VUCA CHALLENGES ON THE DESIGN-ENGINEERING STUDENT SPECTRUM

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ABSTRACT

137 students and 12 staff from a spectrum of three leading design and design engineering (D&DE) courses were surveyed using a VUCA framework. The VUCA acronym has been widely adopted from the US military as a basis for developing leadership and management responses to increasingly volatile, uncertain, complex and ambiguous contexts. The research was motivated by student concerns about Ambiguity in their learning together with the widely recognised need for D&DE courses to transform in response to contemporary pedagogic contexts. Participants were 1st and 3rd year degree students which also provided the basis for a longitudinal perspective of VUCA factors. The results show that psychosocial or affective factors are a significant area for attention in D&DE student learning, although there is evidence that courses do mitigate negative effects, to an extent, between 1st and 3rd year. A new framework is presented for clarifying VUCA factors in D&DE learning and as a basis for faculty attention and development in pedagogy.

1   INTRODUCTION

The Volatility, Uncertainty, Complexity and Ambiguity (VUCA) acronym is claimed to have been coined in the US Army War College [1] and by 2014 was a 'trendy managerial acronym'[2]. The term's military origin has the overall objective to bring order to managing global contexts which apparently defy conventional analysis and forecasting. For example, the US military leadership needed to find effective responses to events such as the 9/11 incident. The VUCA concept provides a framework for acknowledging these factors and a basis for planned leadership responses. The point is made that each VUCA term needs to be considered individually [2] and that each can lead to identifying approaches to deal with the scenarios being faced. The concept provides an interesting lens for exploring a number of significant factors which D&DE education must embrace and manage. First is the subject of *design* and *creativity*. Each term continues to challenge scholars *and* are integral to design education. For example, the concept of design as tackling "wicked problems" [3] or "designerly ways of knowing" [4] are examples of the inherent Ambiguity within these subjects, whilst also presented as distinctive to the design process. Secondly, 50 years of research into design has highlighted a spectrum of process approaches; from creative to engineering [5]. This divergency presents challenges to D&DE education, especially where professional applications for design continually overlap and evolve. Therefore, critical pedagogic decisions need to be made about where an emphasis should be placed within a crowded curriculum. For example, the concept of 'T' shaped individuals or organisations in an educational context needs to deliver sufficient strength in the trunk of the 'T' to avoid developing generalists deficient in the depth to deliver in specialist fields [6]. Thirdly, perhaps most significantly for design and engineering pedagogy, is a range of contextual factors that have created a climate where students and staff are Ambiguity-adverse [7].

Therefore, the overall aim of the study is to explore D&DE education through the VUCA lens, as a basis for understanding and responding to the challenges and opportunities ahead.

2   MAPPING VUCA TERMS TO D&DE EDUCATION

The challenges leading to the creation of the VUCA concept are not unique to the military, with parallels seen in other fields. 'Donald Trump, (is) perhaps the embodiment of the VUCA World' [8]. Typically, the established definitions of the VUCA terms are relevant to their own context. This is represented in Figure 1 showing how definitions have also been placed on a two axis graph with degree of knowledge on the X-axis and a prediction capability on the Y-axis [2]. This emphasises the significance for not only managing a VUCA context, but also preparedness for future scenarios. Other studies provide variations on definitions of the terms [9]. To ensure its relevance to D&DE pedagogy, we need to develop appropriate definitions but without compromising the core etymology of the terms. We also need to be mindful of Love's criticisms of design research: 'that the terminology of design research has become unnecessarily and unhelpfully confused and imprecise…'[10].
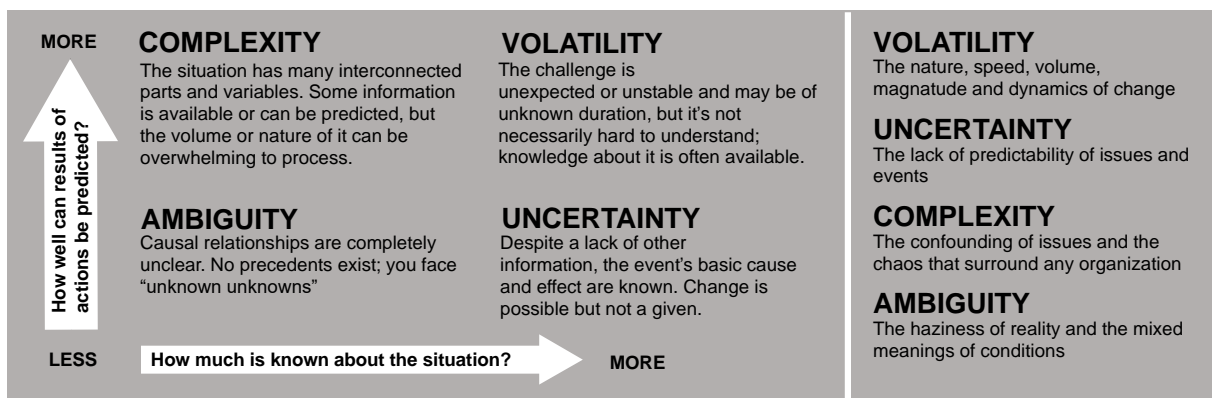

Figure 1 Bennet & Lemoine[2] (left) & Pasmore, O'Shea & Horney [9] VUCA definitions (right)

2.1 Volatility

Majithia cites VUCA and Volatility in a global context where '…rapid changes are challenging the higher education system to keep pace with the industry requirements and learner aspirations. There needs to be a shift in focus for the higher education system towards preparing the learners of today by enabling them with the skills of tomorrow' [7]. She goes on to outline how design education needs to evolve by being 'anticipatory and agile' [ibid]. There is increasing emphasis on shifting attitudinal qualities such as empathy and adaptability to effectively manage these volatile contexts. *Volatility* for those in design education therefore means recognising the 'nature, speed, volume, magnitude and dynamics'[10] occurring now and those of the future. Literature exploring design education futures suggests that the design and design engineering sectors have yet to fully embrace Volatility, whether in shaping attitudes, transforming pedagogic delivery or predicting future professional roles.

2.2 Uncertainty

Design is often considered a fundamentally risky venture where Uncertainty is a significant characteristic of jeopardy [12]. Stereotypically, designers may be portrayed as egotists wanting to impose their subjective and risky concepts onto gullible stakeholders, a negative view of risk. However, calculated risk is also widely viewed as a prerequisite of creativity and innovation. Uncertainty and the response to it in design contexts can therefore be

considered to have both negative and positive connotations. McCardle explores the topic within design education and highlights the negative aspects of student Uncertainty or risk aversion in relation to assessment. This can be compounded by the perceived Ambiguity or subjectivity of design critiques or assessments, ultimately leading to concerns about the impact on creativity [12]. *Uncertainty* in the design education context is therefore defined as a psychosocial construct which can have positive and negative implications for how issues and events are managed.

2.3 Complexity

Donald Norman writing a critique of design education in 2010, noted 'Designers often fail to understand the Complexity of the issues and the depth of knowledge already known' and 'Design schools do not train students about these complex issues, about the interlocking complexities of human and social behaviour, about behavioural sciences, technology, and business. There is little or no training in science, the scientific method, and experimental design' [11]. This is despite the well-established concept of "Wicked Problems" [3] identified as a distinguishing characteristic of designing. Within design pedagogy, the term *Complexity* is therefore judged to encompass the need to deal with a multitude of factors and variables. But clearly, whilst this context-and-process Complexity is widely acknowledged, both students and faculty are perhaps poorly equipped to manage the Complexity of contemporary contexts for design and learning.

2.4 Ambiguity

Anecdotally amongst colleagues teaching design subjects within an engineering environment, a frequently expressed student opinion is that many aspects of design teaching and learning are 'ambiguous'. This might be an echo of Norman's view that 'engineering students' are 'often ignorant of the so-called soft areas of social and behavioural sciences. They do not understand human behaviour' [11]. Ambiguity in design is certainly a factor which many scholars [10] aim to address through a variety of frameworks and epistemological investigation. For example, the Ambiguity of the word *design* itself which can be used as a noun, verb and adjective, or the distinctions identified between research *into*, *through* or *for* design [12] Within this study, the design related meaning of *Ambiguity* is taken as 'haziness'[10] or lack of clarity about how factors influence each other. As with the other VUCA terms the pedagogy contexts require us, not just to consider the fuzzy aspect of Ambiguity between context, methodology and method factors, but also the conscious and unconscious Ambiguity between these and psychosocial factors amongst students and faculty.

3   METHOD FOR EXPLORING VUCA FACTORS

The nature of VUCA factors within design and design engineering education suggests value in exploring views from a spectrum of Higher Education Institutions (HEIs) in the UK. For this study, three Higher Education Institutions (HEIs) with sector leading Product Design, Industrial Design and Design Engineering programmes participated in the survey. The three HEIs represent a spectrum of positions from creative to engineering emphasis. For example, from a BA programme with a strong creative reputation, mixed BA and BSc students from an HEI with a tradition of combining design & technology subjects, through to an MEng Design Engineering programme with a globally recognised engineering heritage. 1st and 3rd year students from each institution were invited to participate to allow for exploration of any longitudinal differences. An interactive online survey was created that could be completed in a controlled lecture environment. This ensured a standard and consistent approach for each

HEI and allowed a convener to provide any additional guidance. Students were also able to view the aggregate results of their cohort survey in real time. To link the VUCA factors to student experience, the survey suggested that they would imagine a bicycle design project set by their course as the context for their responses. For each of the VUCA terms, the students were shown three screens, an introduction to the term, a series of three questions requiring responses on a five point scale and a screen to enter free text comments. The students were also asked to provide responses to question asking what type of designer or design engineer they considered themselves to be and which overall VUCA factor affects them most.

The use of this methodology aimed to gather a wide range of data focusing on understanding the issues from a *student* perspective as a basis for analysis and recommendations for further research and future pedagogy in design and engineering. Overall, the survey questions relating to the VUCA terms are summarised as:

- Responses to **Volatility** and choice of methods (Q1), project scenarios (Q2), overall course interests (Q3) on a scale from considering Volatility unimportant to understanding being vital;
- Responses to **Uncertainty** and knowledge of topics (Q1), process and methods (Q2) and quality of deliverables (Q3) on a very uncertain to very confident scale;
- Responses to **Complexity** and time planning (Q1), pressure and anxiety (Q2) and prioritisation (Q3) on a scale from 'not a strength' to 'I have excellent strategies';
- Responses to **Ambiguity** and assessment rubrics (Q1), design briefs (Q2) and design process (Q3) on a scale from it is problem to it is an advantage.

4   RESULTS

The Mentimeter format for the main data gathering was selected to be easily implemented by staff at each institution and with minimal disruption to existing staff and student learning activities. The survey was not directly linked to any other activity at any of the institutions, so students were only influenced by their overall course experience. Variations in participant numbers at each institution are related to overall cohort sizes and practical factors concerning delivery of the survey to whole year groups. In total, 149 people participated in the survey comprising of 12 staff, 79 3rd year students and 58 1st year students. Figure 2 shows the distribution of responses to the overall question: 'What overall VUCA factor do you feel affects your work most?' The figure provides an indication of consistency in the responses to this question. For the whole group, 42% of the respondents indicated Uncertainty, followed by 29% for Ambiguity as the most significant VUCA factors. Volatility, with a 9% share of responses was rarely considered to be the most significant.
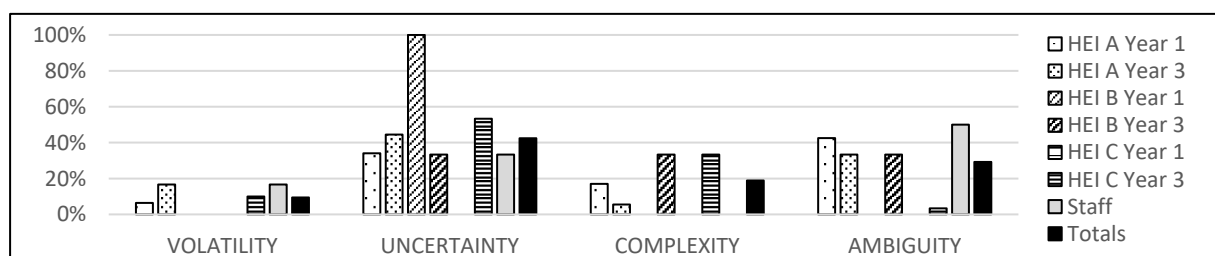

Figure 2. Percentage values for all participant's views of the most significant VUCA factor

The detailed data included responses on a Likert scale for 3 questions in each VUCA category, as well as text comments for each of these factors. An average of 30% of the participants provided comments of value, 188 in total or an average of 47 per factor. For the purpose of quantitative analysis data from HEI-A was used on the basis of having the highest volume of results for 1st years (52 participants) and 3rd years (34 participants), each answering 12 of the questions. Text comments were aggregated for the complete set of results.

4.1 Understanding Volatility

Although Volatility scored the lowest when participants were considering the significance of all VUCA factors, the aggregate scores for HEI-A students clearly indicate that they rated Volatility as a vital aspect of their project considerations, with nearly 60% of the students indicating the two highest significance ratings. Within the three questions asked, there was very little variation between responses from 1st and 3rd years and similar distributions. The marked difference between the low overall result for Volatility, compared to the significance attached to it when considered alone, possibly suggests the need for greater course attention to contextual factors (Figure 3a compared to Figure 2).
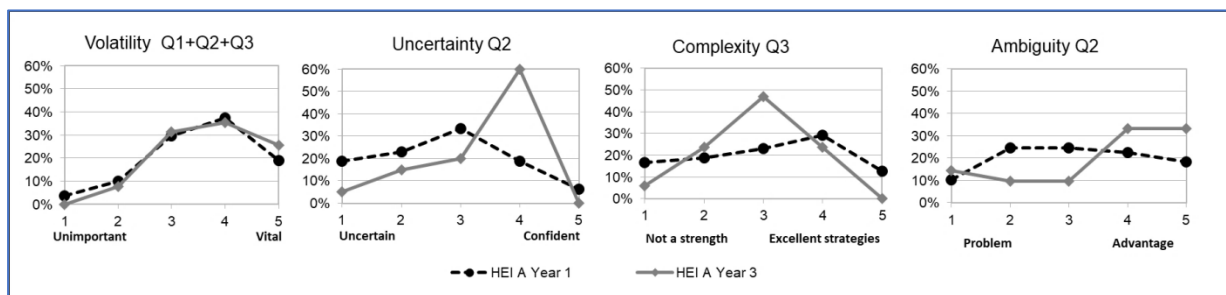

Figure 3a., b., c., d., Graphs of results of VUCA data from HE1 A 1st and 3rd years

Amongst the comments gathered from all three HEIs, 3rd year students were most likely to record an opinion. Students at HEI-C appear to value and enjoy the challenges of Volatility with comments such as 'Understanding Volatility is important to consider so that a projects outcome can be relevant', that Volatility is a driver for innovation, or that designers and contexts 'stagnate or die' if they pay little attention to Volatility. But there is also an acknowledgement that Volatility is linked to risk aversion and a tendency to work within known parameters. A pertinent comment from a 3rd year at HEI-A was 'stay away from the ivory tower and recognise the Volatility in the real world to stay grounded and create real tangible impacts'. This suggests that there could be tension between encouraging concepts of creativity and risk taking and the need to focus on producing 'tangible impacts'.

4.2 Uncertainty or confidence?

The overall profile for the aggregate results for the 3 Uncertainty questions is balanced, with the majority, 28%, being neither uncertain nor confident. For two questions, 1st years are over 10% more uncertain than 3rd years, based on the highest Uncertainty rating. But responses to Q2 regarding Uncertainty or confidence about the process to be used (in projects), show a marked difference between the 1st and 3rd years, with 60% of 3rd years, versus 19% of 1st years, identifying the 2nd highest confidence rating. (ref Figure 3b). The Uncertainty term clearly puts emphasis on the affective or emotional learning domain and how this impacts their overall learning. This is reflected in their comments referencing anxiety, stress and confidence levels. Many comments, particularly from 3rd years are more

reflective and reflect mature views that Uncertainty is a necessary condition for learning. Other comments indicate that students consciously develop strategies to acknowledge and deal with Uncertainty within their work. For example, from an HEI-A 3rd year: 'We are never gonna be the best engineers - nor the best designers. We'll be the jack of all trades and the master of nothing. This might be great in practice - but for jobs and in terms of confidence - it is not very healthy for me. What do I bring?' The comments also evidence polarised thinking. For example, some students saw the time and effort required to deal with Uncertainty as a negative in their learning, whilst others clearly identified the time and effort as a positive element. Overall, the comments suggest that confidence and positive acknowledgement of a state of Uncertainty are important mitigating attributes.

4.3 Dealing with Complexity?

The Complexity questions result in a very balanced view from the combined 1st and 3rd year, with the majority, 27%, scoring the median value between: having excellent strategies for dealing with Complexity – or - not being a strength. This balanced view was particularly marked for 3rd years with a 14% higher median value for Q1 (decomposition and time planning) than 1st years and 24% higher for Q3 (effective prioritisation). (ref Figure 3c). In contrast to the Uncertainty and Ambiguity categories, comments about Complexity clearly reflect that it is considered a positive attribute towards learning. For example, cited from a 3rd year student at HEI-A: 'the world is complex and increasingly so – skills in analysis and synthesis and how to balance them is the key attribute of a design engineer'. However, the comments do still contain many references to affective factors, such as reflected in this comment from a 3rd year student at HEI-C: 'The more I am invested in a project the more I enjoy the Complexity'. Complexity is also seen to contribute to stress, anxiety and being 'overwhelmed'. The form of the survey questions put an emphasis on the degree to which students have strategies to manage Complexity hence the high confidence levels indicated by 3rd year students in the quantitative analysis. The comments suggest that more could be done by the courses to support mitigating Complexity, such as support for decomposition, time planning, balancing priorities and making effective links between practical work and these mitigating approaches.

4.4 Ambiguity is a problem or an advantage?

Values from the Ambiguity questions show a clear identification of this as a problem (43% of 1st years scoring Q1 – concerns about assessment - most problematic). For Q1 and Q2 there was strong consistency of views between 1st and 3rd year students. However, for Q2, which asked for their views on Ambiguity, or openness, of project briefs. 33% of 3rd years compared to 18% of 1st years saw openness as an advantage (ref Figure 3d). Notably in relation to the comments on Ambiguity, is many student's focus on finding fault with their courses, or that Ambiguity is an issue for courses to resolve rather than students themselves. For example, a response expressed by a 1st year student at HEI-A who saw Ambiguity as 'a slap in the face' at an early stage of learning. Generally, any Ambiguity in teaching materials is seen as bad, especially where there is any perception of Ambiguity in assessment schemes. However, it can also be seen that 3rd year students have a more balanced view, with comments such as, from a student at HEI-C: 'You need to know your 'playground' - What you can stretch and what you can't. Ambiguity is not a problem if these are defined clearly'. Or generally the idea that whilst Ambiguity allows scope for creativity, students need high levels of structure and guidance at early stages, reducing as their confidence and experience develops.

5 CONCLUSIONS AND FURTHER WORK

The results from the 149 participants is a rich data set for considering the affective dimension of D&DE education. Whilst of limited statistical significance the results do highlight the links between internal (student, staff, course) factors and the VUCA world. At HEI-A the work relates to a major institution-wide initiative to review and transform pedagogy. This link between affective learning factors and the wider VUCA context is therefore presented as a framework for exploring pedagogic and disciplinary developments (Table 1). The framework highlights mitigating qualities or antidotes to VUCA factors relevant to our subjects. This work highlights the importance of these factors and the framework is a useful contribution to understanding and responding to the inherent VUCA-ness of these topics within D&DE education.

Table 1. Framework for understanding and responding to VUCA factors

VUCA Definitions for D&DE	VOLATILITY The contexts for D&DE are increasingly unstable, with unknown time factors	UNCERTAINTY Some factors understood, but with Uncertainty about attributes needed to respond	COMPLEXITY The contexts have numerous factors and variables and can be overwhelming	AMBIGUITY How factors might influence each other is unknown
Evaluation Scale	Uninformed–to-V. well informed future knowledge	V. uncertain–to-V. confident of understanding	Weak–to-Powerful strategies for managing	Narrow-to-wide perspective
Mitigation or Antidote	Exploration leading to Foresight	Confidence through understanding	Clarity through strategy	Cognitive agility & creativity
Current D&DE student perspectives	Recognition of the significance Tendency to risk aversion Need support for tackling this Creates opportunities for innovation	A necessary condition for learning Creates stress and anxiety Takes time and effort to address Confidence in strengths is valuable	A 'good' motivational driver for learning Adds to stress and anxiety Using strategies is not intuitive Experience and strategies are critical	Bad within assessment rubrics and teaching Creates stress and confusion Can be a creative opportunity Needs phased support
Necessary focus for D&DE educators	Student awareness Provide tools and opportunities for exploration and risk taking	Better recognition of affective factors Approaches to build informed confidence	More support for learning and implementing mitigation strategies Well phased development of experience	Better attention to removing Ambiguity Well phased introduction of Ambiguity and mindsets to mitigate

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