Creating Smart Connected Learning Ecosystems: A Hybrid Model for Design-Based Learning

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Abstract. Emerging technologies and new pedagogies, such as design-based learning, have the potential to revolutionize formal education systems. We postulate that smart learning ecosystems can be co-created through connecting schools and students across the globe to co-design their own virtual learning spaces by exploiting new affordances offered by digital technologies. This paper presents a Hybrid model for Design-Based learning (HyDe), which guides co-located and online design-based learning activities with geographically distributed students. It was conceptualized within a case study, wherein 63 students aged 11 to 13 from three schools in Namibia, Malaysia, and Finland collaborated on co-designing a virtual space to share local perspectives on global challenges. The HyDe model was refined based on reflections from the case study yielding in a model which can be integrated in school curricula across the globe, thereby creating a smart connected learning ecosystem.

Keywords: co-design, children, Finland, Namibia, Malaysia, remote interactions, distributed co-design, design-based learning

1   Introduction

In the past decade the formal education system has undergone much change, with a shift towards new pedagogical approaches, such as project-based, problem-based, and design-based learning in classroom settings, whilst additionally considering social-emotional aspects of schooling more. While, concurrently and seemingly independent, educational technology development prioritized individual learning with an emphasis on academic performance enhancement and management. Emerging technologies, such as mixed reality, life streaming and collaborative virtual learning systems, offer many opportunities to contribute to smart learning, which promotes agentic and social engagement in a connected space with access to resources globally. However rapid

adoptions of existing technologies should be viewed critically as their design is usually not driven by pedagogical theories and practices [1], with a lack of theorisation in the field of educational technology often being highlighted as a critical shortcoming [2]. Furthermore, appropriate organizational communication and collaboration tools were not specifically designed for children nor educational contexts, therefore they do not adequately support creative communication and collaborative learning for children across the globe [3].

Thus, we maintain that it is necessary to develop technologies and techniques that embrace new pedagogical paradigms and most importantly students' agentic engagement in the design of their own online learning environments. Online technologies create the possibility for new connections, sharing ideas, co-creating new understandings, and enabling learning in interconnected situations when learners are geographically distributed [4]. Learners' active engagement in collaborative knowledge, skill, and attitude construction and distribution can be facilitated by online technologies, providing opportunities to connect and expand local learning ecologies across the globe. Despite the potential, very few have engaged children from distant geographical places in the co-design of learning environments and technologies [5]. We postulate that smart learning ecosystems can be co-created through connecting schools and students across the globe to co-design their own virtual learning spaces by exploiting new affordances of digital technologies. This notion has driven our work, with which we aim to research and collaboratively develop smart learning environments that globally connect students to support their educational endeavours. We thus focus on promoting collaboration, creative communication, and learning, among students from various countries. Our contribution is twofold, we provide empirically based techniques for on-line and hybrid co-design with children, while we expand the field of smart learning with a practical model guiding distributed on-line learning.

In this paper, we present a design-based case study, in which students from three schools in different continents connected to design their own platform to discuss globally relevant topics. We developed a Hybrid Design-Based Learning Model (HyDe), which supports students in different physical locations to design their learning environments and technologies together by mixing co-located and online activities. In the following sections, we present related work, our research context, and the HyDe Model which guided our case study. We describe the design-based learning sessions focusing on facilitation, methods and tools. Our learnings are reflected in the refined HyDe model on which we elaborate in detail.

2   Related Work

2.1   Smart Learning Ecosystems

Smart learning ecosystems offer new perspectives and approaches to education [6]. In smart learning ecosystems the focus is not only on technology but on the collaboration of participants [7]. Technologies on their part can mediate and facilitate the connectivity in relationships, and expand learning environments beyond physical places [8]. These learning environments enable new kinds of learning, providing easy access to learning

resources and enhancing interactions at any time and anywhere [9]. Thus simply taking a new technology does not make the learning environment smart - including innovative features and ability to improve understanding and performance is part of it [10]. Adaptation of web-based technologies and tools can create new opportunities for learning environments that want to enable distributed collaboration and global learning experiences [11]. Furthermore, online education can be beneficial for sharing opinions and discussions in geographically distributed interactions [12]. Learners and communities need to be supported by the future school to be able to act globally solving problems together [13]. A smart learning ecosystem can be a means to enable such learning processes by its character of removing or lowering e.g. technical and organisational barriers [14].

2.2 Design-Based Learning

Design-based learning (DBL) is gaining traction as an approach to equip children with 21st century skills [15]. DBL is an inquiry based educational approach [16] in which learning and knowledge construction occurs in active individual and team processes, and in which all stakeholders are empowered [17]. Design Thinking on its part can serve as a link between these pedagogies and the actual work in schools [18]. In their Design Thinking model, Thoring and Mueller [19] suggest a flexible sequence of process steps and iteration loops: (1) Understanding: gathering information about the topic (2) Observing: different insights are collected about learner's problems. (3) Point of view: the insights are synthesized into a problem statement and micro theory; (4) Ideation: generating ideas to solve the problem, (5) Prototyping: the ideas are visualized and further developed; (6) Testing: the prototype is taken to the users to gather feedback which can be used to iterate the prototype or to improve the concept. The collaborative nature of design [20] necessitates that actors work together towards a shared design goal. According to Lahti et. al. [21] in collaborative design participants actively work and communicate together deciding design goals, gather insights about the problems and synthesize the problem statement, work out design restrictions, and construct a design solution. Dillenbourg [22] distinguishes three criteria for collaboration, namely interactivity, synchronicity and negotiability. Implementations of design-based learning in school have been presented for instance by [23] in a game-design-based learning project and [20] in the context of curricula and design and technology. [24] have introduced a Reflective Design-based Learning (RDBL) framework with six dimensions summarizing the web of stakeholders and criteria for design-based learning in the classroom: Design process, collaborative learning and reflection process, design brief, digital learning environment, teacher and child role, and learning goals.

2.3 Distributed Co-Designing with Children

Co-design is a technique or tool to enable people not trained in design to participate in the development process together with designers [25]. Co-designing with children pays particular attention to ensure a genuine participation, by overcoming adult-child power

relations, recognising children as protagonists and the selection of empowering co-design techniques and methods to promote shared decision-making [26]. From 2012 to 2016, Walsh et al. [27-29] focused on the development of tools to support distributed online co-design. Although an established repertoire of co-design approaches in co-located contexts exists, authors [3, 30-32] who recently engaged in on-line co-design activities have realised the need for new tools, techniques and methods. [32] revealed that in a design setting with geographically distributed groups the challenges to address are manifold such as varying language competencies, online group interactions and communication, facilitation techniques, suitable tools and technologies, as well as decision-making strategies in inclusive design collaborations. Considering the unpredictability of online design sessions, Lee et al. [30], adopted improvisation theory and the five key features of improvisation in HCI - reflexivity, transgression, tension, listening and interdependence [33], in conducting synchronous online codesign with children. In their conceptual model Lee et al. [30] present three themes that influence each other throughout the sessions: (1) Project Logistics (the properties of the co-design session that influence which design techniques and digital tools are used), (2) People and Setting (the external factors that exist in the multiple locations of the participants such as technology infrastructure, location changes, spectators) and (3) People's Co-design Interactions (the specific engagements that occur when adults and children meet synchronously online). The model focuses solely on online sessions which can only accommodate a limited number of children considering necessary facilitation efforts. Thus Constantin et al. [3] highlighted the need of developing innovative methods and tools, defining participant roles, and giving strategies for hybrid design models.

3   Research Context

3.1   Collaboration Partners

This study was conducted by an inter-disciplinary team of computer science and educational psychology researchers and students from four Universities situated in Germany, Namibia, Malaysia, and Finland, in partnership with three local schools (convenience sampling). The Namibian public primary school is attended by approximately 1600 students from mostly low income households, with English as language of instruction. The school has collaborated on research projects with a local university since 2017 and is equipped with a high end teleconferencing system as well as a computer lab. The school in Malaysia is a private international school, teaching 280 students using English as an instructional language. The Finnish primary school accommodates 280 students. The language of instruction is Finnish. The school has a partnership with the local University working on innovative technology-enabled learning ecologies such as Remote Presence and Virtual Reality and is therefore well equipped with technologies.

3.2   Research Aims

The overarching aim of the collaboration project is to create enabling distributed hybrid learning and co-design spaces to connect (primary) school students around the globe,

in other words, to create smart connected design-based learning ecosystems. The objectives are to develop technologies, techniques, methods and models framed in pedagogical and design-based theories grounded in empirical co-design work with students from different continents.

The aim of the research presented in this paper was to develop a hybrid model for design-based learning grounded in the empirical study conducted. The objective was to bring students from different continents together to co-design a digital platform to promote design-based learning, with the emphasis on sharing local perspectives on global challenges. The students agreed to delve into the topic of Cyberbullying as a sample application of design-based learning, including the design of features needed to communicate the topic effectively between geographically distributed student groups.

3.3 Research Approach

The research follows a design-based research (DBR) methodology with a case study as a central element to produce new knowledge [34]. Following an exploratory approach, we have conducted a distributed online co-design case study with 63 primary school students from Namibia, Finland and Malaysia over a period of 3 months. The research consisted of three phases, namely (1) the preparation, where the research topic was defined, academic papers were consulted, the model planned, and the co-design case study organized around it; (2) the conducting of the case study, where the model-based process was adopted in sessions; (3) the adaptation and refinement of the model, following our experience of going through the process. An important part for the research was the recording of the sessions, which allowed for an accurate description of the process, including planned activities and unforeseen challenges. Students completed reflection diaries and participated in focus group discussions, however these were not central to the creation of the model. Major contributions to the HyDe model came from facilitators field notes and observations, which were shared and comprehensively discussed in reflective debriefing meetings held after each session. These meetings helped shape the HyDe model in terms of process integration and organization.

3.4 Case Study Design

Participants. The following participants were part of the study on a voluntary basis: (1) Six researchers with one Senior Academic and one PhD student from each of the three Universities in the field of Human-computer Interaction/Educational Technology/Interaction Design and one Educational psychologist from the other University. (2) Four undergraduate computer science students from Malaysia and one from Finland. (3) One teacher from each school: The Malaysian teacher was mainly involved in the co-located sessions, while the teacher from Namibia was involved in all sessions, including the planning and reflection meetings. The Finnish teacher is at the same time a doctoral student researcher on the team. (4) Local group representatives (LGRs) which were one boy and one girl from grade 5 to 7 were selected by their respective teachers in Namibia, Malaysia and Finland to participate in the online

sessions. The students were selected on a voluntary basis. (5) Local classmates formed the co-located group in each country consisting of 14-24 students, aged between 11 and 13, from grades 5 to 7. In Namibia, the 24 students were all part of a weekly extra-curricular tech design programme for which they had signed up at the beginning of the school year. In Finland, the 16 students were selected on a voluntary basis by their classroom teachers from two parallel classes based on their interest in computing, games, and working online. In Malaysia the 23 students formed one class that participated. The students from Malaysia and Finland were well acquainted with online communication tools, such as Skype. The selected Namibian students only recently received their first computer literacy class. Parental/legal guardians informed consent was obtained for all participating students.
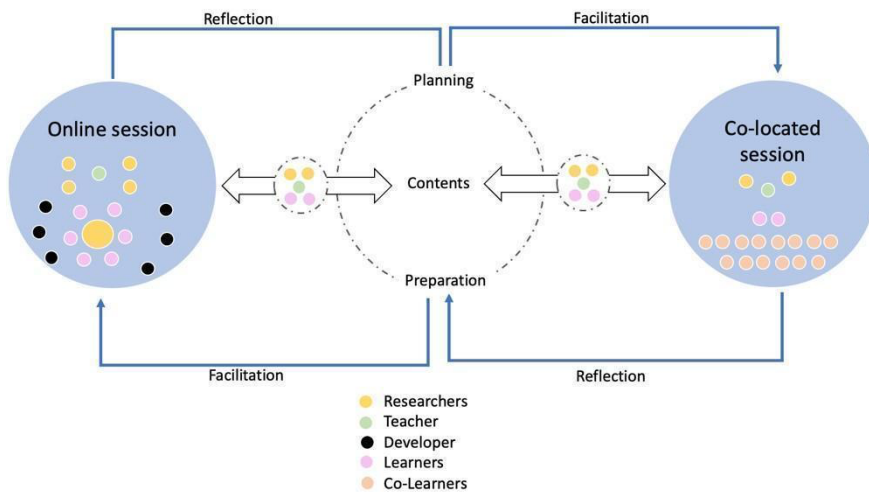

Fig. 1. Study design process

The Process. The study was designed to run through a sequence of cycles (see figure 1).

(1)   Reflection and Planning Weekly 1-2 hours Skype meetings were held, defining the purpose of the next session, techniques and tools to be used, preparations needed and roles determined. After each session the research team reflected on observations and instructed undergraduate students in terms of prototype development.

(2)   Co-located sessions were held in each country: In Finland they were conducted in the school lessons lasting an hour. Due to the COVID-19, the Malaysian schools were closed so the co-located sessions were online using the Zoom platform during the students' usual weekly class time for an hour. In Namibia the sessions were after school lasting two hours. The co-located sessions started with a short briefing of the topic or tasks done in the online sessions followed by mostly the same icebreaker as in the online session and the planned activity.

(3)   Online sessions were 75 minutes long and facilitated by the educational psychologist as the main facilitator. The two LGRs from each country were seated next to each other using only one login. Each online session started with a session related icebreaker to prepare the students for the activities to come. The students then presented the outcomes from their respective co-located groups. The main activity of the session was conducted. In the end of the session there was a short summary of the activities and the results of them as well as tasks for the students to do in the colocated sessions. Breaks and sometimes snack times were also used to keep up the pace and flow in the sessions. In the absence of available technologies that support distributed design-based learning activities with children, we opted to use Skype, Microsoft Whiteboard, PowerPoint, Jamboard and Miro for the sessions.

4   Design-Based Learning Sessions

The eleven DBL sessions were held from March to May 2021, with six being online, four being co-located, and one final online session in which all participants were together. The process was based on the application of the HyDe Model and its underlying framework integrating Design Thinking (see Table 1).

4.1   Session 1 Online: Project Brief and Agreement on Topic

To begin the students got acquainted with each other through a round of Pictionary using Jamboard, which also served as technical training for future sessions. The students were told the aim of the study, and were given a choice of three topics that had global significance (i.e., the pandemic, climate change, and cyberbullying). After arguing their cases in a discussion supported by the main facilitator, the students agreed on cyberbullying. Some students eloquently expressed themselves and others simply agreed. Lastly, the main facilitator explained the project process, i.e., of online and co-located sessions, and the role of the LGRs.

Reflecting on the session, we realized that the students relied heavily on their local facilitators for technical assistance but also for additional explanations, feedback, and encouragement to express their opinions. The local facilitators struggled to address both the co-located and online students simultaneously. Technical challenges included limited internet connection, poor sound quality, and undicernable audio/visuals due to camera sharing and masks.

4.2   Session 2 Co-Located: Local Understanding of Cyberbullying

Prior to the session local facilitators discussed the given task and possible strategies with the two LGRs. The facilitators were to observe and support if needed, while the LGR's role was to facilitate the session by themselves; they were to report back on the online session, get their fellow students interested in the topic, and collect local understanding and concerns about cyberbullying utilizing their own strategies and techniques. Produced texts and drawings were uploaded on Jamboard for sharing in the online session. In Finland, the LGRs took turns explaining the online session and

cyberbullying, and continued by asking what the others knew or thought about it. The two LGRs actively encouraged the others to share their opinions and summarized the lively conversation. They also handed out paper and pencils for each student to write down their thoughts. In the Namibian group all students sat in a circle, and the two LGRs hesitantly and with continuous encouragement from the facilitators described the online session and then prompted questions about the topic. Although many of the students voluntarily spoke up, it became clear that they did not understand the topic. Thereafter the two students asked the others to produce a drawing or text on what was discussed. The Malaysian session was held in Zoom and began with the formal introduction of the facilitators. One of the LGRs presented a summary of the online session including the process of how and why cyberbullying was selected. The students were asked about their thoughts either verbally or via chat box, with the latter being the only method chosen.

The local facilitators observed that the Namibian LGRs were overwhelmed in terms of their understanding of cyberbullying as well as their facilitation abilities. The Finnish LGR were at ease as they are used to this kind of working and being in charge of a group. The Malaysian LGRs were confronted with technical glitches yet well prepared. Overall the produced materials were meaningful.

4.3   Session 3 Online: Online Communication Challenges

After an introduction to the topic of communication challenges the LGRs reported back on the co-located session and the outputs displayed on Jamboard. Jointly they identified communication challenges in the co-located and previous online session. The main facilitator shared her experience with communication cards used in online meetings. To introduce the students to a design thinking approach two sample challenges were chosen and the students were given the task to design a card expressing: "I can't hear you" and "I want to say something". The planning and drawing were done jointly on Jamboard using tablets or a big screen with a pen. The students were drawing in parallel on their own ideas within the given frame of a card. The main facilitator discussed the design ideas with the group leading them to come to an agreement on the final joint design of the card.

Reflecting on the session, we found that communication challenges remained, with assistance required from the local facilitators, leading to co-located side conversations. Moreover, some students preferred not to talk but rather type in the chat box which led to multi-modal communications. The students were not used to working on a shared online space where they should have discussed and drawn together rather than produce individual suggestions only. One of the students did not understand that the Jamboard page was shared with all and deleted the others' work by accident. It was decided that one facilitator, not co-located with any of the students, should become the main facilitator in subsequent sessions. The main facilitator had an individual video stream, and did not wear a mask. According to the students, the main facilitator was easier to see on the screen, had a clear voice, her accent was easy to understand, and she talked straight to them. The local facilitators were to continue to support with technical issues. While some students were still overwhelmed with the technology and tasks, others

complained about the slow pace and the length of the sessions. It was decided to shorten the sessions to 75 minutes, develop a strict structure and schedule (with more breaks), which would be communicated at the beginning of the session. Of concern remained the lack of suitable technology for students to communicate via multi-modal methods to cater for personal preferences and without creating a cognitive overload.

Table 1. Design-Based Learning Sessions

	Goal	How-to	Input	Output
Understand	**1. Session Online: Project brief and agreement of the topic** Pictionary Icebreaker, Introductions, Project briefing, selection of topic			
	Understanding of the problem area, topic, and project goal	**Facilitation:** turn taking local & main facilitators **Tools:** Skype and Jamboard **Methods:** group discussion and topic negotiation	3 topics suggestions	Agreement on topic: Cyberbullying
	2. Session Co-located: Local Understandings of Cyberbullying Local representatives brief the collocated groups, open discussion, groups expressions			
	Collect local understanding about the topic	**Facilitation:** local group representatives (LGRs) **Tools:** writing, drawing material, online comm. **Methods:** group discussion, group, & individual work	Briefing by the LGRs	Drawings, write ups and chat screenshot
Observe	**3. Session Online: Online Communication Challenges** Body Communication Icebreaker, Feedback from collocated groups, Communication Cards Design			
	Gather insights about online communication challenges and needs	**Facilitation:** main facilitator **Tools:** Skype, Jamboard **Methods:** group interview, individual drawing in shared online space	Sample challenges & communication cards	Communication cards, documented in Jamboard
	4. Session Co-located: Online Communication Challenges Body Communication Icebreaker, Feedback from online group, Communication Cards Design			
	Identify communications challenges and design communication items	**Facilitation:** LGRs assisted by the local facilitators **Tools:** writing and drawing **Methods:** group discussion, individual and group cards creation, selection	Sample communication cards	Communication cards, (Jamboard and printed)
Point of View	**5. Session Online: Pair-communication on Cyberbullying** Simon says Ice breaker, pair-communication			
	Observe how the students communicate online about the topic and identify challenges and needs	**Facilitation:** technical facilitation **Tools:** Skype **Methods:** familiarise with each other's communication cards. LGRs were paired: 2 pairs had structured and one pair free conversation (2 rounds)	6 comm. cards (session 6) students' own prepared material	Recorded conversations
	6. Session Co-located: Cyberbullying prevention material production Simon says ice breaker, group work			
	Produce local cyber-bullying materials for sharing globally	**Facilitation:** LGRs assisted by the local facilitators **Tools:** Tablets, pre-printed icons, cameras, writing and drawing materials **Methods:** Group and individual work	Cyberbullying examples	Audio-visual material (videos, drawing & text)
Ideation	**7. Session Online: Communication Scenarios Work** Feelings exercise with emoji, Working on Problem Scenarios			
	Generate and structure ideas to solve identified communication challenges	**Facilitation:** main facilitator **Tools:** Skype, Miro **Methods:** Brainstorming, Grouping of ideas in scenario steps	Scenarios & toolbox on Miro	Students' ideas presented in scenario
	8. Session Co-located: Communication Scenarios Work Online groups brief the collocated groups, Working on Problem Scenarios in subgroups			
	Generate and structure ideas to solve identified communication challenges	**Facilitation:** LGR assisted by the local facilitators **Tools:** Skype, Miro **Methods:** Brainstorming, Grouping of ideas in scenario steps	Scenarios & toolbox on Miro	Students' ideas presented in scenario
Prototype	**9. Session Online: Working on Prototype** Charades Icebreaker, Deciding the prototype features online with the developers			
	Prototype the communication platform features	**Facilitation:** main facilitator **Tools:** Skype, Miro **Methods:** Joint prototyping in shared online space	User interface feature (photos buttons etc)	User interface prototype
Test	**10. Session Online: Prototype Testing and Feedback** Creativity Task Icebreaker, Prototype testing and feature design			
	Gather feedback from children about prototype developed by the developers	**Facilitation:** main facilitator and developers **Tools:** Skype, PowerPoint **Methods:** Scenario based PowerPoints presentation and live change request incorporating	Prototype	Modified prototype
Prototype	**11. Session Online: Project Closure with all Participants** Rhythmic icebreaker, Group and prototype presentations, Dancing and Ending of the project			
	Present the project's product and gather feedback from children about proto-type	**Facilitation:** main facilitator, developers, and local facilitators **Tools:** Skype **Methods:** presentations and feedback	Prototype Students' cyberbullying materials (session 6)	Documentation of the session and feedback

4.4   Session 4 Co-Located: Online Communication Challenges

The LGRs were tasked to produce three communication items with their co-located group, one being prescribed and two of their choice. They were reminded that it does not need to be a card but could also be an object, action or something else. The items were uploaded for sharing in the next online session (see figure 2). The Finnish students reported on the online session and the design task. They asked for ideas, mentioning that they could also use other means than writing or drawing. After a short negotiation the whole group decided the easiest way would be to create cards. The class was divided into two groups, each led by one LGR. In the Namibian group the LGRs described what was done in the online session and then played an icebreaker with the co-located group. They then asked everybody to make a suggestion for communicating "Can you repeat your question?", upon which each student drew or wrote something on paper. All suggestions were collected. A debate arose on how to select the one they would like to present. A voting system was created on the spot and one drawing selected. Then the group decided what to communicate on the other two cards. The group was split into individuals drawing one or the other. Then the individuals from one group selected the best drawing from the other group. The Malaysian Zoom session began with the LGRs reporting on the last online session including reports on the cyberbullying from the other countries' LGRs. After showing the cards created in the online session, the LGRs asked the group to suggest other types of communication cards and design them. The students used padlets or paper to draw their designs which were then uploaded straight in padlet or as a photo. The work was done individually.

This time the LGRs were more comfortable with their roles as facilitators in all countries. However, in Namibia and Malaysia fellow students questioned the selection and challenged their role as "teachers". In the Namibian group a student from an earlier online design project supported the flow of the co-located sessions without interfering with the LGR facilitation. The Namibian local facilitators continued strengthening the LGR facilitation skills while in Malaysia and Finland they remained observers. Involving all students in the design of a tangible object to improve online communication supported students' understanding of DBL. Equally the challenges and the significance of strengthening the communication between the online and the co-located groups led by the LGR was recognised.

4.5   Session 5 Online: Pair-Communication on Cyberbullying

Two cards from each local group were printed out for each student and used in a game for familiarisation and later use. In order to understand communication challenges and needs, the students were split into 3 inter-continental pairs each running their own Skype session. The students were told that they could talk, write, and/or use the communication cards. The first two pairs worked on the topic cyberbullying simultaneously - the one teaching and the other actively trying to learn - meanwhile one pair had a free conversation. Thereafter the pairs switched their roles: the "teachers" had a free conversation with each other and the "learners" explained the topic to their

new partners. At the end the main facilitator summarised what had been done and how the completed tasks during the session are linked to the platform design process.

The pair sessions were held without any facilitation or script to see how the students communicate with each other and which communication features they use. Some pairs had lively conversations about various topics while other pairs struggled to have any conversation at all, having long periods of silence and playing with their own computer. Facial expressions were not always easy to read because some students looked down instead of in the camera. Internet connection problems also caused confusion – students did not always know if there was a technical problem or if the other student did not understand. Some pairs used the communication cards they had designed to communicate (e.g. "I can't hear you"). Chat was also used when the audio was interrupted. The verbally eloquent students talked while others used the chat. While the Malaysian and Finnish students were familiar with cyberbullying it remained abstract for the Namibian students, who then gladly engaged in conversations on other topics. Local technical support was needed all along, e.g., for camera settings and internet connections. The conversations and the usage of chat or communication cards were documented for the developers for future platform modeling.
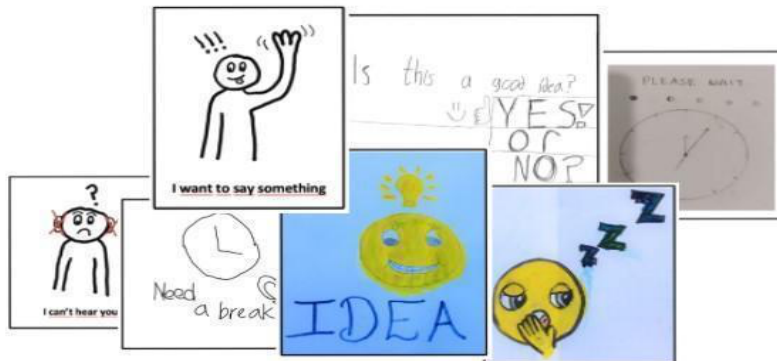

Fig. 2. Students' communication cards

4.6   Session 6 Co-Located: Cyberbullying Prevention Material Production

To determine further communication needs for the platform the students were asked to produce local cyberbullying materials for consecutive online sharing. The Finnish LGRs played the communication card game and presented the cyberbullying task in parallel in two groups. The students opted to make role plays about cyberbullying in two groups: one for girls and one for boys. The plays were recorded by the students using tablets. The processing of the videos was completed later in the week. In Namibia, the LGRs gave examples of what cyberbullying is, orally but also with print-outs

provided by the facilitators. Then the facilitators asked which media they would prefer to use to learn about cyberbullying. Some chose videos, others reading, and others drawings/graphs. They were then requested to produce their own learning material to be shared. The group was provided with print-outs of empty smartphones, laptops, as well as different icons of social media, to be used for their creations. This was to ensure that the creations focused on cyberbullying and not bullying in the physical world. The group split into four, with dedicated roles, such as a camera person, a director, and actors, and produced videos. In Malaysia this was the only face-to-face co-located session. One of the LGRs started the session with a PowerPoint presentation on communication challenges and cards from the previous online session. The cards were printed on paper and distributed to the students to use during the session. The other LGR discussed the concept of cyberbullying and provided few examples of how cyberbullying has adverse effects on children. The LGRs also shared two possible scenarios of cyberbullying with sketches and asked the students if they thought it was cyberbullying. The last activity of the session was an individual brainstorming session where the LGRs asked the class to write/draw a story about cyberbullying.

The facilitators only needed to help with technical issues. The LGRs further improved their facilitation skills. In their own reflections they mentioned that they strive to become better presenters, to include more activities with drawing, writing and playing, and to get more ideas on how to engage their fellow students.

4.7   Session 7 Online: Communication Scenarios Work

The students were given an online communication challenge, namely a pre-drawn scenario sketch (e.g., speaking with a muted microphone") with empty speech bubbles and a toolbox consisting of emojis, buttons and communication cards to create the scenario with a solution in Miro. The main facilitator encouraged the students to develop the scenario jointly. The students mainly worked and communicated by using the chat function and placing objects and writing texts in the sketch (see figure 3).

We observed that some students struggled to use Miro, and most focused more on their own input instead of paying attention to the contributions of others.
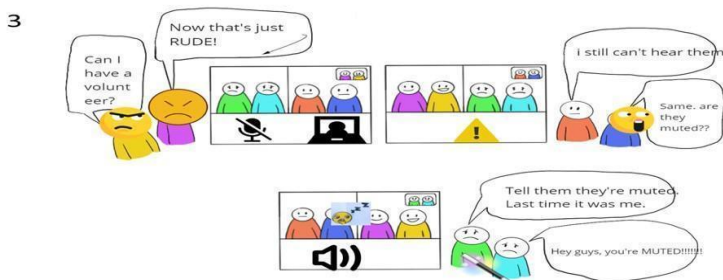

Fig. 3. Students' communication scenarios

4.8 Session 8 Co-located: Communication Scenarios Work

On Miro, three spaces were created with four different scenarios, each for the co-located group to work on following the same process as in the online session. The problems were again real problems that had been identified during previous sessions (e.g., no one responds to a question, moving/deleting others' drawings). The co-located groups were divided into four groups, each tackling one scenario. The Finnish groups worked on a tablet, needing much technical support to use Miro. The students actively used text, feeling emojis, and the communication cards. Each Namibian group worked on one laptop directly on Miro, with one adult facilitator. Students used text, added emojis and used communication cards. The Malaysian group was again using Zoom. The students used a lot of text bubbles and feeling emojis. The technical buttons were used sparsely and the communication cards and notification buttons were rarely used in any scenario. Again the students' working style was different in the physical environment and in Zoom. The Malaysian students who were working from home were more passive during the session compared to their counterparts in Namibia and Finland. The Namibian and Finnish students had lively conversations and made decisions together. The work from home complicated the facilitation because most had to be done by texting the students, as most were not willing to have a visual connection.

4.9 Session 9 Online: Working on Prototype

The session started with a video made by the developers demonstrating possible features of the communication platform based on previous design suggestions. The students then worked on Miro with prepared items, such as different types of buttons and images. Prompted by the main facilitators, they jointly decided on user interface features, such as the placement of videos, chats, and drawing space, the usage of images and backgrounds, as well as the type of buttons and functions.

   The students motivated their design decisions either verbally or through the chat. They appreciated each other's contributions and followed what was being stated. Expressions of feelings through emojis re-occurred as observed previously in the scenarios. Interesting was the suggestion of a button that makes everybody happy. The facilitation was challenging considering the use of multiple platforms with Skype and Miro, multimodal conversations (visual, talking and chat), and the two Malaysian students participating without their camera on.

4.10 Session 10 Online: Prototype Testing and Feedback

The developers demonstrated a new prototype run as a PowerPoint presentation. It was organised in scenarios, and sequences of screens changed upon interface actions such as pressing a button. The students were encouraged to suggest changes which one of the developers incorporated immediately. The students then had a break in which they were requested to create a physical magic wand out of craft material. They could then attribute a function to it, which would be realized in the online platform.

Reflecting on the session, we observed that the co-located pairs contributed well while the two Malaysian students seemed to have technical challenges and were more reserved being in their own home. The students mentioned in their diaries that they enjoyed talking and having the chance to give their own opinions. The facilitation was coordinated with the developers to ensure proper sequencing of features that needed students' design inputs.

4.11 Session 11 Online: Project Closure with All Participants

In the last session we got all the students together and wrapped up the project. The Malaysian students joined individually from home due to Covid restrictions. The prototype was presented with the cyberbullying content produced by the co-located groups. They enjoyed watching their own and those of the other co-located groups. The students provided feedback and asked questions. The session was then concluded with a selection of popular songs to which the Namibian and Finnish students danced.

We observed that it was challenging to have two groups of co-located students from Namibia and Finland and a set of individual participants from Malaysia. In the feedback round after the session the students expressed how proud of the achievements they were and their interest in further developments of the prototype.

5 A Hybrid Model for Design-Based Learning

The empirical work served to refine the originally planned process and derive the Hybrid Design-Based Learning Model (HyDe) as presented below. The model supports the process presented by [24] and the framework's dimensions are being implemented in our hybrid model with particular attention to communication, teachers' and students' roles and learning environment. Important novel elements which are enabled in the model are the active participation of the co-located groups and the intermediating role of the LGRs. The next paragraphs describe the HyDe Model in a direct hands-on manner, including the overall model concept, usage contexts and details.

5.1 High-Level Description

The model is structured to run through a sequence of cycles, with each cycle consisting of (a) session planning by the research team, (b) co-located preparations by the local team, (c) online or co-located DBL session, (d) reflection and prototype development/refinement (see figure 4).

The HyDe Model enables design researchers and teachers to organise and conduct design-based learning sessions with geographically distributed student groups. The approach has a dual goal: scaffolding design based learning and facilitating effective collaboration between students and groups from different geographical places.
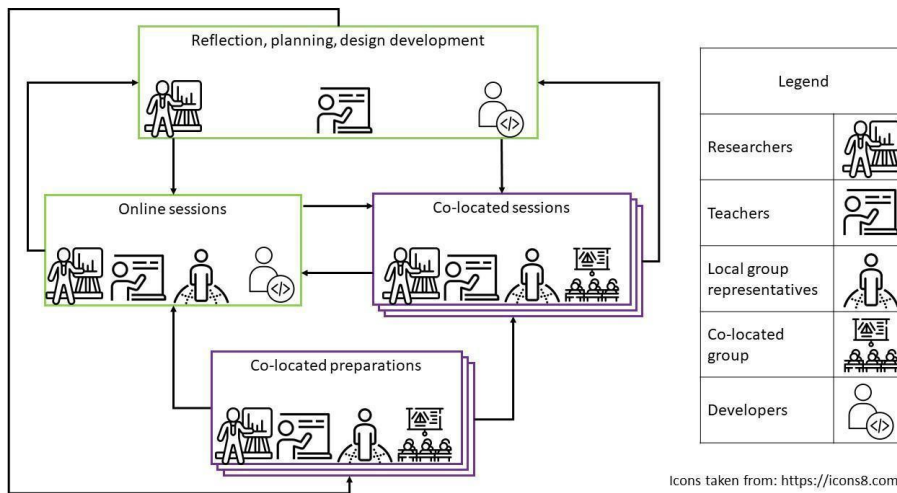
Fig. 4. Hybrid distributed design-based learning process

5.2 Usage Contexts

The HyDe Model can be applied in various learning environments from educational institutes to extracurricular activities and research projects. The HyDe Model is presented in the Design Thinking framework but its generic structure allows design researchers and educators to adapt the model to the needs and special conditions of various age cohorts, group sizes and contexts.

To apply the HyDe Model for the DBL several prerequisite decisions have to be made with regard to the design theme and problems, the groups and the conditions. The design theme should be defined in a way that the participating students can jointly establish the direction and construct the design solution [21]. A broad, or open theme that has connections to the students' lives and simultaneously has a global relatedness is preferred [4]. We suggest integrating the HyDe Model into everyday school either in curricular or extracurricular activities. Based on the theme, real-life and problem-based tasks are assigned. The HyDe approach is developed in the context of K-12 education but it may also be suitable for other age groups and other levels of education from preschool to university because of its generic nature. Considering the need to support communication across languages and cultures [3] the selection of the online group members should be made keeping in mind the dual role of the representatives: they work in both online and co-located groups with assigned tasks. Their communication skills and the knowledge of the used language are traits to consider. For the online group size, based on our experience we recommend six or fewer. The co-located group can be up to the size of a class. Depending on the project and the participating actors, the groups can be working during the normal class hours or extracurricular activities or even out of school environments. This and the geographic distribution with possible time zone aspects all affect the arrangements for the timetables. Access to available

technologies and functional internet connections are also conditions to take into consideration [3, 5]. We recommend facilitators for both online and colocated groups. The local facilitators can be the researchers or the teachers, and need to be trained in DBL facilitation techniques. One main facilitator without own local group is needed for the online group. Since there are several preparations for facilitation and instructional design issues that ought to be considered for collaborating in learning online [35] it is advised to share the responsibilities between facilitators depending on the project management. The sessions also require flexibility and improvisation in planning as well as facilitation during the sessions because of the complexity and uncertainty factors in synchronous online co-design [30].

5.3 Planning and Reflection

The planning and reflection should include all stakeholders if possible. The planning of the next sessions is done based on the reflections from the previous session. The planning consists of defining the purpose of the next session, planning of the activities, deciding techniques and tools to be used, defining preparations needed and determining roles. In planning synchronous online co-design, the usage of features of the improvisational process helps manage the structures to allow new ideas, techniques and interactions into the process [30]. In our planning we had to find new ways to work with students and adults synchronously online while ensuring a continuous information flow with the co-located groups.

5.4 Co-located Preparations

The co-located preparations session attended by the LGRs and the local facilitator ensures linking the online and co-located sessions.

Before the online/co-located session the LGRs reflect on the previous colocated/online session and prepare for the next online/co-located session. The colocated preparations is also the place for skill training for the LGRs, such as technological, transcultural and socio-emotional skills [5]. The co-located preparation is an essential part of the process which enables ideas and contents flow between the on-line and co-located groups of the design process. Being aware how people interact with the environment and each other including changing situations is important in improvisation [30]. Thus when the need for the co-located preparations was observed during the two first sessions they were implemented thereafter. The LGRs also expressed that they wanted to have practical advice, e.g., how to engage the others.

5.5 Online Sessions

In online sessions the LGRs and the main facilitator work together synchronously. The sessions can be of different length depending on the attention span and availability of participants. We have established that 75 minutes is a reasonable time for students aged about 12 years old. It is important to get the students in the same headspace for a session thus carefully selected icebreakers are essential [5]. While following a plan and

structure, it is important to be flexible in terms of unpredictable delays or interactions occurring, which can be handled through improvisation techniques as presented by Lee et al. [30]. Facilitation is one of the most important parts to consider, thus we suggest an independent online facilitator supported by local facilitators, which could also be parents or siblings for children joining from home. It is important for participants to enable their cameras, firstly for the others to relate but also for the facilitator to obtain cues in terms of design engagement. The choice of technology depends on the session activities. We note that many of the technologies currently on the market do not specifically support creative collaborative DBL for children, suggesting that tools have to be integrated and developed. Yet another point which needs attention is the storage of and access to created materials asynchronously, especially considering information flow to and from the co-located sessions

5.6   Co-located Sessions

The co-located session is the place for all local students to take part in the work and design. The sessions are conducted by the LGRs with the assistance of the local facilitator. The tasks for the sessions are decided by the researchers/teachers in planning and reflection talks and given to the LGRs who in turn take it to the group after the Co-located preparations. The session may vary in duration and selection of activities. The LGR's mimicking techniques and repeating parts of the activities conducted in the online sessions helped the children transfer information from the online session to the co-located session. The outcome of such sessions highly depends on the groups. For example in our case study, Malaysian students when given the choice prepared PowerPoint presentations (of very high quality) while the Finnish and Namibian students opted for verbal communication. Either way it is important to digitalize tangible outputs of the session in order to share it in the online session.

5.7   Design Development

Design development meetings are held after the reflection sessions by the developers to implement the designs in the sessions and the insights in the reflection meetings. The role of the developers in the project is critical for implementing the designs that the students want [36]. The process should be transparent in a way that the developers communicate and collaborate with LGRs throughout the project [37].

5.8   Policy Implications

Our proposed HyCo model applied within an inter-school context has direct policy implications in regards to the curriculum development and implementation, resource and data sharing across countries, as well as inter-cultural on-line communication protocols. For curriculum development and implementation a more fluid approach to learning and interaction with a variety of networks of learning spaces need to be integrated. While the Finish system made provision for open content modules in the other two countries the activity was run as extra-curricular activities. The application of the model requires written protocols for data sharing and communication which have to

be stated and agreed upon at national and international level, in order to ensure institutionalisation.

6 Conclusion

In this paper we presented a case study which contributed to the so far scarce empirical and conceptual work of on-line DBL with children. We explored techniques and tools with children from three continents in a hybrid mode, while developing a HyDe model through an iterative reflective process. The HyDe model applied in an inter-school context advances the conceptualisation of smart learning ecosystems, as it provides an approach to connect students across the globe to engage in collaborative and creative DBL activities. It promotes cultural pluralism, allowing the sharing of local perspectives, as well as children gaining new viewpoints, knowledge and skills within the interactions. Future endeavours in research and practice should focus on the integration and institutionalisation of the model across national educational systems and the transformation of independent schools into globally connected learning and knowledge hubs.

References

1. Teräs M., Suoranta J., Teräs H., Curcher, M.: Post-covid-19 education and education technology 'solutionism': A seller's market, Postdigital Science and Education, 2(3), pp. 863 - 878 (2020) https://doi.org/10.1007/s42438-020-00164-x
2. Costa, C., Hammond, M., Younie, S.: Theorising technology in education: An introduction, Technology, Pedagogy and Education, 28(4), pp. 395 – 399 (2019) https://doi.org/10.1080/1475939X.2019.1660089
3. Constantin A., Alexandru C., Korte J., Wilson C., Fails J.A., Sim G., J. Read J.C., Eriksson, E.: Distributing participation in design: Addressing challenges of a global pandemic, International Journal of Child-Computer Interaction, 28, 100255 (2021) https://doi.org/10.1016/j.ijcci.2021.100255
4. Lindsay J.: Connecting beyond the classroom - move from local to global learning modes, Scan, 36, pp. 1–22 (2017) https://doi.org/10.3316/aeipt.217412
5. Winschiers-Theophilus H., Goagoses N., Rötkönen E., Zaman, T.: Pushing political, cultural, and geographical boundaries: Distributed co-design with children from Namibia, Malaysia and Finland, International Journal of Child-Computer Interaction, 100439 (2021) https://doi.org/10.1016/j.ijcci.2021.100439.
6. Krummheuer, A., Rehm, M., Lund, M., Nielsen, K., Rodil, K.: Reflecting on co-creating a smart learning ecosystem for adolescents with congenital brain damage. In: Proceedings of the 2nd International Conference on Smart Learning Ecosystems and Regional Development, pp. 11 – 18. SLERD (2017) https://doi.org/10.1007/978-3-319-61322-2_2
7. Pasov, I., Dascalu, M., Nistor, N., Trausan-Matu, S.A.: Automated prediction of student participation in collaborative dialogs using time series analyses. In: Proceedings of the 3rd International Conference on Smart Learning Ecosystems and Regional Development, pp. 177 – 185. SLERD (2018) https://doi.org/10.1007/978-3-319-92022-1_16

8. Giovannella C., Rehm, M.: A critical approach to ict to support participatory development of people centered smart learning ecosystems and territories, Aarhus Series on Human Centered Computing, 1(1), (2015) http://dx.doi.org/10.7146/aahcc.v1i1.21325

9. Sharma, B., Nand, R., Naseem, M., Reddy, E., Narayan, S.S., Reddy, K.: Smart Learning in the Pacific: Design of New Pedagogical Tools. In: Proceedings of 2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering, pp 573 – 580. IEEE (2018) https://doi.org/10.1109/TALE.2018.8615269

10. Spector, J.M.: Conceptualizing the emerging field of smart learning environments, Smart learning environments, 1(1), pp. 1–10 (2014) https://doi.org/10.1186/s40561-014-0002-7

11. Saadatmand, M., Kumpulainen, K.: Emerging technologies and new learning ecologies: Learners' perceptions of learning in open and networked environments. In: Proceedings of the 8th international conference on networked learning, pp. 266–275. (2012)

12. Dascalu M.-D., Ruseti S., Dascalu M., McNamara D.S., Carabas M., Rebedea T., Trausan-Matu, S.: Before and during covid-19: A cohesion network analysis of students' online participation in moodle courses, Computers in Human Behavior, 121, 106780 (2021) https://doi.org/10.1016/j.chb.2021.106780

13. Facer K.: Learning futures: Education, technology and social change, Routledge, (2011) https://doi.org/10.4324/9780203817308

14. Giovannella, C.: Smart learning eco-systems: "fashion" or "beef"?, Journal of e-Learning and Knowledge Society, 10 (3), pp. 15-23 (2014)

15. Zhang F., Markopoulos P., Bekker, T.: Children's emotions in design-based learning: A systematic review, Journal of Science Education and Technology, 29 (4), pp. 459–481 (2020) https://doi.org/10.1007/s10956-020-09830-y

16. Puente S.M.G., van Eijck M., Jochems, W.: A sampled literature review of design based learning approaches: a search for key characteristics, International Journal of Technology and Design Education, 23 (3), pp. 717–732 (2013) https://doi.org/10.1007/s10798-012-9212-x

17. Zhang F., Markopoulos P., An P., Schüll, M.: Social sharing of task-related emotions in design-based learning: Challenges and opportunities, International Journal of Child Computer Interaction (2021) https://doi.org/10.1016/j.ijcci.2021.100378

18. Scheer A., Noweski C., Meinel, C.: Transforming constructivist learning into action: Design thinking in education, Design and Technology Education: An International Journal, 17 (3) (2012)

19. Thoring, K., Müller, R.M.: Understanding design thinking: A process model based on method engineering. In: DS 69: Proceedings of E and PDE 2011, the 13th International Conference on Engineering and Product Design Education, pp. 493–498. (2011)

20. Doppelt Y., Mehalik M.M., Schunn C.D., Silk E., Krysinski, D.: Engagement and achievements: A case study of design-based learning in a science context, Journal of Technology Education, 19 (2), pp. 22-39 (2008)

21. Lahti H., Seitamaa-Hakkarainen P., Hakkarainen, K.: Collaboration patterns in computer supported collaborative designing, Design Studies, 25, pp. 351–371 (2004) https://doi.org/10.1016/j.destud.2003.12.001.

22. Dillenbourg P.: What do you mean by collaborative learning?, in Collaborative-learning: Cognitive and Computational Approaches, pp. 1–19, Elsevier, Oxford, (1999)

23. Ke, F.: An implementation of design-based learning through creating educational computer games: A case study on mathematics learning during design and computing, Computers & education, 73, pp. 26-39 (2014) https://doi.org/10.1016/j.compedu.2013.12.010.

24. Bekker T., Bakker S., Douma I., Van Der Poel J., Scheltenaar, K.: Teaching children digital literacy through design-based learning with digital toolkits in schools, International Journal of Child-Computer Interaction, 5, pp. 29-38 (2015) https://doi.org/10.1016/j.ijcci.2015.12.001.

25. Sanders E.B.-N., Stappers, P.J.: Co-creation and the new landscapes of design, CoDesign, 4 (1), pp. 5-18 (2008) https://doi.org/10.1080/15710880701875068

26. Kinnula M., Iivari, N.: (2021). Manifesto for children's genuine participation in digital technology design and making, International Journal of Child-Computer Interaction, 28, 100244 (2021) https://doi.org/10.1016/j.ijcci.2020.100244.

27. Walsh, G., Druin, A., Guha, M.L., Bonsignore, E., Foss, E., Yip, J.C., Golub, E., Clegg, T., Brown, Q., Brewer, R., Joshi, A., Brown, R.: DisCo: A co-design online tool for asynchronous distributed child and adult design partners. In: Proceedings of the 11th International Conference on Interaction Design and Children, pp. 11–19. ACM (2012) https://doi.org/10.1145/2307096.2307099

28. Walsh, G., Foss, E.: A case for intergenerational distributed co-design: The online Kidsteam example. In: Proceedings of IDC 2015: The 14th International Conference on Interaction Design and Children, pp. 99–108 (2015) https://doi.org/10.1145/2771839.2771850

29. Walsh, G., Donahue, C., Pease, Z.: Inclusive co-design within a three-dimensional game environment. In: Proceedings of IDC 2016 - The 15th International Conference on Interaction Design and Children, pp. 1–10. (2016) https://doi.org/10.1145/2930674.2930721

30. Lee, K.J., Roldan, W., Zhu, T.Q., Saluja, H.K., Na, S., Chin, B., Zeng, Y., Lee, J.H., Yip, J.: The show must go on: a conceptual model of conducting synchronous participatory design with children online. In: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, pp. 1 – 16. ACM (2021) https://doi.org/10.1145/3411764.3445715

31. Itenge, H., Islas Sedano, C., Winschiers-Theophilus, H.: Virtually escaping lock down - co-designing a mixed reality escape room narrative with Namibian learners. In: Proceedings of the Third African Conference for Human Computer Interaction: Inclusiveness and Empowerment, pp. 103 -112. ACM (2021) https://doi.org/10.1145/3448696.3448700

32. Rötkönen, E., Winschiers-Theophilus, H., Goagoses, N., Itenge, H., Shinedima, G., Sutinen, E.: Playing on the globe: Facilitating virtual communications between Namibian and Finnish learners to co-design an interactive map game. In: Proceedings IDC'21 Interaction Design and Children, pp. 160–170. ACM (2021) https://doi.org/10.1145/3459990.3460707

33. Kang, L., Jackson, S.J., Sengers, P.: Intermodulation: improvisation and collaborative art practice for hci. In: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, pp. 1–13. ACM (2018) https://doi.org/10.1145/3173574.3173734

34. Emmler T., Frehe-Halliwell, P.: The epistemological relevance of case studies as narratives in design-based research, EDeR. Educational Design Research, 4(1), (2020) https://doi.org/10.15460/eder.4.1.1453

35. Bernard R.M., Lundgren-Cayrol, K.: Computer conferencing: An environment for collaborative project-based learning in distance education, Educational Research and Evaluation, 7 (2-3), pp. 241–261 (2001) https://doi.org/10.1076/edre.7.2.241.3866

36. Sanders E.B.-N., Stappers, P.J.: Co-creation and the new landscapes of design, Codesign, 4 (1), pp. 5–18 (2008) https://doi.org/10.1080/15710880701875068

37. Frauenberger C., Good J., Fitzpatrick G., Iversen, O.S.: In pursuit of rigour and accountability in participatory design, International journal of human-computer studies, 74, pp. 93–106 (2015) https://doi.org/10.1016/j.ijhcs.2014.09.004.