**////Title: A New Learner-Centred Design for Online Engineering Courses**

**////Standfirst:**

The COVID-19 pandemic forced many universities to deliver their courses online, exposing the limitations of remote learning strategies. Dr Barrett Caldwell and his team at Purdue University devised a new approach that could help to improve online courses in different engineering subjects. The approach builds on his experience while teaching and developing the ‘Perspectives on Systems Engineering’ course, which is part of the curriculum for the Systems Engineering program at Purdue University.

**////Main text:**

During the COVID-19 pandemic,lockdown and social distancing measures placed significant pressure on universities to deliver most, if not all, of their courses online. While the use of remote learning platforms had grown exponentially in the years before the pandemic, rapidly moving most education online revealed some of the shortcomings of these platforms.

In addition to curbing the spread of infectious diseases, online learning has significant benefits, as it allows students to receive an education from anywhere with an internet connection, without needing to move home or commute. Nonetheless, online education also comes with certain challenges.

Most notably, recent studies have highlighted difficulties in keeping online learners motivated and engaged with their course material. This is particularly true for courses that heavily rely on online lectures, which are susceptible to errors and lagging due to a poor internet connection or servers crashing.

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Dr Barrett Caldwell at Purdue University recently set out to improve the quality of his online courses. This ultimately inspired his team to create a new design for online courses that could be applied to different types of engineering curricula.

Dr Caldwell applied his team’s online design to a systems engineering course that he has been delivering at Purdue University for over a decade. This course, called ‘Perspectives on Systems Engineering’ is a transdisciplinary engineering course, which means that it combines concepts, principles, and tools from different scientific disciplines.

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Systems engineering education requires students to learn concepts rooted in entirely different disciplines, recognise connections between these concepts, and ultimately use them to solve specific engineering problems.

Its multi-disciplinary and complex nature makes systems engineering education particularly difficult to translate to online courses, as it requires both theoretical and practical work. Only through direct experiences do students finally develop the mindset necessary to tackle systems engineering problems. In the words of Dr Caldwell’s student: ‘experience is a harsh, but essential, teacher.’

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‘Perspectives on Systems Engineering’, the course delivered by Dr Caldwell, focuses on five distinct languages of systems engineering. These include systems thinking, cybernetic and operations mathematical analysis, component-whole relationships, the engineering deployment process, and the use of digital platforms and information architectures.

Dr Caldwell started developing the course in 2010, after many of his students expressed an interest in systems engineering. The module was specifically designed to be ‘hybrid’, in the sense that it would be simultaneously delivered on-campus for attending students and remotely to other distant students through the university’s online platforms.

Although the course was already designed to be accessible online before the outbreak of COVID-19, Dr Caldwell’s team developed its online components further during the pandemic, so that they could respect social distancing measures while teaching most effectively.

While teaching the course from 2010 onwards, Dr Caldwell had also realised the importance of offering students the opportunity to take part in practical activities that could also be completed online, which allowed them to refine their skills and fully grasp systems engineering processes.

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Building on student feedback, Dr Caldwell’s team ultimately devised a more universal design that could help to improve the quality and effectiveness of online transdisciplinary engineering education.

The team’s online course is based on a series of principles drawn from the three primary universal design frameworks for creating education programs. The first principle is that the instructional environment – in this case the online platform and resources used by students – should convey course material in an easy and accessible way. Secondly, the instructional environment should allow learners to engage with the course material in different ways.

The course design also highlights the need to create a diverse, inclusive, and welcoming online learning environment, while leveraging technology and other tools to support the students’ learning. Finally, the course instructors should clearly convey to students what the essential parts of the course are.

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To ensure that an online course is tailored to different types of learners, the team’s design also considers different types of students, each with their own level of motivation, attention regulation abilities, learning style, socio-economic background, and prior knowledge or expertise. Dr Caldwell and his team wished to accommodate and support multiple types of learners, rather than a hypothetical ‘average’ or ‘novice’ learner.

To accommodate the needs of different learners, the design highlights the need to create dynamic interfaces for online learning platforms that can adapt to users, allowing them greater control over their interactions with the platforms.

Within this dynamic online learning environment, students perform two main types of tasks. The first are learning tasks, through which they acquire or express knowledge, such as watching videos of lectures or taking a quiz. The second are information searches – tasks that require students to actively explore course material and the connections between different concepts.

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The online course framework proposed by Dr Caldwell’s team has so far proved to be very valuable, as students taking part in his systems engineering course were overall very satisfied with what they learned and with the flexibility it offered.

As stated by Dr Caldwell: ‘The course as it has been taught has been well received. We have not yet tested the new interface.’

In the future, his design could guide the development of similar online or hybrid transdisciplinary engineering programs that meet the unique needs of students with different backgrounds.

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This SciPod is a summary of the papers ‘Learner-Centered Design of Online Courses: A Transdisciplinary Systems Engineering Case Design’ and ‘Eleven Years, Five Factors: Systems Engineering Education Since IERC 2009’ in Proceedings of the 2020 IISE Annual Conference, 2020.

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