

UNDERPINNING INTERRELATED FACTORS OF PHYSICAL, VIRTUAL, AND SOCIAL LEARNING ENVIRONMENTS

Kangas JJJ¹, Poutanen J¹

¹ *Tampere University of Technology (FINLAND)*

Our research addresses how the physical, virtual, and social learning environments support the learning outcomes and the development of learning and teaching practice. It adds to our previous studies by taking into account the interrelated questions of designing learning spaces.

In-class learning activities in higher education have typically included many working modes that are allotted both with time and place. For example, in the engineering education, the lectures, exercise sessions, computer exercises, and laboratory work are arranged in different locations at different times. Newer approaches to learning and teaching practice, such as the flipped learning and the availability of technology, have altered this picture profoundly. Overall, the emphasis has moved from 'transfer of information' to active and collaborative learning with technology being exploited seamlessly before, during, and after in-class sessions. Hence, the design and implementation of learning activities are interlocked with physical and virtual learning spaces. As many universities are continuing to invest in new learning environments, it is important to study factors that underpin successful design of the next generation learning spaces.

We report a case study that addresses small-scale learning space design and consider related factors, such as the underlying learning outcomes, learning and teaching practice, and other facilities (e.g. virtual learning environments, portable 'Mini-labs'). In broad sense, our study question is 'How to interrelate factors that underpin a successful design of learning space.' To understand how the space design embraces the learning objectives and how it facilitates in-class learning activities, we conducted a series of semi-structured theme interviews with instructors who have used the designed space. The interviews are accompanied with student experiences. The material also includes design documents and site visit notes. The findings are formulated using the qualitative content analysis. Our pedagogical reasoning is based on active learning, which includes many forms of student-centred instruction, such as collaborative learning and flipped learning.

In our case, the learning outcomes of an academic study major played an important role in providing a set of unified objectives for learning space designs. The designs were also affected by bring-your-own-device policy that included the use of portable 'Mini-labs' to allow students to perform basic hands-on tasks and testing both in-class and out-of-class. Consequently, 'best practices' should combine the methods of instruction, the learning space design(s), and the virtual and physical tools and devices at a reasonable level.

Keywords: Learning spaces, Next Generation Classroom, Blended Learning and Flipped Classroom, Educational Design

1 INTRODUCTION

Many higher education institutions have highlighted the need for investments in new learning environments to support and enhance the student learning [1],[2]. Consequently, investments for new virtual and physical learning spaces are continuing to take place. One of the key reasons has been the shift in emphasis from 'transfer of information' to active and collaborative learning. Moreover, digitalization has created means to support the student learning with portable tools, online videos, and possibly special learning software. Consequently, also in-class sessions include a greater variety of activities and there are many ways to support students' independent work outside classes. Thus, one must consider the blend of physical, virtual, and social learning environments as all of them contribute in making functional and inspiring learning environments.

Physical designs and the various aspects of design projects are studied in many works. Overall, there seems to be a consensus on that learning should come first as well-captured by the following phrase 'design decisions should be guided by a set of educational principles' [3]. Nonetheless, finding a proper set of objectives for a learning space project is of importance, but not always that easy to form. If the focus is too narrow, the benefits are limited. If the wish list becomes too long, it may be difficult to set practical objectives for a refurbishment. The learning space designs are affected by strategic

decisions, learning outcomes, the methods of instruction, and other facilities. In our case learning objectives of a study major and BYOD policy (e.g. virtual learning environments, portable 'Mini-labs') had important roles. Feedback from teachers and students is exploited in the analysis of the success of the project and the underpinning factors. We have also included practical viewpoints and details of the project since they are often of value when launching similar projects.

2 BACKGROUND

In this section theoretical background underneath learning space refurbishments is briefly reviewed.

2.1 Learning theories and teaching practice

Pedagogical reasoning underneath our project relies on the ideas of *active learning* and *constructivism*. For example, in [4] active learning is defined as 'any instructional method that engages students in the learning process'. In [5] the constructivist view is defined as 'learning is a process which requires the construction of knowledge by the learners themselves'. A fine overview of 'Good practice in undergraduate education' is given in [6]. Firstly, to encourage student-faculty contact, cooperation among students and active learning. Secondly, to give prompt feedback to students. Moreover, good practices include to emphasize time in a task and to communicate high expectations. Finally, to respect the diverse talents and ways of learning. The items underline well also the motivations underneath our study case.

Research has also highlighted social interaction as a crucial part of learning. For example, [7] states that 'the amount of interaction among peers has far-reaching effects on nearly all areas of the student learning and development'. In [8] it is argued that 'learners arrive at meaning by actively selecting, and cumulatively constructing, their own knowledge, through both individual and social activity'. Moreover, related are so called 'generic skills' or 'soft skills' that include e.g. communicational, interpersonal, team-working skills, taking responsibility, and organising skills [9].

The flipped learning [10] is one teaching method that aims to embrace these objectives where roughly speaking the traditional paradigm of 'first-lectures-then-own-work' is flipped around. A particular implementation of the flipped model which includes preparatory construction tasks that utilize 'Mini-labs' is described in our previous paper [11].

2.2 Learning space designs and refurbishment projects

In last decades, universities have been investing in the development of learning spaces along the change in pedagogies and mobile technology. There is also a growing body of literature on the learning space designs and their impact. Here we shortly review both the general factors and educational principles that should influence the design of learning spaces.

In [12] a set of principles for learning spaces are given. The space should be guided by the principle of the Pedagogy first, to allow for active and collaborative learning. Secondly, the space should be Future-proofed for the imminent changes in technological and pedagogic developments. This is related with Flexibility, so that the space accommodates both current and evolving pedagogies to enable the space to be e.g. reconfigured. Moreover, the space should offer Tools fit for purpose.

Furthermore, according to [3] the space should boldly look beyond tried and tested technologies and pedagogies. The space should also be creative in order to energize and inspire learners and instructors. Moreover, to develop the potential of all learners by being supportive and a single space should also be capable of supporting different purposes.

However, only a few articles focus on the interlinked factors of learning goals, as well as physical, social, and virtual environments. Often, the refurbishments are inspected from the otherwise important student engagement viewpoint. As stated in [1], learning will become more collaborative and active, integrated and multidisciplinary, but notably also blending technology and social activity, as well as immersive and hybridizing online and on-location (face-to-face) activities. Hence changing the settings of the general teaching spaces so that they should firstly support a wide range of pedagogies that results as increased diversity in learning settings. Secondly, to accommodate the increased use of group working and collaborative learning. Thirdly, due to the need for flexibility, more space per student is required. Fourthly, [1] state that increased use of technology will and is supporting learning thereby blending the physical and digital spaces. Lastly, lecture theaters become more interactive through various space configurations and/ or enabled by technology.

An interesting and a comprehensive approach was implemented in the SCALE-UP project [13] where the primary goal was to establish 'a highly collaborative, hands-on, computer-rich, interactive learning environment in large-enrollment physics courses.' They integrated the developments of the pedagogy and the physical environment as well as the teaching materials in relation to the novel approach. The outcome of the change is that the students learn substantially more than in traditional classroom settings. Moreover, they were able to help the students acquire work-life skills through the use of carefully redesigned classrooms. The SCALE-UP project provided valuable insights to our case study.

In [14] is discussed 'how the configuration and spatial geometry of learning spaces influences an engagement and interaction, with a particular focus on hierarchies between people within the space'. They argue that spatial hierarchy (layout of the furniture) directly influences the power dynamic between the users within a space. Therefore, an appropriate spatial hierarchy should be adopted for student-centered teaching with their participation and empowerment.

2.3 Educational policies

Universities have strategies that guide their work, in particular, areas where investments are made and where progress is expected. Often strategies are done at the university level and other bodies such as faculties and departments derive their own course of actions in accordance with the strategy.

When considering teaching and learning, physical spaces, software, and online libraries are of importance and require investments. One example are bring-your-own-device (BYOD) policies which aim to make learning more ubiquitous. If, additionally, students are able to install the software needed on their own computer, they can work according to their own timetables and preferences. A particular BYOD policy is described in [15] where every student is given a portable USB-connected 'Mini-lab'.

Outcome based education is implemented in many universities and the planning of education is guided by 'what is essential for all students to be able to do successfully at the end of their learning experiences' [16]. One then derives curriculum, instruction, etc. from the defined learning outcomes. Given a multi-discipline university, the disciplines often have different viewpoints in planning the curricula and implementations of the courses. However, in study majors their key courses often have similar underlying learning outcomes. The similar outcomes reflect in similar approaches to the teaching practice.

3 IMPLEMENTING A LEARNING SPACE REFURBISHMENT --- CASE STUDY

This section discusses factors that have affected the case studied. We begin with the preliminaries of the project to form a solid overall picture of the case. Then the site details are given and discussed.

3.1 Preliminaries of the project

A key starting point was one of the author's visits to SCALE-UP-type learning spaces, especially during flipped classroom sessions. Another was the implementation of a bring-your-own-device (BYOD) policy within the courses of a study major. The project was granted strategic development money which enabled the implementation of the initial plans in 2015.

Certain key aims and guidelines were set at the very beginning:

- a) The classroom should be adaptive and accommodate different forms of work; ordinary lecture, groups of various sizes from 2 to 10, sectioning for e.g. for brainstorming; etc.
- b) Teachers should be able to choose their location freely in the class for which wireless video connection was needed.
- c) All tables and chairs should be movable whilst tables should be easily grouped in various ways to support group work.
- d) Larger displays and possibly also computers should be available in the room for group work.
- e) Support the policy to utilize Minilabs (NI myDAQ, Virtual Bench) in many key courses.
- f) Favor simplicity, pragmatic functionality, and tested technologies.

As the project continued, additional demands and objectives were set for the learning space update:

- a) The front of the room should have only minor modifications to make a smooth transition to teachers that already had used the room.

- b) About five computers that students can use freely and include relevant software incl. license-limited. It was assumed that most students have laptops and this number of additional computers would be adequate, esp. if students work in pairs or in small groups.
- c) Support of different kinds of technologies, e.g. black boards, white boards, smart-board systems, document camera. Teachers and students should be able to wirelessly share their laptop screen for the rest of the class.
- d) Maximum capacity at least 50 seats, previously the capacity was 72 seats.
- e) The project should be completed during the summer break (within three months).
- f) The room should have soft flooring, few bean bag chairs, height-adjustable saddle chairs and tables.

The project team included a teacher (heading the project), department head, architect, senior laboratory engineer, and AV specialist. The team worked informally, everyone had a clear role. A teacher (the first author of this paper) was making sure that pedagogical aims were taken into account, also taking care of the project process. An architect (the second author of this paper) supported in the selection of furniture and materials, and prepared the needed drawings. The department head ensured the department aims to enhance teaching and learning, made financial decisions and hired the external constructors. A senior laboratory engineer advised in the planning of the room appliances and prepared the required plans for wiring of the room. An AV specialist commented on available software and hardware for video/audio.



Figure 1. Picture of the room before the refurbishment.

3.2 Implementation of the chosen design

Originally, the space had around 70 seats accompanied with unmovable tables in long rows. After the refurbishment, space has 18 fully movable tables of three different types all equipped with wheels; 51 chairs of two different types all also equipped with wheels; and a few bean bag chairs. Front wall has two chalkboards, a white board, and two liftable projection screens; the right side wall has one white screen for writing and one projection white screen together with a short throw projector and interactive technology and a computer on a small desk. On the back wall are three fixed computers and displays and two smaller whiteboards between the displays. In the front are also has three large unmovable teacher's tables that are equipped with electricity allowing height adjustment, one computer, and two projectors. A movable cabinet-desk that can accommodate a laptop is also available. A Wireless presentation and collaboration system where a computer is linked via USB-connector was also installed. Soft carpet flooring was installed, the walls were painted, and wall sockets and a network access point were installed on along the walls. Fig. 2-4 show sketch of furniture of the room, the final layout and the realized interior of the refurbished room.



Figure 2. Design phase sketch of the furniture of the room.

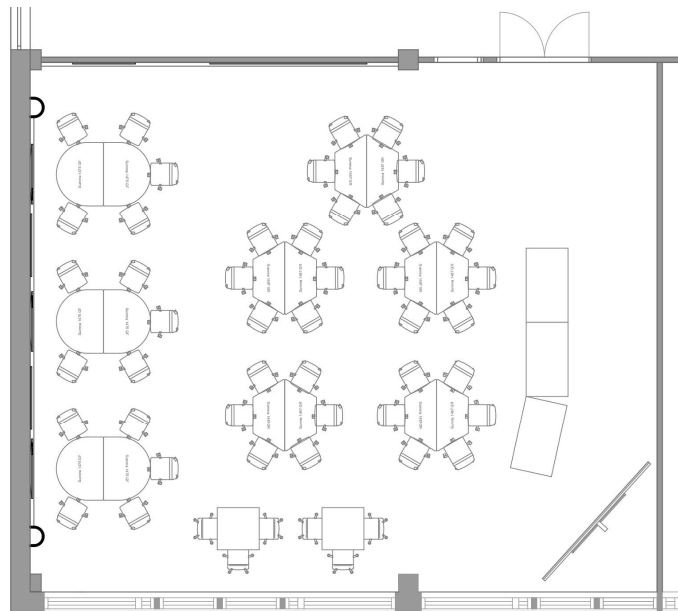


Figure 3. A sketch of layout and furniture of the room. Front of the room shown right.



Figure 4. Room after the refurbishment.

4 METHODOLOGY AND ANALYSIS

The methodology and analysis of the results are given in this section.

4.1 Methodology

The qualitative research approach was chosen to understand the role of the space in education and in relation to learning goals. The methods employed were qualitative semi-structured interviews on key-informants, i.e. theme interviews [17],[18] and open ended questions in a survey to collect feedback from the students. The interviewees were teachers (N=4) who reportedly have classes in the space. All the interviews were recorded and the interviewees signed an approval form following ethical procedures. The questions focused on the learning outcomes, educational aspects, and the use of space. The student questionnaire material had 12 respondents. Furthermore, project documents and site visits were exploited in the analysis of the development and the character of the space.

We conducted first Content-based analysis (directed by the material) and secondly Content analysis directed by theory [17],[18], where material is reflected with theory or the theoretical preconceptions are taken as part of the analysis. The theory based sampling and analysis seem more natural because our research is directed by the viewpoints of environmental psychology, such as the relation of space and the users are in focus. The theory based analyses are found to be more reliable too, but to formulate a comprehensive understanding in qualitative research employing both content-based and theory-based analysis are needed [17],[18]. The qualitative material analysis process consisted of writing down the key notes of the recorded interviews by both of the authors independently. These were then discussed and reviewed. The second round consisted of categorizing the notes into themes. These themes were further on refined.

The qualitative analysis is based on the interpretation, hence the result of the analysis and the accuracy can be pondered [18],[19]. However, the reliability was enhanced with separate analyses by two researcher independently. Yet, the results are context-bound and may vary.

4.2 Results

The space is mainly used by courses in the fields of Electronics and Biomedical engineering. Based on the interviews all the interviewed teachers work actively to develop their courses. They considered that their courses are likely more challenging than on average and they wanted to include meaningful activities in their courses. Based on the study material certain themes were recognized, the findings are organized in the following subsections.

4.2.1 *Perceptions of learning objectives and their relation with the refurbished space*

From the teacher interviews three main learning goal categories were identified: a. the theory and the substance of the field, b. the practical skills of the field and c. general working life skills (such as communication skills). The teachers considered that the three main learning goal categories are in many ways present in their education; they emphasize overall understanding rather than learning by heart. Furthermore, the teachers prefer to use a variety of evaluation methods.

All interviewees found that the space supports the main learning goal categories well, but especially the 'soft skills'. They also found that the space supports the subject matters and the skills needed in field: e.g. constructing of electronic devices, hands-on testing with 'Mini-labs', etc.

Teachers considered that the space is particularly suitable for their teaching, ideally all learning sessions should take place in the same space. They always tried to book the refurbished space first, even if it meant less popular teaching hours. Some even commented manipulating the space booking system to get the desired space because it supports goals in their teaching.

4.2.2 *Space supports student-oriented learning*

One reason why the space supports the learning goals is that it allows the student oriented learning and teaching. Many of the teachers expressed that inspiring and intimate atmosphere is essential for 'the right kind of learning environment' and for better learning outcomes. They aspire for discursive and challenging environment and encourage students to ask questions and question what they are taught. Better a space enables the storytelling, the better it supports the wholeness of education. In a trustworthy and inspiring learning environment the teacher becomes part of the group, intentionally lowering away from any authority position. They also expressed that this is contrary to an

amphitheatre which creates authoritarian atmosphere and thereby inhibits questioning and discussions.

Moreover, they found that the physical space is an important part of inspiring learning situations. A motivating environment helps students learn better and to internalize the content. The space seems to motivate teachers and students alike. Moreover, due to the demanding topics, the students need to be present at the teaching sessions and truly participate in the activities. To do with motivating and inspiring environment, they acknowledged the provision of support, peer-to-peer help and doing the tasks collaboratively (not necessarily group tasks). Moreover, the environment and the teaching sessions have to be inspiring also for the teacher.

In other words, the space supports the communication and easy exchange of information in many ways. It enables making the knowledge visual, hence moving from the tacit knowledge to the explicit knowledge. Students seem to appreciate the possibility to freely form groups as well as working in groups. In the questionnaire data, the refurbished space was in its campus building the only place that more than one student pinpointed as their preferred space part of the timetable.

4.2.3 Methods and approaches employed by the teachers

The space allows various methods of instruction. Moreover, it enables changing the methods of instruction during a teaching session. Methods used in-class are interlinked with the virtual environment and they are often accompanied with pre-tasks and post-tasks. Hence, blending the limit between what takes place on and off location. The blending of the environments is enabled by the provision of equipment on the space, but also by the students' own devices.

It is notable, that most of the interviewed teachers specifically expressed that instead of lectures they rather use another notion for their on-location teaching, such as a teaching lesson or session. The teachers use a great diversity of methods. Lecturing and short practical tasks are blended in the teaching sessions both planned and ad-hoc. The small tasks include retrieving information and formulating opinions and discussing about the emerging viewpoints during the sessions.

Some teachers expressed that to maintain their inspiration and motivation it is not preferable to bring 'old habits' to a new space. One example of a new habit is so called 'calculation day' that allows about 100 students to use the space allocated for 60 students. The classroom is used the whole day and a number of teachers are available on-location and helping if needed. Students can come on a suitable time to solve tasks alone or in small groups and earn activity points to pass the course.

As stated, the teaching methods vary greatly from group works, simulations, use of demonstrations (as a part of a lab course), discussions, use of Moodle for video lecturing and delivering tasks but also doing tasks and discussions are asked to complete virtually. Seminars, fairs, presentations, drawing examples, and project simulations that are also for practicing work like skills.

Moreover, many teachers employ hands-on, active working on teaching sessions, where topics are not provided ready-made on the slides, but students need to write and participate. Many courses use the abovementioned portable 'Mini-labs' that are provided for each student. In exercise sessions, the students are asked first to calculate, then to simulate, and finally to build and do test measures of the outcome with the 'Mini-lab'. According to teachers, the space is perfect for the use of the device. Hence, the software, hardware and videos are all mixed in the teaching sessions. Therefore, the blend of 'analogue' and digital tools is a necessity for teachers.

Due to the study fields and the blended methods, teachers often use two projectors and screens to simultaneously show both theoretical material and practical examples of difficult or sometimes uninteresting topics. Even this basic functionality is missing in many ordinary classrooms, thus the refurbished space offers the possibility to show simultaneously different documents (the provision of equipment) and to connect theory and practice. Students appreciate the approach as based on their feedback.

4.2.4 Flexible use and furniture affords various use-patterns and experiences

In terms of number of users, the enrolled students per course varied typically from 10 to 45, but the space was used even for a course with about 100 enrolled students via the 'calculation day'-activity. The level of the students varied from the 2nd year of bachelor to last year of Master's students.

The space accommodates different furniture groups and solutions. The variety of furniture allows for students to take different situations within the space as well as different furniture to match social

activity. Moreover the various furniture allows ergonomically different positions. In other words, students can choose a seating according to their personal needs and wishes, such as using very relaxed positions, grouping with friends or quieter places near the sides.

According to the teachers, real flexibility and modifiability of the furniture are key elements to a successful teaching space. The flexibility also allows for different atmospheres and learning environment characters, thus creating mental flexibility. Based on our observations, the furniture settings are rearranged constantly. In terms of use patterns, the flexible furniture affords the multiple and various methods the teachers employ both planned and ad hoc during the teaching sessions. The spontaneous modification of the layout within one teaching session repeated in the interviews. It is connected with the very easy use of equipment and the virtual environment. Therefore, the space has to work flawlessly to provide the flexibility of the learning sessions both physically, digitally/ virtually and socially.

A variety of group sizes from pairs to small groups of 4 to 6 or even bigger groups are used in the courses. The flexible furniture and the number of white boards placed around the walls allow flexibility in group sizes and the sharing of knowledge in different settings. If looking from the social environment viewpoint, it supports the group working well, but also creates the possibility for the teacher to interact more freely amongst students. Hence, the teacher can also better monitor whether students keep up with the pace of the learning session. From the physical environment viewpoint, this is enabled by the layout and the flexible furniture. The tables can be organised in different ways and moved around. From the virtual environment viewpoint, the mixture of methods, labs and the provided equipment are interlinked with all aspects.

An example of settings and use patterns are the student preferred group work stations with allocated wall-mounted computers and displays. These are located furthest away from the front of the space. With smaller group sizes, this creates a situation where the teacher moves closer to the students for easier communication. These stations with displays and fixed computer are the main reason why some students even like to use the space after a teaching session for their own group works.

Another use pattern is how much a teacher moves around. As mentioned, the possibility for a teacher to move around the space was found important and in contradiction to a large auditorium with fixed seating. However, most of the interviewees reported that they are mainly in front of the space despite the use of various learning methods.

Altogether, the space encourages student faculty interaction due to the flexible and modifiable layout. An exception to the low hierarchical appearance are the (older) large teacher tables and front wall with the main screens.

4.2.5 Pleasantness, use culture, and atmosphere of the space

The quality of room was found pleasant which has an influence on the user culture and the atmosphere. The pleasant quality consists of layout elements, materials and appearance. The space was found to be spacious enough, due to suitable amount of furniture that allows a teacher to walk among the students. The soft surfaces on the chairs and the soft flooring make the room acoustically more pleasant than a regular classroom with hard surfaces. The soft flooring also makes use of the movable furniture less noisy. The cushioned chairs were found comfortable. As mentioned, the variety of the chairs, that also included bean bags, were appreciated by both teachers and students. Moreover, the tables are large enough to accommodate all the special equipment and BYOD, hence supporting the field related activities.

Altogether, according to the teachers, the quality and atmosphere were better than in any other teaching space. For some (students) the space is like a continuum of the nearby laboratory space.

4.2.6 Pros and cons in room usage

Some teachers have priority in reserving the refurbished space and as there is lack of multifunctional spaces in the campus, some other teachers have even tried to manipulate the room reservation system to be able to use the space. As the atmosphere and functionality are found outstanding by many teachers, they would like to have all education there. However, large group sizes restrict using the space and it is often also fully booked. Thus, there should be more similar places also for larger group sizes.

The limitations that the teachers expressed were mainly technical. The lighting was found to be somewhat good, but boring and leaving blind areas. The chalk boards are left in shadow when both

the main screens are used simultaneously. The combination of the analogue and digital approaches occasionally inevitably non-optimal circumstances.

Moreover, the lack of provision of electricity in the centre areas of the room either inhibits the long-term use of the students' own devices (BYOD) or extension cords on the floor need to be used. This is a common problem with environments that are designed to be fully flexible as most of the electrical appliances fix the layout in some manner.

Digitally, the space is very well equipped. However, teachers reported that they do not exploit all the smart features available due to time limitations. Instead, the devices and their unfamiliar user interfaces may even slow them down. They expressed that the digital environment should work like the 'analogue', it should constantly be in active mode. Some users may unplug screens or cables and change settings, but do not plug back or return the settings. Moreover, the wireless access to allow a teacher to locate oneself freely within the space is not fully utilized as some teachers feel they have not gained enough guidance for the use.

The furniture of the space was highly appreciated otherwise except the teacher's tables. Some find them too large and restricting the use and moving around. Other find that they bring structure to the room and provide a place for the field specific equipment used in the education.

The furniture layout lives according to the uses and activities. The use of the room is not regulated nor the furniture settings. Whilst many of the teachers appreciate this, some expressed wish for general guidelines to return the furniture arrangement to an original setting. Then again, the provision of flexible furniture was found more important than the user-guidelines. Due to the flexibility the space was used for many purposes, e.g. in larger board meetings where wireless sharing were exploited and as temporary workplace for summer workers.

5 DISCUSSION AND CONCLUSIONS

To link back to theory, we can argue that the refurbished space accommodates all the factors stated in [3], [12]. The space was designed with pedagogy first, as it allows for active and collaborative learning. The refurbished space is Future-proofed for the imminent changes in technological and pedagogic developments by the provision of highly flexible furniture. The space is easy to reconfigure even within a teaching session. Moreover, the space is interlinked with virtual learning environment prior to, during and after on-location teaching sessions. Based on the feedback, the space is able to support well achieving the learning outcomes.

The pedagogies employed are bold as they to look beyond the limitations of physical and virtual environments. In fact, the space has inspired teachers to employ the new methods of instructions and evaluation in their courses. The refurbished space has inspired both learners and teachers. The space allows teachers to actively influence the student learning therefore supporting the development of the potential of all learners. Also, it is enterprising as it is monitored to support many different purposes.

Our case learning space accommodates all the principles stated in [1], it allows many pedagogies and diverse teaching and learning methods. Furthermore, it is successful in support of group work and collaborative learning. The layout with flexible furniture accommodates e.g. movement. Furthermore, the physical, digital and social environments are highly interlinked. It is an interactive learning environment enabled by various space configurations and technology.

Space design should accommodate as many possible scenarios for uses as possible as the end-users actions define the purposes for the space. Our case seems to be in many ways very successful and supporting many of the stated learning goals and end-users activities. However, a multitude of aspects determine the success i.e. whether a space has a supporting rather than a defining role. It is good to remember that the link between the physical space and behavior is not causal, but a much more complex with unexpected outcomes (see e.g. [20]). Then again, comprehensive change interlinking pedagogical, physical, virtual and social aspects leads to better learning [13].

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