

LEARNING ENVIRONMENTS SUPPORTING THE DEVELOPMENT OF RESILIENT AND INNOVATIVE PROBLEM SOLVERS

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ABSTRACT

Engineering education must prepare our students for working life where rapid and constant change has become a standard. Companies seek professionals who are creative, resilient, and innovative problem solvers. In order to support the students to develop into resilient professionals, the CDIO syllabus has been developed. The CDIO Syllabus offers goals for undergraduate engineering education. The CDIO Syllabus has been updated (Syllabus 3.0). The external drivers for the recent changes have been sustainability, digitalization and rapidly changing, complex world (Malmqvist et al. 2022). The focus of this paper is on the third change driver, acceleration. Acceleration describes the current time when the change in society, technology and science is accelerating in a way that we have seen before (Malmqvist et al. 2022). The acronym VUCA is utilized to describe a turbulent environment. VUCA stands for volatility, uncertainty, complexity, and ambiguity. VUCA components must be brought to the learning environments to support the students in developing their skills to success in the VUCA world. (Hänti et al. 2021.) The competences related to acceleration include for example interdisciplinary knowledge and collaborative skills, mental flexibility, self-leadership and self-directed learning (Malmqvist et al. 2022). Learning processes and environments should be designed in a way supportive to the development of these competencies. In this paper we will present a method for learning environment design by applying epistemic, spatial, and instrumental, social, and temporal elements. Additionally, in this paper we present a learning environment from TUAS that has tried to develop the operations based on the needed competences and frameworks. During their studies students have a possibility to try working in different environments and they are coached to improve their capabilities to work in VUCA working life. Positive experiences and realizing the personal growth and learning has proven to empower the students. The whole study path supports them to become creative and resilient problem solvers.

KEYWORDS

VUCA, CDIO Syllabus, learning environment, circular economy, Standard 6

BACKGROUND

Today many students find uncertainty in their own lives, their studies and the whole world around them causes various levels of stress. Understanding why uncertainty can be stressful, learning about the uncertain world during studies and learning how to use different tools to handle possible stress can make life easier to manage. There are many uncertainties in student life generally, whether we are talking about a new or returning student. Each stage in the studies brings new challenges, students may be facing new courses they are struggling with, having to take on new responsibilities within the studies or need to enhance the study effort to graduate. In addition, we are today living in a changed Europe, where many students report feeling increased stress because of uncertainties in the world around them, such as political instability, financial uncertainty, and concerns about the climate. The past pandemic has influenced all students' lives, and some are struggling to come back to the new normal or catch up with unsuccessful studies during the pandemic.

Students can learn to adapt their approach, thinking and behaviour to reduce the impact of uncertainty and make them feel more prepared and positive about the future. There will always be some level of uncertainty in life. During their studies they should be coached to take control and plan their studies and lives. Doing this will give them the best possible opportunity of having success during their studies and give them valuable knowledge for their future working life.

It certainly can be stated that the students today live in a VUCA environment: Volatile, Uncertain, Complex, Ambiguous, where tolerance for uncertainty has become a necessary dimension to be able to handle (Hänti et al., 2021). The areas VUCA components are present in educational context are listed in Figure 1. In acronym VUCA the V corresponds to the volatile world the students live in. The students typically choose themselves which courses they attend to and when. The teachers may vary as well as the way the course is carried out. Uncertainty comes to the students' lives in many ways. The situation in the world today is uncertain. The trust in the students' own capacity to carry out the studies may be low; the self-belief can be low. For some students' the no teacher-centricity develops challenges as in this model the students should be highly self-imposed. VUCA C stands for complexity. Already in an early stage of the students' studies are several skills needed; academic, professional as well as personal skills. All these skills develop during the studies but need to be coached and acknowledged during the studies. By modifying the content of the syllabus as well as the activities in learning environments to better correspond to the VUCA world the students today live in, we give them already during their studies the tools to cope in the VUCA environment.

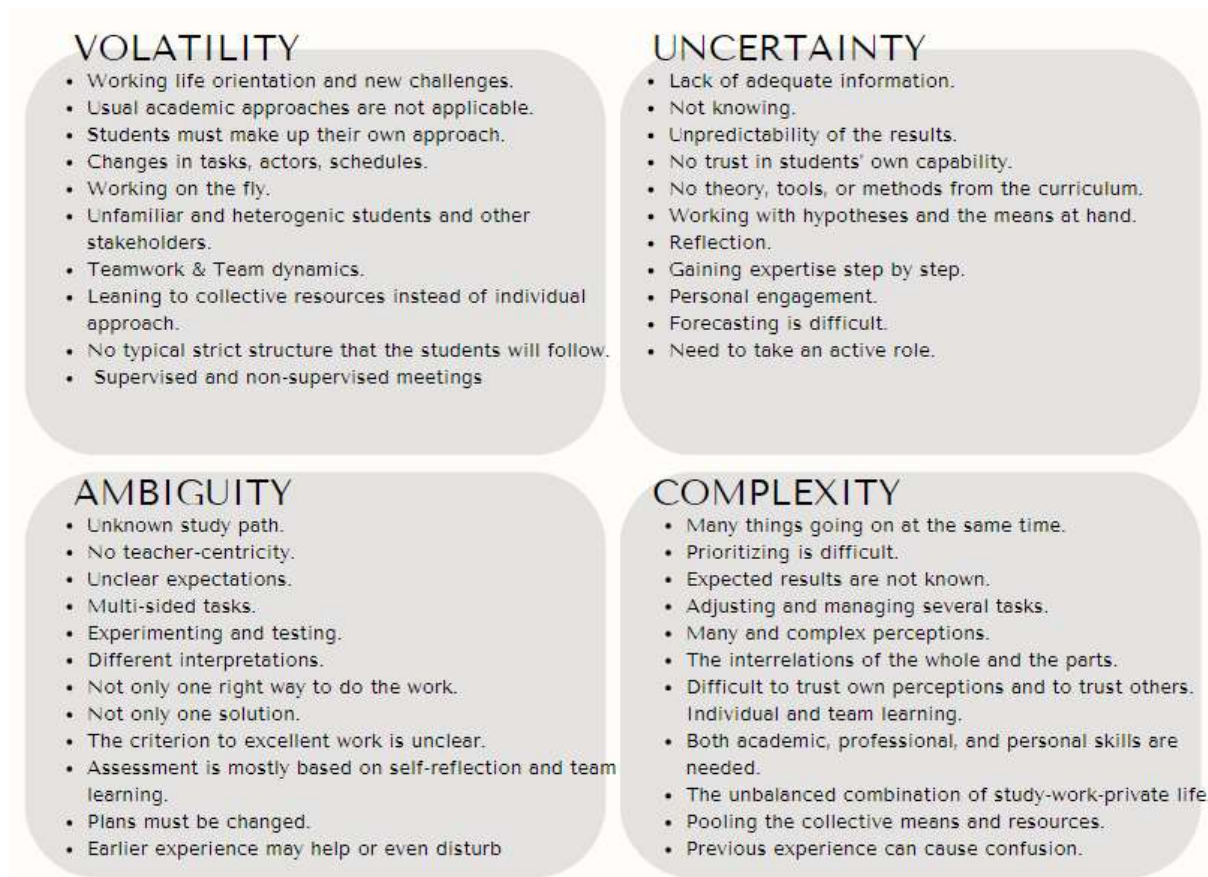


Figure 1. VUCA components in the educational context (Hänti et al., 2021).

The CDIO Syllabus has been widely used in HEI's. The starting point for the first CDIO Syllabus published in 2001 was to consider what knowledge, skills, and attitudes engineering students needed to learn to prepare for in their engineering practice. The aim was to create a clear, complete, and consistent set of goals for first-degree engineering education (Malmqvist et al. 2022). CDIO Syllabus 2.0 was published in 2011 and included two additional sections concerning leadership (4.7) and entrepreneurship (4.8). Updates were made to address innovation, invention, internationalization, mobility, and sustainability, resulting in, for example, the added subsection Sustainability and the Need for Sustainable Development (4.1.7).

The third version of the CDIO Syllabus was published in 2022. One of the change drivers for updating the CDIO Syllabus from 2.0 to 3.0 was the acknowledged situation the students are living in today, the VUCA world (Malmqvist et al., 2022). Students get their education in a world which is accelerating, rapidly changing, and increasingly complex and which is embodied in narratives about Industry 4.0, Society 5.0 and requiring decision-makers to continually be ready to reconsider and adapt. To be able to handle the stress caused by the world around us we need to implement student coaching tools into our syllabus and into our learning environments.

LEARNING ENVIRONMENTS

Learning environments are often understood as physical (e.g., a classroom or laboratory) or virtual premises and spaces (e.g., learning systems or platforms) that are meant and build for learning purposes. In some definitions psychological perspectives (e.g., psychological comfort with the space) are included. The concept of social learning environment includes the aspect of groups and networks. In the VUCA world problems are solved and innovations created in co-operation, thus the social aspect is relevant. (Keinänen & Välivirta Havia, 2022.) In this paper the learning environment includes socio-cultural and the physical or digital settings following Hänti et al. (2021).

Learning environments that support and encourage hands-on learning of disciplinary knowledge and social learning create a possibility for successful design-experiment experiences (Crawley et al., 2007). In the educational institutes learning is often well-planned and structured, even though we have identified the turbulence in the VUCA working life our students are entering. The learning environments should be designed to support our students to tolerate uncertainty and give them tools to survive and thrive in their life (Hänti et al., 2021). Educators' role in creating supportive, safe, encouraging and motivating learning environment is important (Keinänen, 2019).

In the working life employees are expected to develop their competence, knowledge and skills continuously. The learning environments can be designed to enhance participation, collaboration and exchange of knowledge and skills as these are seen as a foundation for learning. Learning is a social process, meaning that we learn in interaction, together with others. We should be able to support our students to develop learning skills they can utilize in work life. We want our students to be able to learn from each other, share knowledge, solve problems and find creative solutions in co-operation with others. (Konst et al., 2020.)

How to design learning environments

In high education institutes learning environments are expected to build a bridge between educational institutions and the working life. Learning is combined with working life practices for example by authentic goal-directed work activities or assignments from companies and RDI-projects. (Keinänen & Välivirta Havia, 2022.) The elements of VUCA and ways of turning professional uncertainty into something positive and productive can be considered when designing a learning environment (Hänti et al., 2021).

Various expectations are set for a learning environment. The use of design elements offers a concrete approach to the creation of learning environments. The design elements are epistemic, social, temporal, and spatial and instrumental elements (Figure 2). (Keinänen & Välivirta Havia, 2022; Hänti et al., 2021.)

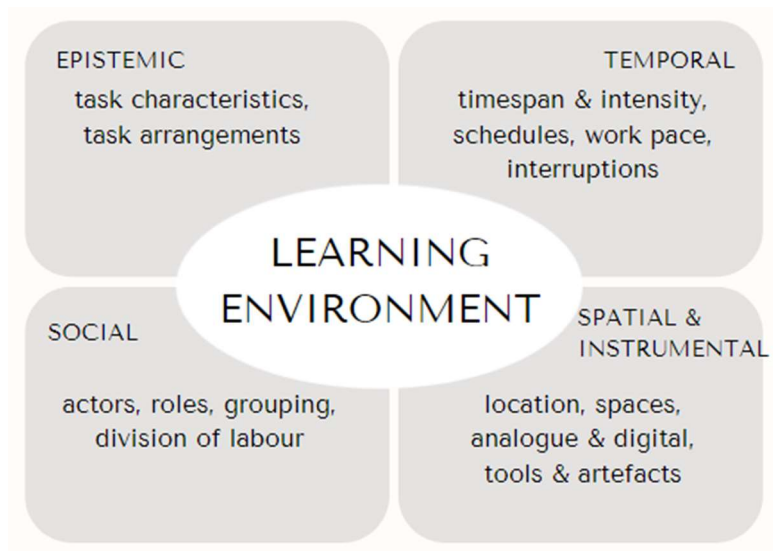


Figure 2. Design elements of learning environments (adapting Hänti et al., 2021).

All the four design elements have an important role in designing a learning environment and they are strongly interconnected. They all are relevant aspects in forming a learning environment that supports gaining disciplinary knowledge, social learning and coping in the VUCA world (Keinänen & Välvirta Havia, 2022.) Educational situations vary, and different approaches are needed. For example, the level of working life engagement varies, and the components of the design elements vary accordingly. And students' readiness to cope with uncertainty is different as well, and they should be supported and challenged in suitable ways. (Hänti et al., 2021.)

Epistemic elements

Epistemic elements are the task arrangements and task characteristics. These elements are based on the disciplinary knowledge, what is needed to learn a vocation. Epistemic elements are related to the occupation for which learners are being prepared. (Bouw, Ziller & de Bruijin, 2020)

When considering the presence of VUCA in a learning environment, educators have highlighted some key characteristics of epistemic elements (Keinänen & Välvirta Havia, 2022):

- balancing instructions and guidance
- learning by doing
- not knowing
- creativity.

Educators typically balance between giving instructions and guidance and giving freedom to the students. Some learning environments are designed for exploring and trial and error type learning while others require clearer tasks, set goals and a well-structured learning process. Many educators have the experience that learning by doing is the best way to enhance the skills needed in the VUCA world. A learning environment that offers possibilities to practice problem solving skills and raise questions about why, when and how things are done, create important skills for working life. Not-knowing is an important aspect of the learning process.

Educators should not offer readymade solutions but encourage the students to explore knowledge and support creativity and creative thinking. (Keinänen & Välivirta Havia, 2022.)

Social elements

Social elements include all actors in the learning environment, their roles, their interactions and how the tasks are appointed, and the work divided (Bouw, Ziller & de Bruijin, 2020). Most reflected topics of the social elements by educators when using the VUCA framework are (Keinänen & Välivirta Havia, 2022):

- role of facilitator and advisor
- avoiding teacher centrality
- teamwork methods.

Educators typically see their role as a facilitator or setter of the learning direction when working in, for example project learning environments. Part of educator's role is to inspire the students and show good practices. Teacher-centricity is often avoided because according to educators' experience, it leads to the passiveness of the students. Working in diverse teams has many positive effects on learning. In a team students can learn from each other, construct knowledge and create solutions together. Trying new approaches or taking risks often feel safer with a team compared to working alone. Working together makes students accountable for their colleagues and it also enables the development of communication and leading skills. (Keinänen & Välivirta Havia, 2022.)

Temporal elements

Temporal elements give attention to the importance of time: timespan and intensity, schedules, work pace and interruptions (Bouw, Ziller & de Bruijin, 2020). Temporal elements in the presence of VUCA raised up by the educators are (Keinänen & Välivirta Havia, 2022):

- balancing structure and schedules
- simulating the pressure of working life.

When discussing temporal elements, the importance of following deadlines and giving the freedom to plan schedules is often discussed. Milestones and deadlines are seen as an important tool to learn time management skills and feel responsible for your own work. In group work agreeing schedules might be difficult. An external partner creates pressure for accountability and delivering on time. A suitable balance between flexibility and set schedules should be found for each learning environment and occasion. (Keinänen & Välivirta Havia, 2022.)

Spatial and instrumental elements

Spatial and instrumental elements include all physical features. Spatial elements are the location, spaces and how these spaces are furnished. Instrumental elements include tools and artefacts needed to perform relevant tasks. (Bouw, Ziller & de Bruijin, 2020.) From the VUCA point of view educators raised up following spatial elements as key characteristics (Keinänen & Välivirta Havia, 2022):

- connection of learning environment and motivation
- safeness in learning environment

- simulation of professional environment.

Educators consider a good learning environment to be as close to the practice as possible. A professional environment supports students in building their professional behaviour, smoothens the way to the working life and has a positive influence on motivation. Educators state that students need to step out from their comfort zone to enable learning which means that experiencing uncertainty is an essential element in learning. The learning environments should offer enough safeness and encouragement to help students to face uncertainty. (Keinänen & Välivirta Havia, 2022.)

There are various learning environments in Turku University of Applied Sciences (TUAS). In this paper the Circular Economy 2.0 project learning environment is presented.

Case: Circular Economy 2.0 Learning Environment

Circular Economy 2.0 learning environment is one of the working project learning environments in TUAS. The idea is based on problem-solving project work. All the assignments come from companies or RDI-projects and are related to circular economy. Circular economy 2.0 operates under the Circular Business Models research group of TUAS and that's where the company connections and RDI-projects come from. The Circular Economy 2.0 learning environment has been functioning since 2013. In the beginning it was just a draft idea and a few students and over the years it has developed into a systematic way of working with over 100 students involved in the activities yearly. Approximately 86% of these are engineer students. The others come from business studies (appr. 10%) and media studies (less than 5%). (Circular economy 2.0, 2023.) The multidisciplinary student pool is an important part of circular economy development projects (Malve-Alroth, Suominen & Nurmi 2019). It is very beneficial to also the engineer students to work as teams and also to have some other disciplines involved.

Different learning environments are in an important role strengthening company cooperation in teaching and learning purposes. Learning environments can be a physical place or virtual platform or something between. Circular Economy 2.0 has a physical environment on TUAS campus. A lot of the work is done online and individually. The students often work in small groups under a student managing director, supported by mentors from the research group. Often students are recruited to the teams for a longer time but at some cases they can join only for one project. Each student gets tasks based on their individual skills and interests. The tasks can be done either individually or in a group. Students meet each other in weekly meetings. (Circular economy 2.0, 2023)

After launching the learning environment in 2013, the personnel started to research the topic and write down the background and aims for the learning environment. The basics was formulated as follows (Malve-Alroth, Suominen & Nurmi, 2019): *"[after] having learned the basics of the circular economy, students can begin to develop their personal expertise in the learning environment, drawing on their special skills and strengths. Throughout the learning process, students assess the development of their own competence and that of others. The areas of competence assessed include:*

- *Participation in a multidisciplinary team*
- *Application of knowledge learned from others*
- *Adoption of a customer-driven approach*
- *Behaviour in situations involving presentation, performance and interaction*

- *Ability to work independently, making use of outside networks and resources*
- *Basic project management skills.”*

In the same article the VUCA aspects of circular economy were described: *“transition to circular economy requires the borders between disciplines to be lowered. It also calls for interdisciplinary systemic thinking. (...) What we need is a new kind of learning that encourages critical, systemic thinking and supports the development of future circular economy experts.”* (Malve-Alroth, Suominen & Nurmi 2019.)

Having the VUCA framework now available, it is easy to see the linkage between the VUCA framework and the ideas behind Circular Economy 2.0 learning environment. In the chapters it is described more in detail how the Circular Economy 2.0 learning environment reflects to the VUCA framework and how the VUCA aspects are applied.

Volatility

The studies in the learning environment can take different forms. The students can work as trainees, thesis workers, earn study credits in projects or some other form of studies. The project topics always come from real life cases, either RDI projects, companies, or other organizations. Sometimes the project topics come from students themselves. The learning objectives are the key to all students: they take an active role in formulating what they want to learn. The students get new challenges. Academic approaches are often used a lot. There are a lot of changes in timetables and heterogenic stakeholders involved. There are multiple types of meetings and individual work. Teamwork and learning how to communicate and manage teamwork are in focus.

Uncertainty

The students experience uncertainty. That is an important part of the studies in a learning environment. The students are mentored in understanding why it is important to “allow and endure uncertainty”. Staff members and coordinators emphasise a lot the need to trust the students and to trust the process. That is important for the student to learn to trust their own capabilities. Students find theory, tools and methods from the curriculum and they can put them in use in the learning environment. Reflection is important part of the studies. Regular one-on-one reflection meetings with the students and the coordinator of the learning environment are organized. Students do get to gain experience step by step and the learn to take an active role.

Ambiguity

The teachers and staff members are important in the learning environment but still the key thing is that students get a lot of responsibility, freedom and opportunities. There is no one right way to work, but communication skills and practices are always of key essence. Tasks for students are multiple sided. It is important to try to clarify the expectations for the students, and to help them understand the ambiguity. Assessment is usually based on four aspects: self-assessment, peer- assessment, teacher assessment and client assessment. Self-reflection is valued. Earlier work experience has proven to be beneficial. Plans are and must be changed. Not only individually, but as a team and by planning and communicating.

Complexity

There are usually well over 10 RDI projects ongoing at the same time as well as the company projects. Appr. 25 students are always involved and active in the learning environment at the same time. They form groups of 2-5 based on the tasks. The leader of the environment is a senior lecturer and her role in organizing the activities is important but still there remains a large amount of complexity. Many of the expected project results are unknown. One key form of activity is that a more experienced students mentor the new ones and that has proven to build trust and good culture amongst the learning environment. Academic and personal skills are needed a lot. There is great risk for unbalanced study-work-private life, but it is emphasised to the students that the aim for good balance is an important working life skill, and this has proven to be a good way to motivate the students to build capacity for better study-work-private life.

Stakeholders' experiences of the project learning environment activities

A study was made in 2018 (Ahopelto 2018) to investigate how the different stakeholder groups of Circular Economy 2.0 have experienced the project learning environment. The study results showed that the interest groups had experienced working in the project learning environment a positive experience and had considered the experience useful to all the parties involved. Since that the learning environment has further developed the practices. Additionally, the operations were adjusted during COVID-19 times. All work was operated almost fully online in 2020-2021. The number of students increased during that time as we wanted to offer traineeship opportunities to a bigger number of students as due to COVID-19 many companies could not take in trainees. Student's feedback during that time was collected and it was highly positive. Students experienced that the Circular Economy 2.0 learning environment offered interesting real-life work, new contacts, community spirit and places where they could gain feelings of achievement during those turbulent COVID times. Circular Economy 2.0 learning environment is eager to continue the operations and offer 100 plus students these learning experiences yearly, and willing to continue studies and cooperation to understand more of VUCA aspects and how to design even more functioning learning experiences. Further research on learning outcomes and a regular review by internal and external interest groups has been identified as an area for further development after the CDIO self-evaluation.

CONCLUSIONS

Today there are several project learning environments in TUAS. The learning environments are field specific, but they work in co-operation creating students a possibility to work in multidisciplinary environments. Studying in project learning environments has become more popular among students.

The design elements (epistemic, social, temporal, spatial and instrumental) are used as a tool in designing the learning environments. In the case example Circular Economy 2.0 students work individually and in groups. They have certain deadlines, they plan their work schedules, and they are accountable for the project owner. Above mentioned are examples of the temporal elements. Social elements are in a central role in this project learning environment as the students are co-operating with peers, teachers and project owners. The teacher and more experienced students are mentors, the basic principle is student-centricity. The students are working with genuine assignments, and they are learning by doing. They are supported and guided, but on the level, they need to develop their skills. These are expressions of the epistemic elements. The spatial and instrumental elements become visible for example in a

way the students are encouraged to face the uncertainty in a safe environment together with fellow students. The way the Circular Economy 2.0 learning environment combines physical and virtual environments reflects the modern working life.

As the project learning activities have already been available and working for several years in TUAS, has one key observation been made. The coaching is very important in all stages of the student's study path, but the coaching should be adapted to the stage the student is in. A first-year student should not be coached in a similar way as a third- or fourth-year student. Students who have during their studies been working in a project learning environment, learning by doing and applying problem solving techniques to proceed in their assignments and projects, grow mentally, become more skilful and is more VUCA competent. A growing percentage of the students starting their studies today enrol in learning environment activities. There is a need for impact assessment. Research should be conducted to study the learning outcomes and test the hypothesis of effectiveness of project learning environments.

During their studies students have a possibility to try working in different environments and they are coached to improve their capabilities to work in VUCA working life. Positive experiences and realizing the personal growth and learning has proven to empower the students. The whole study path supports them to become creative and resilient problem solvers.

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