Redesigning a Postgraduate Software Engineering Module to Increase Engagement

G.J. Collins
University College London, Department of Computer Science
g.collins@ucl.ac.uk

***Abstract* - The COVID-19 pandemic required a complete transition to online teaching. With valid concerns of a potential decrease in student engagement, it was necessary to focus on the most effective learning strategies and reduce cognitive load.**

The software engineering professional practice postgraduate module at University College London uses flipped learning, providing resources prior to online discussions scheduled during normal lecture time. Questionnaires before topics establish student's level of knowledge and ensure well-understood concepts are not repeated. This allowed increased time for more challenging and engaging content.

Industry guest speaker talks are integrated with academic lectures and provide alternative perspectives for each topic. Some industry speakers had less time during the current academic year to prepare videos so alternative 'fireside chats' (as occur in industry conferences) were employed to reduce speakers' preparation time. Analysis, across several measures indicates these changes to both academic and industry sessions have led to more than a 26% increase in student engagement. Whilst this required a substantial increase in workload for lecturers much of this development work can be utilized again in the future. The current module design also gives both academic and industry speakers a greater range of options in delivering their content.

Keywords - student centered learning; cognitive load; flipped learning; curriculum development; motivation; engagement

I. Introduction

The COVID-19 pandemic required the remote delivery of the software engineering professional practice module at University College London (UCL). This module was developed in 2007 for face-to-face teaching. Since March 2020 this module has been delivered online. This module is designed to prepare students for their industry research projects. The module is based on the ethos of UCL's connected curriculum of research-based teaching [1]. Agile and lean practices are core topics. DevOps and continuous delivery, including current approaches to containerization and cloud-native development, are also covered in depth. The module provides perspectives from both academics and leading industry practitioners. Industry guest speakers that contribute to this module are from global organizations: HSBC, Fujitsu, Net App, NGINX, Form3, ThoughtWorks, Lenovo and IBM, and Red Hat. Student feedback indicated that interactive sessions were the most useful, and as a result, all lectures have been transitioned to flipped learning, where real-world problems were discussed in class.

This module is delivered during the 11-week spring term. It has been designed for students to read the required material to prepare for the live interactive sessions. Resources including exercises, case studies, research papers, and industry blogs are provided well in advance online within Moodle. Asynchronous videos are also recorded through the video system Lecturecast. 2 hours synchronous sessions are timetabled each week, with a recommended pre and post average workload of 2.5 hours for each session. The module is delivered by 2 lecturers, 4 support staff, and a team of 15 industry speakers.

II. Curriculum Development

A. *What is Flipped Learning?*

Flipped learning was adopted to increase student motivation, engagement, and reduce cognitive load [2], [3]. Flipped learning is a term applied where the information that would normally be delivered during the lecture is provided before the lecture as self-study preparation or after as consolidation. The lecture time is transformed into collaborative team activities. The lecturer facilitates this active learning and provides guidelines. The lecturer then provides a summary of key learning points once students have an opportunity to discuss and share their ideas online within Moodle.

Moving online entailed redesigning the module and focusing on student centered learning; understanding their research interests; how they want to learn; and what skills they need to develop. It was recognized that working many hours online would be demanding. It was also a concern that an excessive workload could potentially cause burnout. In anticipation of these potential problems, the module was redesigned in consideration of cognitive load: the information and skills that students would be able to process and learn.

Although, the lectures were designed as flipped learning only a limited number of students in the past had completed all pre-lecture activities. In previous years this required a summary of the salient points at the start of lectures. The need to increase engagement with the material beforehand became a priority, otherwise, the synchronous online sessions would revert to summarizing the material, limiting the time for team collaboration. Accepting that not all students would read the suggested material and complete exercises beforehand, five enhancements to the module design were incorporated:

- Adding questionnaires for the students to complete (requiring <10 mins) before synchronous sessions. These provided the lecturer with an understanding of students' prior knowledge. When the questions are completed the students are provided with the correct answers and the rationale. The completed questionnaire displayed a summary of the answers provided by the class to provide a benchmark of progress.
- Providing a summary, taking ~3 minutes to read, covering the essential points for each topic.
- Providing a variety of media to create interest, including podcasts, videos, and blogs.
- Ensuring online resources were available at least 7 days in advance so that students could learn at their own pace.
- Providing thought-provoking questions to encourage students to discuss with each other online.

B. An Example Question to Encourage Engagement

The class was asked to: *"Read the following story and post your ideas as to how this activity supports teamwork: In the 1920s, Revans had been a doctoral student in Cambridge at the Cavendish lab. That was where atomic physics was being pioneered, people were splitting the atom or talking about the idea. There were five Nobel Prize winners there. Every Wednesday the group would have afternoon tea. The Nobel Prize winners would invite to tea a few doctoral students. Revans was honored to be one of those students. There was a rule for that meeting where the only thing one can talk about was a problem they were trying to solve. One could not talk about an accomplishment, nor about what they're doing right. Others, who were all from various fields, would start by questioning him. They could not answer because they did not know the field well, but they could talk enough about it to generate ideas about alternative approaches to the problem. Revans was so impressed by the humbleness of these Nobel Prize winners who would come and say, "this is a problem [I am facing] and I can't get this figured out." Adapted from [4].*

Example posts from the 2020/21 class:

"Discussing a problem supports teamwork because it removes the psychological barriers for people to come and openly admit that you are facing a problem and want help from others. It is extremely difficult for team members, especially if you are known to be an expert or famous person with high expectations. Also, the other team members, who are less experienced or younger, will not feel intimidated and would speak up to give their suggestions, which could possibly address the problems."

"…encourages psychological safety within a team and reduces people's reluctance to engage in conversations in which they fear they'll appear naive and unaware. When individuals willingly expose their own vulnerabilities and openly take risks, it emboldens others to do the same, promoting a healthier and more fruitful environment for the team."

C. Using Cognitive Load Theory to Improve Learning

Providing resources prior to lectures has been shown to reduce cognitive load and reduce the correlation between prior knowledge and attainment after periods of study [5]. The module content was redesigned through the lens of Cognitive Load Theory (CLT) and how much information can be retained. CLT assumes that humans have a limited capacity within short-term memory, also known as working memory. For example, it is difficult to remember a long telephone number. However, if one is already familiar with part of the number, say the area code, it may be easier to remember the code and the new number. In effect, one has embedded the area code in long-term memory and built up the requisite schema. Building on what one already knows and related schemas provide the basis for learning. The theory outlines if the capacity or cognitive load is exceeded then learning is hindered. CLT has three domains: intrinsic, extraneous, and germane [6]. Intrinsic is part of the information and can only be impacted by reducing its volume. Extraneous knowledge is in addition to the core information and can be considered superfluous. Germane refers to the idea that knowledge is built on schemas. Instructors, according to the theory, can design modules focusing on these domains to reduce the cognitive load for students. The theory suggests if the information is presented appropriately it will improve processing, understanding and long-term retention.

Research has shown that reducing intrinsic cognitive load can improve retention [6]. Self-paced learning can also contribute to a reduction in cognitive load and improved recall [7]. Although this may not reduce the intrinsic difficulty, designing modules with smaller units of information to learn at a time helps reduce the demands on working memory. It also allows schemas to be developed as knowledge is acquired. Research shows from a cognitive perspective, students working at their own pace through preparation material is more effective for learning [8]. Furthermore, that the assimilation of new knowledge is linked to students' prior knowledge [5]. Studies have indicated that students with prior knowledge can expend less working memory on linking and assimilating the new information [9].

Tailoring content can have a positive impact on cognitive load. Decreasing germane cognitive load can be achieved by linking knowledge to well-understood schemas. Using established schemas working memory can be devoted to learning the new information rather than learning the schema at the same time. Schemas act as a scaffold to learning new information. Schemas can be considered as "sort of patterns in our heads" [10]. However, a schema can be interpreted more than a pattern as it provides an organized manner for understanding the information logically. An example of a schema used for this module was based on decision-making. For the architecture topic, covering architecture decision-centric reviews, students were introduced to a model outlining the problem, a possible solution, an alternative, pros and cons of the chosen decision, and trade-offs. Within the topic of psychological safety, students noticed the material encouraged them to discuss the problem, suggest a solution, consider alternatives suggested within their team, and when a decision had been decided consider the pros and cons and any trade-offs this entailed. One student remarked that this schema would be useful in their decisions within their research projects. The questionnaires also provide a chance to learn from smaller units of information and allow schemas to be developed. By providing the answers and further resources students can steadily build their knowledge. Analyses of questionnaires were used to tailor the module content as shown in Fig. 1. This allows for well-understood concepts not to be repeated in class time, allowing for more challenging problems to be discussed.

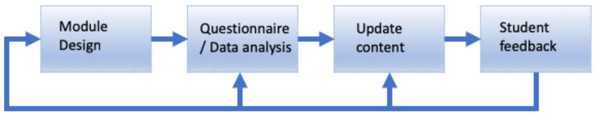

Figure 1. Questionnaires used in conjunction with student feedback to update content and module design.

The problem of knowing who has engaged with the material and completed the preparation work has been outlined [11]. Microsoft Forms allows the lecturer to see which students have participated in questionnaires before the live sessions and which areas need to be added to the online resources or incorporated within the synchronous session. Completing the self-study does not raise students' grades within this module. However, participation is encouraged by outlining that contributions to discussions and code are expected in work or software development communities.

Students' interaction was tracked via Moodle analytics and the embedded software reports showing which students have participated. Data-driven decision-making is an effective way to improve the offering of modules in universities [12]. By providing questionnaires in quiz form with an assessment also provides students with an indication of their progress. These questionnaires provide guidance if their answers were incorrect. By providing detailed explanations after each question is completed also helps students prepare for the lecture, provide time to assimilate this knowledge into a schema, and embeds information into long-term memory.

Reducing extraneous cognitive load can be partly achieved by removing distractions (Table I). Even a background of books during an online session, provides an opportunity for the viewers' attention to be sidetracked by the titles. By logging into the synchronous session in advance, the instructor and students are less likely to be distracted by issues of connectivity or settings. For these sessions joining with the audio off avoids distracting sounds plus feedback and is another way to reduce extraneous cognitive load. Reducing the number of written words on slides also helps reduce intrinsic cognitive load. Also, making diagrams as simple as possible ensures congruence with the explanations.

TABLE I. INTERVENTIONS IN MODULE REDESIGN FOR EACH OF THE COGNITIVE LOAD DOMAINS

Cognitive Load Domain	Interventions
Extraneous	Focus on learning objectives Log onto zoom 10 minutes before the start of synchronous sessions. Create zoom polls in advance Avoid distractions/ avoid jumping too often from one resource to another within video recordings
Intrinsic	Limit amount of information/ ensure limited number of words on slides/ include diagrams where this improves understanding Practice delivery Adapt content to match knowledge (via questionnaires)
Germane	Link content to appropriate schemas Ensure work is organized in topics Reuse schemas wherever possible throughout the module

D. *Industry talks*

Having industry speakers provides students a real-world perspective. Outlining different perspectives reinforces the need to value each other's opinions, a theme emphasized throughout the software engineering module. They can support the development of theory into practice and 'light the fire' within students' engagement in a subject [13]. Industry-academia interaction provides considerable benefits especially research opportunities in software engineering [14]. However, to take full advantage of theory and practice closer collaboration is required [15]. The benefit to students of both perspectives of industry's focus on timely delivery and combining this with the latest academic software engineering research is of immense value to students entering industry. Another advantage is that all the industry speakers within the module are already used to online meetings, as online communication was already their favored mode of working before the outbreak of COVID-19. However, many of the industry speakers had to contend with escalating workloads within their organizations due to the pandemic. This became apparent when guidelines for the video preparation were shared with them via email, asking for four or five 10-15-minutes videos relating to their talk. As this additional workload, in addition to their own organization's priorities was too much in some cases, an alternative talk structure, a 'fireside chat' was suggested. This is commonplace within industry events whether in-person or online. This informal structure decreased the preparation required for the industry speaker. It also provides a wider range of options for the way industry speakers deliver their talks for this module in the future.

For each industry video provided, even though the embedded AI automatically prepares the translation within Lecturecast, the lecturers still had to correct the text. For example, the 7 videos recorded in advance by the Red Hat speakers (27minutes ±10 minutes duration) entailed approximately 6 hours of text correction. Although there was an additional workload for lecturers, these pre-recorded videos will be a valuable asynchronous resource for future students.

Although the lecturer [author] had to check topics that the speaker wanted to answer, students' feedback indicated that they valued the opportunity to post questions relating to their interests. For the 'fireside chat', there was an increase in the number of questions submitted beforehand (Table II). There were 11 questions submitted before the HPC fireside chat, compared to 8 for the Kubernetes talk, during spring 2021, that used pre-recorded video content. Although limited data, the overall increase for discussions and comments when adopting the fireside chat was 27% across all interactions.

Example student questions posted prior to the industry talk covering high-performance computing (HPC) spring term 2021:

- *"In your opinion what is the biggest challenge in HPC? Is it scale, volume or data?"*
- *"How exactly do you measure sustainability? Which aspects are prioritized and why?"*
- *"I'm curious if you think the future of computing will change towards an era where all consumers and businesses will use 'rented' computing power from clusters, opposed to their own machines."*

E. Measuring Student Engagement

Student engagement is often associated with motivation. Velden [16] interprets this as "…the degree at which students engage with their studies in terms of motivation, the depth of their intellectual perception or simply studiousness." However, Ashwin and McVitty [17] have criticized the term 'student engagement' for its vagueness. They suggest that one way to define engagement is by what is 'formed' through student interaction. An interpretation of this would be the class learning developed by collaboration and discussions.

F. Analysis

The example question (Section B), based on problem-solving at the Cavendish Labs, Cambridge University [4] as part of the required pre-class activities created 11 discussion posts (class size N=42) 26% of the class. The modal number of student participation (measured by discussion posts), per 1-hour synchronous session, was 12 (29%). Within synchronous sessions, active team engagement (providing interaction via comments or posts) increased to a maximum of 24 (=57%) students contributing in any one session. Dias et al. [18], within their model, consider both the lecturer's and students' interactions. For this module, engagement was based on student interactions; the number of discussion posts. The number of discussion posts increased from 2019/20 to 2020/21. The annual total for posts for two topics, each with the same speakers, increased from 28 to 38 (Table III). This increase corresponds to 26%, accounting for the difference in class size. This figure suggests an improvement in engagement, assuming the number of students' posts is a valid measure of student engagement.

TABLE II. NUMBER OF STUDENT QUESTIONS SUBMITTED

Academic Year & number of students N	**Topic**		
	Kubernetes and OpenShift	***HPC and Sustainability***	***% change***
2019/20 N=39	11 face-to-face presentation and discussion	12 live online + online discussion	+9%
2020/21 N=42	15 pre-recorded videos (pre-session questions + online discussion) (8 prior +7 relating to topics)	19 pre-session questions + online fireside chat /online discussion (11 prior +8 relating to topics)	+ 27%

III. DISCUSSION

Research indicates that lectures are not an effective way of learning new skills [2]. Having a flipped lecture approach, however, can be conducive to learning and in reducing cognitive load. Luzik et al. [19] argue that education needs an approach "using projects and problem situations instead of traditional classes." When class time is repurposed to provide an opportunity to work in small teams devoted to critical thinking and problem-solving, this also enhances collaboration and communication, skills that industry require. Industry-academia collaborations are time-consuming but if managed successfully can generate research opportunities. Often there are problems with understanding the priorities of the other party in these collaborations. On the one hand timely delivery in industry on the other time available for research. As students progress from academic studies to industry research and development they need to understand these challenges of perception and perspective [15].

Sweller [8] suggests incorporating effective schemas along with the information can reduce the cognitive load. One schema that is developed throughout the module is based on decision making, an important research skill. Therefore, learning interventions need to address both the material and the related schemas. Sweller outlines if elements can be learned "successively rather than simultaneously" then this lowers cognitive load and learning and retention are enhanced. This indicates that designing learning interventions so that new information is linked to established schemas is an effective approach to learning. According to Hostetler and Lou [20] finding relevant research resources can increase students' cognitive load. So, for postgraduate modules where research skills are essential, reducing cognitive load for finding resources needs to be considered. For this module, research papers are available directly via online links with the UCL library. Perusall.com could also provide another means of delivery.

There is limited agreement on the definition of student engagement. However, Baron and Corbin [21] define student engagement as someone who views themselves as an "active participant in their learning communities." The learning community within this module not only involves their peers and academic staff, but also involves industry speakers and associated industry research teams [22]. Van Acker et al. [23] argue for a better definition of concepts and frameworks relating to cognitive load optimization. As proposed by Sinatra et al. [24] engagement has been considered at different levels, for individuals, as well as for teams. The measurements for this module were based on both individual and team interactions. Student engagement via interaction with the learning materials can also be assessed automatically [25]. Dias et al. [18] have suggested that although there are studies on interaction there have been limited attempts to interpret this in terms of learning efficacy. Self-paced study also gives rise to autonomy. Abeysekera and Dawson [11] outline an important aspect of learning is being able to adjust the workload and hence the cognitive load within studies. Collaborating in teams in class also gives rise to relatedness and a sense of community. The opportunities for discussions with their peers created the most engagement. Ironically, creating these activities also involved the least amount of work for redesigning the module.

Although there was an improvement in student engagement as measured by online posts, for the synchronous sessions, this still only involved a minority of the class. While Moodle logs indicate which activities, students have viewed or completed, participation reports can give a more nuanced view of their interaction. In addition, students from some geographic locations did not participate in online discussions as frequently as students based in London. Initial feedback indicated that being based with other students at the university or being part of an online team helped break down barriers to engagement and helped students feel part of a community. However, for different cultures with different expectations [26] of student engagement, further research is needed to find the most effective learning approaches.

Student feedback suggests that interventions for this module may help engagement for other modules:

"My favorite course on the degree, it had leading companies come in and talk through their process and how these processes got implemented, very insightful and super useful." Professional practice student [27].

The initial feedback from UCL Department of Computer Science postgraduate students (N=52) is not to revert to the pre-COVID format which was over 95% live campus tuition, but to increase the online and recorded material [28]. Although, the department will resume face-to-face lectures during 2021/22, this module will continue to be predominantly delivered online. However, recording content from live discussions involving students is problematic for privacy and ethical reasons. One way, being considered to resolve this, is that only the industry speakers' and lecturers' content will be recorded.

TABLE III. NUMBER OF STUDENT DISCUSSIONS SUBMITTED

Topic	**Year and Student Registrations**	
	2019/20 N=39	***2020/21 N=42***
Sustainability	10	18
Teamwork[a], Inclusion and Diversity	18	20

a. Includes psychological safety

IV. CONCLUSION

Having a less constrained view of how industry speakers wish to engage with engineering modules has led to opportunities for both learning and delivery. Focusing on student centered learning: the way students want to be taught and the opportunity to interact with their peers and industry teams enhances this further.

Research indicates that an improvement to the traditional lecture is active learning, engaging students in team problem-solving. This provides the collaboration and communication skills that are increasingly sort by industry. The core concept of flipped learning is to provide these interactions, transforming the lecture into learning activities and providing the resources online when needed.

Adopting flipped learning may not be a panacea to engage all students. However, evidence suggests that consideration of at least some of the implicit ideas in flipped learning to optimize cognitive load can enhance learning and may be applicable to other learning environments.

ACKNOWLEDGMENT

The author greatly appreciates the support from the industry speakers that have delivered talks for this module, including Anthony Kesterton and Ian Lawson, Red Hat, IBM and Wil Wellington, Lenovo.

REFERENCES

[1] D. Fung, A Connected Curriculum for Higher Education, UCL Press, London, 2017.

[2] N.T.T. Thai, B. De Wever, and M. Valcke, "The impact of a flipped classroom design on learning performance in higher education: Looking for the best 'blend' of lectures and guiding questions with feedback," *Computers and Education*, 107, pp. 113-126, 2017, doi: 10.1016/jcompedu.2017.01.003

[3] Z.Yulei, D.Yan, and B.Amer, "A large-scale blended and flipped class: Class design and investigation of factors influencing students' intention to learn," *IEEE Trans. on Education*, vol. 59, no. 4, pp. 263-273, 2016, doi: 10/1109/TE.2016.2535205

[4] S. Yusuf and S Reese, "Nancy Dixon: Empowering the learning organisation through psychological safety," The learning organisation, vol. 27, no. 3, pp. 259-266, 2020.

[5] G. Sirhan, C. Gray, A.H. Johnstone, N. Reid, "Preparing the mind of the learner," Univeristy Chemistry Education, vol. 3, no. 2, pp. 43-46, 1999.

[6] J. Jordan, J. Wagner, D.E. Manthey, M. Wolff, S. Santen, and S.J. Cico, "Optimizing lectures from a cognitive load Perspective," *AEM education and training*, vol. 4, no. 3, pp. 306–312, 2020-7.

[7] M. de Jonge, H.K. Tabbers, D. Pecher, Y. Jang, and R. Zeelenberg, "The efficacy of self-paced study in multitrial learning," *Journal of experimental psychology. Learning, memory, and cognition*, vol. 41, no. 3, pp. 851–858, 2015.

[8] J. Sweller, "Cognitive Load Theory, learning difficulty, and instructional design," *Learning and instruction*, vol. 4, no. 4, pp. 295–312, 1994.

[9] M.K. Seery and R. Donnelly, "The implementation of pre-lecture resources to reduce in-class cognitive load: A case study for higher education chemistry," *British Journal of Educational Technology*, vol. 43, no. 4, pp. 667-677, 2012.

[10] C. Kohls and K. Scheiter, "The relation between design patterns and schema theory," in Proc. *15th Conf. on Pattern Languages of Programs (PLoP '08)*, Association for Computing Machinery, New York, NY, USA, Article 15, 2008, pp. 1–16, doi: 10.1145/1753196.1753214

[11] L. Abeysekera and P. Dawson, "Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research," *Higher education research and development*, vol. 34, no. 1, pp.1–14, 2015.

[12] Mckinsey, "The new possible," (accessed 26 May 2021). https://www.mckinsey.com/about-us/covid-response-center/covid-19-impact/the-new-possible/acknowledged-but-unaddressed

[13] v.H, Remko, J. Godsell, J., and A. Harrison, A. "Embedding 'insights from industry' in supply chain programmes: The role of guest lecturers," *Supply Chain Management*, vol. 16, no. 2, pp. 142-147, 2011, doi: 10.1108/13598541111115383

[14] D. Marijan and A. Gotlieb, "Industry-Academia research collaboration in software engineering: The Certus model," *Information and software technology*, 132, pp. Information and software technology, Vol.132, Apr. 2021.

[15] A. Sandberg, "Academia-Industry collaboration: Getting closer is the key," in J. Bosch (eds) *Continuous Software Engineering*, Springer, Cham. 2014, pp. 29-39.

[16] G. V. D. Velden, "Staff perceptions of student engagement," in E. Dunne & D. Owen (Eds.), *The student engagement handbook: Practice in higher education*, 2013, pp. 77–91: Emerald

[17] P. Ashwin and D. McVitty, "The meanings of student engagement: Implications for policies and practices," In: A. Curaj, L. Matei, R. Pricopie, J. Salmi, P. Scott, (eds) *The European Higher Education Area*, Springer, Cham. 2015, doi: 10.1007/978-3-319-20877-0 23

[18] S.B. Dias, S.J. Hadjileontiadou, J. Diniz, and L.J. Hadjileontiadis, "DeepLMS: A deep learning predictive model for supporting online learning in the covid-19 era," *Scientific Reports (Nature Publisher Group)*, vol. 10, no. 1, 2020, doi: 10.1038/s41598-020-76740-9

[19] E. Luzik, O. Akmaldinova, and L. Tereminko, "Developing softwrae engineering students' readiness for professional mobility through blended learning," *Novìtnâ osvìta*, vol. 6, no. 13, 2019, pp.103–111.

[20] K. Hostetler and T. Luo, "Managing cognitive load in information literacy instruction," *Educational technology research and development*, vol. 69, no. 2, pp. 583–606, 2021, doi: 10.1007/s11423-021-09962-x

[21] P. Baron and L. Corbin, "Student engagement: Rhetoric and reality," *Higher Education Research and Development*, vol. 31, no. 6, pp. 759–772, 2012.

[22] G. J. Collins, "Integrating industry seminars within a software engineering module to enhance student motivation", in *Proc. 43rd Int. Conv. MIPRO (MIPRO 2021)*, in Engineering Education, Opatija, Croatia, Sept 28 - Oct 2, 2020, pp. 1797-1802.

[23] B. B. Van Acker, D.D. Parmentier, P. Vlerick, and J. Saldien, "Understanding mental workload: From a clarifying concept analysis toward an implementable framework," *Cognition, technology & work*, vol. 20, no. 3, pp. 351–365, 2018.

[24] G. M. Sinatra, B.C. Heddy, and D. Lombardi, "The Challenges of Defining and Measuring Student Engagement in Science," *Educational psychologist*, vol. 50, no. 1, pp.1–13, 2015.

[25] A. Rubio-Fernandez, P. J. Muñoz-Merino, and C.D. Kloos, "A learning analytics tool for the support of the flipped classroom," *Computer applications in engineering education*, vol. 27, no. 5, pp. 1168-1185, 2019.

[26] D. Vallee, "Student engagement and inclusive education: Reframing student engagement," *Int. Journal of Inclusive Education*, vol. 21, no. 9, pp. 920-937, 2017, doi: 10.1080/13603116.2017.1296033

[27] G. Collins, "Integrating industry seminars into a professional practice module to prepare students for future engineering challenges," in *Proc. 47th Annu. Conf. SEFI (SEFI 2019)*, Budapest, Hungary, Sept. 12-20, 2019, pp. 259-269.

[28] L. Griffin, "Lecture preference post-Covid pandemic", survey report, Department of Computer Science, UCL, May 2021.