered by numbers of instances. The highest instance is students recognising, in their own work, the value of project management and that this supports mitigating stress. This potentially shows confirmation bias but does indicate a useful level of reflection on this important correlation. The second most frequent factor is the mention of motivation. This links to the earlier key word exercise with terms such as 'excitement,' 'engaged' or 'invigorating.' Significantly this links to another common theme discussed as the "ebb and flow" of feelings within the course of a project. The social dimension, often linked to teamworking is frequently reported. Distributed across the results one sees considerable evidence and awareness of the negative impacts of stress and anxiety, but often with what one might consider as poor levels of, or misplaced agency in managing negative feelings. A spectrum of intrinsic and extrinsic motivating factors also emerges from the data. From the tutor comments one can see some awareness of student affective factors, but limited strategies or confidence in providing cohort level content to address these factors.

4   CONCLUSIONS AND FURTHER WORK

Returning to our 3 key questions we can draw conclusions from the relationships between our data findings, earlier theory and recommended further development. Firstly, we expose an important and underexplored topic (the relationship between PBL, project management and student emotions) which, confirmed by our evidence, is a significant topic to address. Secondly, and with considerable scope for further work, we evidence awareness of students' affective factors amongst tutors, but somewhat limited cohort level strategies to address the challenges. Finally, the main outcome of our work at this point is, based on review of relevant literature and correlations with our research data, that three aspects of Agile approaches to project management provide a basis for addressing affective factors in D&DE PBL. The aspects of Agile are: 1) **Agile values** – Agile methods emphasise establishing an agreed set of values at the outset of activities, 2) **Agile operation** - which embraces iteration, review and reflection as integral to the underpinning values, this also links with PBL and experiential learning qualities and 3) **Agile decomposition**, the process for identifying and managing discrete chunks of work in a collaborative and sustainable manner supports managing ambiguity and what was described as the 'ebb and flow' of emotions in PBL. Table 1 maps these three elements to a summary of potential action areas for tutors. There is considerable scope for further research in the confluence of topics and we would hope that the broader D&DE PBL community will respond with targeted research and practical interventions.

Table 1. Mapping Agile elements to PBL, Project and Feelings management

	Agile values	Agile review & reflection	Agile decomposition & workflow
D&DE PBL factors	Recognising motivation & emotion in setting values	Review and reflection are an overlooked aspect of PBL	Decomposition for PM & managing ambiguity are key attributes for PBL
Project management support	Co-creating and establishing working values and principles in PBL	Building-in and developing agency in review and reflection practice	Scaffolding decomposition as a more explicit part of PBL
Managing feelings & emotions	Collaboratively defining values addressing the affective domain	Using review and reflection to target affective factors in PBL practice	Attending to scaffolding for decomposition & developing agency

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