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The Experience of Co-Designing a Learning Space with Teachers and Students

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Abstract: This paper presents the findings of an empirical research study investigating the perspectives of students and teachers on learning spaces in higher education and their participation in the design process of such spaces. The study employed a participatory design method, using workshops to involve teachers and students in redesigning a prototype learning space named the 'Cube'. This approach allowed the researchers to actively engage users in reflective thinking on the learning spaces and their role in learning and to co-create new learning spaces through the use of their experiences and ideas. The findings are organised into 10 design themes, highlighting key considerations for the design of meaningful and effective learning spaces. The study concludes that involving teachers and students in the design process can significantly improve the learning and teaching experiences by fostering an active sense of agency and ownership over the learning spaces.

Keywords: learning spaces; large classroom; participatory design; students' participation

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1. Introduction

Research on higher education (HE) has not addressed, until recently, the issue of the physical spaces where learning occurs, as the research focus has traditionally been on areas related to pedagogical practices, curriculum design, policy, academic identities, or technology-enhanced learning [1]. However, with recent and current challenges and changes in the sector, new areas for research have emerged, including those concerning learning spaces and the impact these may have on both the learners' experience and teaching practices [2].

Learning spaces design may have become a trendy topic [1,3], but evidence indicates that there is still much research to be conducted around it, particularly in terms of when and how learning experiences and pedagogical practices can inform the design process [4–6]. Research on learning spaces has concerned itself more with the impact changes may have on students' learning rather than considering the design process in itself [5].

Research on learning spaces has been providing evidence that the physical space influences teaching and learning practices. Jessop et al. [7] found that space influences how teachers teach either by encouraging new pedagogical approaches or by constraining creativity and teaching practices. Brooks [8] compared the student and the teacher behaviours in a traditional classroom with a technology-enhanced active learning classroom, regarding classroom activities and the level of tasks conducted. This research shows that not only there are clear differences in terms of the type of instruction within each space, but that behaviour changes according to how the space is set up and the level of existing technology. It seems unnatural to suggest to a teacher that s/he must deliver active learning strategies in a large lecture theatre [9]. Lecture theatres convey a message of unidirectional learning and lack of flexibility. By having a single focal point at the front of the room, the space is giving a message that the role of the teacher is to speak, and the role of the student is to listen [10]. On the other hand, by providing a room where 30 students can sit on square or

rounded tables with chairs on each side, there is an implicit message that the role of the student is to engage in teamwork or discussions [10]. Oblinger [11] adds that changing the space layout may have a collateral effect on teaching and learning practices. She argues that a learning space can bring people together and encourage exploration, collaboration, and discussion, but it can also have the opposite effect.

In their research, Jessop et al. [7] found that students and teachers have different perceptions about what is more relevant in their learning space. Whilst students' perceptions point towards a predominance of the function of the space for each teaching approach (spaces organised for lectures, seminars, or tutorials), constraining their imagination to other possibilities, teachers discuss the potential and limitations of learning spaces, reflecting more about concepts of familiarity, space–time dimensions, territoriality, and collegiality. This view results in both users reacting differently to the learning space, as it conducts different meanings depending on their own experiences. Whilst the teacher reflects more emotionally to a physical structure that will follow practice during their professional life, i.e., influenced by rich encounters in a diverse range of contexts of teaching and cohorts of students, the student is more pragmatic and functional, trying to resolve a problem with an easy win. This view is supported by other studies. For example, a study in Korea [12] aimed to understand students' perceptions of what students found relevant in learning spaces. The study identified the existence of a golden zone and a shadow zone. The golden zone represented those seats considered to be the students' preference since they are situated in an optimal learning condition. They considered these seats as a golden opportunity: (i) to receive good eye contact and interaction with the instructor; (ii) as a superior environment for maintaining concentration and motivation for longer periods; and (iii) as the best view towards the screen and whiteboard without being distracted or bothered by other students. In this study, students suggested three main aspects when designing learning spaces: (i) being close to the teacher; (ii) a sense of belonging and being engaged; and (iii) having good visibility.

Brown and Long [13] suggest that there are three main principles to assist learning spaces design: (i) it should be focused on the learning experience and pedagogical theories and how students learn individually and in a group; (ii) there should be an increase in ownership of the technological devices that enrich learning; and (iii) it should be influenced by human-centred design, thus needing to respond to the integration of services and devices that support learning, rather than just making them accessible. The latter is also discussed by Casanova et al. [14].

Another aspect that is often considered in the design of learning spaces is how technology informs the organization of the space and the pedagogy used within it. According to Mei and May [15], teachers may be encouraged to experiment with new teaching methods and strategies when technology is incorporated into the classroom, but they may also have negative perceptions of certain technologies, even if they have received training in their use. The authors of this study found that teachers had negative perceptions of document cameras, classroom iPad sets, and Extron screen consoles, viewing them as neither useful nor user-friendly, and ultimately harmful to teaching. As a result, the authors concluded that for technology to be effective in learning spaces, it must be easy to use, reliable, and pedagogically relevant.

Henderson et al. [16] conducted a large-scale study at two higher education institutions in Australia to examine students' perceptions of the usefulness of digital technology in university teaching and learning. The study found that students tended to place more importance on technology that helped them to organize and manage the logistics of their studies and that enabled them to access information from anywhere. However, there were fewer references to how technology is being used in the classroom to enhance learning, foster collaboration, increase engagement and interaction, or facilitate deeper learning. It has been suggested that this may be because technology in learning spaces is not perceived as being sophisticated enough or relevant enough to fit into traditional teaching and learning processes [16–18].

The recent global pandemic has further emphasized the importance of technology in learning spaces, as it has reinforced the use of technology-rich environments that can accommodate new pedagogical models such as hybrid learning, where students can attend lectures in person or remotely [19]. As a result, universities are now seeking ways to improve classrooms to make them inclusive and engaging for both in-person and remote students [19–21]. The process of designing such hybrid learning spaces is complex, particularly because students often play an active role in adapting the learning space to better meet their needs, making the outcomes of the design less predictable, as discussed by Goodyear [22]. The author concurs with Leijon [23] about the importance of observing learning and teaching practices when designing learning spaces. It is important to understand the learning experiences and needs of the user groups as well as to consider the technology to provide an inclusive and engaging learning space.

One unique example of a practical method for designing learning spaces that can be found in the literature is the one introduced by Lincoln University in the United Kingdom. The space planning team at the university facilitated a workshop in 2013 in which students and teachers were involved in the design process. Using conceptual themes, a group of 15 participants aimed to design a set of elements that would inform the design of learning spaces. The findings were clustered into two groups: (i) spatial, which included aspects such as room layout, environment, and furniture; and (ii) social, which encompassed elements such as how the room would facilitate participation, engagement, and collaboration [24].

It is noteworthy to consider how both students and teachers were actively engaged in the workshops, working collaboratively to find solutions to a given problem. This approach is intriguing, as it provides opportunities for discussions and encourages the confrontation of different perspectives and roles within the learning space design. This research suggests that it is important to scaffold users' perceptions, providing them with an understanding of both 'the what' and 'the how' when discussing the design of the space. By using conceptual themes as a guide, this method aims to involve all participants within a common framework of thinking, especially students who may not feel as prepared to discuss at the same level as their teachers.

However, it could also be argued that by having students and teachers in the same group, the opinions of the latter may dominate, as they may see themselves as more experienced users of the space. Nevertheless, the use of conceptual themes appears to be a suitable method for space design, as it can bridge the gap between the more functional and the more conceptual aspects of the space. It can provide a clear structure and common ground for discussing and designing effective learning spaces.

Taking into account the importance of engaging teachers and students in the design of learning spaces, this research paper is based on a methodology that actively involves both groups in the design process. We align with the perspective of Bligh [4] that by involving students and teachers in reflecting on and designing learning spaces, it is possible to design more meaningful, innovative, and effective learning spaces. We believe that by including these stakeholders in the design process, we can encourage the development of a community and participatory governance in higher education which, as Temple and Barnett [25] argue, should be the direction institutions should pursue.

Additionally, by conducting systematic research on the design process, we will be able to gain insights into the perceptions of students and teachers regarding the learning space and their role in it. These insights will also inform research in the wider field of higher education. The main question driving this research is: how different would a learning space be if we were to integrate its main users in its design in a creative manner?

2. Materials and Methods

The educational literature seems to agree that we should understand learning spaces through an analysis of the interactions, habits, and perceptions of the different users [4,5,22,26]. Bligh [4] suggests that the process of managing and designing learning spaces needs to become more inclusive by involving students and teachers. The author

justifies this argument by presenting three reasons: (i) because they are inhabiting the space and thus being able to reflect and transmit how practices are conducted, which would be difficult to understand for someone looking in from the outside; (ii) because their opinion is still seen as undervalued when compared to other actors such as estate managers, architects, and those managing timetables; and (iii) because the level of expert architects and estate managers have about learning and teaching is frugal and over-attached either to their own empirical experiences as learners or to common sense.

An approach that involves users in the design of learning spaces is participatory design (PD) [5,27]. PD is a set of practices and research methods that aim to include end-users as active participants in the design process. By doing so, users become not only participants but also experts and partners with an active voice in the final product. Walden [28] argues that participation in design needs to be seen twofold, firstly as means of involving those that live in the space and listening to their concerns, and secondly as a sense of self-realisation, engagement, and well-being.

In a normal scenario, PD research may involve observation, surveys, informal interviewing, and participation in focus groups. For this research, we decided to use sandpits [27,29], which are creative, design-driven focus groups in which, provoked by a narrative and by conceptual themes, participants are encouraged to redesign a product, a service, or in the case of this research, a learning space. We used the sandpits both for data collection of perceptions about learning spaces and as a means to redesign the prototype of a large learning space aiming to find new design solutions.

2.1. Data Collection

The research study made use of a sandpits methodology, which was held at a single university located in the south of England. At the time of the research, this institution was undergoing a significant investment in the construction and refurbishment of new learning spaces, however, with limited engagement from both teachers and students.

To conduct the study, the researchers obtained ethical clearance from the university and subsequently contacted thirty students who were course representatives. Through the Students' Union, a purposive sample of sixteen students was ultimately obtained to participate in the study. The participants were selected by sending out invitations via email to course representatives. The age range of the students was between nineteen and thirty-five years old, and the sample consisted of seven men and nine women from different academic levels including undergraduate years 1, 3 and postgraduate. The participants came from a diverse range of disciplines including science and engineering, design, social sciences, and business.

In addition to the student participants, the research also involved twenty-two teachers. An invitation to participate in the study was sent out to fifty-two academics who were actively involved in various pedagogical activities such as seminars and workshops, from which a purposive sample of twenty-two teachers was obtained. The sample consisted of ten men and twelve women at different stages in their careers representing a diverse range of disciplines such as science and engineering, design, business, marketing, education, and healthcare.

To ensure a comprehensive examination of the data, the researchers decided not to organize the groups by discipline, level of study, or experience. Instead, the data collection included five sandpits with twenty-two teachers arranged around seven design tables, as well as three sandpits with sixteen students arranged around five tables.

In order to ensure that each participant's voice was given adequate space to be heard, it was decided that each design table should not have more than four participants. Therefore, in some sandpits, there was more than one design table to accommodate this decision.

Each sandpit had a maximum duration of one hour and was divided into four moments:

1. In the first moment, we presented the research and explained the instructions for the session. This took approximately 5 min.
2. In the second moment, using a storytelling technique, we read the story of John Lock and Richard Perry, two personas created to characterise how the teacher and the students would become involved in teaching and learning in the 'Cube' [30]. For the teachers' sandpit, we used John Lock's perspective of teaching in the 'Cube'. John was a Professor of Archaeology at Bloom's University. For the students' sandpits, we used Richard Perry, a student from archaeology at the same university. Whilst reading the narrative, the narrator showed images of the 'Cube' depicting each element of the space. This took approximately 15 min.
3. In a third moment, each group had time to discuss and reflect on the presentation of the 'Cube'. They had 15 min for discussing the prototype and writing down what they would like to keep, lose, or change. To conduct this exercise, they used an A3 sheet and coloured sticky notes to express their points of view: (i) to keep (in green sticky notes) represented what they liked in the space and what they wanted to keep; (ii) to change (yellow sticky notes) represented areas or features they liked but wanted to change to further improve it; and (iii) to lose (in red sticky notes) represented areas that were not appreciated.
4. In the fourth moment, participants tried to redesign the 'Cube' based on the outcomes of the discussions. Aiming at fostering a design environment, at each table (Figure 1), participants had at their disposal 30 photos of the layout, furniture and technological solutions, a scissor, sticky tape, different pencils and markers, the screenshots of the 'Cube' (Figure 2) used during the narrative, and a flipchart paper pad. At the end of the activity, the group gave a name to the space that represented their ideal teaching and learning environment. A rapporteur was then selected by the groups to share the main topics during the discussions. This was particularly relevant when there was more than one design table.

Figure 1. Picture taken before a sandpit, illustrating the different tools participants had at their disposal.

Data collection for this study was carried out using a variety of methods, including the use of sticky notes, sketches created by participants, and field notes taken by the research team. Additionally, pictures of the sticky notes and sketches were utilized as secondary data sources in order to better understand the design thinking elements that emerged during the group discussions. To ensure the completeness and accuracy of the data collected, the final summary of each group discussion was recorded and transcribed.

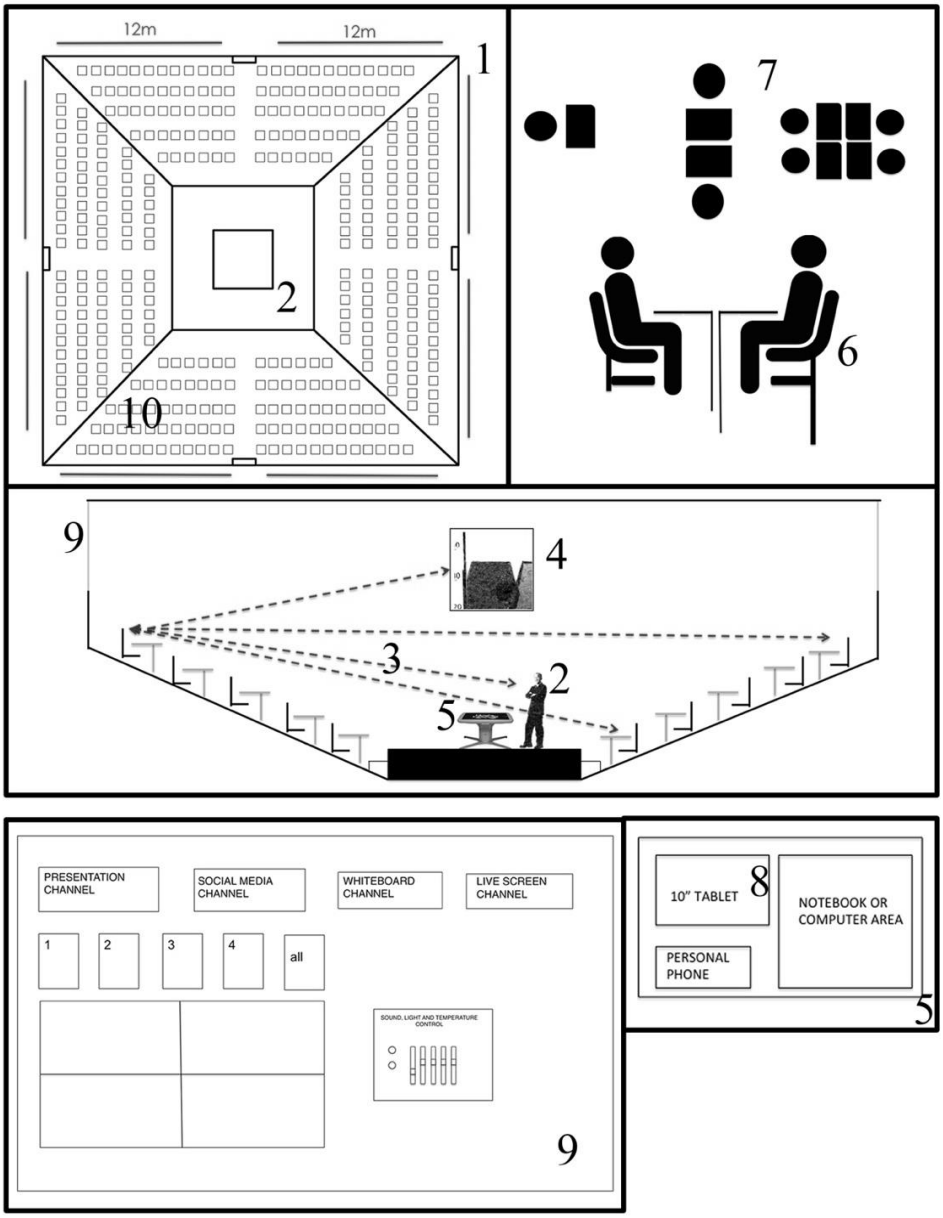

Figure 2. Screenshots of the images used to support the narrative during the sandpits (see Supplementary Materials).

All ethical requirements were strictly adhered to during the data collection and analysis process. This included measures such as maintaining anonymity and protecting the confidentiality of the data [31,32].

Once the data had been collected, it was analysed using the software QSR International NVivo version 9. The data were coded and categorised into pre-defined themes using a deductive thematic analysis approach. This allowed for a thorough examination of the data in order to uncover any patterns or insights that were relevant to the study.

2.2. The 'Cube' and the Guiding Themes

The design of the learning space prototype was informed by recent trends in the design of learning spaces [26,33]. Given the diversity of participants, including students and teachers from different professional and disciplinary backgrounds, it was important to establish a common starting point and the same object of analysis. To achieve this, we employed a narrative approach during the storytelling phase, which provided a shared

context for all participants. This narrative was informed by ten conceptual design themes, which were integrated into the persona's statements and actions and into the visual representations, specifically the screenshots of the 'Cube' classroom (Figure 2). These themes were not explicitly introduced to the participants during the storytelling phase; they were included surreptitiously.

The numbers in the figure (1 to 10) indicate to the reader when each conceptual theme was introduced. These numbers were not provided to the participants during the sandpit sessions, allowing them to arrive at their own conclusions based on the information provided in the narrative and visual representations. This approach aimed to encourage independent thinking and creativity in the redesign of the learning space.

The 'Cube' represents a large lecture theatre. It aims to provide an immersive experience to the students, making them closer to the teacher who would be in the 'box' (the centre of the room). Students could follow the session by looking directly at the teacher or by looking at the multiple projector screens.

Below, we present the ten conceptual themes explored in the study and the rationale of how and why they were introduced in the prototype of the 'Cube':

1. Size. The 'Cube' classroom had a capacity for almost 400 students; this large capacity was intended to serve as a catalyst for debate over the appropriate size of a classroom and the relationship between classroom size and pedagogical practice.
2. Teacher-led. The teacher was in the middle of the room acting almost like a performer on stage. This layout would confront the idea of active learning as well as making the teacher more exposed to the students.
3. Proximity. The 'Cube' was designed in a square format aiming to enable the teacher to be closer to students. The student would be up to 12 m from the podium—much closer to the typical atmosphere of traditional lecture theatres.
4. Visualization. We aimed to challenge the traditional approach of using small, inaccessible projectors by designing a unique set of four projector screens that were placed above the teacher's head in the 'Cube' classroom. The idea behind this was to allow students who were not able to see the lecture from their seats to look up at the screens for better visibility. Additionally, we introduced the possibility of using multiple channels simultaneously, such as mixing a slide presentation with a live Twitter feed or a visualisation of an object.
5. Technology integration. Each student would have access to a 10-inch tablet embedded in their table; the teacher would also have access to a large tablet that they could use to manage the session. We wanted to explore technology integration for the teacher and the student.
6. Comfort. Each seat in the classroom was adjustable in height and recline, allowing students to adjust their posture to suit the task at hand, whether that be sitting upright for writing or reclining to read or view the projector screens. At each table, there was an area where the tablet was embedded and where students could place their smartphones and a free area where the student could place the laptop or a notepad. Every seat had its socket for charging personal devices and an area to place bags and coats.
7. Collaboration. The seating and tables had a rotating feature that could enable collaborative work. This feature allowed students to move to the back row and rotate their tables using the seat as its axis, allowing for the merge of each table as jigsaw pieces forming a collaborative worktable. With this theme, we wanted to explore active and collaborative learning features in a lecture theatre which typically is not conducive to this type of learning.
8. Control. Each student's tablet could allow for interaction and projecting on the big projector screens. This option could facilitate the use of electronic voting, interacting with a digital whiteboard, or posting a social media channel. When requested by the teacher, each tablet could become the primary source device, thus broadcasting to the lecture room.

9. Ambience. The 'Cube' had windows with 2 m height above all the 4 walls but, rather than being in eyesight, they were above the students' heads. The reason for this layout was to serve the purpose of having natural light and fresh air when needed without distracting the students. The teacher, using the central tablet, could configure all the ambience features of the 'Cube'; the tablet allowed the teacher to darken the window, levelling the temperature, the light, and the sound. Using this tablet, the teacher could also automatically close/lock the 4 exit doors to prevent students from coming in late.
10. Shape. The 'Cube' forced the idea of a square shape with a traditional row and column layout that does not suggest the existence of flexibility. The objective was to encourage users to reflect on the need for flexibility and to encourage them to think creatively.

Notwithstanding the value of the conceptual themes, it is important to recall the importance of the visual clues provided by the layout photos, furniture, and technological solutions given for the redesign exercise (Figure 1). Those were also important to inform discussions and to suggest ways forward to each design table, as we will be able to see in the next section.

3. Results

Our findings were organised based on the conceptual themes previously identified, which served as a means to structure the main points of discussion and innovations. It is important to consider how these themes individually or collectively contributed to the creation of new and redesigned learning spaces.

One notable observation was the divide between the functional and conceptual perspectives, and whether these perspectives aligned with the experiences and needs of the participants. During the discussions, students appeared to be more focused on the functional aspects of the space, while teachers were more concerned with the conceptual perspectives. However, the final designs did not necessarily reflect these perspectives. Both students and teachers had different perceptions and needs when discussing each of the themes, but there were also some common concerns such as the size of the room and the role and position of the teacher in the space. The final designs thus reflect a harmonisation of all the perspectives for effective and efficient learning spaces.

3.1. Size

All of the groups involved in the study also discussed the size of the room and its impact on the teaching and learning experience. They noted that the number of seats in the room was considered excessive, and this was seen as a constraint that hindered active learning possibilities and created a physical distance between the teacher and the students.

Three of the teacher groups suggested that if the rationale behind having such a large space was to save on real estate, then they would prefer to teach remotely using video conferencing. On the other hand, students were more open to compromise on the size of the room, as they were motivated by the potential for increased interaction and engagement. They proposed to reduce the size of the room (up to 200 seats) and to instead focus on creating dynamic and flexible layouts. Figure 3 depicts an example of such a proposal, the 'Horseshoe', which was suggested by the students of Sandpit 3.

In this proposal, the teacher would be able to walk in the middle of the room and engage with all students who would sit around the teacher's space. This proposal still allowed for proximity between the student and the teacher but would additionally suggest a more intimate classroom setting. A similar proposal was suggested by another group; however, in this case, the room was still within a lecture theatre format with its stands elevated to allow for better visualisation.

Only group one of the teachers' groups found value in large learning spaces and aimed at suggesting a more creative and innovative solution, the 'Spheredome' (Figure 4).

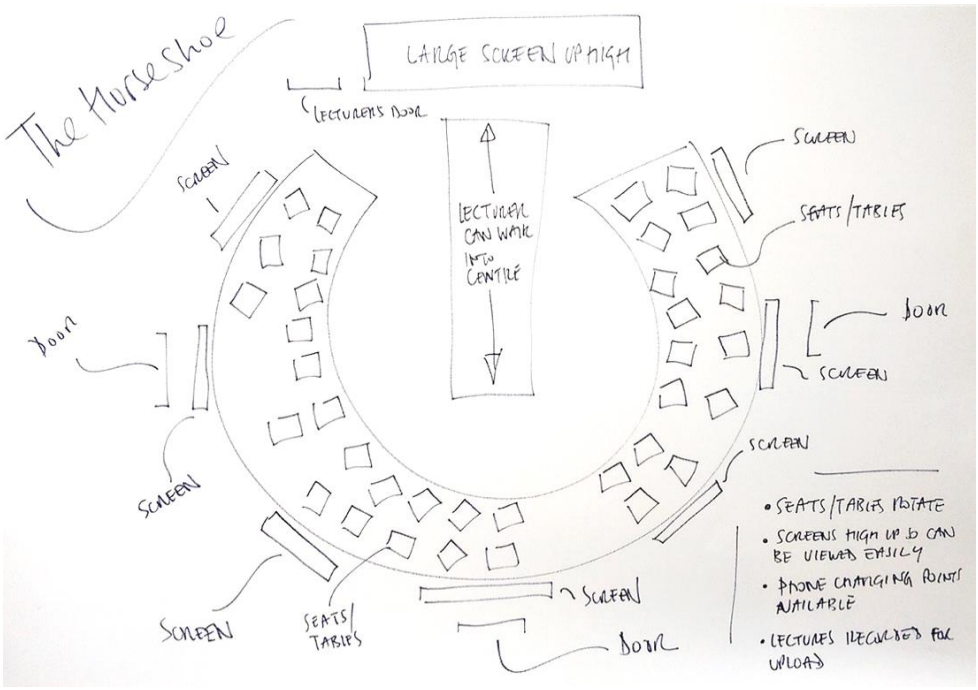

Figure 3. The horseshoe is the proposed design by group 3—students.

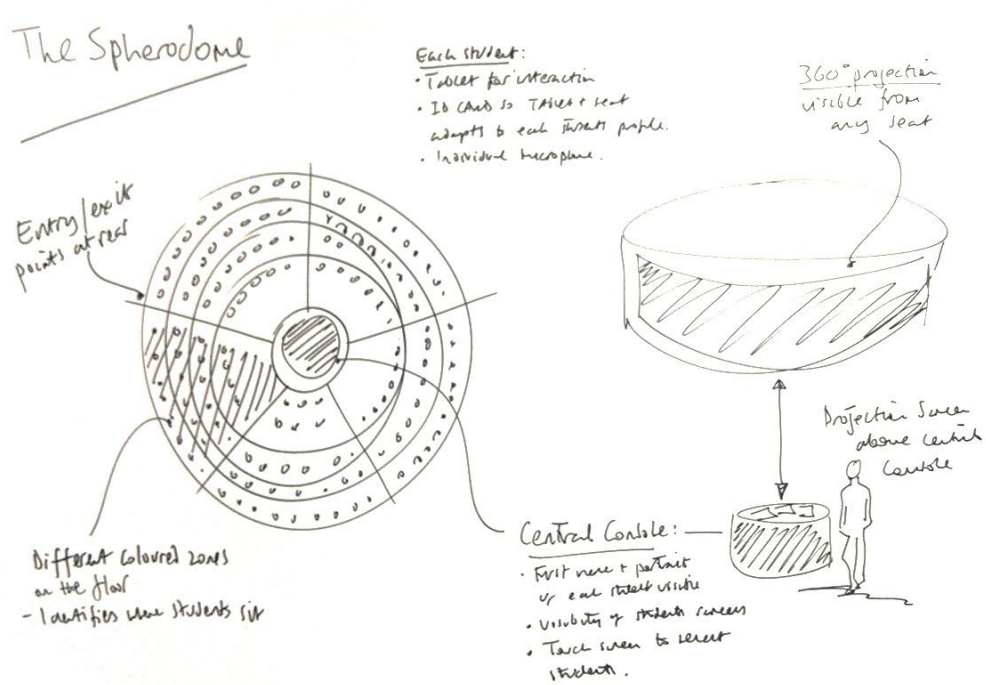

Figure 4. The 'Spheredome' is the redesign proposal by group 1—teachers.

3.2. Teacher-Led

The position of the teacher in the classroom was a topic of discussion among all groups involved in the study. It was acknowledged that placing the teacher with their back facing a significant portion of the room was not an optimal arrangement for teaching. This is because maintaining eye contact and interaction with students is a crucial aspect of effective teaching.

However, the students felt that having a central position for the teacher in the classroom was important, as it conveyed a sense of leadership and authority and served as a

key design feature in the learning space. All student groups emphasized the importance of the teacher being able to move around the room and interact with the students.

On the other hand, the teachers had concerns about the level of exposure and potential difficulties they may encounter while engaging with students in this type of setting. Inexperienced teachers may struggle to engage all students effectively, instead focusing on just one group while neglecting the others.

However, group one argued that teachers with more teaching experience could be even more effective in a room such as this, as it enabled performance and engagement. One of the members said, "it could be a one-man show". Nonetheless, most of the teacher groups did not share the same opinion; they preferred to reduce the role of the teacher and increase opportunities for peer learning.

This led to the creation of redesigns of the 'Cube', such as the 'Sofa' (Figure 5), where there was no space for the teacher to sit and only student pods where they could engage in peer learning. In this design, the teacher could facilitate group work by moving around the room to check in with each group.

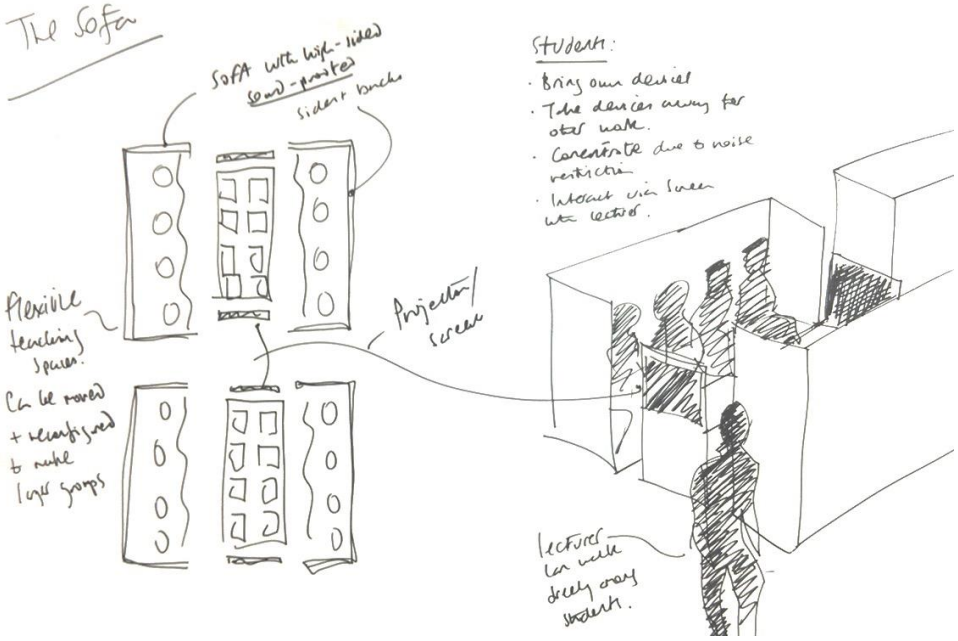

Figure 5. The 'Sofa' is the redesign proposal by group 4—teachers.

3.3. Proximity

Students had a positive overall response to the 'Cube' space, with many of them noting that they felt particularly immersed in the environment. They believed that having a closer proximity to the teacher would lead to more effective learning; however, they did not have the same level of enthusiasm about being close to their peers. Many students expressed a preference for more space between seats in order to support a more comfortable and quieter environment:

> "I like the idea of having empty seats around me because there is less distraction. However, if we are to spread around the room, we do not have the feeling of learning together . . . as a group. What I'm saying is that it would be nice to have my colleagues around, but if I am listening to a lecture or doing independent work, then I would prefer not having my colleagues around".

One group of teachers expressed that they appreciated the idea of students being able to see each other in different stands; however, they also highlighted that the use of tablets for interaction could limit a sense of openness and debate. There was a consensus among both teachers and students that a room with the shape of a traditional theatre would

promote proximity and engagement and would not encourage the teachers to have their backs to the students.

3.4. Visualisation

The 'Cube' projector screen solution was upheld by all groups. They enjoyed that the screen was not projected on the wall in the back of the teacher, and they were also encouraged by the number and size of the screens. In one group, a student said:

> "In my lectures, the teacher uses only whiteboards to write on. If this would be projected, then we would have a better view and we could access to it which could be really good".

In another group, students praised the design of the projector screen as being higher up, as it would allow everyone to have the same view and not block the students' views. This opinion was echoed in other groups, particularly among students who had expressed concerns about existing solutions. One student group suggested that there could have been more screens fixed on the walls to ensure that everyone has the best visual experience possible.

In addition to this, students suggested that having multiple screens could allow for the integration of different channels at the same time such as social media streams and slide shows, which could promote a sense of interaction and dialogue between the podium and the stands.

On the other hand, one group of teachers suggested that the projector screen could have a cylindrical shape, as this would suggest a "feeling of greater depth". Another teacher group suggested that the projected image could be seen on students' tablets or even on their own devices through a web stream.

3.5. Technology Integration

Technology integration was one of the most contrasting perspectives shared between students and teachers. The teachers suggested that students would not use institutional devices, and instead, they preferred to use their own devices to interact with the teacher.

On the other hand, students were enthusiastic about having embedded institutional tablets, but they suggested that they should have a degree of personalization, such as being able to log in with their institutional ID and password. Additionally, two of the student groups said they would rather lose the power sockets in every seat, as they felt it would send the message that students should be using their personal phones and interacting with the outside world, rather than focusing on their studies.

One group of students and one group of teachers suggested that the use of tablets could be a solution for students to write notes during the lectures, but students also noted that a 7-inch tablet (the one provided in the 'Cube') might be too big and would take up important space needed for a sheet of paper or a notebook.

Lastly, one group discussed the teacher's tablet, saying that it was too complex and had too many functions, and that the dependency on technology could create problems in the long run. This group was also concerned about the excessive dependency on technology.

> "What happens if technology fails? The space is too dependent on the technology, and we lose what is essential which is the interaction with the student".

Unsurprisingly, this over-dependence of technology was more discussed with teachers than with students.

3.6. Comfort

The seating arrangements were a significant topic of discussion, in particular among the students. One main concern was the size of the tables, as students wanted to be able to use tablets, laptops, notebooks, and calculators all at the same time, and suggested that tables should be at least 20 $\times$ 20 inches to accommodate these activities and func-

tions. One group even indicated that they would need space for an A3 sheet to work on mathematical formulas.

While recognizing that compromise may be necessary, students suggested some possible solutions such as the tables could be tilted to facilitate the use of tablets or be made of acrylic, allowing students to write directly on the table. They also suggested that the storage space underneath the seat should be larger to accommodate coats, lab equipment, and laptop bags, and some suggested a backpack-format storage space in the back of the chair.

Two important aspects not covered in the 'Cube' description were the needs of wheelchair users and tables for left-handed students, showing the need to take into account the needs of all students to create an inclusive and accessible learning environment.

Both students and teachers found the seating too comfortable, arguing that students could potentially feel too relaxed and informal. Therefore, although referring to the importance of ergonomic seating, they suggested losing the reclining feature. One group of teachers suggested that chairs and seating should be more flexible to allow for a degree of movement around the room.

3.7. Collaboration

Teachers were more interested in discussing the collaborative feature than the students. One group of teachers suggested that large classrooms should not be used for group work, as it has limited usefulness and it would be difficult to manage the buzz coming from the groups. They suggested having learning pods within the room to enable interactions and group work in a smaller group of students (Figure 4).

Teachers also presented concerns about how they could plan a lecture using the collaborative feature and how they would use it in a pedagogically effective way.

Students were more interested in discussing the rotating chair table features. They were happy with it, although one group highlighted that there could be a danger of students playing around with the seat rather than engaging in active and collaborative learning. Student behaviour with the seating proposed in the 'Cube' was a matter of concern shared by both students and teachers.

3.8. Control

Control was not a widely discussed theme. Both students and teachers generally welcomed the possibility of interaction using electronic voting and social media using tablets. They also suggested having a built-in microphone to enable the students to speak and be heard, which could be activated by the teacher when questioning students. There was a sense across the groups that the control of the lecture should be exercised by the teacher and only occasionally handed over to individual students when required.

However, teachers also expressed concerns about the dependency on technology to exercise control in the space, highlighting the importance of considering the potential drawbacks of technology integration in the classroom. The main concern raised by the teachers was the abovementioned dependency on technology to exercise control in the space.

Teachers felt they needed both technological and pedagogical training to help them take advantage of all the features available in the 'Cube', in particular, the integration with students' tablets and the ability to project onto multiple screens. They also felt overwhelmed with the level of options available to control the room ambience.

3.9. Ambience

The ambiance of the room was a topic of discussion, with students showing more interest in this aspect than teachers. One topic of discussion was the lighting and the use of windows. Students were concerned about the size of the windows, which might reduce visibility. One group said that the light could reflect off the board or screen, reducing visibility, while another group mentioned that direct sunlight could be distracting. They suggested using curtains or blinds with an automatic adjusting feature to address these

issues. There was also a suggestion to allow for different light densities in different sections of the room to help prevent students from falling asleep. This highlights the importance of considering the impact of lighting on student's learning experience and how it can be adjusted to promote optimal learning conditions.

Teachers were more interested in discussing the acoustics of the room, which they generally felt were poor. They stressed the importance of having noise-cancelling partitions between rows or between sections to help mitigate any negative impact on the learning experience.

Additionally, teachers placed a lot of importance on good circulation of air and the right temperature. They felt that the room temperature greatly affected student learning, and this was a concern shared by both teachers and students.

3.10. Shape

One of the key messages from students and teachers was the lack of flexibility in the room. According to the teachers, flexibility would enable students to move from one group to another with ease. Two groups of teachers and one group of students suggested that, rather than a traditional lecture theatre, the 'Cube' should be designed based on walled terraces that would enable a combination of zones with different environments and pedagogical uses. This would promote adaptability in teaching and learning methods, allowing teachers to adjust their teaching styles to different groups of students.

Additionally, one group of teachers suggested the use of sofas, beanbags, and rounded tables as alternative seating solutions to promote flexibility and a more relaxed learning atmosphere.

One group of students suggested that the walled terraces could be levelled in height to suit different contexts such as lectures, exhibitions, experiments, or performances. The podium would also be on an elevated terrace with the possibility of going up and down, which would enable more effective use of the room (Figure 6).

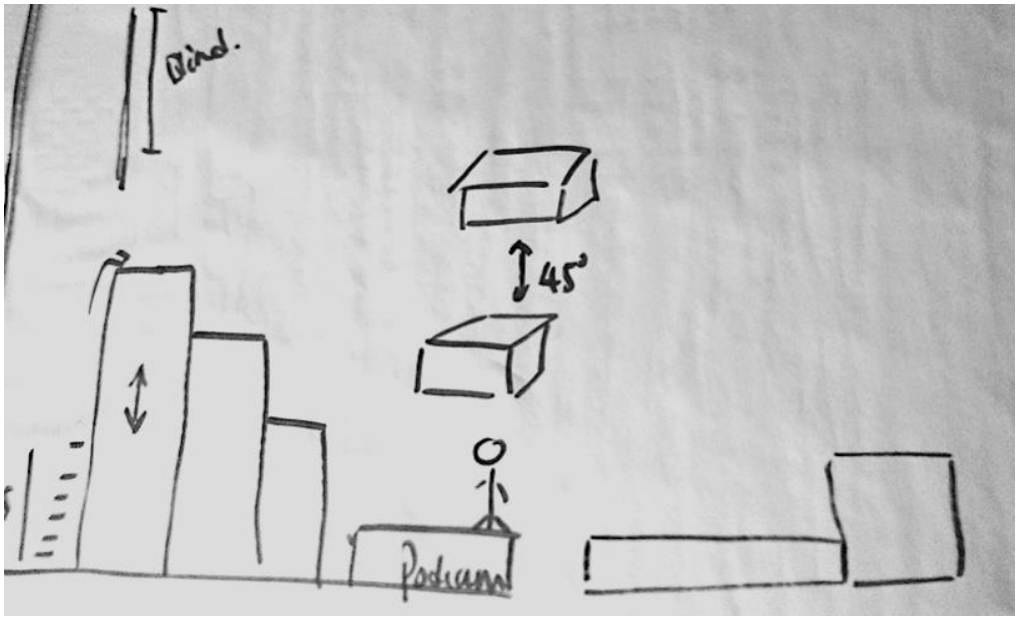

Figure 6. The Rubik's cube is the redesign proposal by group 3—students.

Additionally, there were suggestions from various groups of teachers and students about the shape of the room. Rather than being in a square format, it should be rounded or circular since it would give a sense of "openness and be more inspirational" and a sense of "depth." The 'Spheredome' (Figure 4) is an example of redesigns of the 'Cube' that focuses on changing the shape of the room to a circular layout.

Importantly, the shape of the room was not only discussed in terms of its layout and walls but also furniture and visual elements. Teachers were particularly interested in exploring spaces that were built based on rounded shapes.

4. Discussion

The pedagogic value of the 'Cube' was widely discussed during the discussions and the redesign phases. References to active and collaborative learning, interaction, and student engagement were included in the narrative to encourage participants to discuss how pedagogically effective and aligned the 'Cube' was to their existing practices. While some teachers felt that the design of the 'Cube' was not coherent with trends towards active and collaborative learning, others still saw value in lectures and lecturing. Additionally, they acknowledged that not all teaching should be led by the teacher, indicating that there is a balance that needs to be struck between different teaching methods and a diverse range of pedagogical approaches.

Students shared a similar viewpoint reflecting on how they felt more comfortable when listening to their teachers. This is consistent with the findings of French and Kennedy [34], who concluded that, although widely questioned in the higher education sector, lecturing is still perceived as a valuable learning experience by both teachers and students. Many of these pedagogical preferences and perspectives also come from personal experiences, educational background, and the field of study of the participants. Thus, it is important to consider this diversity in the design and decision making of a learning space. The space should be able to adapt to different teaching methodologies and support the educational goals of the institution.

The changes in pedagogical foundations can also affect the existing pillars of the sector in a way that can lead to redesign the physical learning spaces. The 'Sofa' for example, is a concept of a more flexible and collaborative learning environment in which students can gather in small groups to work together and teachers can move around to offer help and guidance as needed, rather than standing at the front of a traditional lecture hall. This kind of design encourages students to take a more active role in their learning and can change the dynamic between students and teachers.

During the sandpits, there was also discussion about the shape of the 'Cube'. The names 'Cube' and 'Box' may have influenced the students and teachers, as there was a demand from all groups for more circular rooms, rounded projector screens, rounded furniture, and even windows with different shapes. It was found that rounded shapes could enhance engagement and create a feeling of an immersive environment that could not be achieved with traditional straight-line spaces. This finding is noteworthy, as it suggests that rounded shapes have the potential to enhance engagement and create a more immersive learning environment than those that feature traditional straight lines. This is particularly interesting, as straight lines have traditionally been used in educational settings, which may limit creativity in the design of learning spaces. Furthermore, it raises questions about whether the decision to use straight lines in learning spaces is based on pedagogy or practicality in terms of design and room allocation. This is an area that has received little attention in the literature on learning spaces and may warrant further investigation, particularly as it was an area of agreement among the students and teachers during the sandpits.

A strong sense of engagement and purpose was evident among the teacher's groups. Participants reported a feeling of self-realisation and empowerment, as they were given the opportunity to share their perspectives and have their voices heard. Although no explicit promises were made regarding the impact of the research on the design of new learning spaces at the institution, the opportunity to engage in meaningful discussions about an often-overlooked topic was highly valued by participants. Furthermore, there was a genuine interest among the teacher's groups to learn more about the designs proposed by other groups and to compare their outcomes.

In contrast, although the student participants were motivated and enjoyed the experience, they did not exhibit the same level of excitement or sense of purpose as the teachers. For the students, the discussion was mainly functional, focused on the practical aspects of the proposed designs. In contrast, for the teachers, there was an emotional element present throughout the discussions, as they were deeply invested in the topic and its potential impact on their teaching practices and students' learning experiences.

The findings of the research study suggest that both students and teachers have well-informed ideas about the desired characteristics of learning spaces and that these ideas can inform the design process. However, there are clear contradictions between the desire for personalised learning experiences, characterised by small class sizes and an environment that promotes active and collaborative learning, and the realities of cost-effectiveness and sustainability [26]. This highlights the need for further discussion and decision making around what is truly important and valuable in a learning space, and how to balance the various competing priorities.

Additionally, there are questions to be answered about the relationship between academic identity, student expectations, and the role of lectures and lecturing in a modern educational setting.

Overall, the research findings indicate that there are still ongoing discussions and difficult decisions to be made about the design and function of learning spaces, and that a comprehensive understanding of the perspectives and desires of both students and teachers is crucial to the design process.

5. Conclusions

The findings of our research are not only provided by the sketches that suggest redesigned learning spaces but also the rationale behind these redesigns.

Flexibility was a key theme that emerged across all the sandpits. We agree with Goodyear [22] that the design of learning spaces should be dynamic and adaptable to changes promoted by students and teachers, as well as new learning challenges and opportunities. The space should be able to accommodate a range of group sizes and teaching styles, including lectures, collaborative learning, hybrid learning, and simulations. Flexibility can be introduced through the use of different layouts, flexible furniture and seating, multiple tiers and environments (e.g., through the use of different colours), and technological solutions.

Technology integration was also a common theme in the discussions. It is important to consider the purpose of the space and how technology can support this purpose. As noted by the teachers and discussed in the literature [14,17], it is more important to have functional technology in the space than a wide array of technology that is not being used. Our research found that teachers were more concerned about the technology, its use, and potential failures related to its use than we initially anticipated. Therefore, it is crucial to provide sufficient training and support to teachers on how to enhance their practice using technology, in addition to considering its role in the space.

It is also important to consider the role of technology in student learning practices in the classroom. While ownership and student agency in the space were not explicitly discussed during the sandpits, there were references made to the importance of the teacher's role and the need to reinforce it in the learning space, particularly in regard to the value given to lecturing. However, references to the use of individual tablets for student interaction and collaborative learning spaces such as the 'sofa', where the teacher acts as a facilitator without a designated seating area, suggest a potential for increased ownership and agency by students in the learning process. These findings, obtained in the UK where active learning is widely accepted and encouraged in universities, may differ in other regions where traditional teaching methods are more prevalent. It is important to consider how cultural expectations and practices may influence users' perceptions of pedagogy and learning.

The sandpits were not organised by discipline, and thus, we were unable to identify any clear differences in how teachers and students from arts or engineering perceived their learning spaces. As a result of mixing the groups, discussions tended to be more generic, and participants sought to find commonalities rather than specific elements of the space that may be relevant to their disciplines. However, we did find that disciplinary background had some impact on how teachers thought about the functional aspects of the learning space. For example, in the 'Spheredome' group, which consisted of teachers with backgrounds in pharmacy and computing, the space was designed to accommodate the shared need for immersive visual projections of formulas and coding. Whilst organising the sandpits by discipline may have resulted in different learning spaces results, our intention was to facilitate a design experience that could incorporate different viewpoints and approaches and be applicable to a range of scenarios rather than being specific to a single discipline.

The originality of this research lies in allowing, and subsequently evaluating, the process of designing learning spaces by its main users in an agentic, experiential, and systematic manner. Whilst firmly embedded within the participatory design tradition, our research exemplifies what happens when we give the opportunity to teachers and students to design learning spaces. We argue that our approach to learning-spaces design mirrors some of the main principles of active learning, of which the design process of our research itself aims to explore: (i) dialogic encounters nurtured through discussions and experimentation; (ii) the exploitation and use of people's mindsets for learning purposes; (iii) the sharing of power between the different users in the act of learning itself; (iv) and pattern making and comparative activities as a way to learn [35]. Aligning the principles of active learning with the process of learning spaces design is, to us, essential in a truly user-centred, more democratic idea of institutional governance in higher education [25].

Supplementary Materials: The following supporting information can be downloaded at: https://www.researchgate.net/project/Redesigning-technology-enhanced-learning-spaces-using-a-participatory-design-approach: The narrative used during the sandpits and the Screenshots from the 'Cube'.

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