A Dozen Considerations While Modernising Education Spaces

Dr. ing. A.H.W. (Piet) van der Zanden

University Corporate Office
Shared Service Centre – ICT, Education Technology
Delft University of Technology (The Netherlands)
a.h.w.vanderzanden@tudelft.nl

1. Contemporary literature considers traditional lecture halls inferior

Contemporary higher education literature is all about learning spaces and flexible arrangements therein to facilitate a diversity of education practices (Cleveland & Fisher, 2014; Fraser, 2014; Kuuskorpi & C., 2011; Ling & Fraser, 2014; Marmot, 2014; Sparrow & Whitmer, 2014; Temple, 2014; White, Williams, & England, 2014). A fierce discussion has started to reconsider the traditional lecture hall since the successful transformation of university libraries took place (JISC, 2006; Mitchell, White, & Pospisil, 2010; Oblinger, 2006), where the library's deadly silence zones have made place for social coherence in informal learning spaces (Bennett, 2006).

Successively, a serious movement has been coming up to demonstrate active learning classes within formal education (Freeman et al., 2014). Active learning classes are interpreted with two perceptions in mind:

1. Integrating interactive moments in class where students practice with the instructed methods and techniques, and
2. Modernised learning spaces with movable furniture arranged in group settings to facilitate collaborative assignments.

Especially at conferences modern learning spaces are hype, alongside new impressive education buildings. Fortunes are spent to show-off.

However, most of these universities demonstrating their showpiece do not tell about their legacy of teacher-centred education spaces. Such teaching spaces, representing an estimated eighty percent of their stock of lecture halls and classrooms, hardly got any attention, let alone modernisation. Conclusive figures are not yet available. The percentage of conventional education spaces is an educated guess based upon personal observations and several discussions with international peers. Is it then fair to conclude that contemporary literature is biased, considering that most of the presented and published evaluations contain mere opinions of enthusiasts without empirical evidence.

2. Contemporary literature advises to focus on active learning classes

The largest and most comprehensive meta-analysis of undergraduate STEM education to date questions the traditional lecturing practice and advises active learning as the preferred teaching practice in regular classrooms (Freeman et al., 2014). The study of Freeman cs has focussed on student success and student scores from which impressive figures are presented: Student scores were improved by 6 % in active learning settings versus lecture settings. Additionally, students in traditional classes were 1.5 times more likely to fail. The greatest effects were found for small classes ($n < 50$).

However, their study has focused on the design of in-class sessions. Homework assignments were deliberately ignored, and that while practice and drill assignments are key for internalisation. Homework is the lecture's other side of the coin; explanation during lecture and internalisation by practice through homework assignments are one of a kind. Instead of fighting traditional practices for higher education we should enhance the persistent chalkboard pedagogy to sustain our blended practices of tomorrow; *Change the medium, not the pedagogy*!

3. Education space shapes teacher's pedagogy and students' behaviour

Learning theories, such as Behaviourism, Cognitivism, Constructivism, Social Constructivism and Connectivism, are start for instructional design and also may be of use to imagine spaces where such learning concepts thrive. D. Christopher Brooks has indicated that form of an education space influences the behaviour of instructor and student; different spaces are better suited for some types of activities and conducive to students' time-on-task (Brooks, 2012). Brooks has even stated the following syllogistic terms:

1. Space shapes instructor behaviour and classroom activities
2. Instructor behaviour and classroom activities shape on-task student behaviour. Therefore,
3. Space shapes on-task student behaviour.

Literature shows interesting frameworks that support the idea of dedicated learning spaces, such as the Pedagogy-Space-Technology (PST) Framework for designing and evaluating learning places (Radcliffe, 2008) and the Technological Pedagogical and Content Knowledge Framework (TPACK) for teachers and teacher educators (Koehler, Mishra, Akcaoglu, & Rosenberg, 2013). Unfortunately, thus far no description of teaching and learning spaces for specific pedagogies could be found. With the main learning theories as fundamental principles combined with conducive spaces to instructor and student behaviour we came to the following classification of teaching and learning spaces, which are dependent on AV-IT technologies, interior arrangements and pedagogy (Marmot, 2014; Zanden, 2015):

- **Frontal pedagogies** are teacher-centred. The lecturer situated at the front elaborates on a subject, shows a presentation on the screen or chalks a complicated formula on the board while explaining its structure. The expert focuses on a topic, but deep learning happens during homework and other ex-situ (out of place) assignments. Lectures expect a "practice and drill" follow-up from students to internalise the subject matter.
- **Mixed pedagogies** are student-centred. They focus on classes with alternating practices, such as frontal introduction about a topic and subsequently tutoring student groups while working in teams on assignments. Student-centred pedagogies have an all-in-one learning objective.

Students have to understand a certain criterion, method or technique and have to apply it within the assignment.

- **Meet & collaborate** focus on team work and group assignments. Students work on problem-based scenarios and learn to communicate with professionals and peers when talking in dedicated jargon. They must understand the on-going methodologies and procedures instantly, and be able to operate in teams. Collaboration spaces are for constant communication and review. Ideally, student teams may use a dedicated space for longer periods.
- **(Digital) exams & computer practices** still are the testing situations where students demonstrate what they have learned. It is about knowledge, understanding and application, about comparing their personal construct with the institute's learning objectives. It is an instrument for easy determining the students' progress, especially with large cohorts. In the near future digital testing for campus education is bridged with the online practices of tomorrow.

This classification with appropriate requirements is been working out by the Transforming Education Spaces (TES) group and is to be presented in the TU Delft Cookbook Education Spaces.

4. Chalkboard Pedagogy is essential to teach reasoning and know-how

Natural science lecturers love the chalkboard when teaching theorems and proofs. Chalkboards provide the proper affordances to facilitate their "talking-writing" way of reasoning, it is an extension of their mind. While thinking aloud they simultaneously produce and write arguments in successive order on the board. In such way their reasoning becomes visible; students see the process and structure of the several step-by-step arguments that appear on the board written in full. By this chalkboard pedagogy students gain the ability to recognise patterns and interconnections.

Chalkboard pedagogy is to make students clear how reasoning takes place instead of just presenting facts. It is about know-how and not the know-that. Students have to take notes, because they must themselves think with their eyes and hands. If one wants to understand an argument, one must be able to see how process and structure are interconnected. When students write down notes during for instance a mathematics discourse, the thinking already becomes inextricably interwoven with it (Greiffenhagen, 2014). To internalise it further students must practice and drill until patterns are recognised instantly and the subsequent action has become familiar. This behaviouristic approach to learn such knowledge by heart must be done by repetition just until automatic execution is taking over.

5. Homework as part of learning seems gradually abandoned

It may be only an assumption but it seems that homework is slowly abandoned. In earlier days practice and drill assignments were a significant part of the curriculum. Lectures took about 12 to 16 formal contact hours, i.e. lecturer meets students in class whether for frontal instruction or practical experience to apply the taught methods and techniques. The non-contact hours of the 5-days study week were meant for internalisation at home next to university bonding through student activities. Today, students spend those non-contact hours differently, whether on a temporary job to lighten the study debt, to socialise with friends, or to enjoy several sorts of activities.

Education is changing to more active classes, not because of this decreasing homework attitude, however, it counters that attitude at the same time. It are flipped and inversed classes that focus on practicing the former homework assignments in class in attendance with coaching lecturer or assistant. As a consequence, classroom layouts are strived for to facilitate a more collaborating setting between students. Peer-learning is taking its place and flexible classroom furniture facilitates multiple education practices within one timetabled slot. All resulting in a gradually eroding homework attitude.

6. Chalk- and whiteboards run out of sync with Open & Online Education

Board pedagogy is still going strong within higher education. It fits with teaching the more scientific courses as is explained at Consideration 4. At the same time such board pedagogy loses connection with the contemporary but pressing movement of Open & Online education practices. Consequence of online practices is that materials, instructions, practices and assignments all are becoming digital. Successively, the chalkboard should follow this digitisation in order to fit the upcoming blended classes.

Thus far chalkboard lectures are being captured in videos. However, lecture capture as such will not do in the end, because chalkboard derivations are encapsulated within the video codecs and subsequently unable to be worked with any further; no editing possibilities remain for students. With a virtual chalkboard such content matter remain editable, for instance to copy and paste variables in other ICT applications without manual transcription. Thus, only when digital chalk is used such actions bridge physical classes with online classes more easily.

7. Empirical four-quadrant practice shows promising results

Many computer applications have been coming into lessons for in-between demonstration, animation, simulation or presentation. Such applications are alternatively presented in class, one by one when appropriate. However, when facilitating blended practices multiple signals should be presented simultaneously. We have chosen to present four video signals in parallel, meaning that a classroom computer must be available holding a four-video output card. If the lecturer wants to use just one video signal at a time then a brought along laptop or tablet will do. Of course the classroom system is able to present one signal in full-screen mode too.

The TU Delft's four-quadrant system with interactive SMARTboard for presenting multiple video signals has been tested within practices for over three years now. It is important for the teacher to conduct the course following the own pedagogy. The feel and touch of the interactive SMARTboard for digital chalk should therefore be close to their physical chalk experience. Exchanging normal chalk for virtual chalk has to be as natural as possible; virtual written characters should appear without delay or parallax at the very spot where the virtual chalkpen is moving. Lecturers use the pen to write and sketch, they use their finger to select and navigate, and they use the back of their hand to erase. These three main functions "write", "select" and "erase" make it really easy for lecturers to exchange physical chalk for virtual chalk. The small writeable surface of the used SMARTboard was overcome with the introduction of the four parallel video signals also. More details about the use and valuation

of this system is available at http://pietvanderzanden.weblog.tudelft.nl/ and “Advanced Teaching with Four Parallel Video Signals” (Zanden, 2013).

Digital chalk in combination with a four quadrant system is a very promising teaching environment. Student evaluation of nine 10-weeks education periods have already led to success. Hence we stopped with these student questionnaires. Successively, a study looking into student results has started. Preliminary results show student success and scores that are even more impressive than the study from Consideration 2. Scores were improved by 7 percent and success rates raised with nearly 15 percent.

8. Readability in classrooms should be considered as a whole

It should be compulsory that written and presented information in classrooms and lecture halls is easy to produce by the lecturer and easy to read and followed by students. It may be of no difference for readability that written or presented texts are projected on dry eraser whiteboards, on projection screens or on electronic displays. Readability of written and presented characters in lecture halls and classrooms is dependent on sight lines, reading distance, character heights, viewing angles, displays, screens and lighting. Proposed readability guidelines are:

- Presentation screen’s underside preferably about 140 cm above floor level
- Vertical viewing angle at the first row preferably about 25 degrees
- Horizontal viewing angle at the first row preferably about 35 degrees
- Written and presented character height preferably about 20 arc minutes
- Written characters preferably presented white on a black background
- Projector’s illumination preferably about 1000 lumen per m2 of projection screen
- Projector preferably back projection, prevent hot spot or reflection in case of front projection
- Brightness of LED display preferably 2000 nits or more
- Pixel density of electronic displays preferably larger than 30 PPI

More details about these readability guidelines are available at http://pietvanderzanden.weblog.tudelft.nl/ and “Readability in Classrooms” (Zanden, 2014).

9. Timetabling is to be adapted to affordances next to capacity planning

Lecture halls and classrooms were once designed for frontal instruction only. Today, group assignments are increasingly practiced. Moreover, active learning practices are being pushed into universities' policies. As a result, a mismatch is emerging between present education spaces and desired, yet even required, active learning spaces. Occupation and utilisation figures indeed show that current education practices increasingly do not match the available spaces any longer (Beyrouthy et al., 2009; Winkels & Sprong, 2008).

Since state-of-the-art teaching environments and flexible education spaces are becoming (omni-) present for teachers, instructors and coaches, they count on the availability for their practice. Thus, timetabling is to be the very first supporting process to be adapted in order to handle the several pedagogical classes of frontal and mixed pedagogies (Temple, 2014). Teachers, lecturers and instructors absolutely have to be booked in the right education spaces that support their new

pedagogy once they have made such effort (Zanden, 2015). Thus, timetabling agents have to deal with all education space classes and must consider an affordances planning next to capacity planning.

10. Engage academic staff, teachers and students with space design

When planning the construction or renovation of education buildings and spaces often service and operational considerations have focus above education practices (Bennett, 2006). Striking is that new education spaces are still drawn by architects as if teaching is equal to presenting; just one projector and projection screen over, and if we are lucky, adjacent to a writing board. Today's education building designers simply neglect the fact that in almost every discipline the computer and other peripherals have taken their place in daily practice (Marmot, 2014). It is non more than logical that such IT should be integrated within teaching and learning practices. An attempt to provide the proper affordances is absolute key to prepare for education transform. Luckily, emergent literature already aims on a better engagement of teachers and students during conceptualisation, design and developments of university spaces (Bligh, 2014).

Even today, replacing audio-visual installations and furniture follow standardised procurement policies. Subsequently, presenting situations are replaced with similar ones but newer. Such automatic replacements must stop; developments in education have to be considered when preparing education spaces to sustain pedagogical change. If appropriate pedagogy affordances are absent or counterproductive then nothing encourages its users. The result is that progress within education remains undoable (Temple, 2014).

11. Consider multiple perceptions, but constrain too much flexibility

Contemporary literature advises to make education spaces flexible in order to force a breakthrough into the inert situation of non-changing higher education. The assumption goes that flexible spaces facilitate multiple practices, which on their turn should give rise to educational change. Unlike this advice, we recommend to retrofit current education spaces for dedicated of dual mode practices only.

Flexibility comes in several dimensions, such as versatility of the teacher environment with multiple AV-IT functionalities, it comes as convertibility of the space's layout for mixed pedagogies, and it comes as scalability when bridging multiple education spaces when one had to cope with large students cohorts. Experiences with flexible spaces and a multitude of features have been showing that it discourages lecturers, teachers and instructors to use any of the provided possibilities (Brooks, 2012). Over-featured spaces simply do not work and are similar to multi-tools that have drills, circular-saw and reciprocating-saw attachments or Swiss pocket-knifes with screwdrivers and can-opener. Those smart things are sometimes interesting but a professional still prefers a dedicated saw and real screwdriver.

Hence the recommendation would be to design education spaces dedicated to specific pedagogies or bimodal sessions (Brooks, 2012; Marmot, 2014). Different lay-outs in education spaces should be easy to arrange with appropriate furniture such as the Flexstool. More information about the product is available at http://www.eromes.nl/Producten/Studentenmeubilair/flexstool- , information

about its design and evaluation is available at http://pietvanderzanden.weblog.tudelft.nl/. Only spaces with dedicated pedagogies encourage teacher and learner to behave in ways where the specific teaching or learning space was developed for (Brooks, 2012). It just cannot be that a teacher is confronted with a different lay-out as expected upon entering the space and that he himself has to lug around with tables and chairs before class can start.

12. Digitisation converges the AV and IT design and support domains

Education spaces are fast becoming multimedia-intensive, both for presentation and collaboration means next to upcoming blended education practices. AV and IT infrastructures will intertwine to facilitate these technology-enabled teaching and learning spaces (Daigneau et al., 2005). Today IT technologies has made it to mission-critical for education processes, AV technologies not just yet, but they will become rapidly. Still, coordination of the different parties responsible for design and delivery of education space facilities is frequently not achieved (Marmot, 2014).

The AV-IT convergence stimulates the development of tools to control and manage AV and IT installations and its infrastructures as a whole across campus. Technology-enabled education spaces will affect every facet of universities' facilities and systems design, engineering, implementation and operation (Daigneau et al., 2005). InfoComm International, the worldwide trade association for audio-visual and information communications since 1939, has meanwhile completely focused their strategy on AV-IT infrastructures (Persichitte, 2014). Soon all classroom video and also audio signals will be digital asking for a new generation of support. Was it once possible to daisy chain video and audio signals in order to put an installation in place for ad hoc events, today it needs a well-considered installation because of all digital protocols. Successively, the demand for dedicated AV-IT personnel will emerge sooner or later!

Bibliography

Bennett, S. (2006). First Questions for Designing Higher Education Learning Spaces. *Journal of Academic Librianship, 33*(1), 13.

Beyrouthy, C., Burke, E. K., Landa-Silva, D., McCollum, B., McMullan, P., & Parkes, A. J. (2009). Towards improving the utilization of university teaching space. *Journal of the Operational Research Society*(60), 14.

Bligh, B. (2014). Examining New Processes for Learning Space Design. In P. Temple (Ed.), *The Physical University: Contours of Space and Place in Higher Education* (pp. 24). London: Routledge.

Brooks, D. C. (2012). Space and Consequences: The Impact of Different Formal Learning Spaces on Instructor and Student Behavior. *Journal of Learning Spaces, 1*(2), 10.

Cleveland, B., & Fisher, K. (2014). The Evaluation of Physical Learning Environments: a Critical Review of the Literature. *Learning Environ Res*(17), 28.

Daigneau, W. A., Valenti, M. S., Ricciarini, S., Bender, S. O., Nicole, A., Di Grappa, M., . . . Sanchez, M. A. E. (2005). *Planning, Designing and Managing Higher Education Institutions*. Paper presented at the PEB Exchange, Programme on Educational Building.

Fraser, K. (2014). *The Future of Learning and Teaching in Next Generation Learning Spaces* (Vol. 12). Bingley, UK: Emerald Group Publishing Limited.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active Learning increases student performance in science, engineering, and mathematics. *PNAS, 111*(23), 6.

JISC. (2006). Designing Spaces for Effective Learning: A guide to 21st century learning space design (pp. 36). Bristol: JISC.

Koehler, M. J., Mishra, P., Akcaoglu, M., & Rosenberg, J. M. (2013). *The Technological Pedagogical Content Knowledge Framework for Teachers and Teacher Educators*. East Lansing, MI.

Kuuskorpi, M., & C., G. N. (2011). The Future of the Physical Learning Environment: School Facilities that Support the User. *CELE Exchange, Centre for Effective Learning Environments, 11*, 7.

Ling, P., & Fraser, K. (2014). Pedagogies for Next Generation Learning Spaces, Theory, Context, Action. In K. Fraser (Ed.), *The Future of Learning and Teaching in Next Generation Learning Spaces* (Vol. 12, pp. 65-84). Bingley, UK: Emerald Group Publishing Limited.

Marmot, A. (2014). Managing the Campus; Facility Management and Design, the Student Experience and University Effectiveness. In P. Temple (Ed.), *The Physical University: Contours of Space and Place in Higher Education* (pp. 14). London: Routledge.

Mitchell, G., White, B., & Pospisil, R. (2010). Retrofitting University Learning Spaces. In A. L. T. Council (Ed.), (pp. 31): Australian Government Department of Education, Employment and Workplace Relations.

Oblinger, D. G. (2006). *Learning Spaces*. Washington, DC: Educause.

Persichitte, K. A. (2014). AV-IT Infrastructure Guidelines for Higher Education (pp. 143). Fairfax, USA: InfoComm International.

Radcliffe, D. (2008). *A Pedagogy Space Technology Framework for Designing and Evaluating Learning Places.* Paper presented at the Learning Spaces in Higher Education, University of Queensland.

Sparrow, J., & Whitmer, S. (2014). Transforming the Student Experience through Learning Space Design. In K. Fraser (Ed.), *The Future of Learning and Teaching in Next Generation Learning Spaces* (Vol. 12, pp. 299-315). Bingley, UK: Emerald Group Publishing Limited.

Temple, P. (2014). *The Physical University: Contours of Space and Place in Higher Education*. London: Routledge.

White, B., Williams, G., & England, R. (2014). Diverse Pictures of Learning, The Hidden Work of Shaping Next Generation Learning Spaces. In K. Fraser (Ed.), *The Future of Learning and Teaching in Next Generation Learning Spaces* (Vol. 12, pp. 23-46). Bingley, UK: Emerald Group Publishing Limited.

Winkels, B. H. M., & Sprong, G. J. M. (2008). *Onderzoek Bezetting en Benutting*. Delft.

Zanden, A. H. W. v. d. (2013, Mar 4 - 6). *Advanced Teaching with Four Parallel Video Signals.* Paper presented at the 7th International Technology, Education and Development Conference, Valencia, Spain.

Zanden, A. H. W. v. d. (2014). Readability in Classrooms (pp. 12). Delft: Delft University of Technology.

Zanden, A. H. W. v. d. (2015, Mar 2-4). *Transforming Education Spaces to Sustain Pedagogical Change.* Paper presented at the 9th International Technology, Education and Development Conference, Madrid, Spain.