A case study in learning spaces for physical-virtual two-campus interaction

Robin Støckert[1], Alexander Refsum Jensenius[2], Anna Xambó Sedó [3], Øyvind Brandtsegg[4]

[1] Norwegian University of Science and Technology, 7491 Trondheim, robin.stockert@ntnu.no
[2] University of Oslo, 0316 Oslo, P.O. Box 1072 Blindern, a.r.jensenius@imv.uio.no
[3] Norwegian University of Science and Technology, 7491 Trondheim, anna.xambo@ntnu.no
[4] Norwegian University of Science and Technology, 7491 Trondheim, oyvind.brandtsegg@ntnu.no

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ABSTRACT

In this paper we present results from our ongoing project *Student Active Learning in a Two campus Organization* (SALTO). This is funded as part of the Norwegian University of Science and Technology's (NTNU) Teaching Excellence scheme. The initiative consists of a portfolio of development measures, with the purpose of developing innovative approaches to learning, teaching and assessment. The aim of SALTO is to develop pedagogical strategies for the two-campus master's program *Music, Communication and Technology* (MCT). This is a joint program between NTNU and the University of Oslo, with the students being split between the cities of Trondheim and Oslo 500 km apart. The program is built around a shared physical-virtual space - the Portal - with a range of high-quality audiovisual technologies. The SALTO project focuses on how the Portal can be used for all activities in the program, with an emphasis on human-computer interaction, resource sharing and collaboration. This is done by students and teachers exploring educational, methodological, and technological solutions together. As such, the SALTO project uses the Portal as a "living lab", which is constantly evolving and being optimized for student-active learning scenarios. In this paper, we present and discuss three cases from the first year of the project: (1) The MCT Opening Ceremony, (2) A "Christmas concert" between to upper secondary schools in Trondheim and Oslo, (3) An intensive workshop-based course with a mix of preparations, lectures and hands-on exercises. The three cases do in various ways present some of the challenges and possibilities of two-campus teaching.

1. INTRODUCTION

Technology is changing the way we perceive and use space as an arena for learning, teaching and researching. New technologies also enable new modes of interaction, collaboration and communication. Today it is possible to learn anywhere and anytime, using a large variety of technologies and methods. Learning can happen in an ordinary auditorium or in a space consisting of elements from virtual, augmented, cross, cinematic, extended or mixed realities. Such a spectrum of "immersive" technologies encompasses new ways of blending between physical and virtual learning. This again influences the way in which we interact with other learners, and with the machines that enable such interaction.

A recent report shows that higher education institutions in Norway do not use the full potential of new technologies in education (Kunnskapsdepartementet, 2018).The technology may be in place, but the effect of the technology on the learning outcome(Morgan, Morgan, Johansson, & Ruud, 2016) depends on how the digital tools are implemented and used effectively, within the applied pedagogy and learning design. One way to optimize the implementation of technologies in education, may be to create a more comprehensive teaching and learning ecosystem. There is a need for a clear strategy connecting curriculum, pedagogical methods, feedback, learning management systems, and teacher training.

In this paper, we present some lessons learned from using a shared learning space - the Portal - between two universities in Norway. In the next sections, we present the SALTO project, the MCT programme, some theoretical and methodological considerations, and, finally, three scenarios that showcase the potential applications of the Portal.

2. BACKGROUND

2.1 The MCT Programme

The master's programme in *Music, Communication and Technology* (MCT) started up in August 2018. It is an innovative programme in many ways. It is one of the first joint masters programmes in Norway, shared between The University of Oslo (UiO) and The Norwegian University of Science and technology (NTNU). The students are recruited as one group, but with two study places, either in Trondheim or Oslo. Music is at the core of the programme, but the scope is larger. The students are educated as technological humanists, with technical, reflective, and aesthetic skills. This is motivated by the belief that the solutions to tomorrow's societal challenges need to be based on intimate links between technological competence, musical sensibility, humanistic reflection, and a creative sense.

At the core of the programme is the Portal, a physical-virtual space for communication. It consists of a dedicated physical space in each location, equipped with hiqh-quality audiovisual technologies, and a fast internet connection through Norway's research and education network (NREN). The Portal is the primary workspace for the students, in which most of the programme activities take place. The main idea has been to set up and develop the Portal as a seamless, natural, common workspace, even though the students are 500 km apart. At the core of the setup are several low latency AV networking technologies, as well as high quality audio and video solutions in each room.

As shown in Figure 1, the Portal can be seen also as a hub connecting multiple physical rooms on each campus: workspaces, meeting rooms, recording studios and streams of information and controller data (R. Støckert, Jensenius, & Saue, 2017). All the resources are interconnected, which makes it possible to communicate and collaborate on many levels. We have also seen that (the features of) the Portal may also be used together with other partners, both in the public and private sector.

Figure 1 A schematic overview of how the Portal also functions as a hub for connecting other local and partner resources

2.2 The SALTO Project

The SALTO project was set up in parallel to the MCT programme, as a means to both develop pedagogical tools and methods for MCT (and beyond), as well as a way of reflecting on how these tools and methods work in a real-life teaching scenario (https://ntnu.edu/salto). The goal is to create cross-campus common learning spaces that enables:

1. extensive cross-campus collaboration and communication
2. active student participation
3. transferable skills and knowledge for other learning environments

To enable these bullet points, we are currently exploring the use of flipped learning and different types of collaboration (case-, team-, project- and event-based) in the MCT (R. Støckert & Stoica, 2018). Since we focus exclusively on these types of novel learning methods, we are also paying close attention to systematically evaluate and reflect on the experiences. This is important as we continue to overcome cross-campus communication challenges and to improve the learning experience for everyone involved.

3. THEORY

Many factors will influence the planning, construction, use and evaluation of the Portal as a cross-campus learning space. All stakeholders need to be involved in this process, especially the students and teachers, but also the study administration and technical support staff. Working together is important, whether it is on an organizational level, or discussing details such as what chairs and tables to use, air quality, technical infrastructure, AV equipment, or the pedagogical methods to be used. For a novel programme as ours, it is particularly important to ensure that all stakeholders are involved, and that we have a shared language for how to discuss.

The Pedagogy – Space - Technology (PST) framework (Radcliffe, 2008) presented in Figure 2, provides a basis from which to develop design, assess alternative concepts, understand dependencies and relations, and finally evaluate learning environments. The PST framework should be used during the whole lifecycle of the learningspace and be the center of an iterative process for continuous improvement and evaluation. In addition, the framework will give all stakeholders an opportunity to contribute in different stages of the lifecycle and to receive feedback on their actions and the progress of the project.

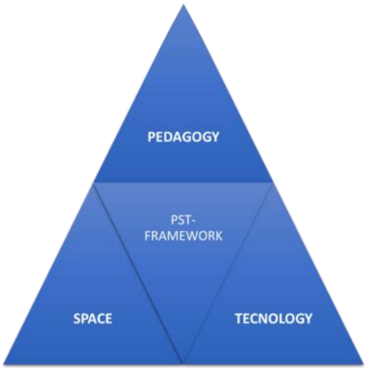

Figure 2 PST-Framework

Figure 3 Lifecycle stages

Figure 3 outlines the different stages or phases to be considered (Germany, 2014; Lee & Tan, 2011). Usually, if a learning space is evaluated at all, it is done after the teacher and students have occupied the room and started to use it. However, the evaluation should start as early as possible, to investigate whether the concept of the learning space aligns with a common understanding of the impact and desired outcome, between all stakeholders. If the common understanding and planned outcome is absent in the Concept phase, the evaluation in the Occupation phase will not be able to measure if goals have been met, and the Adaption and Modification phase have no effect toward reaching the original design outcome (Powell, 2008).

All of these stages therefore need to be anchored at both Universities to clarify if the purpose and desired outcome of the learning space measures up to the overall strategy

(Oblinger & Lippincott, 2006). This strategy should as well include related curriculum design, student active learning and pedagogical approaches, as well as training of teachers and support staff functions. The process needs to be anchored on all levels of the two universities, enabling interdepartmental understanding, cooperation and collaboration. As an extended model of the PST framework (Figure 4), it would be relevant to use the TU Delft Governance model, which includes people and governance (Robin Støckert, Van der Zanden, & Peberdy, 2019)

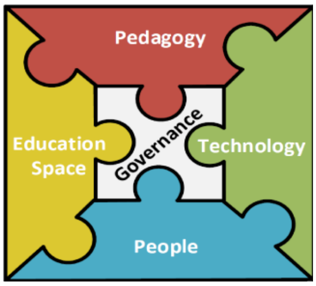

Figure 4 TU Delft Governance model

4. METHODS

4.1. General description of student active learning

The SALTO project has developed effective strategies for cross-campus collaboration learning in the MCT programme. When it comes to group-based learning activities, we mainly focus on three different forms of collaborative learning:

1. Shorter group projects with a duration of one week, aimed as a specialization in subject-specific topics
2. Problem-based learning in the form of semester-long projects with external clients.
3. Operational groups with long-term responsibility for documentation, evaluation and development of the physical, methodological and pedagogical framework conditions for learning, communication and interaction.

The latter function is particularly important for the operational capacity of the Portal, but also as a strategy for sharper reflection on the learning processes. This is, in fact a student-driven educational development project in itself, including hands-on-exercises and a considerably element of technological innovation with the aim of optimizing the environment of the Portal into the optimal learning scenario.

Knowledge transfer in the MCT programme primarily takes place in the form of Flipped Learning. This means that development, storage, and distribution of digital learning materials in various forms, will play an important role in the project, especially initially. Individual learning obtained by working with the premade digital learning material, must be followed up with joint student activities that stimulate engagement and reflection, in the form of discussions, group work and smaller projects. This section requires testing and concretization over time and will vary from subject to topic. Flipped Learning is in any case the preferred model in all theory subjects.

4.2. Learning scenarios

The main components in the Portal learning environment are associated with the SALTO framework to examine their content, interaction, and dependencies. Due to the SALTO project, there is a focus on an infrastructure and technology that enables and enhances. The pedagogical design of the different courses of the master is based on a range of novel pedagogical methods, including: team-based learning (TBL)(Michaelsen, Knight, & Fink, 2004), active learning (Ballen, Wieman, Salehi, Searle, & Zamudio, 2017) and flipped learning (Bergmann & Sams, 2012).The mixture of national and international students with different backgrounds, skills and competences needs to be addressed and is an important reason why the Experts in Team Course, developed by NTNU, is presented to the students at the start of the semester.

Experts in Teams (EiT) is a successful program at NTNU that promotes interdisciplinary teamwork to solve real-world problems. The desired learning outcomes in EiT are strongly focused around the students' ability to become aware, reflect upon, and improve their interdisciplinary group work, dynamics, and processes. The students reflect on how they communicate, plan, make decisions, solve tasks, handle disagreements, and relate to academic, social, and personal differences, and write down their reflections. Through individual and team reflection activities, as well as the application of relevant concepts and fundamental group theory, the student teams can become aware of their group dynamics and learn how to collaborate in interdisciplinary teams by taking actions to improve their teamwork if necessary. This approach is a model for the design of the collaborative activities between interdisciplinary teams in the Portal.

5. SCENARIOS

The following illustrative scenarios represent a sample selection from the first semester of MCT and highlights the issues, challenges and potential in relation to the SALTO project.

5.1. The Opening Ceremony

The Opening Ceremony in August 2018 marked the official «connection» between the two universities, done by Rector Gunnar Bovim (NTNU) and Rector Svein Stølen (UiO). Figure 5.

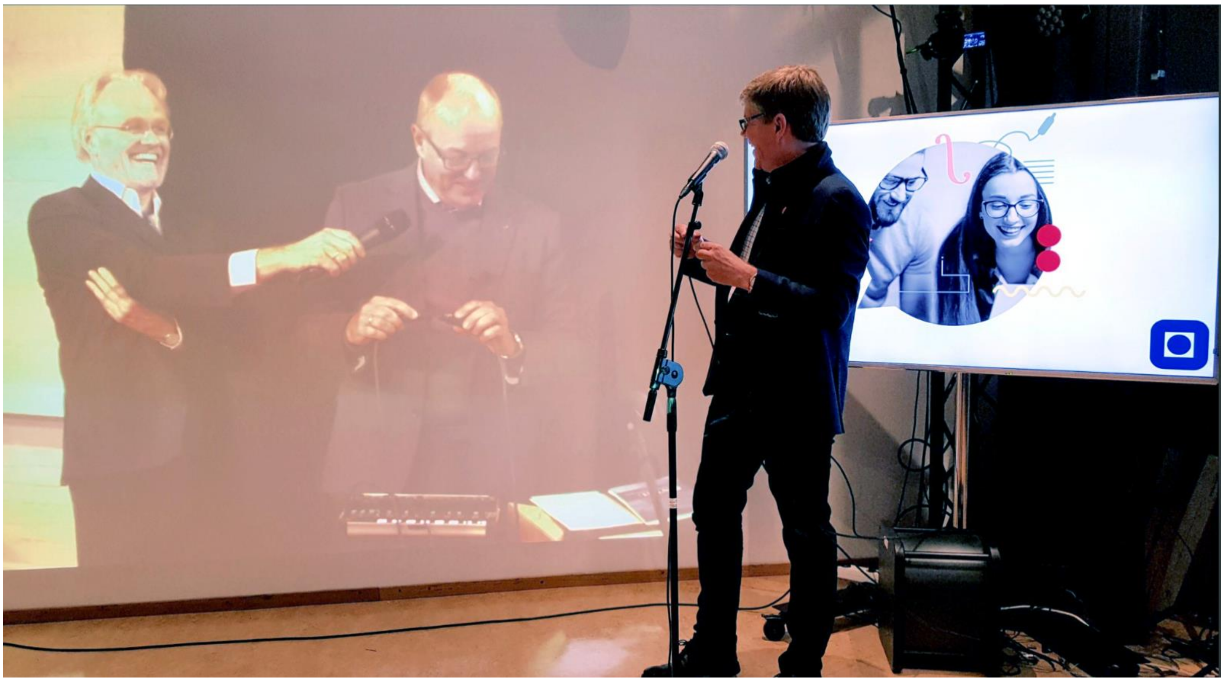

Figure 5 Connecting the Universities. Opening ceremony seen from Oslo.

Since the opening happened a few weeks after the students started, the Opening Ceremony was the first real-life experience of the students working in the MCT Portal. They were involved in setting up equipment and running the event, together with technical personnel and the teachers to create a common arena between the two universities. Several systems were running in parallel, to obtain redundancy and to demonstrate low and high-end communications systems and real-time connection via parametric data-transfer. Several types of interconnected artistic performances were done by teachers and students located in Trondheim and Oslo, to showcase some of the features of the extended Portal functionality. At the second part of the Opening Ceremony a seminar was held with speakers from both locations, using the Portal setup.

Figure 6 Performance: "Stillness under Tension" (UiO-NTNU muscle band)

One part of the opening performance was by students and teachers from both locations, connected live via a sensor system. Figure 6 shows the one of the production screens at NTNU, from the technician viewpoint. Here is a snippet from a blogpost made by the students who performed:

“So, what was this Muscle Band Performance all about? Not all of the members were body builders, we must admit. We were six performers all together, three in Trondheim and three in Oslo. Each one wore a Myo bracelet and created together a 9 minutes long musical composition, by nothing more than standing still and changing the droning sounds with our arm positions. Myo is a bracelet that acts as a sensor and picks up the position and muscle tension of our arms. Charles Martin, Alexander Refsum Jensenius and Jim Torresen

(a research intersection of informatics and musicology) developed a method that would allow converting muscle tension and orientation of the bracelets into different sounds by wirelessly connecting them with Bela, a small computer running the program and generating the sound. Each of us wore an armband at one of our arms, and to say it simply, these bracelets were our instruments. To make any sound at all we had to stand as still as we could. Then we could modify the timbre of the sound by gently flexing our arm muscles. The whole scenario must have looked and sounded like it was taken right out of a science fiction movie! "

Another part of the opening performances consisted of a virtual instrument spanning the two connected sites. The performance was done by Øyvind Brandtsegg and Bernt Isak Wærstad, and the musicians had significant earlier experience of improvising together in the same room with conventional instruments. This allowed an experimental approach where the design of the instrument and the development of the performance was tightly integrated, and custom fitted for the particular qualities of performing in the Portal. The instrument was implemented as a physical model of a vibrating string, with situation-specific modifications to the well-known Karplus-Strong model.(Karplus & Strong, 1983). The modifications consisted of extending the virtual string across the portal boundary, so that a performer in each location could inject energy into the same string. In effect, this created a one-string instrument with two performers, where the performers were spaced 500 km apart. Each performer could modify the parameters for his part of the string, also effecting changes in pitch and filter characteristics for the other performer due to the connectedness of the physical model. Adaptive methods for control of the round-trip feedback were implemented to ensure a large degree of performative freedom with a reduced risk of exponential growth (which would lead to signal overload and very unpleasant sounds). This performative experiment was experienced as high degree of interdependency between the performers. Any action on one part of the instrument would significantly change the affordances and features available to the other performer. This being combined with the physical distance created a pronounced experience of *closeness over distance*. Figure 7.

Figure 7 Performance by Øyvind Brandtsegg and Bernt Isak Wærstad seen from UiO

5.2. Christmas Concert

Most of the MCT activities are happening in the Portal, but to prepare students for working in the "real world", we have also developed a portable Portal-concept that can be used in other venues. In December 2018, we organized a network performance between our two partner schools, Trondheim Katedralskole and Edvard Munch Upper Secondary School.

Here we brought one of our network systems (LOLA) to the schools, and the MCT students were responsible for the technical setup, running of the concert, and documentation of the event. As expected, working in a new environment led to many unexpected problems for the students. This included issues with getting the network to properly, for which they had to contact the internet service providers to find a solution. It also included thinking about all the equipment that is necessary to bring for such an external event, to avoid many trips back to the home base in the Portal at the universities.

The students also got to experience the time-pressure of getting everything ready for the final performance between the two schools. In an overall perspective, it was very successful[1].

At times the preparations were stressful and chaotic, but the students experienced working through all the issues at hand and succeeding in delivering a concert experience that exceeded their expectations. Figure 6. The pupils participating in the performance from each side where also thrilled by the possibilities of playing together. It turned out that in Trondheim they only had one jazz pupil at the time, so he did not have any regular band to play with. For him the Christmas Concert allowed for playing together with other jazz musicians, something he would not otherwise have been able to accomplish at school.

The quality of the setup allowed for a very authentic concert experience. We managed to achieve a very low latency between the two schools in the end, so the musicians commented that they managed to adjust easily after a few minutes. Our focus was primarily on getting the network connectivity to work properly, and good sound. For a next iteration we will also work more on getting a better visual display on both sides. This is important for both the audiences on each side, but also for the visual communication between musicians during the concert.

5.3. A cross-university hands-on course

We present here one of the MCT courses that exemplifies the combination of lectures and hands-on activities, the MCT4048 Audio Programming course. The aim of the course is to provide a solid foundation in digital signal processing and audio-based application development. The lectures provide an overview of the fundamental concepts of audio programming. The hands-on workshops are based on building web applications based on web audio technologies, both individually and in team. The evaluation of the course is based on the daily activity and two mini-projects that incorporate the theory and practice learned over the course. During the first week, the students develop an individual mini-project, whilst in the second week, the students develop a group mini-project. The MCT students have a student-led blog (https://mct-master.github.io) related to MCT's master program. As part of the assessment, they publish blog posts related to the projects developed by the students.

The benefits of teaching courses in the portal is that the ecosystem supports team-based learning and a cross-campus experience. The students can form cross-disciplinary and cross-campus teams based on project interests and not limited to their locations. Supporting different levels of communication (from lectures to demos and performances) is a key element for a successful class of these characteristics.

As challenges, we still need an instructor for each site that supports the on-site learning experience, even more if it implies the development of technical skills. Another challenge is to satisfy both beginners and experts in programming, which is irrespective of the portal. However, the emphasis of team-based learning in the master's curriculum should be helpful to see the different students' backgrounds as beneficial and not a hindrance. Another observation is that the portal technologies are still under development, and so it is unavoidable to keep trying different setups in parallel to teaching, as part of the ongoing research of this new ecosystem.

This aligns with previous results from other courses and workshops held in the Portal(Xambo, Saue, Jensenius, Støckert, & Brandtsegg, n.d.). Reflection is an important aspect of this master's curriculum, which should include the students' and teachers' experience from the perspective of communication, and as part of the SALTO framework. We thus need to formalize feedback channels from students and teachers across the different courses to be able to reflect and improve the next iteration of the courses and master's edition.

6. DISCUSSION

From the three case studies, we identified the following main issues: 1) Network, 2) Audiovisual quality, 3) Seamless experience and consistency

[1] Video documentation: https://mct-master.github.io/portal/2018/12/02/LOLA-vgs.html

Many issues are a combination of several elements and this will be elaborated after the listing of the major issues.

Network: In all three user cases network issues are appearing on two levels:

- Sending and receiving location
- Public network(internet)

There is a need for technical assistance locally, to get a network connection in/out on public network.

There is no control on the public network regarding stability, latency, packet loss, bandwidth etc.

Audiovisual quality: Local conditions, type and quality of equipment, communication method.

- Local conditions: Acoustics, lights, placement of equipment, furniture and people.
- Image quality factors: resolution, size, latency, light output.
- Audio quality factors: Levels, latency, speech intelligibility, automation and Echo cancelling.
- Standard communication: High compression, automated, long latency, low/medium quality.
- High end communication: No compression, low latency, high quality, manual configuration.

There is a no default template for a technical setup and related experienced quality, which is valid for a random space.

Seamless experience: Real-time, real-size , physical/virtual distance, consistency.

- Audiovisual communication over networks is not real-time. Processing of signals and transport of signals introduce artifacts and latency and creates a "distance" between sender and receiver.
- There is no natural 1:1 proportion of spaces and people participating, due to camera view and size of display-surfaces/shared workspace surfaces.
- Showing/sharing/working on material through a common virtual workspace, needs to be configured for each learning activity. No natural/seamless transition between tasks.
- Working on complex a group task (elements of electronics, programming, interfaces) between locations, requires a skilled facilitator to be physically present in each connected location, in order to deliver the same experience/support to all participants.

The observed issues are creating barriers for a continuous/seamless/natural experience and workflow in and between connected locations.

In addition to these obvious factors, there are many more factors and interdependencies that need to be defined and taken into consideration. A multidimensional matrix with elements ranging from technical equipment, pedagogical methods, price, time, performance, evaluations, experience, operability, flexibility, space, placement, scalability, acoustics, lights, air-quality usability, infrastructure, feelings, people and learning outcome.

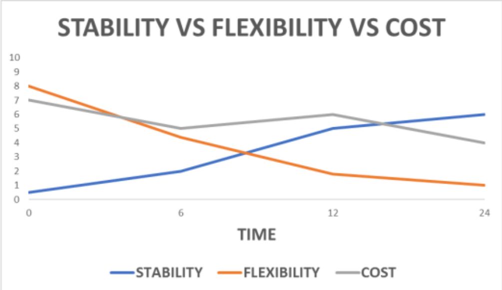

Figure 8 Stability, flexibility and cost

To illustrate one of the correlations, we can simulate a process. Figure 8: First we invest in a variety of equipment and try out many setups manually, using a lot of time and money. Then the best setups are locked down and we invest in a control system to select between these setups. Creating a solution that is more stable, easier to use and maintain. We spend less time on troubleshooting and saves time and money. Some question to consider amongst the stakeholder in this process might be: When should we stop experimenting with flexible solutions? When is the time to invest in a stabile solution and what is the cost over time? Who is taking these decisions, based on what?

All the factors mentioned needs to be considered and the major task is to process this multidimensional matrix and reorganize the intervening and mutually dependent elements, in order to create common areas/bubbles of "gravity", which define our different learning scenarios. Where are the optimal solutions and combos to achieve our goals? In many ways we are back to the PST-Framework, with a lot of new factors to be taken into consideration, in the process of developing a cross-campus learning environment.

Based on this process, we can define the basic requirements, building blocks and applied pedagogy for each type of learning scenario, ranging from a high-quality real-time concert to a video-chat using a mobile phone. What is good enough, for each of the learning scenarios? This is a continuous process during the lifecycle of a learning space/scenario and requires a research-based approach with all stakeholders.

Future work and opportunities

Space: The major learning scenarios in the Portal need to be clearly defined. Technical templates and "room presets" must be adapted to and documented, for each learning activity/scenario. The Portal is flexible and is like a theatre black box, which can be adapted to different "scenes" and activities, so it is up to the students and teachers to take the stage.

Technology: There is a need for a technical overarching model for handling future service and transporting audiovisual and parametric data on networks from University to University via UNINETT or other suppliers. We need to address and allocate resources outside the SALTO organization in order to make this a stable and adequate "connection", with routines for assistance, reconfiguration monitoring and measurements. We are now in the process of creating a meeting arena, in order to do a synchronized effort to develop the next level of networked infrastructure, with SALTO and the Portal as a user case and sandbox. A Portal technician is needed at each location to facilitate users and do technical setups and maintenance.

Pedagogy: Involve the students more as a resource in research-based development and evaluation of student active learning. Optimize learning scenarios to be a part of a larger scalable eco-system of resources for student activity. Train teachers to work in teams and to develop concepts, material and solutions for student active learning.

Expected results: Delivering impact, scalability and transfer value from SALTO, regarding student active learning, might be difficult according to research presented at seminar arranged by Statsbygg and Ministry of Education and Research ('New learning arenas in existing and new buildings for education', 2019). Based on two systematic reviews, three categories were identified as barriers, which prevents student active learning: Institutional inertia, The quality of courses for teachers and finally academic leadership. (Lillejord, Børte, Nesje, & Ruud, 2017, 2018).

7. CONCLUSION

In this paper we have presented examples of how student active learning can be done cross-campus. The examples illustrate a variety of activities, possibilities and barriers for cross-campus collaboration. There are many technical, pedagogical and administrative challenges ahead, but we hope that the SALTO project can be a step stone in the transition to active learning spaces in higher education, whether the space is a physical room, cross-campus or virtual.

At this stage the SALTO project brings valuable experience into the design of a learning-space, which facilitate active learning and the required use of technology and pedagogy in a cross-location setting. SALTO results may be used in the future design of blended learning and media-rich platforms for interaction, real-time collaboration and communication.

Connecting all stakeholders in the transition towards the development of new eco-system for learning, is a necessity to obtain more engaging and personal experiences for learners in order to equip them with the 21st skills, competences and character qualities needed to thrive in the society and their future jobs.

A step in the right direction is for the academic leadership to understand that a transition to more student active learning scenarios presupposes that teaching, as well as research, is perceived as teamwork with allocated resources, support, related physical and technical infrastructure. A collaborative effort on many levels, anchored with the institutional and national leadership.

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9. AUTHORS' BIOGRAPHIES

Robin Støckert

Is an Audio-Visual expert and have more than 35 years of experience in design and creation of arenas for interaction, experimentation, collaboration and communication. Has been engaged in several EU-projects with design, construction and use of future learning spaces and interactive tools in higher education. He is the designer of the Portal at NTNU and the project manager of SALTO. Member of AES, AVIXIA and Flexspace.

https://www.ntnu.edu/employees/robin.stockert

Alexander Refsum Jensenius

is a music researcher and research musician. His research focuses on why music makes us move, which he explores through empirical studies using different types of motion sensing technologies. He also uses the analytic knowledge and tools in the creation of new music, with both traditional and very untraditional instruments. As chair of the NIME steering committee, he is a leading figure in the international computer music community. He co-directs RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion, an interdisciplinary centre of excellence at the University of Oslo. As a member of the Young Academy of Norway and the EUA Open Science Committee, he is also involved in pushing for modernizing the way research is conceived and conducted

http://people.uio.no/alexanje/

Anna Xambó

is a researcher and an experimental electronic music producer. Her research focuses on interactive real-time systems for music looking at live coding and generative computer music, collaborative and participatory interfaces, multichannel spatialization and real-time MIR. She is an associate professor in music technology at NTNU, a visiting lecturer at the Centre for Digital Music, Queen Mary University of London, and co-founder and chair of Women Nordic Music Tech (WoNoMute).

https://www.ntnu.edu/employees/anna.xambo.sedo

Øyvind Brandtsegg

is a composer and performer working in the fields of crossadaptive performance, algorithmic improvisation and sound installations. He also produces software for audio processing and performance, e.g. *ImproSculpt*, *Hadron Particle Synthesizer*, *Partikkel* and *Featexmod*. He is a Professor in music technology at NTNU. As musician and composer, he has collaborated with a number of excellent artists, e.g. Motorpsycho, Maja Ratkje, and he runs the ensemble Trondheim EMP. The latest release with Trondheim EMP is "Poke it With a Stick" / "Joining the Bots" on the Crónica label in March 2019.

https://innsida.ntnu.no/person/oyvinbra

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