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Accelerating the transition towards Edu 4.0 in HEIs

TEACH4EDU4

Learning Design Models

- Version 1.0 -

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Executive summary

This document describes the Learning Design (LD) used for Joint Creative Classrooms (JCC) course development under IO3. We start by outlining the starting point, which is the Open University Learning Design Initiative (OULDI) approach that defines seven basic learning design activities. The main rationale for choosing this particular learning design approach as the starting point in the Teach4EDU project is a very respectable number of conceptual and empirical studies that have analyzed and confirmed its appropriateness and adaptability to many different contexts. After a thorough analysis of the OULDI and its implementation, the results from the IO1 (literature review) and the additional literature review of the studies related to computer science courses (in Appendix A) have been integrated with the existing OULDI. As a result, three major categories/templates of the learning design were proposed for JCC (IO3). Next, teachers of the specific JCCs used the proposed learning design tool (T4ELD) to design their own courses that will be taught as JCCs. Their individual proposals were then reviewed and mapped back to the proposed templates in T4ELD, which were then further improved. In the end, based on the theoretical findings, the online tool T4ELD enables the design of courses under JCCs following the OULDI methodology and three proposed templates were created. Teachers used T4ELD to plan, design and re-think together about the courses they will carry out as JCCs.

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Introduction

The Open University Learning Design Initiative (OULDI) is an approach developed and used by the Open University (OU), which is described as “a methodology for enabling teachers/designers to make more informed decisions in how they go about designing learning activities and interventions, which is pedagogically informed and makes effective use of appropriate resources and technologies” (Conole, 2012). In other words, OULDI is focused on ‘what students do’ as part of their learning, rather than on ‘what teachers do’ or on what will be taught. Within the OU, there is an increased recognition that LD is an essential driver for learning (Nguyen et al., 2017; Rienties & Toetenel, 2016; Toetenel & Rienties, 2016).

Besides OU that was found as the leading institution in a number of published papers on learning design, there are also other examples that have captured and combined these data with behavioral traces of students in order to reflect on how these modules are delivered to students (Holmes et al., 2019; Mangaroska & Giannakos, 2019; Nguyen et al., 2017; Rienties & Toetenel, 2016; Wasson & Kirschner, 2020). After seventeen years of developing, testing, implementing and evaluating the evolving large-scale practice of LD at the OU, the OULDI approach is now business as usual. Furthermore, the sharing of learning design practices from the OU with other HEIs has resulted in an impact on the understanding, learning and practice of 1541 university educators over a dozen countries, including Belarus (Olney et al., 2020), China (Olney et al., 2021), Kenia (Mittelmeier et al., 2018), and South Africa (Greyling et al., 2020).

In the OULDI model seven distinct learning design activities are distinguished, as indicated in Table 1. *Assimilative* activities are tasks in which learners attend to discipline-specific information. This includes reading text (online or offline), watching videos, or listening to an audio file. *Finding and handling information activities* (which might involve information sources such as the Internet or spreadsheets) are those which focus on skills development and encourage learners to take more responsibility for their learning. *Communicative* activities are those in which students communicate with another person about module content. *Productive* activities are those in which learners build and co-construct new artifacts. This could be a list, a piece of narrative text which answers a question, a reflective account, a report, a video or a presentation. *Experiential* activities provide learners with the opportunity to apply their learning to a real-life setting. The key here is that students receive real-life feedback on the activity (for example, from customers or clients, work colleagues or the environment) and have an opportunity to reflect in context. *Interactive / adaptive* activities do a similar thing but in a pedagogically or practically safe setting, such as those provided by simulations. Activities falling into this category might include role-play, problem-based scenarios, simulated case studies or simulated experiments. Finally, *assessment* activities encompass all activities focused on assessment, whether formative (to monitor and feedback on progress, peer review or self-assessment) or summative (for measurement and qualifications).

LD activity	Details	Example

Assimilative	Attending to information	Read, Watch, Listen, Think about, Access
Finding and handling information	Searching for and processing information	List, Analyse, Collate, Plot, Find, Discover, Access, Use, Gather
Communication	Discussing module related content with at least one other person (student or tutor)	Communicate, Debate, Discuss, Argue, Share, Report, Collaborate, Present, Describe
Productive	Actively constructing an artefact	Create, Build, Make, Design, Construct, Contribute, Complete
Experiential	Applying learning in a real-world setting	Practice, Apply, Mimic, Experience, Explore, Investigate
Interactive/adaptive	Applying learning in a simulated setting	Explore, Experiment, Trial, Improve, Model, Simulate
Assessment	All forms of assessment (summative, formative and self-assessment)	Write, Present, Report, Demonstrate, Critique

Table 1. OULDI learning design activities

For the development, review or redesign of modules, the OU uses a process of so-called "module mapping". Beginning with a stakeholders' workshop, in which the various possible LD activities are discussed in the context of the module being designed, the module's initially intended LD is analyzed and subsequently presented back to the module team as a combination of graphics and text (by means of the OU's Activity Planner visualisation tool), as illustrated in Figure 1. The aim is to make explicit the module teams' otherwise tacit LD decisions so that they might consider whether amendments to their LD might enhance the quality of their module. This OULDI tool is publicly made available by JISC (Van Ameijde, 2015)

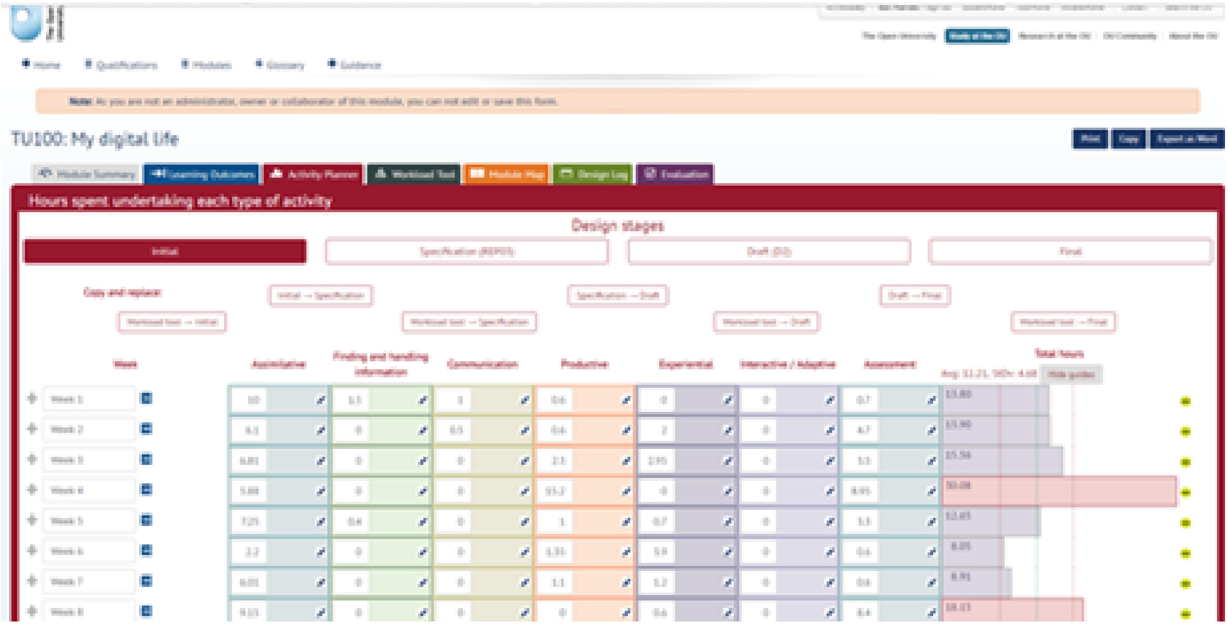


Figure 1. Module activities within a level 1 module (overview of first 8 weeks)

Common OULDI learning design approaches

A range of empirical studies have specifically looked at a large number of blended and online courses in order to identify common patterns of the way teachers design courses. In the first study of large-scale implementation of OULDI, Rienties et al (2015) looked at 87 learning designs available at the OU and identified four specific clusters, as indicated in Figure 2. 28% of included modules were labeled as cluster 1 constructivist learning designs, whereby nearly 60% of learning activities were labeled as assimilative (i.e., reading, watching, listening). 25% of modules were identified cluster 2 assessment driven, whereby around 44% of learning activities were labeled as assessment (i.e., formative, summative). 28% of modules were identified as cluster 3 balanced-variety (later identified as productive), whereby there was a fairly equal balance between activities. Finally, 18% of modules had a strong focus on student-centered activities including communication and productivity, which was labeled as cluster 4 social constructivist.

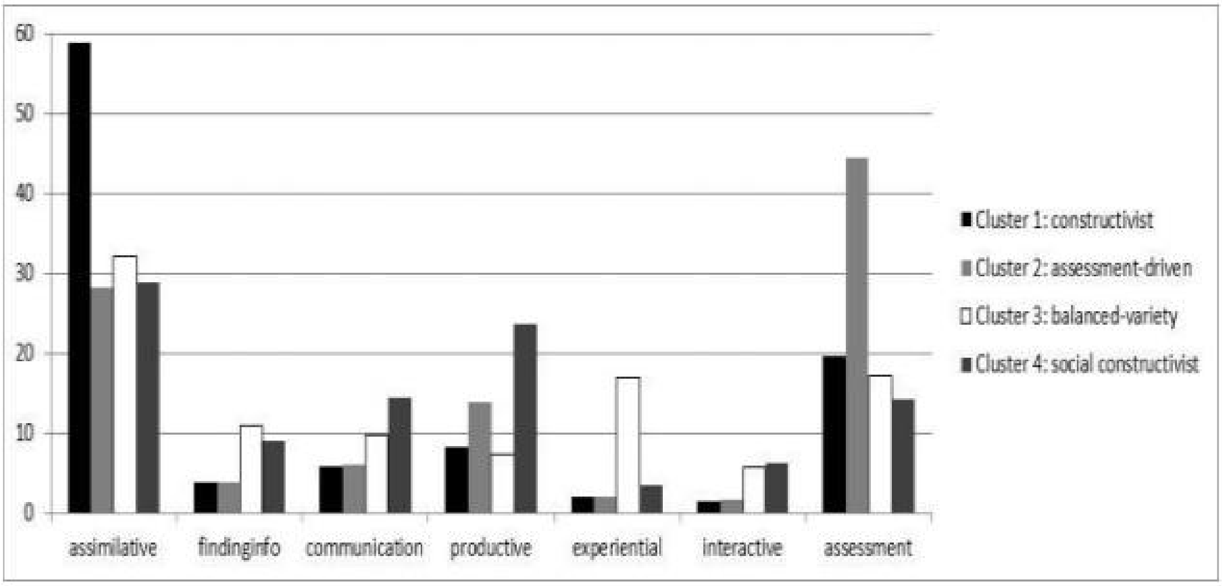


Figure 2. Cluster analysis of Learning design (Rienties et al., 2015)

In a follow-up study, Toetenel and Rienties (2016) identified 157 learning designs and found substantial variation across modules. On average, as is indicated in Figure 3 the most planned learning design activities (in percentages) consisted of assimilative learning activities (M = 39.27, SD = 17.17), followed by assessment (M = 21.50, SD = 14.58). The categories of productive, communicative, finding information, experimental and interactive were relatively little used, as can be seen from their average use (productive [M = 13.13, SD = 10.40], communicative [M = 8.41, SD = 7.40], finding information [M = 6.76, SD = 7.08], experiential [M = 5.79, SD = 7.61] and interactive [M = 5.14, SD = 6.75]). In follow-up studies (e.g., Nguyen et al., 2017; Rienties & Toetenel, 2016) linking these learning designs with actual student engagement, academic performance and retention the key learning design activity driving student success was communication. A 1% increase in communication on average would lead to a 0.5% increase in retention (Rienties & Toetenel, 2016). Indeed, 69% of weekly engagement by learners was found to be predicted by how teachers design and implement their learning design (Nguyen et al., 2017).

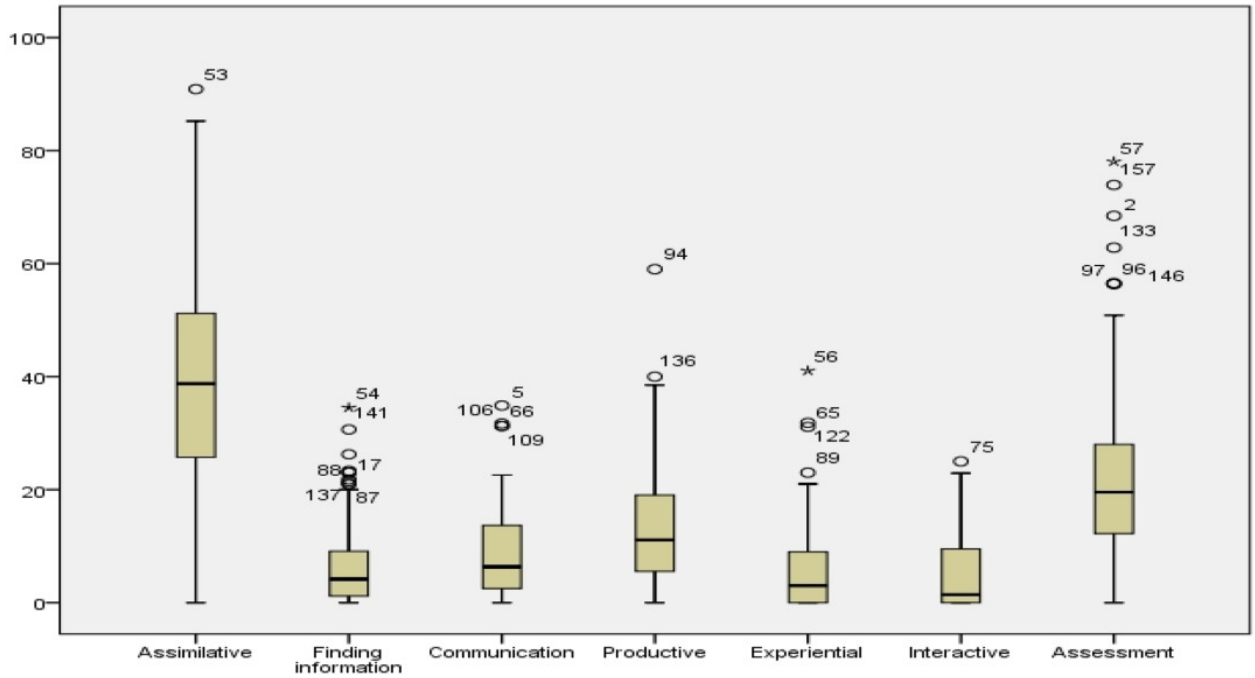


Figure 3. Boxplot of 157 learning designs (in percentages) (Toetenel & Rienties, 2016)

In a follow-up study of 55 learning designs by Holmes et al. (2019) six distinct clusters were identified in OU courses, as indicated in Figure 4. Cluster 1 allocated the highest relative frequencies (in percentages) for assessment activities (M = 37.39, SD = 10.39) and the lowest for assimilative activities (M = 29.51, SD = 10.39), compared to other clusters. Meanwhile, cluster 2 had the highest frequency for finding information (M = 15.10, SD = 16.92) and interactive activities (M = 29.38, SD = 28.10). Cluster 3 had the highest frequency of assimilative activities (60.51, SD = 10.86). Cluster 4 had a relatively high frequency of communication (M = 10.68, SD = 7.68) and productive activities (M = 20.25, SD = 13.08). Cluster 5 was highest in experiential activities (M = 4.25, SD = 7.61). Cluster 6, which is the largest cluster, allocated the majority of time for assimilative (M = 48.64, SD = 12.45), assessment (M = 23.99, SD = 8.89), and productive activities (M = 19.37, SD = 11.69), while ranking low in communication, experiential, interactive, and finding information activities.

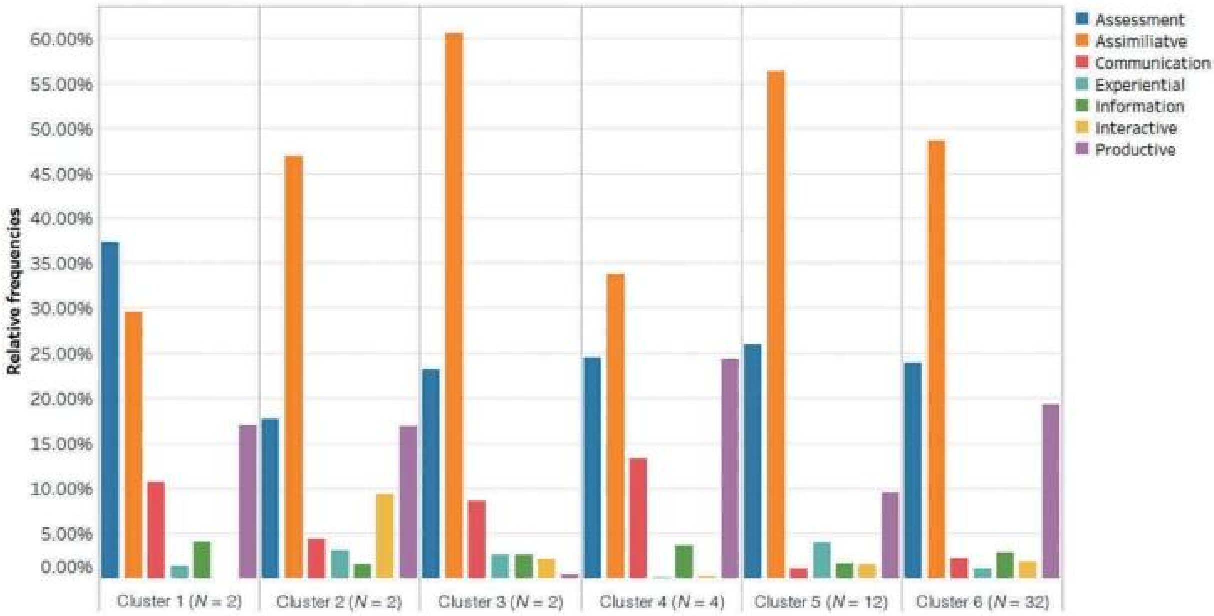


Figure 4. Cluster of learning design among 55 learning designs (Holmes et al., 2019).

While these above studies show the importance of mapping learning design in how students engage with online learning, one obvious limitation is that these studies did not specifically look at Computer Science courses (although these were included in the analysis). Furthermore, all these studies were conducted within the context of the Open University UK, which is a distance learning university. Within Teach4Edu a range of universities use a combination of face-to-face, blended and online learning activities for their JCCs, and therefore the OULDI approach may need to be updated for this context.

Mapping the literature review findings to OULDI

From IO1 two systematic literature reviews were conducted to explore how teachers in computer science design and implement innovative approaches and technology. In an initial explorative study (Rienties et al., 2021a) of 20 studies in Europe we found that most European teachers used only one or two out of nine elements of Edu 4.0 (1) Learning any time / anywhere, 2) Personalised learning, 3) Choice how to learn, 4) Project-based learning, 5) Hands-on learning, 6) Data interpretation, 7) Assessed differently, 8) Student ownership of curriculum, 9) More independent). In a follow-up study with 66 innovative approaches of EDU 4.0 embedded into CS we found further support for three distinct clusters in how CS teachers design innovative courses (Rienties et al., 2021b). As illustrated in Figure 5, there seemed to be three clusters of CS designs, which we label as 1) *EDU 4.0 light* (n = 18), 2) *project-based/hands-on learning* (n = 22), and 3) *full EDU 4.0* (n = 26). In EDU 4.0 light studies teachers mostly focussed on more independent learning (61%), learning anytime anywhere (44%), personalised learning (39%), and choice over how to learn (39%), but with limited hands-on learning (17%) and no project-based (0%). The second cluster that we labelled as project-based/hands-on learning had a strong focus on Hussin (2018) project-based (86%) and hands-on learning (86%), with relatively limited focus on choice how to learn (5%), personalised learning (5%), and learning anytime anywhere (18%). The third and final cluster which we labelled as the full EDU 4.0 version was strongly focussed on hands-on learning (100%), becoming more independent (96%), personalised learning (85%), learning anytime anywhere (77%) and choice how to learn (77%).

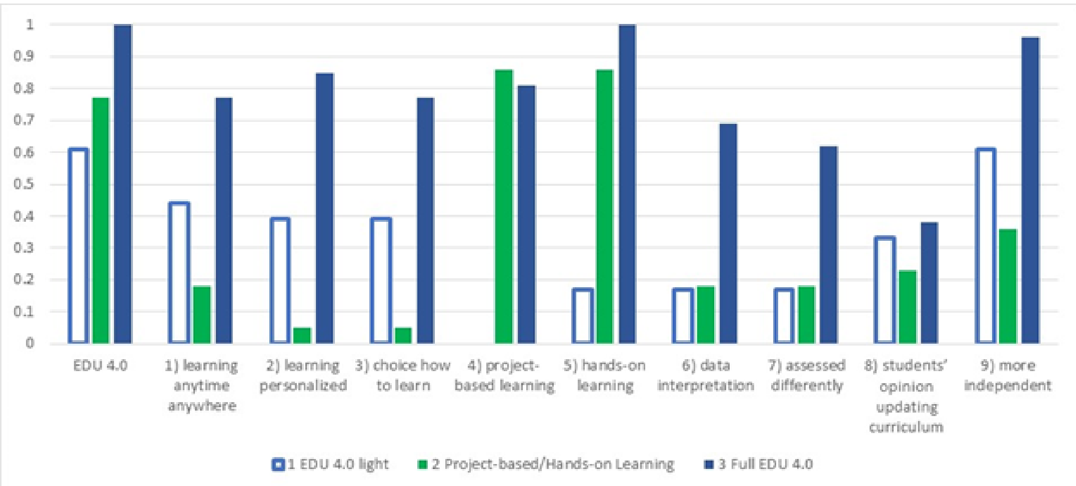


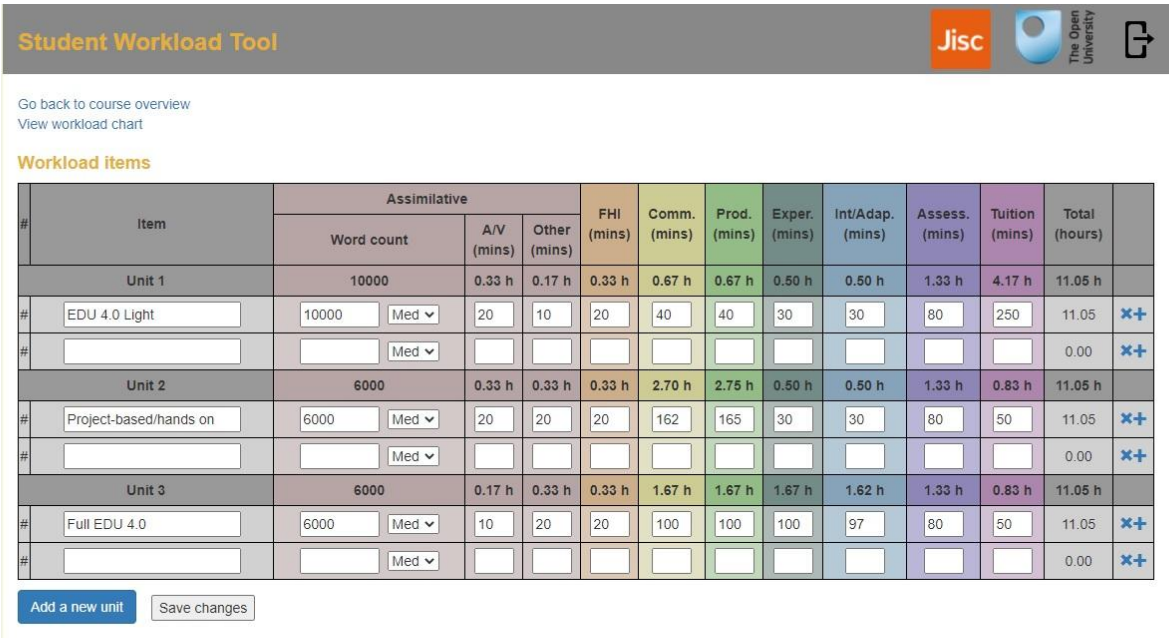
Figure 5. Cluster analysis of EDU 4.0 (3 cluster solution)

An additional literature review was also done as a part of this IO indicating:
(1) if there are any cases of CS courses that used activities which are not covered by the OULDI;
(2) which OULDI activities are used the most frequently;
(3) are there any OULDI activities that are not recorded in CS courses

The review confirmed the work done under IO1 and presented above and also indicated that all OULDI activities were reported in CS courses. The detailed analysis is presented in Appendix A.

Possible templates for JCC

Triangulating the CS findings from the previous section with the findings from OULDI courses we could identify the following three common clusters that are often present in CS courses. Assuming around 11.05 hours of study in a particular week, the following division of activities could be used for the three templates. As indicated in Figure 6, in the 1) EDU 4 light JCCs (Unit 1), there is a relatively higher focus on assimilative activities, including tuition (i.e., taught provision) and reading materials. The other five activities are more or less equally spread. This is in line with assimilative and balanced clusters previously identified (Holmes et al., 2019; Rienties et al., 2015).



#	Item	Assimilative: Word count		Assimilative: A/V (mins)	Assimilative: Other (mins)	FHI (mins)	Comm. (mins)	Prod. (mins)	Exper. (mins)	Int/Adap. (mins)	Assess. (mins)	Tuition (mins)	Total (hours)
	Unit 1	10000		0.33 h	0.17 h	0.33 h	0.67 h	0.67 h	0.50 h	0.50 h	1.33 h	4.17 h	11.05 h
#	EDU 4.0 Light	10000	Med	20	10	20	40	40	30	30	80	250	11.05
#			Med										0.00
	Unit 2	6000		0.33 h	0.33 h	0.33 h	2.70 h	2.75 h	0.50 h	0.50 h	1.33 h	0.83 h	11.05 h
#	Project-based/hands on	6000	Med	20	20	20	162	165	30	30	80	50	11.05
#			Med										0.00
	Unit 3	6000		0.17 h	0.33 h	0.33 h	1.67 h	1.67 h	1.67 h	1.62 h	1.33 h	0.83 h	11.05 h
#	Full EDU 4.0	6000	Med	10	20	20	100	100	100	97	80	50	11.05
#			Med										0.00

Figure 6. Teach 4.0 Workload for EDU 4.0 light, Project-based, and Full EDU 4.0 courses[1]

In the 2) project-based/hands on JCCs (Unit 2 in Figure 6)around half of the workload time is allocated towards communication and productive activities, encouraging collaborative and project-based learning activities, with a relatively lower amount of assimilative materials and tuition. This design is in line with productive and socio-constructive designs previously identified (Holmes et al., 2019; Rienties et al., 2015).

Finally, the 3) Full EDU 4.0 JCCS (Unit 3 in Figure 6) aims to integrate most of the nine EDU 4.0 characteristics, with a strong focus on student-centred learning and giving students choice. As a result a balanced mix between the seven learning design activities are provided with a focus on communication, productive, interactive, and experiential learning, and like with 2) project-based/hands on a relatively low focus on assimilative. As illustrated in Figure 7, obviously these three templates are just initial draft templates, and could potentially be mixed together based upon the requirements of Teach 4.0.

[1] The numbers in boxes indicate estimated workload in minutes. For the Tuition category, 250 minutes was planned for the Edu 4.0 Light profile, and 50 minutes for Project-based/hands on and Full Edu 4.0 profiles. The system automatically sums up the figures and converts it into hours.

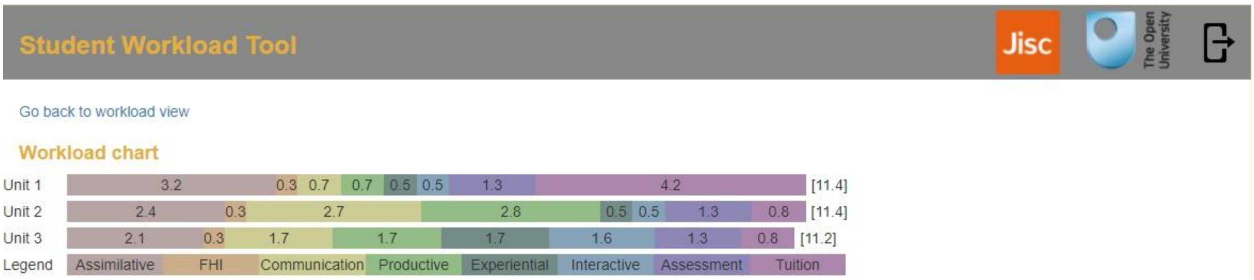


Figure 7. Workload visualisation across the three clusters

Final templates for JCC

This part will be completed in the version 2.0 in February 2022 once all teachers plan and deliver their JCCs. The initial templates will be cross-matched with the ones that JCC teachers will plan (a part of the exercise, explained in Appendix B) and revised accordingly.

Tool for planning JCCs

In order to enable teachers to plan their JCCs in accordance with the requirements of this project, and taking into account the defined JCC templates, the OULDI has been upgraded. However, the leading organization, Faculty of Organization and Informatics decided to even further improve the tool

The previously mentioned templates will be implemented in the T4

The T4ELD tool is available at: https://bdp-ld.foi.hr

Except the planning of the JCC as courses according to the OULDI, the T4ELD tool tackles another three main aims:

1. To enable teachers to define learning outcomes at course level.
2. To improve the overall quality of our courses by providing a specific methodology and accompanying tool that will enable teachers and stakeholders to rethink their course delivery.
3. To allow multiple users to work on the same course design and to provide users with advanced analytics and design sharing capabilities.

The T4ELD tool is based on Learning Design Methodology developed at the Faculty of Organization and Informatics as a part of this project, and another Erasmus+ project (RAPIDE). Within this project, a small portion of the tool regarding the planning phase was developed as for JCCs teachers need to plan their activities according to OU LD. All other components were developed mostly from our own fundings as the funds from this project were very modest for the development of the tool for planning the JCCs.

In Figure 8 a detailed conceptual data model of the tool/LD methodology is presented.

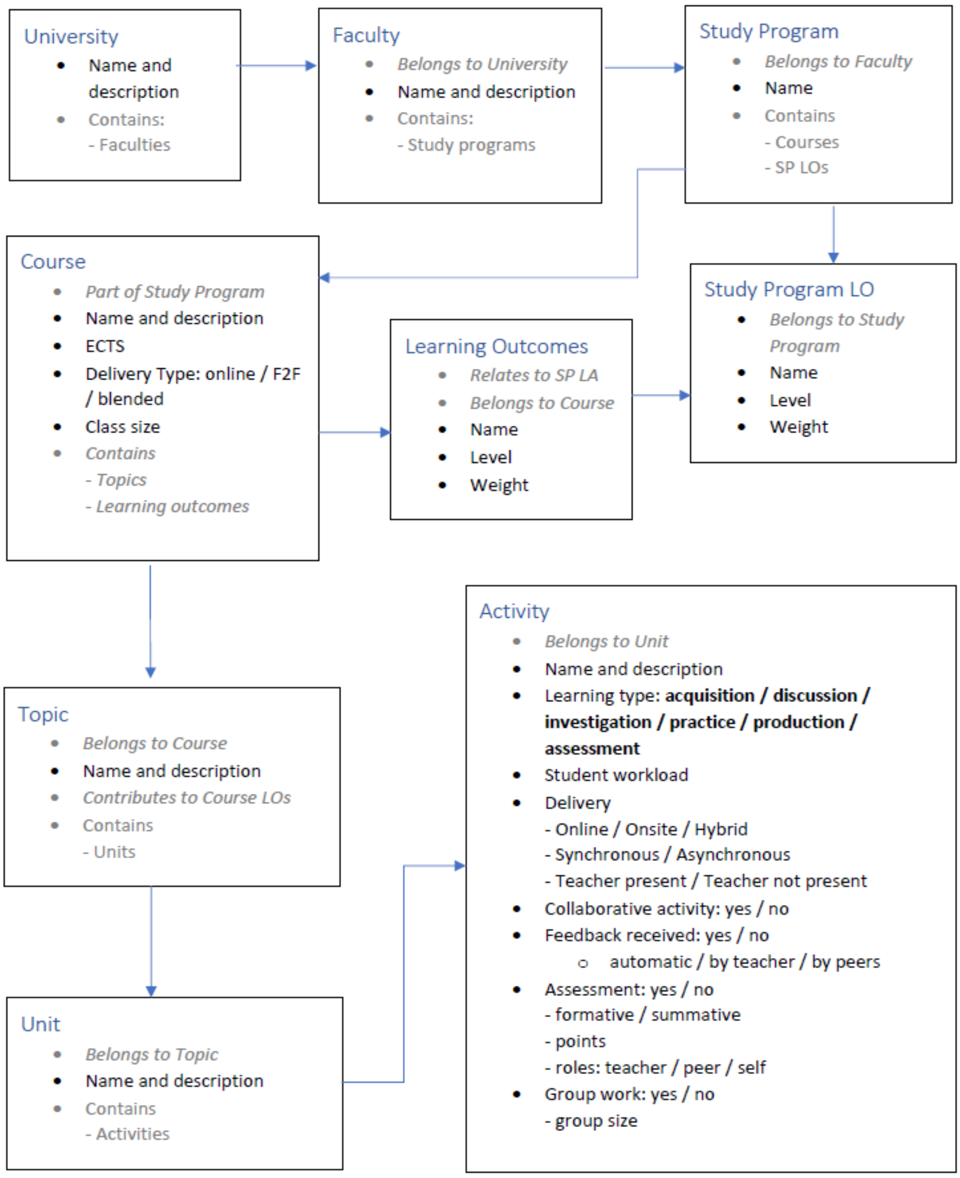


Figure 8. The conceptual and data model of the tool

Each course can belong to a particular study program. For each of the courses, teachers can define general data (e.g., name, description, delivery type, …) and learning outcomes. After that, specific course topics need to be defined and one or more learning units for each of the topics. At the end, for each of the learning units specific Teaching and Learning Activities (TLA) need to be defined. For each of the TLA's, teachers need to decide about the respective learning type and several additional descriptors.

In Figure 9 a detailed concept is presented at micro level which outlines the course design process described above. For every course, Course Learning Objectives (CLO) can be defined, but these can be skipped as well. In addition, Topics (T) and Units (U) as sub-elements of the course content are defined. For every Unit (U), a set of activities (A) are defined within TLA types.

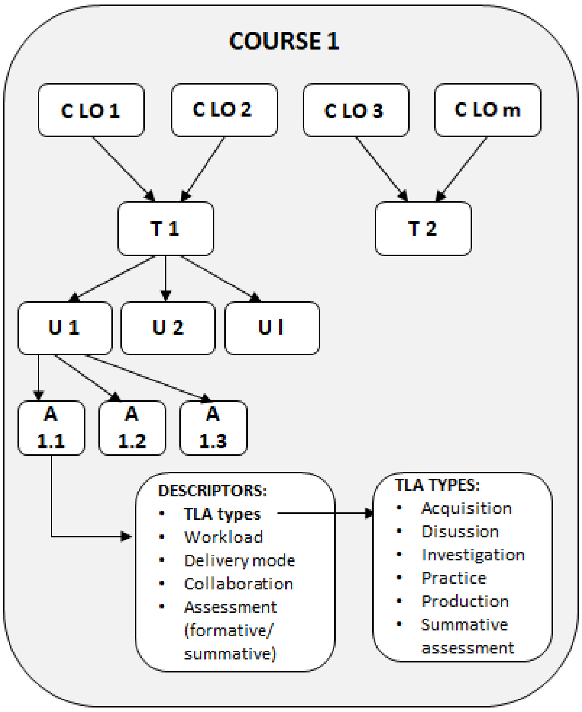


Figure 9. The detailed concept

Online tool screenshots

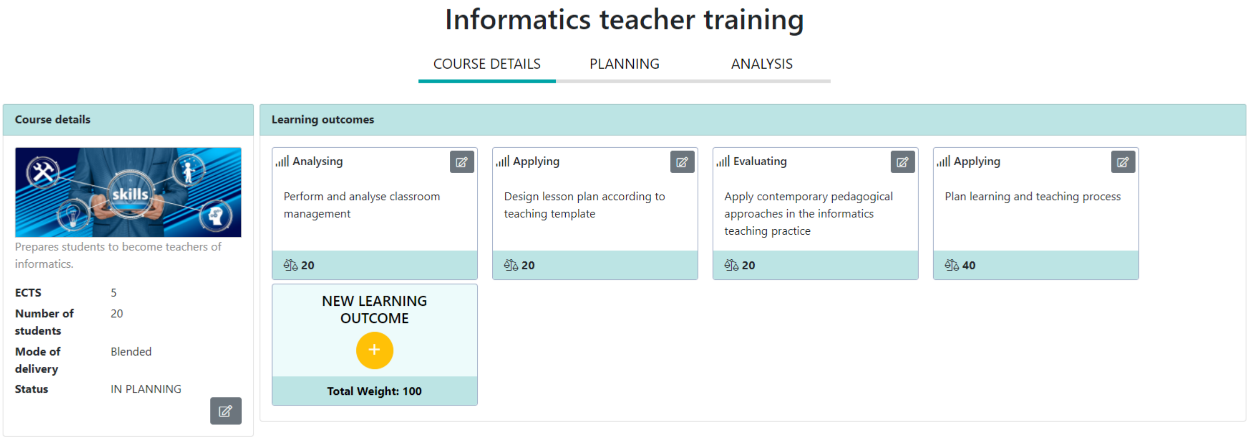


Figure 10. Course details with learning outcomes

For each JCC, the first page presents course details, as on Fig. 10.

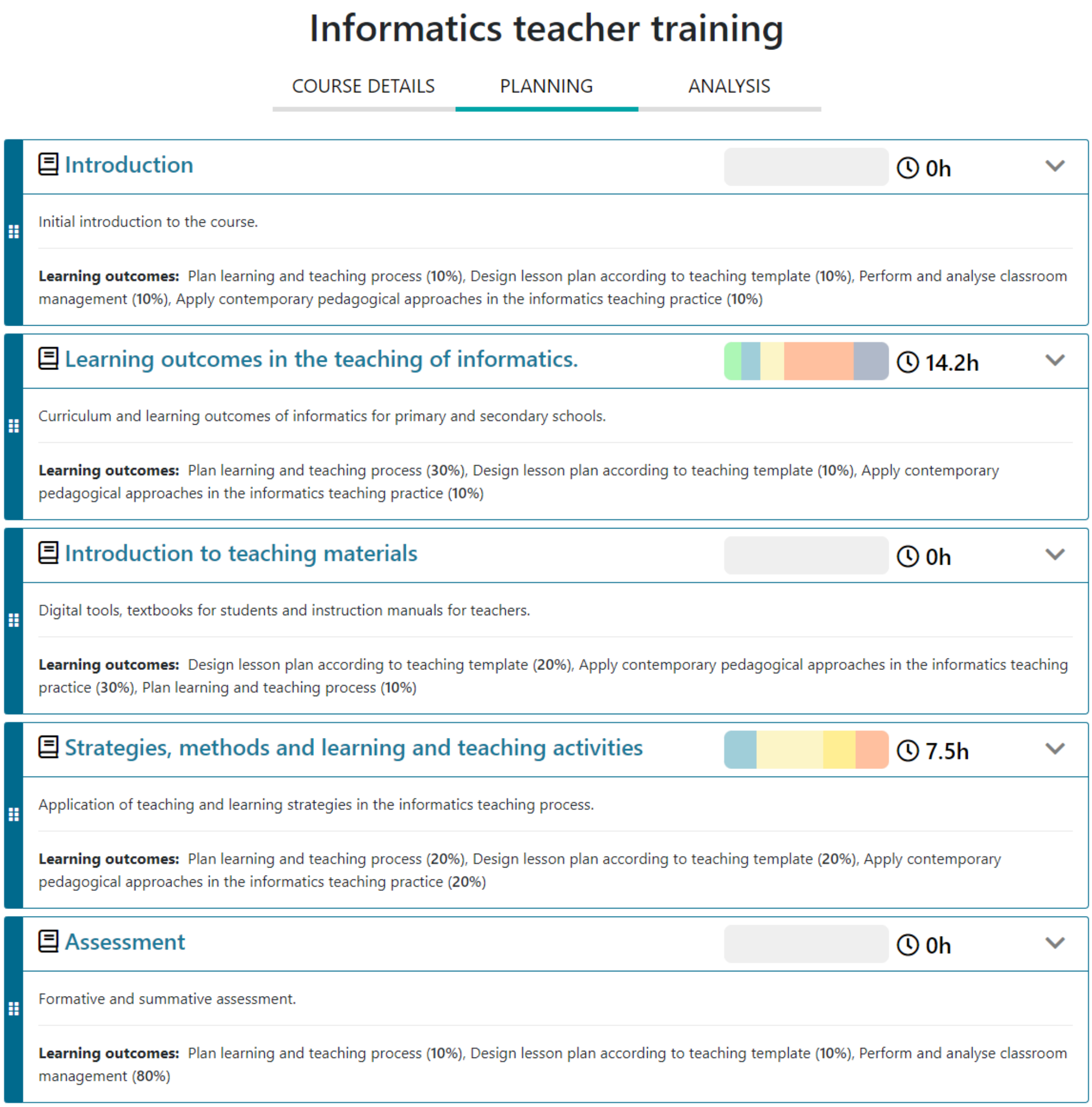


Figure 11. List of course topics

Fig. 11 shows the Planning page which allows teachers to create topics and units. This view presents an overview of topics that can be rearranged at any time, and for each topic teachers can see the students' workload in hours.

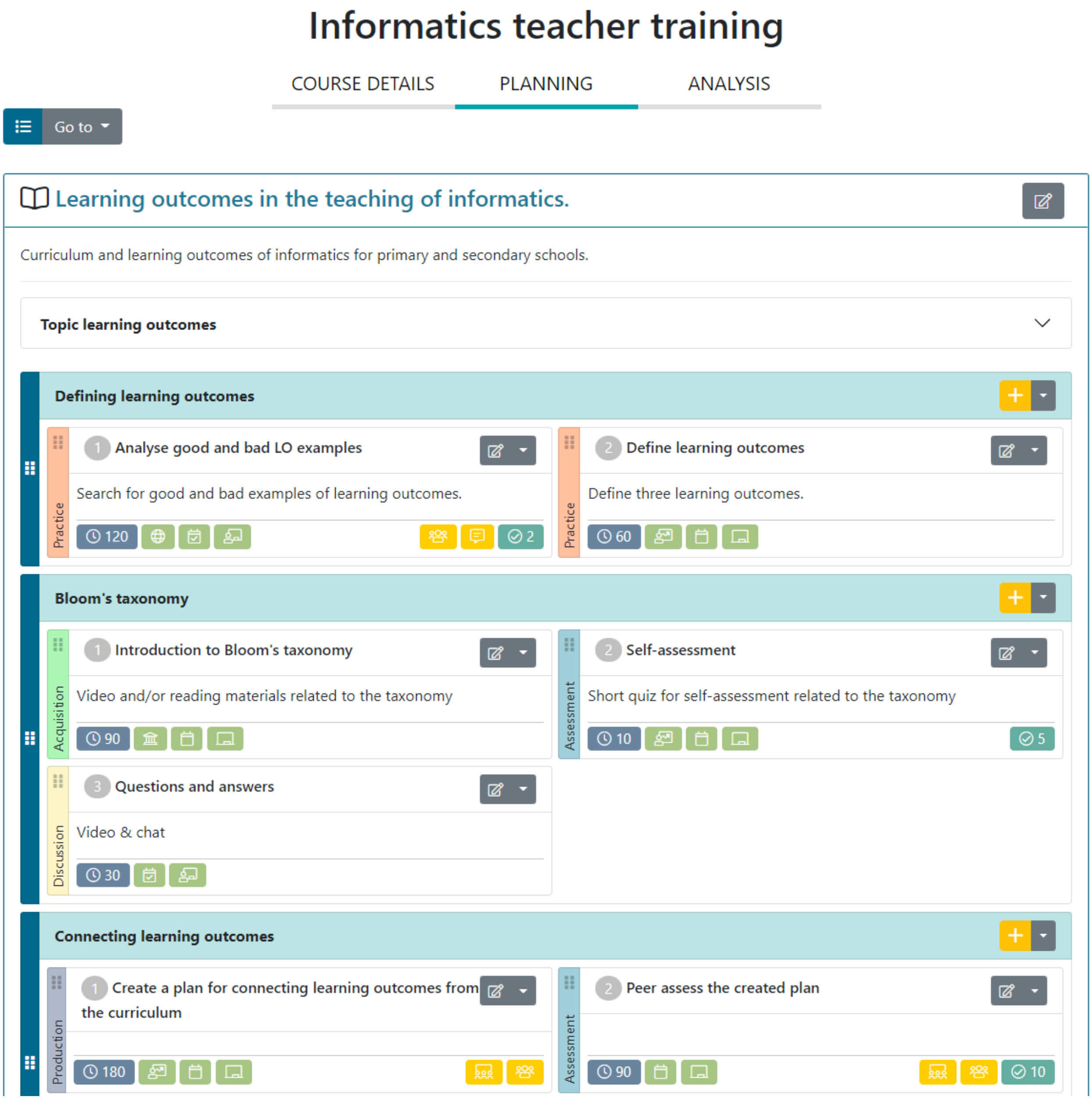


Figure 12. Units and Teaching and Learning Activities for specific topic

Fig. 12. shows detailed information for a single unit. Each Unit consists of one or more Learning Activities. The order of activities can also be rearranged and teachers can set properties for every activity such as delivery mode (blended/online/f2f), workload, type of activity (acquisition, communication, etc.), presence of a teacher, etc.

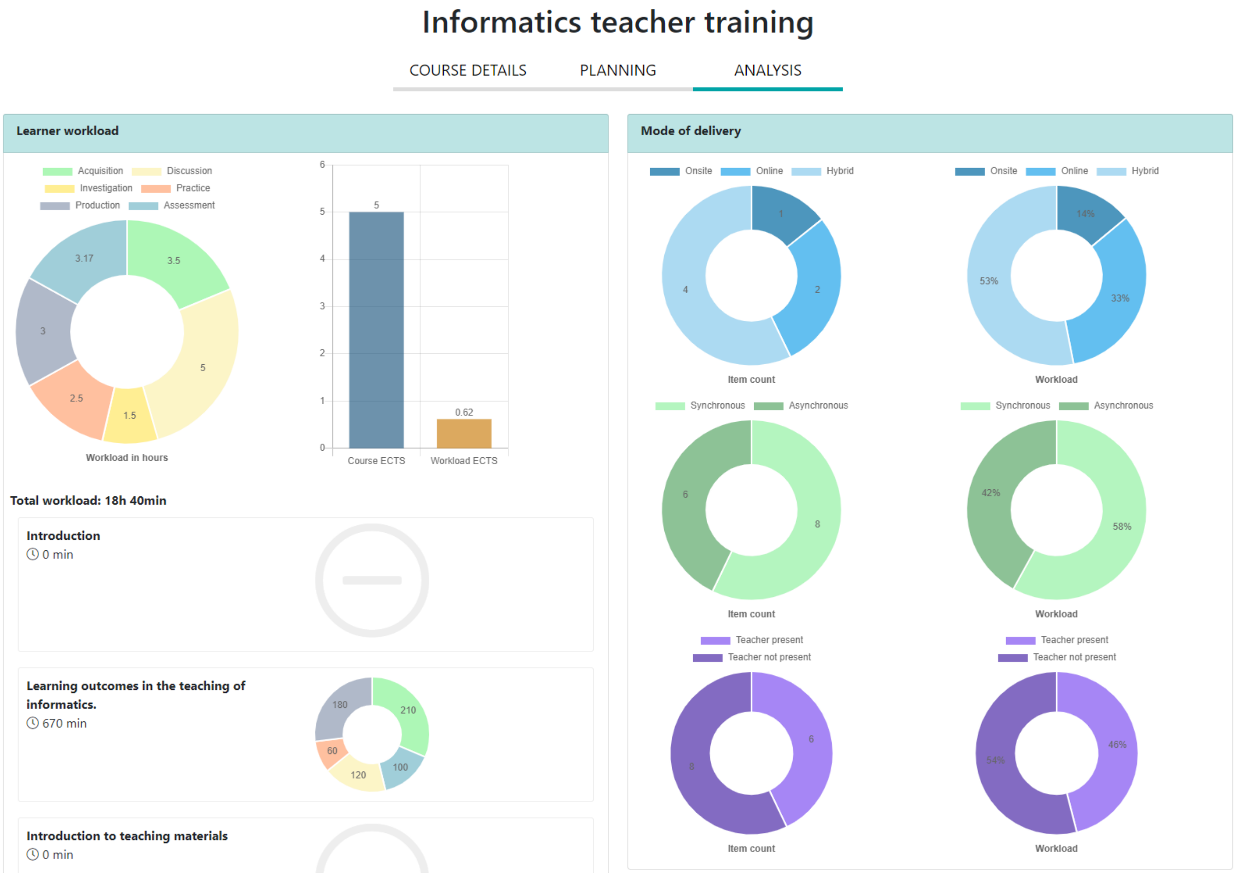


Figure 13. Learning Design analysis for specific course

The Analysis interface presents a summary for a course across different characteristics that help teachers to get an overview about their plan, such as Learner workload on the course, and some modes of delivery (Fig. 13).

Appendix A: Literature mapping to OULD

Literature	Important findings / Contributions	Does it support activities from OU LD, which one?	Does it suggest activities which are not tapped by LD? Or are there any other findings that should be highlighted?
Alasbali & Benatallah, 2015	The acquisition of a wide range of skills, increasing student motivation, support for contextual learning and student-centered courses as well as the availability of a wealth of data to inform and support decision- making by educators are the main advantages as identified by the SLR. Similarly, high barriers to entry in open source projects, difficulties related to student support, assessments, grouping of students and choice of an adequate OS project are the potential challenges. The main characteristic of the wider range of activities compared to a traditional setting is the strong focus on soft skills along with more technical ones Educators planning to use open source for computer education courses should be aware of the level of communication skills in their students as compared with the environment of the OS project chosen	**It is more of a lab oriented course.** **1) Communication** - extremely important (Collaborative learning); **2)Assessment** (formative assessment, summative assessment, peer assessment, online test, quiz questions) - recommends continuous evaluation **3) Interactive/adaptive** (project-based learning, contextualized learning)	The paper used RASE framework for course design and delivery
Berikan & Özdemir, 2020	Higher order thinking skill that incorporates skills such as evidence-based reasoning, critical thinking, analytical thinking, and abstract thinking. Evidence- based reasoning was the most mentioned as subskill associated with PSWD Technical skills, including analyzing data, collecting data, presenting data, storing data, and creating data are the most important ones for Problem-solving with datasets.	**1)Finding and handling information** (including analyzing data, collecting data, presenting data, storing data, and creating data) - analyzing data sa the most important subset skill **2)Experiential** (Real-world problems -authentic problems) **3) Communication** (Interdisciplinary learning environment) **4) Productive; interactive/adaptive** (Problem-based learning, Task-based learning)	
Borge, Ong, &	Strong focus on communication.	**1) Assimilative** (reading	The paper used SCAD

Goggins, 2020	Students took over responsibility for the discussions over time, maintained strong connections with multiple peers, engaged in meaningful conversations about course content, and increased the sophistication of cogni- tive activity over time, even after instructor faded from the environment. Suggest to replace classic assessment such as individual homework activities with online discussion activities	course content, one chapter per week) **2) Communication** - very strong focus (engagement in rich conversations to understand course content together and complete projects; Collaborative work) **3) Experiential** - Project based work - real-world setting: to help the local community by solving the problem **4) Assessment** - project work evaluation, discussion evaluation	model - Socio-cultural activity design
Broisin et al., 2017	Study only deals with laboratory exercises and advancing them to a virtual level. An exploratory study conducted with 139 undergraduate students enrolled in the first year of a computer science degree suggests a positive effect of the framework on learners' engagement when they come to practice system administration, and reveals a significant positive correlation between students' activity within the system and students' learning achievement.	**1) Interactive/adaptive** - they work in a virtualized laboratory, they conduct experiments with equipment 2) **Experiential** - students needed to do the exercise on their own computer (to deploy a virtual machine) **3) Communication** (very important aspect offered throughout the platform to offer students ability to communicate and to be socially aware - to feel connected to their peers and instructors) **4) Assimilative** - in a small percent, just to find their way to the theoretical content related to practical assignment. Guided by teacher (presentation) **5) Assessment** - quiz	Artifact awareness - brings an alternative to support awareness during collaborative experiments (Tee et al. 2009); these authors define artifact awareness as Bone person's up-to-the-moment knowledge of the artifacts and tools that other distributed people are using as they perform their individual, ongoing work^ (Tee et al. 2009, p. 678). In the context of Lab4CE, a person engaged in a practical session should be aware of (i) who is working on the same experiment, and (ii) what other people are doing, especially in case of a collaborative work.
Charlton, 2016	The aim of the study was to identify learning indicators within three dimensions (a) Social: the context for collaborative learning (b) Theme-based: for problem-based learning and (c) Boundary crossing: for multidisciplinary learning. The analysis of findings highlights the value of collaborative learning (behaviour of acknowledgement,	**(1) Communication** (Collaborative learning); **(2) Productive; Interactive/adaptive** (Problem-based learning using tangible and digital artifacts); **(3) Experiential** (Multidisciplinary learning)	

	explicit exchange and sharing of knowledge), problem-based (production) learning, multidisciplinary learning (purposeful learning).		
Mäkiö, 2020	This study compared the original teaching in the Java programming course against the teaching using T-CHAT (task-centric holistic agile teaching approach). The results from students' evaluation of the course using T-CHAT are promising and in line with the expectations.	**The original teaching in the course** **(1) Communication** (partner discussions, individual and group assignments/work, discussion in lectures/labs, perceptional learning activities in lectures, students' feedback on understanding the lecture) **(2) Assessment** (formative assessment, summative assessment, peer assessment, online test, quiz questions) **(3) Interactive/adaptive** (problem-based learning activities in labs, project-based learning, research-based learning) **(4) Experiential** (requirements engineering, modelling, coding, testing and delivering)	
Liang, 2018	In this paper we propose a top-down approach to teaching app development. The proposed approach combines the merits of both objectivism and constructivism learning and can be used by teachers to implement specific instructional and learning strategies. Most students in the course successfully completed their capstone projects and delivered functional real-world web applications within extremely limited course hours.	**(1) Assimilative** (tutorials made on behalf of a teacher) **(1) Communication** (work in pairs, interpersonal communication, discussions in class, students' presentations) **(2) Experiential** (real-world problems, project management on behalf of students) **(3) Productive** **(**project-based learning, pair programming, incremental assignments) (4) Assessment (peer-review,	
Ruiz, 2020	The findings show an improvement in student's learning of UI design principles when using the FENIkS approach. FENIkS improved the understanding of novice designers' UI design principles, resulting in significantly improved learning outcomes.	**(1) Assessment** (formative - instructional feedback on behalf of a system, paper-and-pencil test) **(2) Interactive/adaptive** (learning by experiencing through simulation - "active" learning)	
Scatalon, 2020	Analysed 195 papers. Our results shed light on how the integration of software testing has been done in	**(1) Assimilative** (instructors teach testing concepts in programming	

	different classroom contexts of programming education. We discuss the practices in terms of their application context (i.e. the course), how testing was introduced in theory and practice, and the adopted support tools.	courses using tutorials, showing best practices, guidelines to students about the programming process, tutor systems that combine materials and exercises for students) **(2) Productive** (testing practices, design test cases, execute test cases) **(3) Finding and handling information** (submitting program to an automated assessment system that provides the feedback, and similar) **(3) Assessment** (tutor systems contains automated assessment tool for students' programs)	
Tlili, 2017	The results showed that learning by doing strategy and the ARCS model help in improving student motivation, keeps them active, and helps them gain the needed technical skills to develop their own educational games.	**(1) Assimilative** (Course materials, lectures, presentations, invited lectures - real life experiences,class discussions) **(2) Productive** (learning by doing, developing 2-D web educational games) **(3) Finding and handling information** (system that provides the feedback, positive and encouraging feedback from the teacher) **(4) Interactive/adaptive** (learning by doing in class)	
Bielefeldt, 2017	Paper synthesises the integration of Ethics into the education of computing students (example of teaching the non-core topics). Given the wealth of analysed examples across a broad range of computing courses, Ethics-related topics could be integrated into any course. This frequent integration of non-core topics into many courses, even if only very briefly, might help communicate to students the importance of such topics. However, to leverage students' reasoning abilities, deeper discussions and assignments will be needed. If computing and engineering instructors feel unprepared to incorporate these richer and deeper teaching strategies for Ethical topics, professional development and team teaching with philosophy faculty are ideas to consider.	1. **Assimilative** (lectures, online lectures before class, online modules based on textbooks) 2. **Communication** (in-class discussions, online discussions, attending meetings/conferences) 3. **Experiential** (case studies, role-plays, examples of professional scenarios, service-learning) 4. **Finding and handling info** (video clips, news stories, readings, reflections, think-pair-share, student presentations/research papers) 5. **Productive** (project based learning, engineering designs, writing analyses of issues) 6. **Interactive/Adaptive**	-

		(problem-solving heuristics) 7. **Assessment methods** - reflective essays, individual rubric-graded homework assignments/essays/papers, tests/quizzes, group-based written assignments, small-group projects	
Broisin, 2017	Given the importance of acquiring practical skills in computer education, virtualized remote laboratories give instructors the ability to implement realistic practical learning activities, and learners to engage in authentic and problem-based learning. This paper explores how to address pedagogical concerns when using virtualization solutions as a foundation of remote labs - by including a set of scaffolding tools and interfaces to the virtualized lab environment. Proposed environment contributes to the improvement of hands-on lab sessions (productive interactions between students, and between students and tutors), has a positive impact on students' engagement in practical learning and positive correlation of students' activity in the system with students' performance at the academic achievement test was observed.	1. **Assimilative** (embedded brief intros/talks at the beginning of a lab) 2. **Communication** (instant messaging/chat rooms - students and tutors) 3. **Interactive/Adaptive** (weekly hands-on task solving/experimenting in virtual computer labs, collaborative work via session sharing) 4. **Assessment methods** - uploaded reports about the given activities, final multiple-choice quiz	Proposed scaffolding tools and interfaces can be used for: 1. Pre-Classes activities - integrations with authoring tools for designing experiments that students have to perform in virtual labs 2. Post-classes feedback - inclusion of learning analytics tools and dashboards (activity tracking, timelines, artifact-awareness, observing the actions of others), whose data is accessible to both students and tutors
Burrows, 2019	The research group identified a problem: undergraduate engineering student soft skill understanding. Enhancement of participant engagement with this problem was done by utilizing Action Research and Lesson Study techniques in one lesson focused on soft skills, over three research lesson iterations in three distinct university semesters. Research question: 'How do we design a soft skills engineering lesson that encourages undergraduate computer science and engineering students to talk to each other and use the conflict management negotiation skills presented?'	1. **Assimilative** (classes) 2. F**inding/handling information** (taking notes, think/pair/share) 3. **Communication** (teacher-led discussions) 4. **Experiential** (real-world engineering examples) 5. **Interactive** (team games, peer interactions)	-
Corritore, 2020	Problem: poor student performance and high major dropout rates in the Management Information System (MIS) academic program due to a required computer science programming course. This study reports the outcome of how a first pilot semester introductory programming course was redesigned	1. **Finding/Handling information** (class preparations - video clips/demos, readings (textbooks, online resources)) 2. **Communication** (in-class and out of class teamwork - paired	The researchers divided the semester course into two parts. The first half would focus on the students learning how to program. The second half of the course would focus on mobile app projects. **Flipped classroom**

	to provide tangible evidence in support of the concept of Student Ownership of Learning (SOL) and how the outcomes of this programming course facilitate effective student learning. Flipped pedagogy allowed the researchers to move the most difficult part of the course - actually writing code and problem-solving in the classroom where teachers and peers would be available to help.	programming, 2-3 member project teams; project presentation) 3. **Productive** (in-class homeworks - actual coding, problem solving) 4. **Experiential** (designing a non-trivial working mobile app) 5. **Assessment** (pre-class quizzes - related to class preparations, project-related midterms, final project grading)	**considerations:** - Students identify their own project idea - Students decide on what instructor demonstrations they want in class - Students choose the amount of complexity to include in their project - Students develop goals and plans for each milestone - Students find, build, manipulate, and explore functionality they want to incorporate into their apps, adopting some, abandoning others - The teacher could help students solve problems, see alternate solutions, and think about approaches - The role of the instructor would be as a facilitator, coach and resource, not simply a giver of knowledge
Gonçalves, 2017	This paper proposes employment of the Instructional Feedback, as an essential technique in order to help the students to learn based on the evaluation of their own actions. Instructional feedback is integrated into the project management tool, providing automated feedback based on the project plan being developed with the tool. Being automated, it is expected that students receive the feedback messages at the right moment, addressing the content properly; such feedback does not depend on the instructor availability, nor his/her constant analysis of students' behaviour. The technique has been evaluated through a series of case studies.	1. **Assimilative** (classes - introductory lectures and slides for each syllabus topic) 2. **Experiential** (students use a PM tool to carry out the respective part of the PM process presented the previous theoretical lecture; learning through errors; recommendations, examples and explanations provided in feedback) 3. **Communication** (teamwork discussions during project planning) 4. **Finding/handling** (students' reflections upon their own actions based on automated instructional feedback) 5. **Interactive/adaptive** (inclusion of almost real-time automated feedback, as the project advances through its stages) 7. **Assessment** (project evaluation using rubrics and exam questions - written and oral presentations)	-
Goumopoulous, 2017	This paper presents the experiences in organising, managing and teaching a	1. **Communication** (student mentoring;	- intelligent tutoring system is used for

	PerComp (Pervasive Computing) curriculum at a postgraduate level using distance learning methodologies in the Open University environment. **Probably irrelevant for this phase - paper describes 4-year curriculum level of activities and refers to multiple courses.**	physical meetings - short presentations, Q&A, upcoming assignments presentations; (a)synchronous communication in LMS) 2. **Finding/Handling info** (course materials - documents, presentations, videos, books, research papers, articles) 3. **Experiential** (individual and group activities & exercises related to course materials; demo case studies which support laboratory exercises; case studies explaining system architectures, design principles and methodologies) 4. **Productive** (student involvement in small-scale SW/HW projects) 5. **Assessment** (short self-assessments related to course materials; ongoing written assignments per course; final written exams)	individual adaptation of learning process - virtual labs for acquisition of practical skills - plagiarism detection tools

Appendix B: Results of the exercise with teachers

This activity is a part of the planning of the specific JCCs and will be carried out from December 2021 until February 2022. The results will be used to refine the mentioned JCC templates.

Literature

Alasbali, N., & Benatallah, B. (2015). Open source as an innovative approach in computer science education A systematic review of advantages and challenges. In *2015 IEEE 3rd International Conference on MOOCs, Innovation and Technology in Education (MITE)*, 278-283.

Berikan, B., & Özdemir, S. (2020). Investigating "Problem-Solving With Datasets" as an Implementation of Computational Thinking: A Literature Review. *Journal of Educational Computing Research, 58*(2), 502-534.

Bielefeldt, A.R., Polmear, M., Swan, C., Knight, D., & Canney, N. (2017). An overview of the microethics and macroethics education of computing students in the United States. In *2017 IEEE Frontiers in Education Conference (FIE)*, 1-9.

Borge, M., Ong, Y.S., & Goggins, S. (2019). A sociocultural approach to using social networking sites as learning tools. *Educational Technology Research and Development*, 1-32.

Broisin, J., Venant, R., & Vidal, P. (2017). Lab4CE: a remote laboratory for computer education. *International Journal of Artificial Intelligence in Education, 27*(1), 154-180.

Burrows, A.C., & Borowczak, M. (2019). Computer science and engineering: utilizing action research and lesson study. *Educational Action Research, 27*(4), 631-646.

Charlton, P., & Avramides, K. (2016). Knowledge construction in computer science and engineering when learning through making. *IEEE Transactions on Learning Technologies, 9*(4), 379-390.

Conole, G. (2012). *Designing for Learning in an Open World* [Book]. Springer.

Corritore, C.L., & Love, B. (2020). Redesigning an Introductory Programming Course to Facilitate Effective Student Learning: A Case Study. *Journal of Information Technology Education: Innovations in Practice, 19*, 91-135.

Gonçalves, R.Q., von Wangenheim, C.A.G., Hauck, J.C., & Zanella, A. (2017). An instructional feedback technique for teaching project management tools aligned with PMBOK. *IEEE Transactions on Education, 61*(2), 143-150.

Goumopoulos, C., Nicopolitidis, P., Gavalas, D., & Kameas, A. (2017). A distance learning curriculum on pervasive computing. *International Journal of Continuing Engineering Education and Life Long Learning, 27*(1-2), 122-146.

Greyling, L. E., Huntley, B., Reedy, K., & Rogaten, J. (2020). Improving distance learning mathematics modules in South Africa: A learning design perspective. *South African Journal of Higher Education, 34*(3), 89-111.

Holmes, W., Nguyen, Q., Zhang, J., Mavrikis, M., & Rienties, B. (2019). Learning analytics for learning design in online distance learning. *Distance Education, 40*(3), 309-329. https://doi.org/10.1080/01587919.2019.1637716

Liang, Z., & Chapa-Martell, M.A. (2018). A Top-Down Approach to Teaching Web Development in the Cloud. In 2*018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, 32-39).

Mäkiö, E., Mäkiö, J., Colombo, A.W., Harrison, R., Ahmad, B., & Azmat, F. (2020). Work in Progress: Task-centric Holistic Teaching Approach to Teaching Programming with Java. In *2020 IEEE Global Engineering Education Conference (EDUCON)*, 1487-1492.

Mangaroska, K., & Giannakos, M. N. (2019). Learning analytics for learning design: A systematic literature review of analytics-driven design to enhance learning. *IEEE Transactions on Learning Technologies, 12*(4), 516-534. https://doi.org/10.1109/TLT.2018.2868673

Mittelmeier, J., Long, D., Melis Cin, F., Reedy, K., Gunter, A., Raghuram, P., & Rienties, B. (2018). Learning design in diverse institutional and cultural contexts: Suggestions from a participatory workshop with higher education leaders in Africa. *Open Learning, 33*(3), 250-266. https://doi.org/10.1080/02680513.2018.1486185

Nguyen, Q., Rienties, B., Toetenel, L., Ferguson, F., & Whitelock, D. (2017). Examining the designs of computer-based assessment and its impact on student engagement, satisfaction, and pass rates. *Computers in Human Behavior, 76*(November 2017), 703-714. https://doi.org/10.1016/j.chb.2017.03.028

Olney, T., Endean, M., & Banks, D. (2020). Evaluating the impact of the learning design and course creation (LDCC) workshop on the participants of the enhancement of lifelong learning in Belarus (BELL) project. Proceedings of the final conference on the Erasmus+ project,

Olney, T., Li, C., & Luo, J. (2021). Enhancing the quality of open and distance learning in China through the identification and development of learning design skills and competencies. *Asian Association of Open Universities Journal, ahead-of-print*(ahead-of-print). https://doi.org/10.1108/AAOUJ-11-2020-0097

Rienties, B., Toetenel, L., Bryan, A. (2015). "Scaling up" learning design: impact of learning design activities on LMS behavior and performance. Proceedings of LAK 2015, Poughkeepsie, USA, pp. 315-319.

Rienties, B., & Toetenel, L. (2016). The impact of learning design on student behaviour, satisfaction and performance: a cross-institutional comparison across 151 modules. *Computers in Human Behavior, 60*, 333-341. https://doi.org/10.1016/j.chb.2016.02.074

Rienties, B., Balaban, I., Ferguson, R., Herodotou, C., Iniesto, F., Muccini, H., Sargent, J., & Virkus, S. (2021a). Education 4.0 and computer science: A European perspective. Paper presented at 32rd Central European Conference on Information and Intelligent Systems CECIIS 2021.

Rienties, B., Ferguson, R., Gonda, D., Hajdin, G., Herodotou, C., Iniesto, F., Llorens-Garcia, A., Muccini, H., Sargent, J., Virkus, S., Vittoria Isidori, M. (2021b, Submitted). Education 4.0 and Computer Science: a systematic review.

Ruiz, J., Asensio, E.S., & Snoeck, M. (2020). Learning UI Functional Design Principles Through Simulation With Feedback. *IEEE Transactions on Learning Technologies, 13*(4), 833-846.

Scatalon, L.P., Garcia, R.E., & Barbosa, E.F. (2020). Teaching Practices of Software Testing in Programming Education. In *2020 IEEE Frontiers in Education Conference (FIE)*, 1-9.

Tlili, A., Essalmi, F., & Jemni, M. (2017). Towards applying Keller's ARCS model and learning by doing strategy in classroom courses. In *Innovations in Smart Learning*, Springer, Singapore, 189-198

Toetenel, L., & Rienties, B. (2016). Analysing 157 Learning Designs using Learning Analytic approaches as a means to evaluate the impact of pedagogical decision-making. *British Journal of Educational Technology, 47*(5), 981–992. https://doi.org/10.1111/bjet.12423

Van Ameijde, J. (2015). *Jisc Student Workload Tool.* In https://github.com/IET-OU/jisc-workload

Wasson, B., & Kirschner, P. A. (2020). Learning Design: European Approaches. *TechTrends*, 1-13. https://link.springer.com/content/pdf/10.1007/s11528-020-00498-0.pdf