MASTER'S THESIS ASSIGNMENT

I. Personal and study details

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Master's thesis title in English:

Design of an app for distance learning

Master's thesis title in Czech:

Design aplikace pro podporu výuky na dálku

Guidelines:

In the past year, distance learning became the new normal for the majority of schools around the globe. The absence of in-person communication brought challenges for both teachers and students, especially when it comes to communication [1].
Conduct user research with both teachers and students, analyze their needs and issues they face when it comes to distance education. Analyze also the apps that are currently used for communication between students and teachers. Follow the User-Centered Design methodology [2] and based on the learnings, propose a set of designs of an app that will help to resolve issues that are currently connected to distance learning. In each design iteration evaluate the designs with the target audience.

Bibliography / sources:

[1] M. G. Moore.Handbook of distance education. Routledge, 2019.
[2] International Organization for Standardization.Ergonomics of Human-system Interaction: Part 210: Human-centred Design for InteractiveSystems. ISO, 2010

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Date of master's thesis assignment: **14.09.2021** Deadline for master's thesis submission: _____

Assignment valid until: **19.02.2023**

Ing. Dominika Palivcová Supervisor's signature	Head of department's signature	prof. Mgr. Petr Páta, Ph.D. Dean's signature

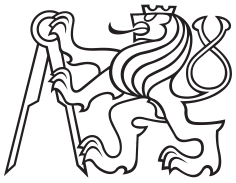
III. Assignment receipt

The student acknowledges that the master's thesis is an individual work. The student must produce his thesis without the assistance of others, with the exception of provided consultations. Within the master's thesis, the author must state the names of consultants and include a list of references.

11. 11. 2021
Date of assignment receipt

Student's signature

Master Thesis



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Design of an app for distance learning

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December 2021

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This thesis owes its completion to so many people.

First, I am incredibly grateful to my supervisor Ing. Dominika Palivcová whose positive attitude has never failed to motivate me. She believed in the quality of my work and kept pushing me when I was in doubt. This thesis would not have been possible without her irreplaceable guidance.

I cannot begin to express my thanks to my lovely family. My parents have always shown their unwavering confidence in my success inside and outside of school; they have never doubted my abilities even when I was not so optimistic myself. Thank you, mom and dad, for being the never-ending source of emotional support. I am truly proud to be your son, despite not being so vocal about it.

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Declaration

I hereby declare that this thesis has been composed solely by myself. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions.

Prague, December 27, 2021

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Abstract

In order to tackle educational disparities caused by the COVID-19 pandemic, schools in the Czech Republic (and around the world) transitioned to unconventional distance education on an unprecedented scale. Despite enabling the continuation of educational activities, due to institutions' lack of experience with the now normalised distance education, it has been quite apparent that many serious difficulties which need to be addressed have emerged. This thesis employs User-Centered Design to analyse the needs of the target user group (educators and students from elementary schools and high-schools) and presents two prototypes of an interactive videoconferencing tool replicating real-life spaces and interactions. Following the mentioned methodology, these prototypes were evaluated against the target user group and the findings suggest that the solution can indeed elevate the students' and educators' experience in distance education.

Keywords: distance education, user research, User-Centered design, interactive, video conferencing tool, COVID-19

Supervisor: Ing. Dominika Palivcová

Abstrakt

Za účelem zmírnění rozdílů ve vzdělávání způsobené pandemií COVID-19, přešly školy v České republice (a po celém světě) na nekonvenční distanční výuku. I přes to, že distanční výuka umožnila zachovat většinu vzdělávacích aktivit, vzhledem k nedostačujícím zkušenostem škol, se vyskytlo mnoho nových problémů, které je třeba řešit. Tato práce využívá User-Centered Design metodiku k analýze potřeb cílové skupiny (studenti a vyučující ze základních a středních škol) a představuje dva prototypy interaktivního videokonferenčního nástroje, který simuluje fyzické školní prostory a reálné denní interakce jedinců. Podle uvedené metodiky byly následovně tyto prototypy otestovány s participanty z cílové skupiny. Zjištěné poznatky naznačují, že naše navrhuté řešení má skutečně potenciál zlepšit průběh synchronní distanční výuky.

Klíčová slova: distanční výuka, uživalteský výzkum, User-Centered design, interaktivní, videokonferenční nástroj, COVID-19

Překlad názvu: Design aplikace pro podporu výuky na dálku

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Chapter 1

Introduction

1.1 Motivation

Since the global outbreak of the COVID-19 pandemic, the world has met with significant restrictions in all aspects of life, including social activities. Education especially has been drastically changed as schools across the country were forced to close down. According to UNESCO's policy brief [23], The pandemic has been exacerbating pre-existing disparities, and the vast majority of children and youth, including those from poorer backgrounds, disabled individuals, girls and refugees, were stripped of opportunities to learn and develop in areas that would typically be available (see figure 2.1). Furthermore, the crisis affects future generations as approximately 23.8 million children are to drop out or may not have an accessible school by next year.

In order to tackle some of these identified disparities, schools in the Czech Republic began adapting and transitioned to unconventional distance education on an unprecedented scale. Despite enabling the continuation of educational activities, due to institutions' lack of experience with the now normalised distant education, it has been quite apparent that many serious difficulties which need to be addressed have either remained or newly emerged. We can highlight a small portion of school closures' consequences provided by UNESCO's article [22]:

- **Social isolation.** The school environment, for many children, represents the main source of social activity and human interaction; thus, when they close, these individuals become deprived of essential contact needed to develop and learn [22]. Unfortunately, this issue has prevailed in some form even within the arrival of distance education as mentioned by a report from the European Commission [14] and will be further inspected in section 2.3 as well.
- **Challenges measuring and validating learning.** A standard part of face-to-face education includes tests on a regular basis, high-stakes examinations, as well as any form of assessment. These, however, turned out to pose quite an issue in a distant form since fairness becomes a question, especially when learning materials become accessible to students practically anywhere [23] .

- **Confusion and stress for teachers.** As schools closed down, teachers were left wondering what obligations they had and how to maintain connections with their students to keep supporting them. The transition to online platforms required for distance education, in many cases, can be quite tiring and excessively long, which in return can lead to stress and confusion [22]. This reasonably induced stress and confusion also stem from the fact that educators were tasked to implement distance education without proper guidance and training, which, as can be seen from figure 1.2, occurred on every level of education. Teachers across the globe were largely unprepared, and even educators in developed countries with adequate infrastructure lacked the technical skills needed to educate on a high level effectively [23] .

Keeping these issues in mind, a very natural question surfaces:

"How can we elevate the user experience in the environment of distance education?".

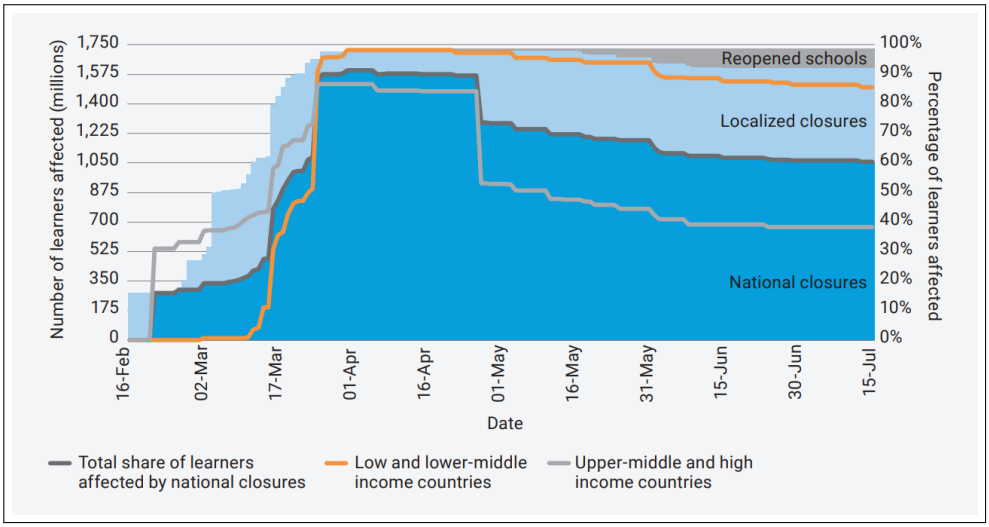

Figure 1.1: Number of children affected by school closures globally, from [23] .

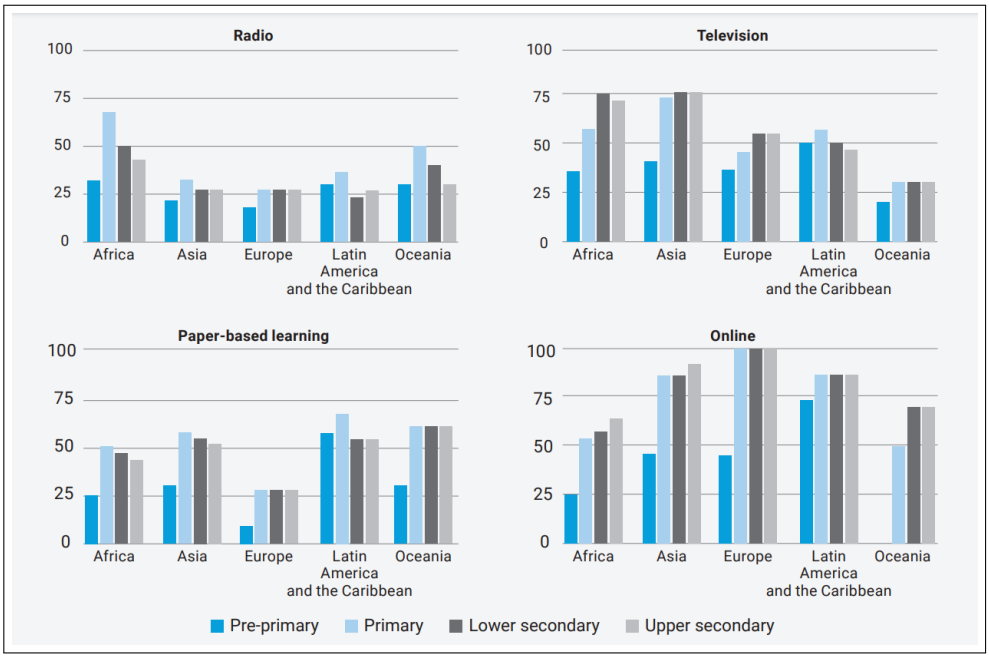

Figure 1.2: Country choice of distance learning during school closures was influenced by education level and region (percentage), from [23] .

1.2 Research questions

It is in our interest to explore the field of the problem; therefore, in order to thoroughly understand the circumstances of distance education (in the Czech Republic), we first define the following research questions for which this thesis aims to find the answers. These questions are further divided into two parts based on our target user groups, which we describe in more detail in chapter 2.

Research questions concerning educators:

- Research question 1:
  What issues and difficulties do educators face in online education?
- Research question 2:
  How do educators currently manage online classes?
- Research question 3:
  How does distance education affect educators psychologically?
- Research question 4:
  Which areas of online education do educators need the most help with?

Research questions concerning students:

- Research question 1:
  How does a standard online class look like for a student?
- Research question 2:
  What issues and difficulties do students face in online education?
- Research question 3:
  How do students communicate during online education (with each other and with educators)?

1.3 Goals

The objective of this thesis can be broken down into goals which are as follows:

- Goal 1: **Conduct user research with both educators and students.** As mentioned, we conduct user research to comprehend our user group's needs and pain points. This, according to User-Centered Design (UCD), is the first crucial phase required for a successful project.

- Goal 2: **Analyze educators' and students' needs and issues they face regarding distance education.** By identifying what our user group, in our case, educators and students, struggles with, we can ultimately decide which issue needs to be addressed by our end solution.
- Goal 3: **Analyze applications and tools used for communication between students and educators.** Analysing existing solutions allows pinpointing functionalities suitable for the user group as well as gaps that our solution can subsequently fill.
- Goal 4: **Follow the UCD methodology and propose a set of designs that will resolve issues currently connected to distance education based on the learnings.**
- Goal 5: **Evaluate the designs with the target audience in each iteration.** User-Centered Design is defined as an iterative process; hence we evaluate our design in every iteration possible. This method serves as a tool to spot crucial usability issues that we eventually fix in the next iteration.

Chapter 2

Analysis

2.1 Methodology

Before proceeding with the analysis, it is useful first to outline key terms frequently used in the thesis.

2.1.1 User-Centered Design

UCD, a term popularised by Don Norman in the late 80s, is an iterative process in which designers utilise investigative and generative methods to identify users' needs to create highly usable and accessible products. As the name suggests, UCD mainly focuses on users' needs, and it does so in every phase of the process [15]. Each iteration consists of four distinct phases:

1. **Understand context of use.** The initial phase emphasises understanding the users themselves. Specifying who will be using the product, what they will use it for and under what conditions will they use it.

2. **Specify user requirements.** After understanding the users, a natural follow up is to specify requirements essential to design an appropriate solution.

3. **Design solutions.** Designing solutions can be done through generative methods and in teams.

4. **Evaluate against requirements.** Lastly, this phase stresses the evaluation of the created solution. The point of doing so is to assess whether the design truly addresses users' needs. Therefore, ideally, testing is done by involving actual end-users.

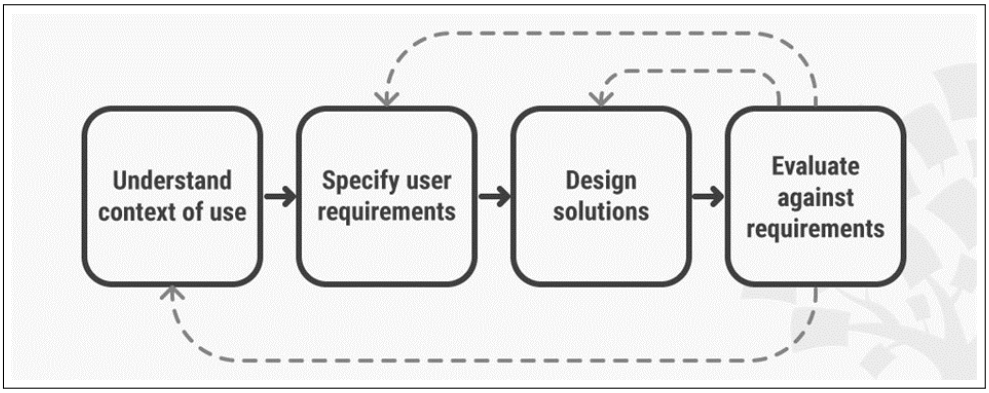

Figure 2.1: Visualised phases of UCD, from [15] .

2.1.2 Usability

As stated by the Nielsen Norman Group, usability is a quality attribute that measures how easy a user interface is to use. If the usability of a design is high, users are able to accomplish tasks efficiently, effectively and satisfactorily. Notably, it is defined by five quality components [24]:

- **Learnability.** How easy it is for a user to accomplish desired tasks the first time they interact with the design?
- **Efficiency.** After learning how the design works, can users accomplish their tasks rapidly?
- **Memorability.** Upon returning to the design, how easily can the users reestablish proficiency?
- **Errors.** Do users err while using the design? How serious are these errors, and can they recover from them?
- **Satisfaction.** Is it pleasant for users to use the design?

2.2 Literature review

2.2.1 Definition of Distance Education

Alongside the ever-evolving technology, the notion of Distance Education has been gradually changing over the past decades, therefore it is only reasonable to wonder: *"How exactly is Distance Education defined?"*.

It is essential to understand that Distance Education heavily relies on communication technology (and mainly its evolution) as its delivery media [17]. Thus, unfortunately, there does not exist a unified definition. To capture the nature of Distance Education, this thesis will work with two definitions, the first one being by Moore & Kearsley, which is as follows: *"Distance education is teaching and planned learning in which teaching normally occurs in a different place from learning, requiring communication through technologies*

as well as special institutional organisation" [21] . Moore emphasises two words from his definition. To begin with, *'normally'* is supposed to remind us that the use of communication technology in distance education is not an optional choice but a characteristic, whereas, in a physical classroom, the same technology is accessory to the educator's presence. Similarly, *'Planned'* distinguishes education from independent learning, as education involves a student who deliberately wants to learn something and an educator who deliberately plans a way to teach the student.

In the light of recent events, the Czech Ministry of Education, Youth and Sports (MEYS) publicised a guide for distance education which, among other things, divides distance education into two main parts [28]:

1. **Online education.** Online education utilises the internet as its medium and is often simultaneously supported by digital technology and software tools. In addition, online education includes both synchronous and asynchronous education. The former takes place in a real-time online environment and more or less simulates a traditional lecture/class where an educator directly works with their students. On the other hand, in the latter, students work independently without the participation of an educator and at their own pace. They work on an assignment whenever they see fit. As mentioned, educators themselves choose which assisting technology is being used, often being online platforms, applications, portals.

2. **Offline education.** Offline education indicates work without the necessity of using the internet and digital technology. This might entail self-study, exercises from a physical book, learning material, worksheets etc. or even practical tasks performed in the environment of the student's home.

The purpose of discussing this definition lies in the context of our user research (see 2.3), which was conducted in the Czech Republic; hence most educator participants are familiar with this particular definition.

Notably, there has been a number of terms that are frequently associated with distance education. Such terms include e-learning, m-learning, online learning and virtual education. Indeed very similar at first glance, these terms are not interchangeable. To illustrate the differences between these terms, let us dissect the definitions of m-learning and e-learning. Moore strongly considers m-learning to be a part of e-learning due to the fact that m-learning is defined as *"learning across different contexts, through social or content-based interaction by using a personal electronic device"* which is roughly also the definition of e-learning, though the context (by different context we mean different locations, situations — in a class, outside of class etc.) in e-learning is constrained by one place/situation [20]. In other words, e-learning (and m-learning) draws attention to the point of view a student since they are the one learning, this makes all of these loosely used terms fall within the domain of distance education [21] (as illustrated in figure 2.2).

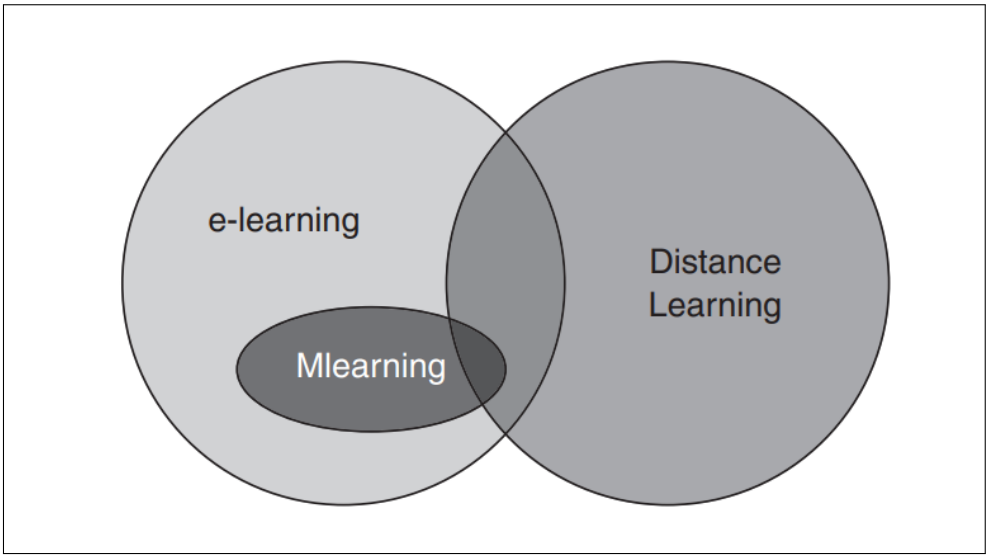

Figure 2.2: Relationships between e-learning, m-learning and distance education, from [20] .

2.2.2 Theory of transactional distance

Cited as the significant and perhaps the only solid theory of distance education [26], theory of transactional distance (TDT) was initially coined by Michael Moore in the early 70s when distance education was still in its infancy, and its academic research had been heavily neglected. As Moore himself confirms *"Scholarly research, in the sense of research that is driven by theory and that contributes to theory, was impossible, simply because there was no theory to start with"* [20]. As of today, the theory has become the base framework for many research papers and is often considered to be *"invaluable in guiding the complex practice of a rational process such as teaching and learning at a distance"* [16].

The theory describes distance, not as a geographical distance, but as a physical separation of student and educator occurring in distance education, hence the term *"transactional distance"*. Not only does the separation result in psychological and communicational gaps, it also creates potential misunderstandings and feelings of isolation [25]. That said, transactional distance depends on both the amount of educator-student dialogue and the very structure of the class. The more structured one class is, the fewer dialogues occur in said class (as illustrated in figure 2.3). In a traditional face-to-face lecture, the level of transactional distance is, in fact, relatively high because the lecturer himself structured the lesson this way, presenting to the whole class without much interaction with the students. Whereas in traditional education, a high level of transactional distance is mandatory to maintain control of the class, it is not desirable in distance education, the reason being that an educator has to create an environment in which open communication is possible in all directions: educator-student, student-educator and student-student.

Besides this theory, it is appropriate also to define the term 'transaction'

itself, which connotes *'the interplay of the behaviours of teachers and learners in environments in which they are in separate places and have to communicate through a technology"* [20]. In regards to transactions, Dewey states that transaction between individuals and their environment is vital to creating a good experience. That is why interactive lessons in distance education (for instance, interactive tools are used) can arguably be compared to lessons in traditional education quality-wise [25].

Moore further elaborates on the theory and, through the results of empirical studies, presents three main components, which he considers to be the foundation of distance education and its research: *dialogue, structure and autonomy of a student.* The effectiveness of distance education is determined by the quality of dialogues, stability of the class's structure and how well the students learn by themselves. Regarding dialogue, we define transactions as interactions during lessons, which can take the form of [29]:

1. *Learner-learner interaction* indicating mutual interaction between students or group work both in and without the presence of an educator — a discussion or group assignment.

2. *Learner-tutor interaction* focuses on the interactive dialogue between an educator and a student. This might include the educator's advice, recommendation, support or guidance.

3. *Learner-content interaction* references the interaction between a student and the material concerning education — watching an educational video, activities based on the gamification of learning etc.

Most significantly, by using the interactions mentioned above, decreasing the transactional distance in distance education is very much achievable. On top of that, interaction also influences students' satisfaction with distance education, as Moore claims *"Creating a way for socialisation in distance education may represent a key for student satisfaction. "* [20].

One of the main difficulties for educators in distance education is using the appropriate tools and techniques which develop interaction in a lesson. Kerr proposes the following recommendations for educators to tackle this issue [25]:

1. Keep providing timely, profound feedback, which helps mitigate the feeling of distance.

2. Give students chances to present their knowledge of the learning material.

3. Create an authentic experience that involves learning.

4. Talk with students during lessons to build rapport.

5. Make sure students understand the technical conditions to pass the course/subject successfully.

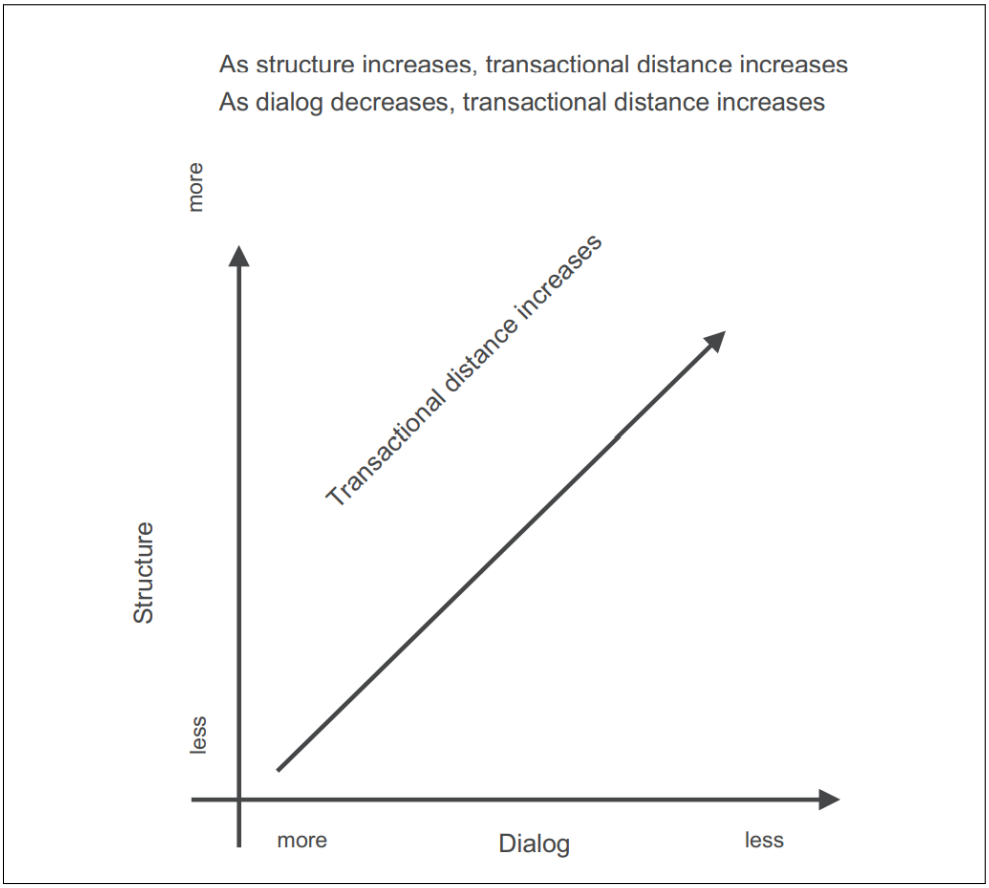

Figure 2.3: Relation of course structure and instructor-student dialogue in transactional distance, from [20] .

2.2.3 Community of Inquiry framework

Community of Inquiry framework (CoI), a theoretical framework created by Garrison, Anderson & Archer, was a direct result of trying to understand developments in online learning. It was designed to guide the study of online learning effectiveness in higher education [9]. This theory states that deep and meaningful learning is experienced in an online course through the development of three presences (illustrated in figure 2.4):

- **Social presence.** Social presence describes the ability of participants to identify with the group or course of study, purposefully communicate in a trusting environment and affective relationships progressively by way of projecting their individual personalities [20]. In other words, social presence means creating an environment in which participants have a sense of belonging, which in return encourages probing questions, scepticism and expressing one's ideas. There are another two concepts related to social presence — intimacy and immediacy. Intimacy is dependent on factors such as physical distance, eye contact, smiling and conversation topic. On the other hand, immediacy measures the

psychological distance individuals create between each other. Verbal and non-verbal cues like physical proximity, the formality of dress and facial expression, etc., indicate immediacy. Both intimacy and immediacy enhance social presence [27].

- **Teaching presence.** This presence points out *"the design, facilitation and direction of cognitive and social processes for the purpose of realising personally meaningful and educationally worthwhile learning outcomes"* [20].

- **Cognitive presence.** Cognitive presence can be defined as *"the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry"* [20]. We can understand cognitive presence as critical thinking or the extent of learners' reflection on what is being taught.

According to Moore, CoI has had a high adoption rate and has been substantially influential in explaining and prescribing the effective conduct of online learning [20]. The success it has had can be attributed to the growing demand for change in education as CoI provides a new way of thinking about delivering education; specifically, it offers more engaging and sustainable learning skills on the part of students.

That said, we have defined two of the most influential theories in distance education over the past few decades; the question is, how do they compare against each other? Both Moore and Garrison were revolutionary in the sense that they focused on transactional communication, dynamics between teacher and student and attempted to clarify the concept of independence. Moore himself confirms that CoI and the theory of transactional distance have parallels in terms of the affordances of technology and design/organisation in the Community of Inquiry [20]. Salle and Wicks discuss the strengths and weaknesses of these theories in the article [18] and come to a conclusion that CoI is more suitable for research on online education. In contrast, valid and reliable instruments that can measure the TDT's effects need to be developed before being widely used in empirical research. Then again, this claim of CoI's supremacy is very rare, and many consider TDT to be the global theory of distance education.

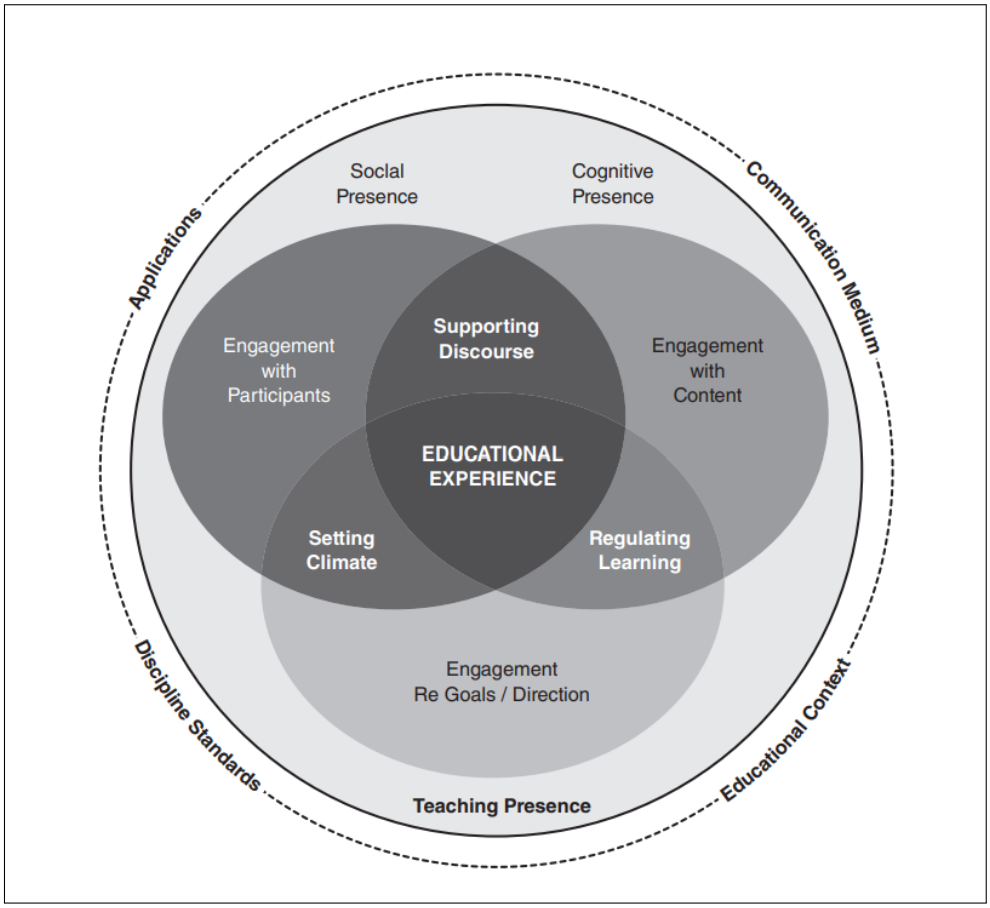

Figure 2.4: The Community of Inquiry framework, from [20] .

2.2.4 Tools and techniques

Standard tools and techniques

O'Brien's PhD thesis [25] identifies the tools and techniques used by teachers in their live-virtual classroom environment. This subsection aims to summarise the tools and techniques mentioned in her work and additionally discuss other ones.

- **Videoconferencing tool.** One of the core media in synchronous communication between an educator and students ought to be a videoconferencing tool as it implements a way to cooperate with students as well as provide them with timely, consistent feedback. Apart from standard videoconferencing functionalities, platforms like Google Meet, Microsoft Teams and Zoom add functionalities such as audio-conferencing, polling in real-time, quizzes, screen sharing, virtual board, meeting recording, importing files, chat, and the list goes on. As further elaborated by O'Brien, all of these named functionalities are a significant prerequisite for effective communication in an online environment. In essence, functionalities that mimic the communication in a traditional education

(breakout rooms, polling, hand raising) are the ones that ease the feeling of isolation created by the physical separation of educator and student.

- **Virtual board.** After conducting user research [25], O'Brien accentuates the importance of a virtual board which educators use as a substitute for a blackboard in order to share a presentation, write notes etc. Participants in mentioned user research labelled as *"highly-qualified teachers in live-virtual classroom environment"* rely on a virtual board to keep the attention of students and to maintain the structure of a class. What they found out was that a dull presentation leads to students' boredom. In contrast, an over-saturated presentation generally caused students to be lost in the overwhelming amount of information. To support the significance of a virtual board, Clark & Kwinn [25] state that virtual board is the predominating element in online education and that with the underutilisation of a virtual board comes a sub-par education.

- **Chat, emoticons, polling.** As highlighted in TDT 2.2.2, dialogue plays a crucial part in online education. In the form of online discussions, they can help students engage in a lesson which then produces students' satisfaction. Online dialogues are realised through audio-conferencing, chat, emoticons, and polling to mimic a real face-to-face discussion. Participants in O'Brien's user research considered emoticons and polling to be one of the main tools to find out if students had paid attention to a lesson and if they had understood the material being taught. Emoticons, specifically, served as a means for instant feedback without having to speak.

- **Breakout rooms.** Group work, a standard and easy to implement technique in traditional education, finds its counterpart in an online environment through breakout rooms. Although relatively easy to implement, one of the main drawbacks of breakout rooms is that the educator does not have a straightforward way to spectate all of the groups at once, meaning they have to move from one group to another to check up on it, which obviously is not the case of group work in traditional education.

- **Learning Management System (LMS).** Defined by MEYS as a tool to organise and realise online education, communicate, share learning material [28], LMSs have relatively recently become one of the staples in distance education. Had it not been for LMSs, there would not be an efficient way for educators to manage education asynchronously. The reason is that LMSs store all of the information in one place, which makes it very convenient; students can access learning material whenever and wherever they want to. Not to mention, LMSs facilitate a way to create assignments, hand in assignments, collect data to analyse students and a lot more.

- **Learning analytics**. Recent years have brought to life a new field of learning analytics for a simple reason — online education generates an

immense amount of data, some visible at first glance (for instance, messages from an educator), some not so much. Learning analytics represent a tool to collect valuable data from students — performance, individual strengths, weaknesses and noted difficulties with various learning tasks to help educators elevate the quality of education [20]. The potential of what learning analytics can measure is almost unfathomable — time spent on a platform, the number of clicks, patterns in which students engage in the lesson. With the help of this data, educators can easily evaluate their quality of teaching and modify areas that can be improved upon. Needless to say, a natural question of privacy and ethics comes to mind when discussing what data should be and should not be analysed.

- **Massive open online course (MOOC).** MOOCs reached a pinnacle in public awareness in 2012 when three major platforms were launched: Coursera, Udacity, and edX [20]. They offer free or low-cost education online through individual courses with an almost unlimited number of students. Experts or professors commonly lead these courses in the area of interest. Yet, they rarely interact with the students directly, mainly due to the focus being on content-based learning — interactive videos, gamification of the lessons. MOOCs have become one of the more controversial topics in education; some view them only as an over-hyped [20] product of the ever-evolving technology, whereas some consider them to be a revolutionary development in distance education. Another interesting fact as to why MOOCs have become so popular is that *"as advancing technology alters the requisite skills for on-the-job success, knowledge gained through a diploma becomes obsolete and as higher demands for critical skills are placed on workers"* [20], which is precisely what MOOCs excel at.

Innovative tools

We take a look at some specific tools that have set themselves apart from the rest by having a different viewpoint on online education and communication.

Kahoot! Kahoot! is a game-based student response system (GSRS) that temporarily transforms a classroom into a game show where the educator is the game show host, and the students are the contenders [30]. Essentially, educators create quizzes called "kahoots" that contain questions ranging from puzzles, open-ended questions, polls, to word clouds and slides. Afterwards, educators share these with their students through a unique pin code, and as soon as students enter the pin code in the lobby of Kahoot's web application, they join the game.

Studies suggest that Kahoot! can positively affect learning compared to traditional learning and other learning tools/approaches. It was found that Kahoot! had a positive effect on learning both for K-12 and higher education and for language learning, technical and engineering fields, science, math, business, and nursing. For instance, an experiment with 77 students of an

English course was conducted at the University of Taiwan to compare the effectiveness of learnings review when using Kahoot! and paper quizzes. The results were firmly in favour of Kahoot! as students using Kahoot! performed significantly better (+14.2%) than students using paper quizzes [30].

Moreover, Wang [30] reviews the existing studies regarding Kahoots's influence on students' anxiety and concludes that Kahoots! can reduce students' stress/anxiety, encourages participation without being judged, adds humour to the class and allow shy students to get involved.

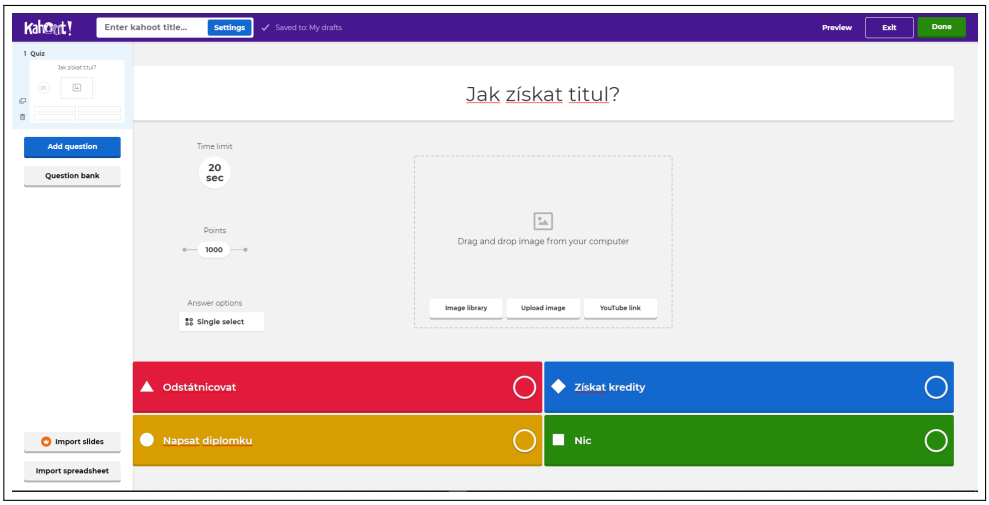

Figure 2.5: The user interface of Kahoot!, created by the author.

Gather Town. Gather Town is a videoconferencing platform taking advantage of a video chat gamification. Participants are offered a user interface imitating a 2D RPG game (as seen in figure 2.6)in which they freely move their character within a pre-designed space to interact with shared content such as videos, images and other files and, of course, interact with other users. Furthermore, Gather Town utilises a feature called spatial audio; in other words, users video chat based on the proximity of their characters — if their characters "run" into each other, they enter a call, and when they start moving away, they gradually leave a video call.

Gather Town have been widely used for online events and virtual offices; however, in terms of education, the tool has not seen much success yet. McClure & Williams from the Queen's University Belfast conducted a case study [19] which aimed to investigate the practical usefulness of Gather Town in the context of a research-intensive UK university, as they believed that Gather Town could present opportunities for peer-to-peer communication and development of a sense of identity within students' learning community. Similarly, according to the study, educators could benefit from Gather town as well, thanks to the ability to communicate effortlessly between entire spaces and small groups and to provide tailored support to students as they progress through the activities in an online synchronous environment.

The study results propose that online education can indeed benefit from

the use of Gather Town. Its major advantages are the ability to support tailored and self-paced learning, enabling students to interact with educators on a more informal basis, engage with their peers in discussions, and the opportunity to use the designed resources in an individualised manner [19].

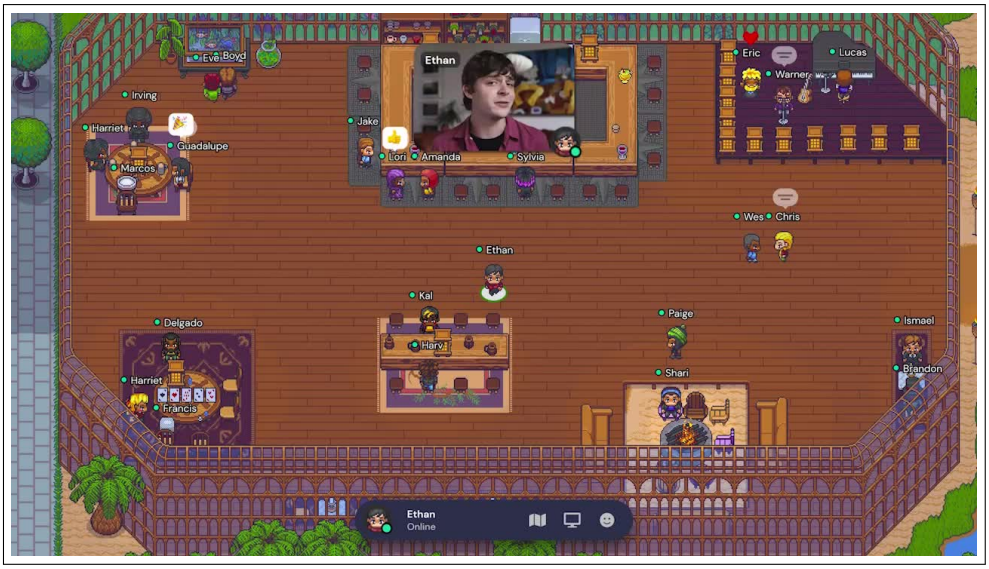

Figure 2.6: The user interface of Gather Town, from [5] .

2.3 Qualitative user research

The previous sections have presented the current theory and research around distance education alongside the most problematic focal points. In this manner, this section covers the qualitative user research as a method to deeply investigate individual issues and difficulties that educators and students deal with in distance education.

2.3.1 Target user group

The European Commission's report [14] sheds light on the fact that the switch from traditional education to distance education is substantially affecting children in primary and lower secondary schools as well as high schools since they have higher difficulties adjusting to new environments. The learning loss is more significant among younger students compared to older students in the sense that this group is more likely to engage in an interaction with an educator or another student. These interactions are detrimental in building their softer skills (e.g. communication skills, teamwork) and future development of their career, self-esteem, self-confidence and a sense of identity.

It is solely for this reason, that this thesis will narrow its target user group to:

1. **Students from elementary schools and high-schools**

2. **Educators from elementary schools and high-schools**

2.3.2 Method

This subsection explains the procedure of user research.

Interview

The user research was realised through semi-structured interviews with the participants of the target user group. The research took place during a lockdown, and restrictions imposed by the COVID-19 pandemic made it impossible to meet up with the participants physically. Thus all of the interviews had to be conducted remotely with the help of the platform Google Meet.

At the start of each interview, we started recording the video call under the participant's agreement, which later assisted with the transcription of the whole interview. The participant was welcomed, introduced to the interview procedure, and subsequently asked questions from the pre-test based on the group they belonged to (educator or student). The contents of the pre-test are presented below.

Pre-test for educators.

1. *How old are you?*
2. *At what school do you teach?*
3. *What responsibilities do you have?*
4. *Which subjects do you teach?*
5. *How often did you use a computer prior to the switch to distance education?*
6. *For what purpose do you usually use a computer?*

Pre-test for students.

1. *How old are you?*
2. *At what school do you study?*

After completing the pre-test, we proceeded to the main questionnaire.

Questionnaire for educators.

1. *Please describe the routine of your workday (details of an online lesson, structure of the lesson, the environment you teach in)*
2. *What tools do you use for distance education?*

3. *Please describe the process of communication with your students during an online lesson.*
   a. *On which occasions do you typically communicate?*
   b. *What media do you use to communicate with your students?*
   c. *What are the differences between the communication in an online lesson and communication in a traditional lesson?*
   d. *In your opinion, what effects does distance education have on students' activity and their behaviour?*
4. *What problems do you have to face in distance education?*
5. *How do you deal with these problems?*
6. *Imagine that you are about to start an online lesson; how do you feel? What are your thoughts? How do you feel after the lesson ends?*
7. *In your opinion, what are the benefits and drawbacks of distance education?*
8. *In order to prepare for an online lesson, what do you have to do?*
9. *How did the transition to distance education affect your work?*
10. *How did the transition to distance education affect your personal life?*
11. *Do you see any differences between the difficulty of distance education's management and traditional education's management? If yes, how do they differ?*
12. *Do you lack any tools during online education which would normally be available? If yes, which ones and why?*

Questionnaire for students.

1. *Please describe how your school day looks like after the transition to distance education.*
2. *How much time do you spend studying?*
   a. *How much time do you spend self-studying?*
   b. *How much time do you spend studying in an online lesson?*
3. *What environment do you study in?*
   a. *Where do you typically study at?*
   b. *When studying, is there anyone else in the room?*
   c. *What devices do you use in online education?*
4. *How do you feel during an online lesson?*

5. *Did you enjoy attending school prior to distance education?*
   a. *What did you enjoy about it?*
   b. *What did you not enjoy about it?*
6. *Do you miss attending school? If yes, what do you miss about it?*
7. *Do you prefer distance education over traditional education? Why? Why not?*
8. *What tools do you use to communicate with your teacher?*
9. *How often do you communicate with your teacher?*
10. *On what occasions do you communicate with your teacher?*
11. *How often do you communicate with your classmates?*
12. *Do you see any differences between distance education and traditional education? If yes, how do they differ?*
13. *Do you face any problems in distance education?*
14. *How do you deal with these problems?*
15. *Do you feel anxiety regarding distance education? Why?*
16. *Has your attitude towards learning changed after the transition to distance education? If yes, how has it changed?*

Following the completion of questionnaire, we concluded the interview by asking for the participant's feedback on the interview.

Participants

In total, 15 participants engaged in our user research. 7 of them being educators (5 females, average age = 46.7, SD = 10.6, MIN = 31, MAX = 57) while 8 of them being students (4 females, average age = 13.75, SD = 2.43, MIN = 11, MAX = 18). The participants were recruited through personal messages via portal *UčímeOnline* or the method *snowball sampling*. Details about the individual participants are illustrated in the tables below.

Participant ID	Sex	Age	Type of school
PE1	female	51–60	elementary school
PE2	female	51–60	high-school
PE3	female	51–60	high-school
PE4	female	31–40	high-school
PE5	male	51–60	primary-school
PE6	female	41–50	primary-school
PE7	male	31–40	high-school

Table 2.1: Educator participants

Participant ID	Sex	Age	Type of school
PS1	female	12	elementary school
PS2	male	18	high-school
PS3	female	15	high-school
PS4	female	13	high-school
PS5	female	17	high-school
PS6	male	11	elementary school
PS7	male	12	elementary school
PS8	male	12	elementary school

Table 2.2: Student participants

2.3.3 Findings

We put forward findings from the user research. Notably, a number of these findings are closely related to or implied by theories and researches that have been covered in the previous section 2.2 and the introduction 1.

Educators' interview

Educators' view on distance education. It was apparent from the user research that the vast majority of educators viewed distance education in a negative light. Nonetheless, 2 (PE1, PE2) out of 7 participants noted that they had believed distance education to have enormous potential if combined with traditional education. One of the reasons they praised distance education was because they found the communication with their students to be more intimate and personal than talking face-to-face. PE3 notes that *"Me and my colleagues have agreed on the fact that communication can actually be more intimate. Some shy students whom I would have normally never heard from actually contacted me by themselves"*.

Quality of feedback. A common theme brought up by educators was the poor quality of feedback from students. 6 (PE2, PE3, PE4, PE5, PE6) out of 7 participants expressed their dissatisfaction with how little feedback they

get from their students during an online class. Since turning on webcams is optional, most students do not turn them on, which frustrates educators, and feelings of confusion and ambiguity surface. They are not sure whether their students are listening, paying attention etc. It is also a recurrent event for students to not answer at all after being asked to, or it takes a considerable amount of time before they answer. This leads to situations where the educators stop enjoying teaching, and for instance, PE2 considers distance teaching to be a completely different job. PU4 mentions *"Distance education can be quite hard on me; it is like talking to an empty screen the whole day"*. PU5 adds *"Interaction with my students is almost non-existent, I do not see them, I do not know if they are working or falling asleep in their room, nobody answers my questions "*. It is essential to mention that even if students turned on their webcams, it would only slightly improve the situation as in a class of more than 15 people, it becomes difficult to distinguish small pixels of faces on the screen.

Management of distance education. Another issue highlighted by the participants was the difficulty of distance education management. 5 (PE2, PE3, PE4, PE5, PE6) out of 7 participants found it more challenging to prepare for distance education. This includes tasks like correcting exams, homework, and other assignments and handing them back to the student. PE4 complains that *"Correcting assignments and handing them back can eat a generous amount of my time. To give you an example, if I were to assess 30 exams, I would have to upload each one of them in the system. Let us say that one exam takes 1 minute to upload; therefore, uploading 30 exams takes half an hour, which is ridiculous. Whereas If I were to be in a school, I could walk around the desks and hand all the exams back in 2 minutes. Afterwards, If ten students ask for a revision of the same exam, I am obliged to do it again and again; it can be kind of a handful."* Moreover, creating assignments also proved to be more exhausting due to the details an educator has to go into — what page, which exercises, what link etc. Generally, we can observe that higher-quality distance education requires more time and effort from the educators — for instance, the more ambitious educators such as PE6 record educational videos for their students.

Students' motivation. 4 (PE2, PE3, PE5, PE7) out of 7 participants question students' motivation and routine. PE2 reveals *"It has become a new norm for many students to just breeze through the materials once without further preparation because they just simply do not have to study hard."*. Additionally, PU5 complains that *"Some of the students do not even pay attention and do not have a routine to stick to. They casually lie in a bed during a lesson because they are in their comfort zone at home."*. The importance of a routine also applies to the educators themselves, as stressed by PE2 and PE3.

Fair assessment. There is no doubt that validating learning has become more challenging after transitioning to distance education, as briefly mentioned in

the introduction 1. 4 out of 7 participants (PE2, PE3, PE5, PE7) encountered the same issue and reported that there was no guarantee that students would not cheat during exams and other individual assessments. Some educators even resorted to strategies like skipping and postponing exams and other assessments, PE7 comments on the issue *"Validating learnings on any level is a big question. Is there even any point in writing exams? Students who want to cheat will find a way to cheat anyway"*.

Technical literacy. Although some participants received training regarding technical skills needed for distance education, 3 (PE1, PE2, PU5) out of 7 participants, considered to be of older age, stated that the training had been too rushed and insufficient. Since they were not as technically literate as their younger coworkers, the technical issues they were not used to could not be dealt with as efficiently. These participants did not feel confident when teaching, which inherently affected the quality of teaching because they could not deliver teaching in a way they wanted to and sometimes even lacked an efficient way to work with tools such as geographic atlas.

Electronic textbooks. On a positive note, 2(PE1, PE6) out of 7 participants greatly appreciated the use of electronic textbooks in distance education because of how effortless it is to 1) reference specific exercises while assigning tasks and 2) work with them directly during an online lesson. PE1 praises them and says *"It is great, that I can just directly attach links to specific exercises without having to describe them verbally, that saves me a lot of time"*.

Educators' health. Unfortunately, 2 (PE2, PE6) out of 7 participants suffered from health issues indirectly caused by distance education. Not being used to sitting at a desk using a computer for an extended period of time (as much as 14 hours), these participants experienced back pain.

Students' interview

Students' view on distance education. It became clear that all students preferred traditional education over distance education. That said, PS2 and PS5 claim that distance education had helped them focus on subjects they considered more important because they had had more time to revise.

Social interaction with peers. It is safe to say that social interaction is one of the most crucial aspects when it comes to education in general. 5 (PS1, PS2, PS4, PS5, PS6) out of 8 participants feel like they lack social interaction with their peers, and despite being in touch through social media, these participants desire physical contact with their peers as PS5 admits *"What I miss most about school is talking to my friends, being alone at home drives me crazy"*.

Social interaction with other educators. As far as social interaction with educators is concerned, 5 (PS2, PS3, PS5, PS7, PS8) out of 8 participants suggest that distance education quality is noticeably poorer compared to how often they interact with educators in the school. PS2 notices that *"Almost all of my educators approach distance education as a reading contest, meaning that they usually just read notes for us to copy, which is obviously really boring. I would appreciate it if some of the lessons were a bit more interactive; that way, I would pay more attention. It is true though that some proactive educators try their best, so that is more fun. Also, it irritates me that most educators only assign homework; these can stack up pretty quickly up to the point that I cannot keep up with them. From my point of view, online communication is impersonal and unpleasant"*. Another issue students point out is the increased difficulty of learning new topics/concepts in distance education; educators cannot visualise the concept the way they could personally; thus, students have to rely on themselves or other classmates.

Lack of routine. Students explain that attending school gives them a sense of routine that they can follow. 4 (PS2, PS3, PS4, PS5) out of 7 participants admitted having problems with time management. PS5 confesses *"Sometimes the number of assignments is so overwhelming that I get lost in which ones I am supposed to do first, and eventually I forget the ones I have not finished'*.

Turning off webcams. Lastly, 2 (PS2, PS4) out of 7 participants find turning on the webcam problematic. These participants are under the impression that they lose privacy by turning on their webcam and have to be careful of what they do. Interestingly, PS5 dislikes turning on a webcam during exams: *"I despise the feeling of being watched by an educator during exams, it makes me feel isolated and scared"*.

2.4 User group's needs

Taking both the results of user research and literature review into consideration, we identify the fundamental needs of educators and students in distance education.

2.4.1 Educators' needs

EN1: Feedback.
As an educator, I need to have strong and timely (verbal and non-verbal — eye contact, body language) feedback, so I can make sure that my students are paying attention and that they understand the material being taught.

EN2: Time to prepare a lesson's structure.
As an educator, I need more efficiency in creating materials for the education, correcting assignments/tests and handing out corrected assignments/tests since, as of right now, it is too time-consuming and leaves me with no space for myself.

EN3: Time management.
As an educator, I need to properly allocate my time between work and personal life, since as of right now, in an online environment, I feel like I have to be available for my students 24/7.

EN4: Fair assessment.
As an educator, I need a method to mitigate plagiarism and cheating during online tests, so I can fairly assess my students' work.

EN5: Technical support.
As an educator, who is not technically literate, I need to be technically supported so that I am not restricted by Information and Communication Technologies (ICT) and can teach the way I intended to.

EN6: Students' supervision.
As an educator, who cannot walk around a class and check up on students, I need another way to supervise them during an online lesson, so I can correct them or give them feedback.

EN7: Social interaction with students.
As an educator, I need an improved social interaction with my students, so I can enjoy teaching and be motivated to teach.

2.4.2 Students' needs

SN1: Social interaction with peers.
As a student, I need stronger social interaction with my peers, so I can socially develop.

SN2: Social interaction with educators.
As a student, I need stronger social interaction with my educators, so I can better understand the material being taught, and if I need anything, I can personally ask an educator.

SN3: Interactive lessons.
As a student, I need the online lessons to be more interactive, so I can be motivated and actually pay attention during a lesson.

SN4: Time Management.
As a student, I need an overview of which assignments need to be handed in and when to allocate my time better.

2.5 Discussion

It is essential we realise that, on no account can we satisfy every target group's need identified in the previous section. Furthermore, we are inclined to converge to a single issue this thesis will focus on. The question is, among

so many needs, which ones are solvable and which ones are not within the scope of this thesis?

Firstly, let us discuss the differences between issues solely related to distance education and issues caused by individuals' approaches to education. We mean that elements like the educator's teaching method or a student's attitude towards learning cannot be changed no matter how hard we try. That would require change on a more fundamental level — modification of the whole educational system, which is obviously not the purpose of this thesis. With this piece of information in mind, we can eliminate the need to solve SN3 (2.4.2) — student's need to have an interactive lesson since that is dependent on how the educator decides to teach.

At the same time, it would be reasonable to avoid needs that already have a well-working solution. For instance, there are many mainstream platforms like Google Classroom that take care of SN4 (2.4.2) — student's need to have an overview of which assignments need to be handed in and when.

This leaves us with needs mostly regarding the lack of social interaction in distance education. These include:

- **EN1: Feedback** (2.4.1)
- **EN7: Social interaction with students** (2.4.1)
- **SN1: Social interaction with peers** (2.4.2)
- **SN2: Social interaction with educators** (2.4.2)

These needs are what we consider to be solely related to distance education, and therefore the situation around these needs can be solvable or improved upon through ICT.

2.6 Conclusion

To conclude, this chapter initially defined general terms frequently used in user experience design: User-Centered Design and usability. Afterwards, it reviewed the literature regarding distance education and defined two critical theories:

1. *Theory of transactional distance*, which discusses the types of interactions in distance education and introduces "transaction", a term relevant to understanding why communication in distance education cannot be treated in the same way as in traditional education.
2. *Community of inquiry framework* a theory defining three main components which ought to be developed in order to increase the effectiveness of distance education.

The chapter then proceeded to describe tools and techniques used in distance education and further discussed the details of conducted user research. Finally, based on the findings, we identified the fundamental needs of our user group and specified the ones this thesis will focus on.

Chapter 3

Design

3.1 Personas

With the learnings that have been extracted by conducting user research and defining our target user group, we now produce personas to materialise reliable and realistic representations of our key audience.

- **Eve — a high-school educator (see appendix A for a detailed description)** is an older educator who has been teaching at a high school most of her career. With her experience, she has a very traditional style of teaching. She does not use a computer very often and only does so when necessary. She has been having trouble adapting to online classes and frequently requires help with technical difficulties.
- **Alina — a high-school student (see appendix B for a detailed description)** is a 17-year old high school student in Prague. She is graduating from high school in 1 year and therefore has been focusing on her studies more than ever. She has been struggling with productivity and material retention during online classes.
- **Thomas — an elementary school student (see appendix C for a detailed description)** is 12 years old, he is a student at an elementary school in Prague. Since the start of quarantine, he has been spending a lot of his time watching animated series and has not had many opportunities to talk to most of his friends. He is quite smart and always does well in school; however, online classes are very boring for him.

3.2 Design studio

In accordance with UCD, the next phase ought to be the design of a solution based on the needs identified in the previous sections. To make sense of the vast amount of collected data, we set up an online design studio workshop for the purpose of generating as many ideas as possible and subsequently converging to a single idea that may inspire the final solution. Generative methods in teams such as design studio workshops are fully compliant with

standards in design. In fact, they are often strongly recommended by many sources like IDEO's DesignKit [6] or Nielsen Norman Group [2]. Facilitating a design studio brings many advantages to the table [2]:

- *Design studios include diverse perspectives.* People with unique backgrounds, experiences and mindsets join forces to share knowledge and different perspectives.
- *Design studios fit into tight timelines and fast workflows.* A design studio typically condenses ideation into the span of a few hours or less; therefore, it is quite time-efficient.
- *Design studios are collaborative.* Attendees work together to come up with ideas, identify themes and create direction as a team. Everyone contributes — therefore, everyone has increased buy-in into the success of the project.

3.2.1 Participants

Overall, 5 participants were invited to the workshop, out of which 4 had had experience of at least four years as a user experience designer. In addition, participants varied in nationality (Czech Republic, Netherlands, Vietnam, Beirut), gender (4 males, 1 female) and age (between 21 and 30).

3.2.2 Procedure

Due to the different locations of the participants, the workshop was held remotely through the videoconferencing tool Google Meet. Another helpful tool used during the workshop was Miro, an online collaborative whiteboard platform that enables distributed teams to work effectively together. In our case, Miro mainly served the purposes of note-taking, writing ideas on digital sticky notes and presenting sketches to the rest of the participants (see figure 3.1). As noted in the previous section, design studios are condensed into a span of a few hours; in our case, this took 4 hours to finish. To lead a successful workshop, it was equally as important to have a facilitator who could manage the team and activities which were to come. For this purpose, we chose the most experienced designer among the participant, who was comfortable with the role.

As for the structure of the workshop, it was organised into four main sections:

1. **Introduction.** In this section, the participants were introduced to the following elements essential for the challenge:
   - *Motivation.* Content-wise, we put up a board in Miro summarising the motivation behind the challenge — the same text can be found in the introduction of this thesis 1.

- *Personas.* In order to understand whom the participants were designing for, we presented personas (see appendices A,B, C) and their stories, pain points, characteristics and goals. To clarify, these needs directly reflected real needs that we previously elaborated on in section 2.3.
- *How might we (HMW).* By defining themes and insights, we identified the problem area that poses a challenge to the target group. For designers to create solutions, we have to re-frame our insights and identified needs into HMW questions that suggest a solution is possible because you can answer them in different ways [6]. In our case, we defined 3 HMWs:
  - *"HMW improve the interaction between a student and an educator so that the teacher can make sure his students are paying attention?*
  - *HMW help students to socially interact with their peers during an online class so they can socially develop and enjoy themselves?*
  - *HMW increase social interaction between a student and an educator so that the educator/student does not feel isolated/alone during an online class?*

  Again, these HMW questions are more or less re-framed versions of the needs we discussed in section 2.5.

2. **Lightning demos.** Before actually creating their own solutions, to inspire themselves, the participants took some time to find products or services that solved similar or related challenges, so-called *"lightning demos"*. Each participant had 20 minutes to research and come up with 2-3 examples they thought the team could use as inspiration. After finding an example, they put up an image with three sticky notes describing the main ideas of the product in Miro (see figure 3.2). Following this step, each participant was asked to present their ideas one by one, showing the whole team what was interesting about the idea.

3. **Sketching** Arguably the most valuable section of the workshop was to generate as many ideas as possible in the form of sketches. We split this section into 3 parts:

   - *Note taking.* The point of this activity was to enable the participants to recompose themselves and *"lock-in"* the decisions made earlier in the previous section. With the initial part out of the way, each participant was given 10 minutes to write down exciting ideas from lightning demos that had caught their attention.
   - *Doodling.* We opted for a slower approach; thus, before the actual sketching, we gave the participants additional 8 minutes to doodle their ideas out for themselves. That way, the participants would have a feeling of security.

- *"Crazy 8s."* The prior activities gradually build-up to the *"Crazy 8s"* (see figure 3.3), a technique used by designers to help generate and visualise ideas. It is a sketching activity comprising of 3 tasks:

  a. *Sketch.* Each participant takes a piece of paper and folds it in half 3 times to create 8 cells. The participants then have 8 minutes to work individually and sketch out 8 ideas in each cell.

  b. *Present.* The facilitator instructs participants to post their sketches to the wall (in our case, a Miro board) and explain the core idea, while the other team members who are not presenting at the time provide critique.

  c. *Remix.* Each person works individually to sketch two big ideas in 10 minutes on a new piece of paper. The participants can build on previous ideas (not necessarily their own ideas) or combine elements of several ideas from the first task. After the times runs up, participants present their ideas as in the previous step.

4. **Converge.** Once the most substantial areas of each idea had been identified; the facilitator instructed participants to vote for what they thought was the best idea. This allowed the convergence to a single idea that would be developed. The following subsection outlines the final concept more in-depth.

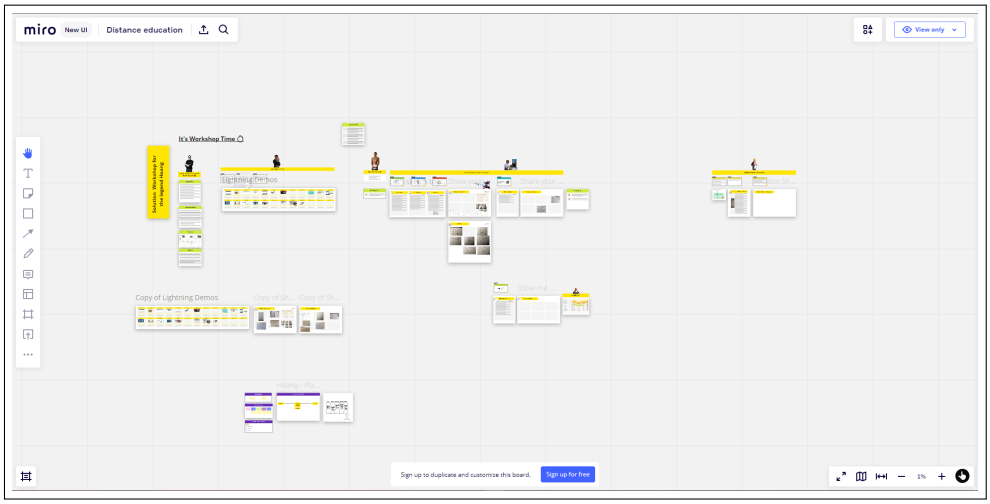

Figure 3.1: Miro project for the design studio.

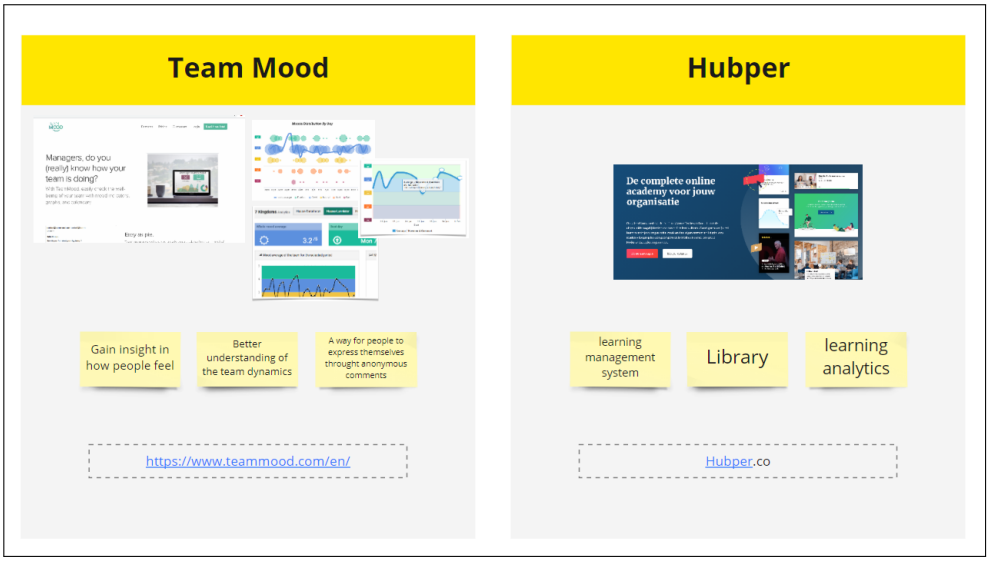

Figure 3.2: Examples of Lightning Demos.

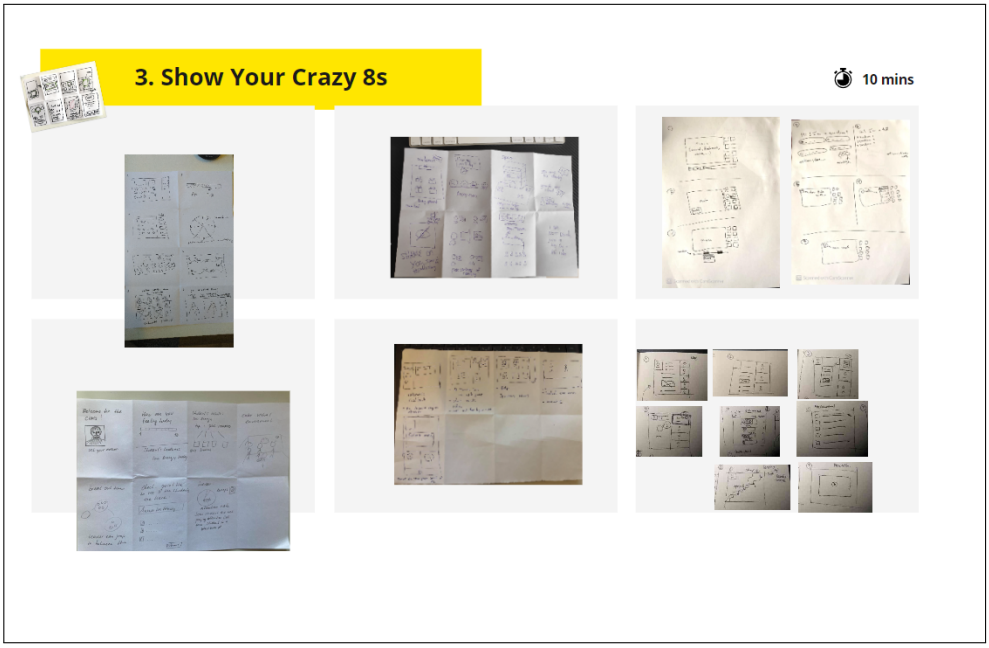

Figure 3.3: Examples of Crazy 8s.

3.2.3 Final concept

The consensus view seems to be that the current market lacks highly interactive tools explicitly targeting students and educators as their users, tools that would provide more assertive communication. Therefore, the participants all supported the concept of a new videoconferencing tool that would allow students and educators to interact more organically as in real life. Consequently, the idea of simulating a real physical school (real conversations, real

school space without restrictions) through a videoconferencing tool seemed innovative and, above all, tackled the identified needs of the target group. Let us present the features that the participants regarded as the core of the concept:

1. *Real virtual space.* Currently, schools implement online education through videoconferencing platforms such as Zoom and Microsoft Teams. While some of them admittedly offer the integration of the whole organisation (meaning the organisation creates a virtual school containing all classes or subjects where the lessons are held), the space simply does not feel real. Lessons are held separately by accessing an absurd number of links; students do not meet other people outside of their class etc. A real space enables seamless transitions between classes — an educator or a student enters a classroom full of students, leaves the room at the end of the class and passes through a hall full of people to attend a subject taught in another classroom. This is what creates the unified and unique experience of a school.

   Our concept creates a virtual space where users are represented by their avatar icons; they enter and leave virtual spaces like classrooms without the need to access other links, meet students and educators outside of the curriculum and talk with them. During a class, users can sit with each other and privately discuss what is being taught (see figure 3.4)- the same way they do in a real school, which increases the social interaction between students. Classrooms are all placed within one virtual space representing a school (see figure 3.5), making the experience of switching classrooms quick and straightforward.

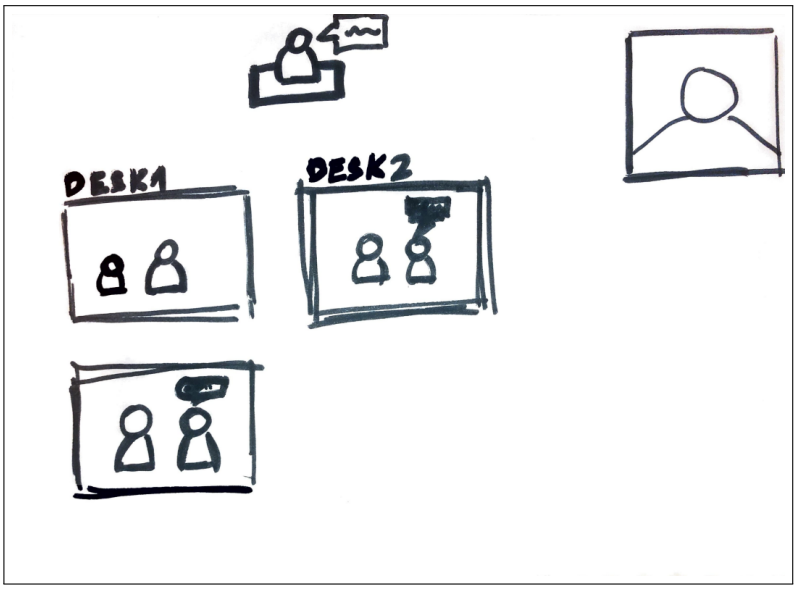

Figure 3.4: Virtual classroom — a sketch made during design studio

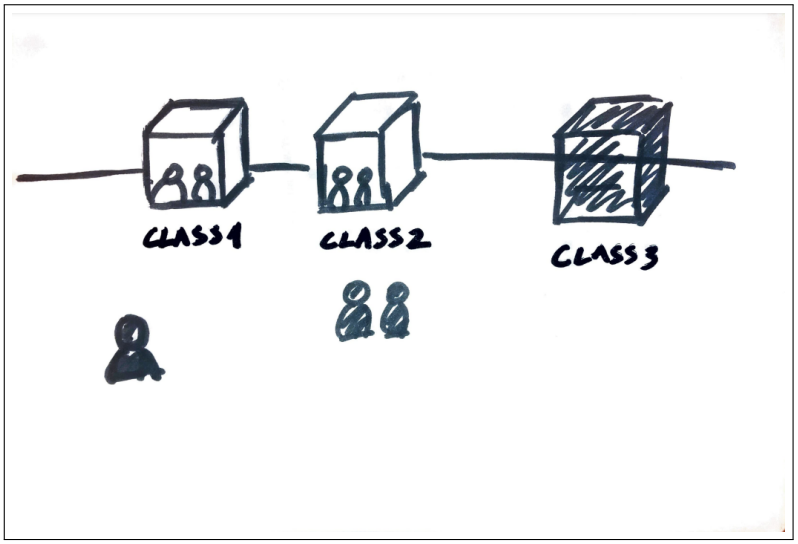

Figure 3.5: Quizzes — a sketch made during design studio

2. *Quizzes.* An educator can easily create quizzes called "Quiz time", which will appear on students' screens (see figure 3.12). The educator can check students' answers in real-time and see the statistics of the quiz. This increases interaction between an educator and a student, allowing them to give immediate feedback.

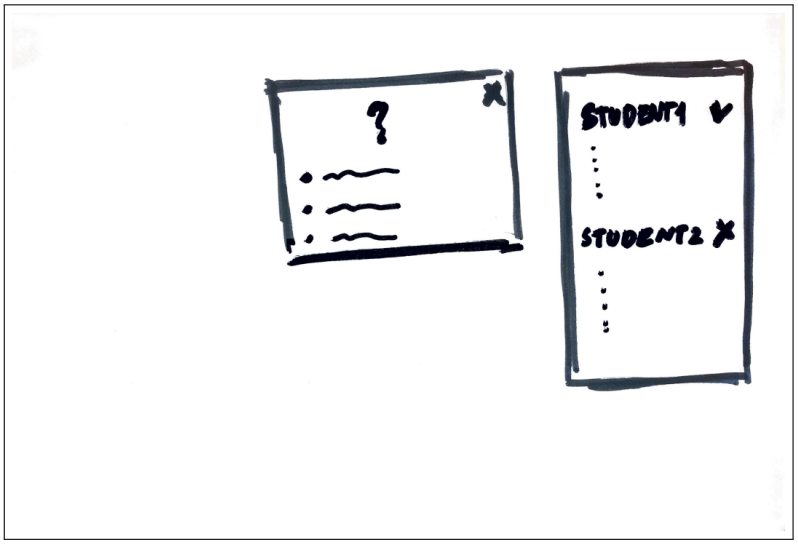

Figure 3.6: Quizzes — a sketch made during design studio

3. *Pan and Zoom.* Users can move around the virtual space by dragging their avatar icon, which introduces an element of gamification and increases the overall interactivity of the tool since users have to keep in touch with the application and pay attention to where their icon is. This also creates the experience of real-life communication; users can pass by other users' icons and initiate contact as they would in a real school.

3.3 Requirements

On the basis of the profound study of our target user group and the detailed description of our final concept, we define specific requirements as a means to design future prototypes.

Functional requirements:

- **FR1: Virtual rooms.** Authorised users can create virtual rooms (e.g. classrooms) for other users to enter.
- **FR2: Virtual areas.** Authorised users can create virtual areas in rooms for other users to join (e.g. educators can create desks, students can then join these desks as they would in a real classroom and talk with other students by the desk.)
- **FR3: Check up on students.** Educators can enter an area of students and listen to their discussion.
- **FR4: Privacy in spaces.** Users in a common space cannot be heard from outside of the space.
- **FR5: Broadcast.** Authorised users can turn on the broadcast to talk to the whole classroom.
- **FR6: Drag.** Users move in the virtual space by dragging their avatar icon.
- **FR7: Video chat.** Users can turn on their webcams to be seen by other users.
- **FR8: Creating quizzes.** Educators can create quizzes for assessing students' understanding of the material being taught or ask for feedback.
- **FR9: Launching quizzes.** Educators can create a quiz in advance and launch it during a class when they decide to do so.
- **FR10: Anonymity.** Educators can choose whether the answers are going to be anonymous or not.
- **FR11: Statistics.** Educators can view statistics regarding a quiz — how many people answered correctly/incorrectly. If the quiz is not anonymous, they can see individual answers from each student.
- **FR12: Switching rooms.** Users can leave the virtual room they are currently in, look through all the other rooms and enter an arbitrary room.

Nonfunctional requirements:

- **NR1: Usability.** The UI ought to be designed in accordance with educators' abilities, age, limitations.

3.4 Formal description of the user interface

In this section, we aim to formally describe the user interface of our solution through user scenarios.

3.4.1 User scenarios

US1: Checkup on students. Eve has been teaching an English class since 8:00. After explaining the concept of "Past simple'' to the students, she would now like to create a group assignment consisting of a speaking exercise from the textbook; thus, she instructs the students to start discussing the exercise in pairs as they are sitting. A couple of minutes has passed, Eve decides to check up on the first group to see if they are doing well. She drags her avatar icon from the front of the class to the designated desk of the group and starts listening to their conversation. She notices Peter, a student in the first group, making a grammar mistake and immediately corrects him.

US2: Switch classrooms. Eve feels extremely exhausted following the last English class; she cannot wait for the end of the day to have a bit of time for herself. Then it suddenly dawned on her; she had been daydreaming for the last 5 minutes and did not realise her next class in "VI.AG" was literally starting in 10 seconds. Eve quickly presses the button to leave her current classroom, and after the system loads the space of the entire school, she swiftly navigates her avatar icon to the desired classroom. The system loads the space of "VI.AG", and Eve feels grateful she has made it in time.

US3: Join a class. Alina has just finished her breakfast, and her first class of the day is starting in 5 minutes. She logs into the online conferencing tool and instantly sees an overview of all the classrooms in the virtual school space. After a few seconds, she spots her classroom, "VII.BG", and so she drags her avatar icon into the designated space. The system then loads the virtual space of her classroom.

US4: Sit with a classmate. The system finished loading the virtual space of "VII.BG". Suddenly, Alina realises her best friend Paulina has already arrived. She is elated her best friend is alone by her desk and decides to sit with her during this class. Therefore, She drags her avatar icon into the visualisation of the desk, and the system connects her with Paulina. It is then that she is finally able to greet Alina cheerfully and talk with her about the last episode of the TV series *"You"*.

US5: Meet outside of curriculum. Thomas is currently in the middle of a long lunch break. His friend Adriano from another class sends him a message on Facebook, asking him whether he had some time to spare. Thomas agrees, logs into the conferencing tool and creates a private room where he and Adriano can talk and play.

3.5 Prototypes

We followed the iterative process of UCD, and after the initial sketches from the design studio, we developed low-fidelity and high-fidelity prototypes. As can be seen from UCD, we refine and enhance a prototype in each iteration using the previous prototype's evaluation results as input.

3.5.1 Low-fidelity prototype

Our low-fidelity prototype is primarily concerned with the rough visualisation of ideas that were put forward in the discussion of the final concept 3.2.3 and requirements we elaborated on in 3.3 and 3.4.1. As our low-fidelity prototype aims to focus on visualising key ideas, we ignore the visual identity of the design (colours, fonts, logo, etc.) for now and instead establish the main layout and basic elements. In an effort to describe the low-fidelity prototype, let us examine what we consider to be essential parts of the prototype.

Basic controls. Users control the space they are situated in by using 3 basic interactions:

- *Drag.* Each user represented by their avatar icon (see figure 3.7) contains either an avatar of choice or a webcam stream, depending on whether their webcam is turned on. In order to move in the space, they drag their avatar icon with a mouse/touchpad to the desired place.
- *Pan.* Users pan to reveal different areas of the space (imagine panning a map to explore the desired area).
- *Zoom.* Users control the scope by zooming in and out.

Figure 3.7: Low-fidelity prototype — User's avatar icon

Toolbar and sidebar. The contents of the sidebar (see figure 3.8) changes based on the selected tab, the room type a user is in and the type of user (educator or student). When situated in a classroom, a user might interact with the sidebar to see an overview of all participants in the room, create quizzes, and display their results or chat. Correspondingly, when situated in a school space, the sidebar displays an overview of all classrooms alongside buttons to enter them.

The toolbar (see figure 3.9), on the other hand, serves the purpose of modifying the user's own settings — turning on/off their webcams, muting

their microphones, leaving the current room, sharing their screen, broadcasting and using emojis.

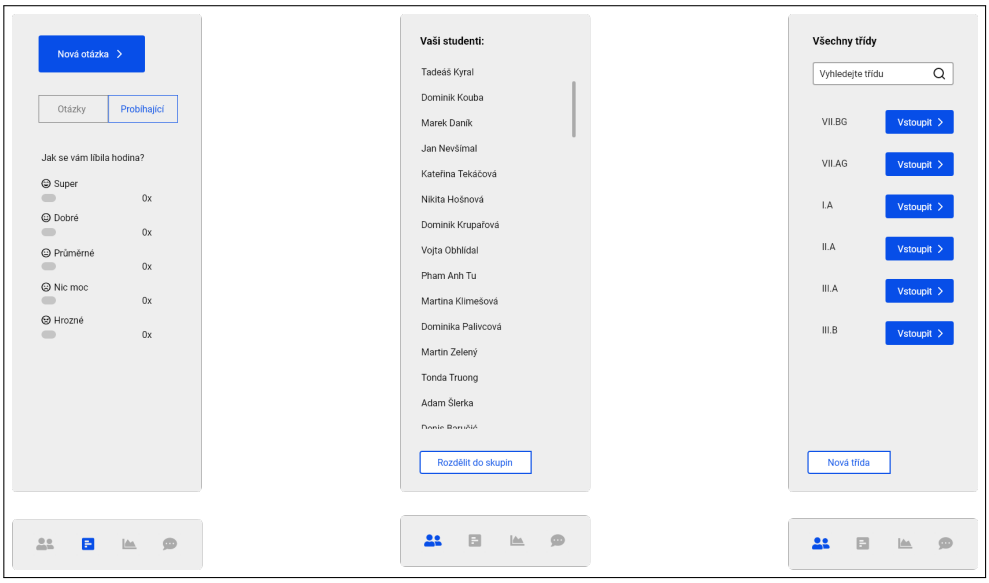

Figure 3.8: Low-fidelity prototype — Examples of sidebar contents

Figure 3.9: Low-fidelity prototype — Toolbar

School space. As soon as a user logs in, they are loaded into what we call a *"school space"* (see figure 3.10), which is roughly comparable to a school's hall. This is where students can *"bump into"* other students or educators to deliver the same experience of activities outside of the curriculum. Naturally, a school space includes all classrooms as it typically would in a physical school. A virtual room symbolises each classroom with an icon avatar of an educator who is currently teaching there. In order to enter a classroom, a user drags their icon into the virtual room as indicated by the previous explanation of basic controls.

It follows that authorised users can create additional classrooms (or rooms for whatever purpose in that sense) if needed through a button located in the sidebar (see figure 3.10).

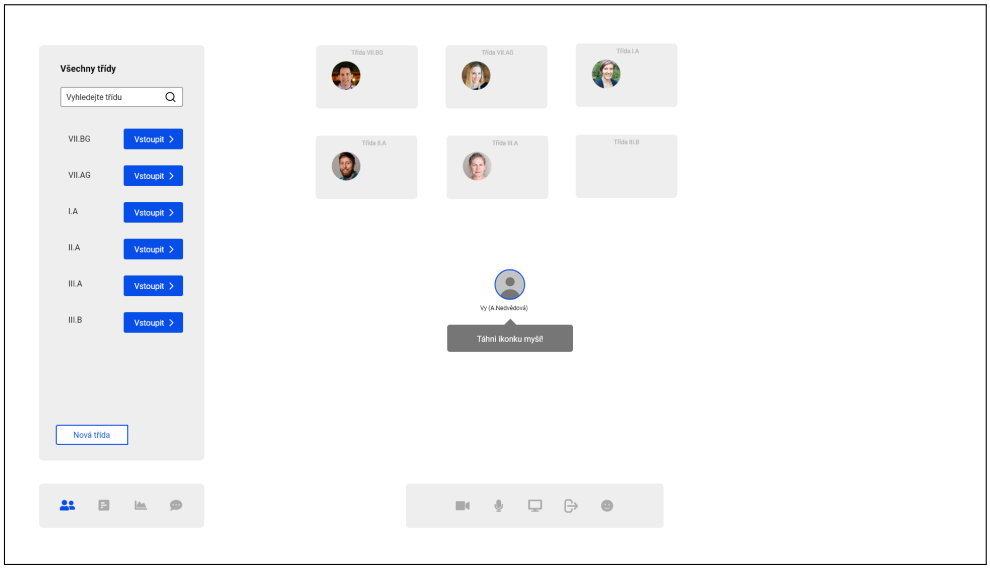

Figure 3.10: Low-fidelity prototype — school space

Classroom space. Upon entering a classroom, the users are introduced to several new elements. As a student, you choose a desk symbolised by a virtual area to sit at as they would in a physical classroom (see figure 3.11). Again, they achieve this by dragging the avatar icon into the virtual area. A private connection is created by sitting at a common desk, only available to users at the same desk. As an educator, you gain access to a number of new functionalities:

- *Creating groups.* It is a standard practice for educators to create groups of students to assign a group project or task. There are two ways to achieve this in our prototype — an educator can either manually drag students' avatar icons into a virtual area (a desk) or create random groups through a button *"Create groups"* available from the sidebar. The latter prompts the educator to enter the number of desired groups (see figure 3.13) and subsequently moves the students on its own.

- *Creating quizzes.* Educators can create new quizzes through a button *"New quizz"* located in the sidebar (see figure 3.8). Upon clicking this button, the educator is prompted to enter the details of the quiz (see figure 3.12) such as the question itself, the option to keep the quiz anonymous and an option to add an image.

- *Joining a video call.* By dragging their avatar icons into a virtual area of students (a desk), an educator joins the private video call and can listen to the ongoing discussion in the virtual area (see figure 3.14).

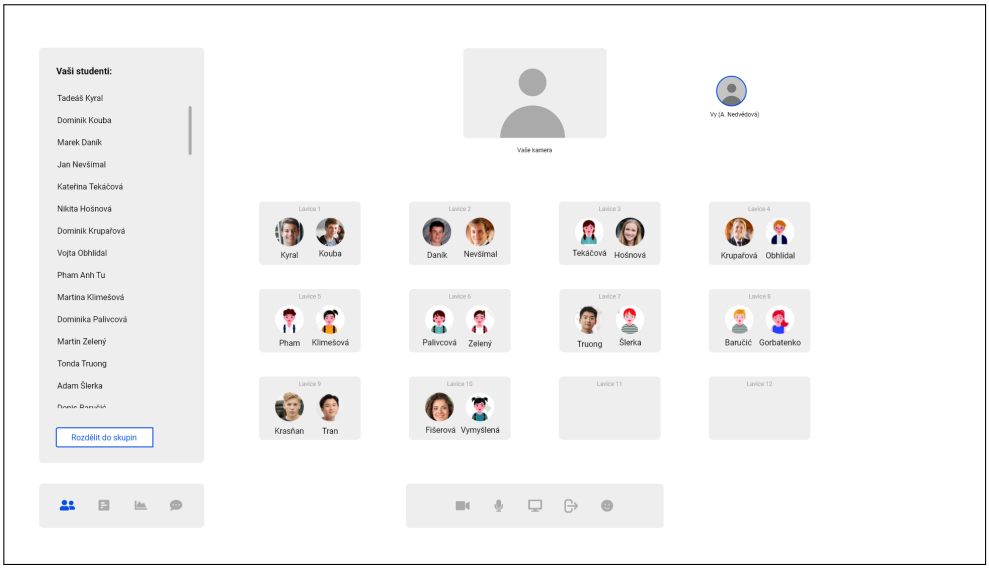

Figure 3.11: Low-fidelity prototype — Classroom space

Figure 3.12: Low-fidelity prototype — Creating a quiz

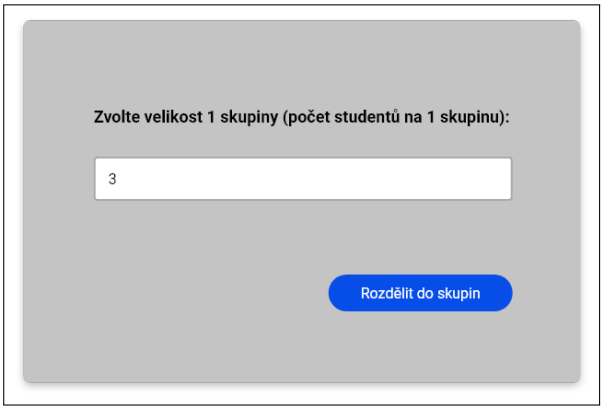

Figure 3.13: Low-fidelity prototype — Creating random groups

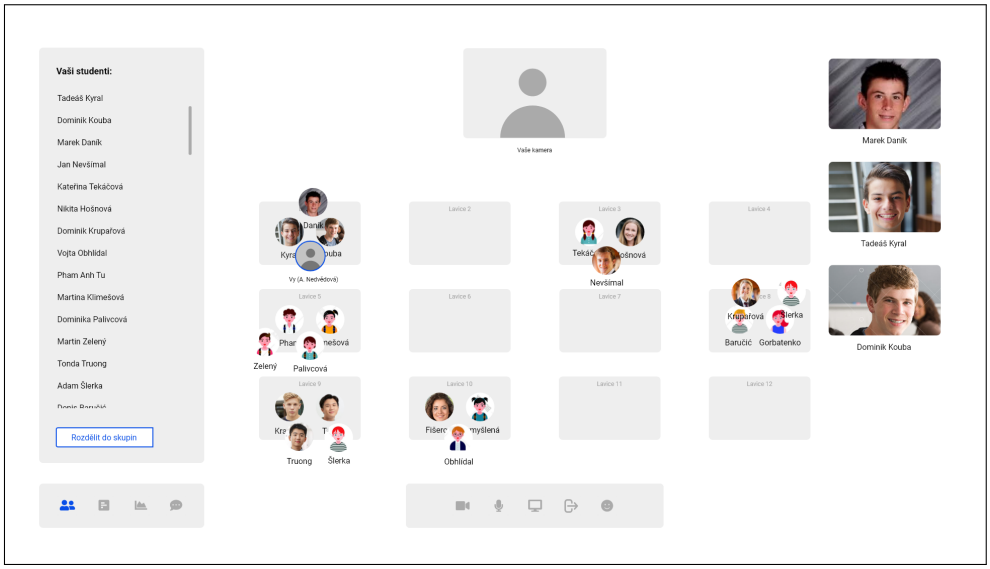

Figure 3.14: Low-fidelity prototype — joining a video call

3.5.2 High-fidelity prototype

The high-fidelity prototype sought to address the issues of low-fidelity prototype found in its evaluation as well as create a visual identity that would bring us closer to the embodiment of the final product. We built on the already established layout and core components to add finer details like colours, interactions without limitations (drag, zoom, pan), animations and actual webcam stream. Creating fundamental interactions without limitations was achieved mainly due to the nature of the implementation (further elaborated on in chapter 4), as it was developed through programming. In contrast, the low-fidelity prototype was developed in the design tool Adobe XD where dragging, panning, zooming is heavily limited or even unavailable in the case of zooming; thus, the experience of using these interactions is not as authentic.

We present the notable changes made to the high-fidelity prototype:

Visual changes. The most noticeable change has to do with the overall design of our prototype. We chose blue as the primary colour of the design to signify reliability, intelligence and stability, which goes hand in hand with a tool focusing on education. As an attempt to create the sensation of spaciousness in the user interface, we added a geometrical pattern background (see figure 3.15), which is frequently used in interactive tools such as Figma, Adobe XD where panning is a vital interaction. Other components like buttons, popups, sidebar, and toolbar were also refined to match the prototype's overall aesthetics. During the design of the prototype, we strove to form a minimalistic and simple user interface to aid users who were not as technically literate.

Initial tutorial. To tackle the issue of users not being familiarised with the basic controls (see 5.1.2), we designed an initial tutorial (see figure 3.16) that appeared in the form of a popup immediately after the user's entrance to the school space. This tutorial is comprised of four steps, each containing an instructional video demonstrating an individual interaction along with a specific description. The steps included the demonstrations of controlling the user's avatar icon through dragging, panning to explore the space, zooming, entering a room by dragging the user's avatar icon into the room.

Screen sharing. To gain insight into our designed solution, it would be appropriate first to discuss the thought process behind designing solutions concerning the finding 5.1.2 — losing the context of the application during screen sharing.

Initially, one of the first ideas that came to mind was automatically splitting the screen in half once screen sharing was turned on. One of the halves would display our videoconferencing tool, while the other would be the shared screen. Unfortunately, this turned out to be an unimplementable solution because web browsers do not allow window resizing from code (unless the code itself opens the window). However, it can be manually done by the user himself, depending on the operational system.

Another idea was to implement a picture-in-picture feature to increase the user experience of sharing a screen. The idea behind this solution was quite similar to the one mentioned above. However, instead of the whole web browser being split in half, we would *"cherry-pick"* webcams of the users in the video call. Nevertheless, upon research, we found out a few issues with this feature would need to be addressed. As of right now, the picture-in-picture API for web browsers is very limited in styling and only allows the modification of the picture's width and height. Therefore it would not be possible to 1. style them as shown in images 1.0 and 2. allow icons (emoticons and hand-raising icons) to show next to the picture. Not to mention that in a class with dozens of students, it would become challenging to display all of the users' webcams on the screen.

Ultimately, we came to the conclusion that instead of sharing a screen, it would be best for educators to upload their presentations/images/videos (which is often why they share a screen) directly into the user interface beforehand (see figure 3.17). Then when needed, they would start presenting in the videoconferencing tool. This way, the context of the whole classroom would not be lost since the presentation would be displayed outside of the app. This was probably one of the more plausible solutions (even though not an entirely satisfying one since it would not cover use cases where the user would need to share a screen honestly); thus, we opted to implement this idea in our prototype.

Custom settings. As a solution to the usability issue 5.1.2, we believed it would be convenient for the user to make the process (of a student talking to the whole class) optional by implementing a settings section (see figure 3.18) where the user, in this case, an educator would manage whether the students

need to raise their hands to enable the megaphone functionality. This ought to satisfy both parties, users who welcomed the functionality and users who did not.

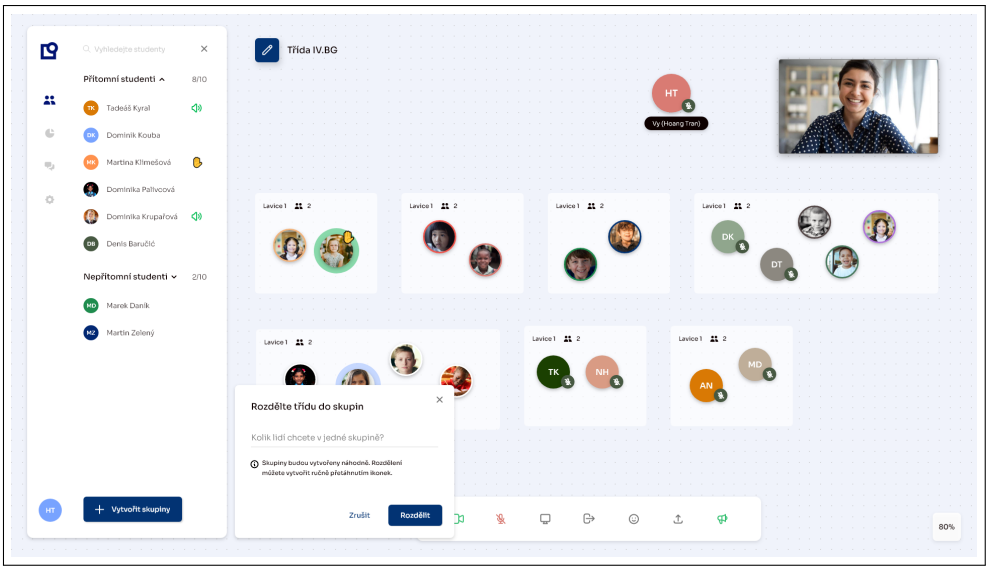

Figure 3.15: High-fidelity prototype — Classroom space

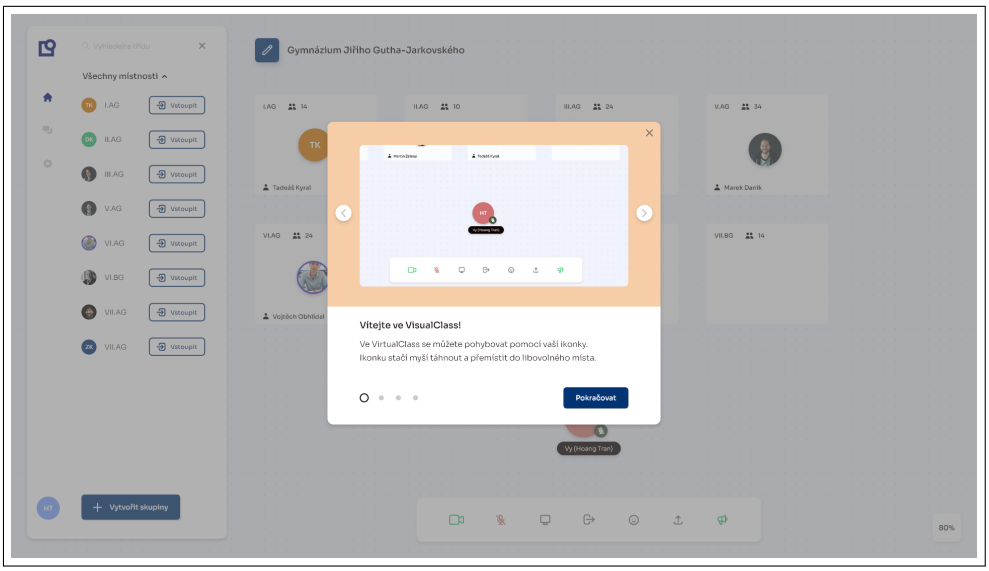

Figure 3.16: High-fidelity prototype — Initial tutorial

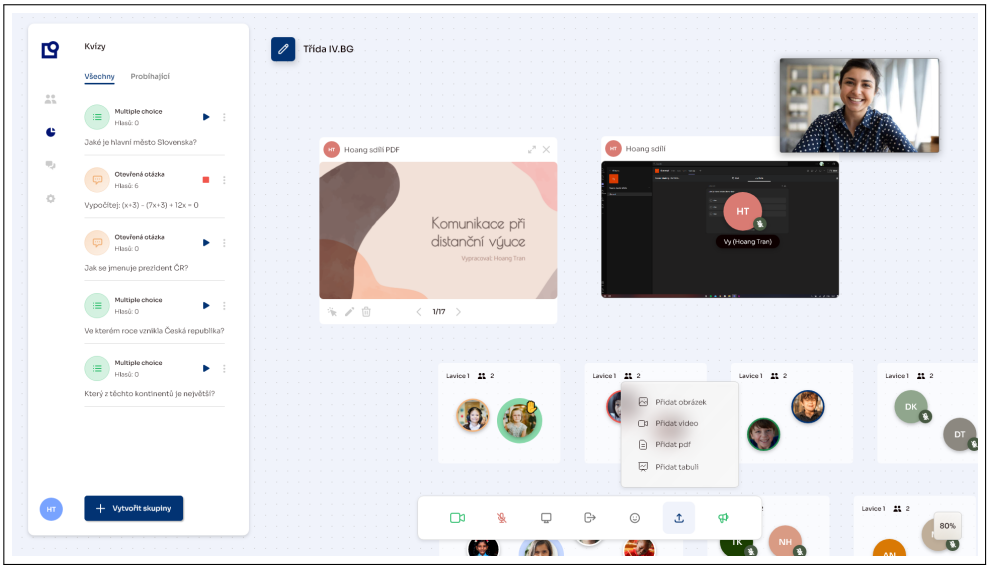

Figure 3.17: High-fidelity prototype — Importing a presentation

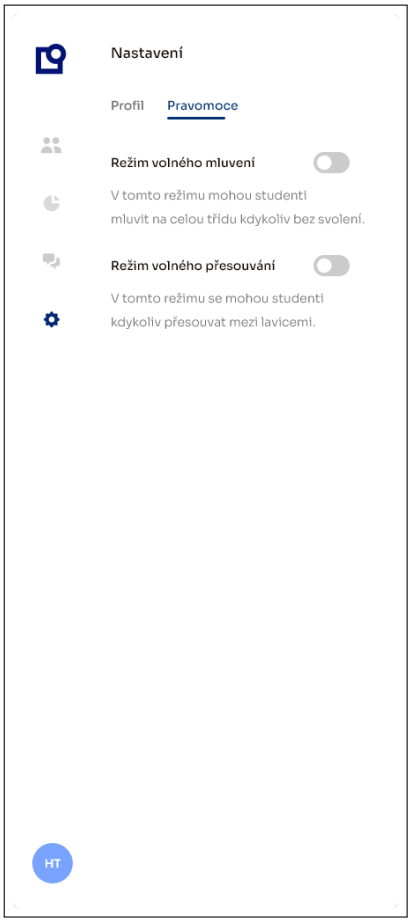

Figure 3.18: High-fidelity prototype — Settings section

3.6 Conclusion

This chapter has outlined our solution's design based on the learnings extracted from the analysis. We began by presenting the personas to materialise the target user group. Afterwards, we examined the design studio workshop, which was carried out with other experienced designers to visualise and give form to a concept that would later be developed. Building on this concept, we defined requirements and user scenarios for the purpose of a deeper and more technical description of our solution. Subsequently, following the process of UCD, two iterations of the design were created, a low-fidelity prototype and a high-fidelity prototype. Whereas the low-fidelity prototype's role was to establish the core layout and components, the high-fidelity prototype took into account the previous iteration's evaluation results and was designed to resemble the final, perfected product.

Chapter 4

Implementation

4.1 Used technology

This section provides an overview of the technologies used while implementing our prototypes.

4.1.1 Adobe XD

Adobe XD [1] is a powerful and easy-to-use vector-based experience design platform that gives teams the tools they need to craft experiences collaboratively. It is aimed at designers who need to:

1. *Design user interfaces*
2. *Prototype user flows and interactions*
3. *Export image assets for development*

It is a direct market competitor to products like Sketch [10] or Figma [3].

4.1.2 React

React [9] is an open-source, declarative, front-end JavaScript [7] library responsible for the application's view layer. In Model View Controller (MVC) architecture, the view layer manages the application's appearance and behaviour. React aims to create time-efficient user interfaces by abstracting the Document Object Model (DOM) away from the developer. Instead, it offers its own virtual DOM, a simpler programming model and better in performance.

React applications' building blocks are components that manage their own state. These components are reusable and can be composed into a more complex UI resulting in a reduced development time.

Despite not being required, a highly recommended syntax extension for React is JavaScript XML (JSX) which enables writing HTML elements inside JavaScript without using complex JavaScript DOM structures. This leads to higher readability and easier debugging.

4.1.3 Typescript

Left to its own devices, as JavaScript code grows, it typically becomes harder to manage. This, along with the fact that the language fails to incorporate types and compile-time error checks, makes it an inferior choice for larger projects.

To overcome this issue, Typescript [12] was introduced as a programming language that was a typed superset of JavaScript compiled to JavaScript. In other words, Typescript extends JavaScript by adding static typing. We list the main advantages of using Typescript below.

- *Optional static typing.* Typescript offers optional static typing and an inference system that will most likely infer a type of a variable, declared without a type, based on its value. These types can be added to variables and functions, which assists the compiler in detecting errors before the application is run.

- *Support of JavaScript libraries.* Since compiled Typescript is JavaScript, it can consume existing JavaScript tools and libraries.

- *Portability.* Typescript can be run on virtually any browser, device, and operating system.

4.1.4 Zustand

Zustand [13] is an open-source state management library for React. At 1.5KB, this lightweight library distinguishes itself by being very straightforward, requiring almost no boilerplate code, which cannot be said about its market competitors like Redux.

4.1.5 Styled-components

Styled-components [11] is a React library allowing component-level styles in the application. It also removes the mapping between components and styles, making it easier to pinpoint CSS code related to a specific component. Styled-components utilises tagged template literals; hence real CSS code is written between backticks. Aside from the overall elevated experience for developers, Styled-components provides [11]:

- *Automatic critical CSS.* Styled-components detects which components are rendered on a page and injects the corresponding styles without anything else, only loading the least amount of code.

- *No class name bugs.* Generating unique classes avoids the issue of class names duplicates, misspellings, and overlaps which are frequent in larger projects.

- *Easier deletion of CSS.* Developers do not have to wonder whether a particular class name is already being used somewhere in the codebase as using Styled-components, styles are tied to specific components, promoting easier management of these styles.

- *Simple dynamic styling.* By using props and global themes, adapting styles of components becomes simple and intuitive without the need to manage dozens of classes.

4.2 Low-fidelity prototype

It was decided that the most suitable apparatus to create the low-fidelity prototype was Adobe XD. By using Adobe XD we could afford to design only the most critical parts of the prototype, which in return allowed us to iterate through the designs rapidly. What we mean by this is that instead of implementing the whole logic of our solution (dragging, panning, zooming, actual data, etc.), we designed the core screens and created only the most necessary interactions based on the use cases included in the usability tests.

To lay the foundations of the project in Adobe XD, we first defined the core assets that were used across the project (see figure 4.1); this included types of buttons (primary, secondary, tertiary), typography, sidebar, toolbar icons and colours. Doing so was essential since in the case of later modifications of one asset; we would not have to adjust on every screen individually; instead, we let Adobe XD manage these changes automatically.

While enabling the design of only the most essential parts, we were limited in certain parts — creating a transition between screens had to be done manually, which proved to be a lengthy task. To illustrate, in order to simulate displaying a popup on a button click, we had to design two separate screen states, one with the button and the second identical screen but with the popup. Next, connecting these two screens was required to define the type of trigger (in this case, a mouse click). These mentioned connections formed a flow (see figure 4.2), which represented all the use cases in one usability test.

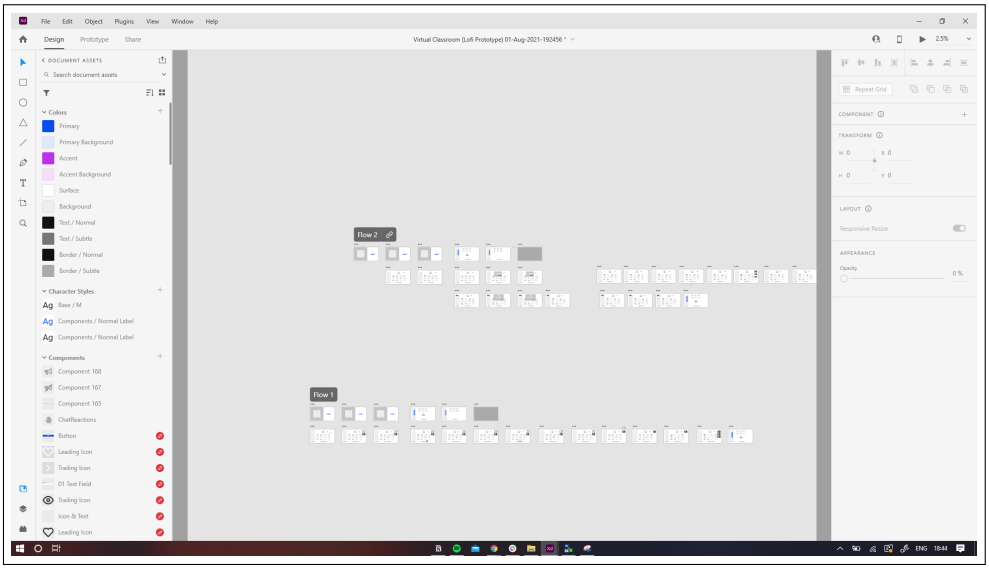

Figure 4.1: Project in Adobe XD

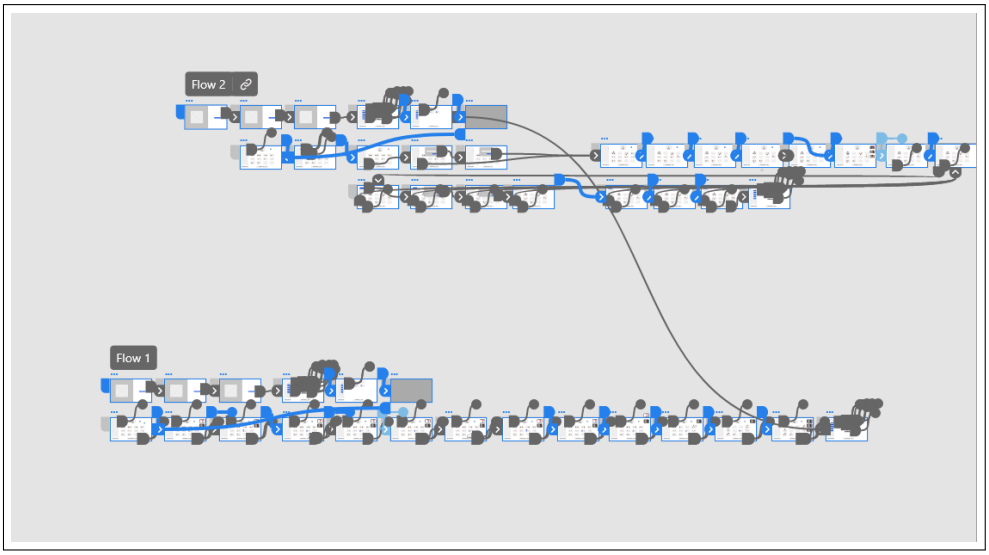

Figure 4.2: Examples of flows

4.3 High-fidelity prototype

The high-fidelity prototype was implemented through a React application with the assistance of Typescript, Styled-components and Zustand. It is essential first to mention that the application's back-end was not implemented since, for the prototype's evaluation, it sufficed to create only the core user interface. Naturally, without the back-end, we had to mimic fetching from a database, which was achieved through static JSON like files — these included data like user information, webcam streaming, users logged into the application, room information etc.

4.3.1 Architecture

Next, to understand the mechanism underlying the key interactions in our react application, we describe the flux architecture (see figure 4.3). The flux architecture suggests splitting the application into four parts:

- *Store.* Stores serve the purpose of managing the states of the UI and the domain. In order to retrieve the value of these stored states, an action is passed to the dispatcher, which decides to act depending on the action. After retrieving the data, the application decides whether it is necessary to update the view.

- *Dispatcher.* Dispatcher is the core manager of this whole flux process. Put simply, a store represents a registry of callbacks into the stores and possesses no real intelligence of its own. It is responsible for distributing the actions to the stores which register themselves and provide callbacks [4].

- *Action.* Actions are simply functions that are called through the view layer (think of events on button click). In the case of these actions modifying the application's state, the view gets updated.

- *View.* View represents the user interface component. It is responsible for rendering the UI and can be updated if the application's state is changed.

Defining this architecture is important because the Zustand state-management library used in our application is built on it. However, it simplifies this process by omitting the use of a dispatcher. Instead, actions directly communicate with the stores. To visualise this process, let us investigate the use case of a user (a student) joining their classmate's desk in our application's project. When a user drags and drops their avatar icon in a desk area, an action with a function signature `detectEnter` (located in the script `virtualroom.ts`) is invoked. This action gives notice to the store responsible for this action — `useRoomStore` (located in the script `virtualroom.ts`) which in return updates its states. Ultimately, the view realises the state has been changed and updates the UI, meaning it re-renders the webcam windows of all the students *"sitting"* at the same desk as the user.

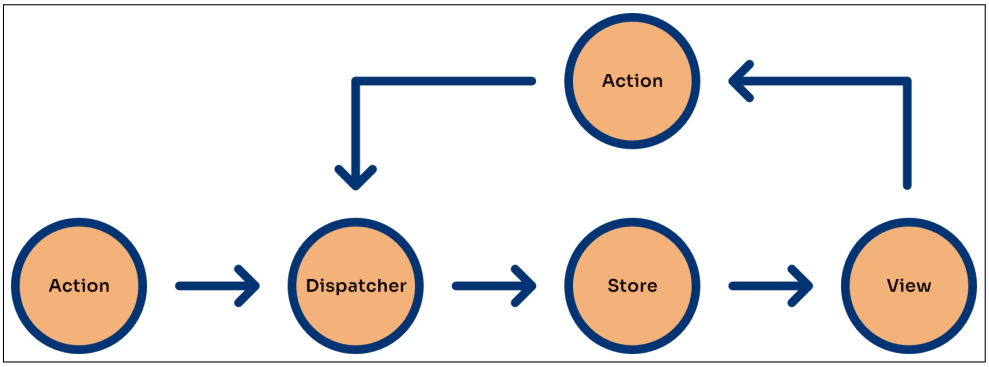

Figure 4.3: Flux architecture

Regarding the dragging interaction itself, instead of relying on an overly complicated library, we have decided to implement the logic by ourselves. In our project, the *hook* responsible for dragging is `usePan` (in `pan.ts`). In short, react hooks enable extracting component logic into reusable functions, and unlike normal functions, they can contain built-in hooks, such as `useState` and `useEffect`.

Our hook, `usePan` manages the state representing the current position of an avatar icon on the screen. Upon dragging the avatar icon, the function calculates the margin between the avatar icon's position and the cursor's current position, eventually updating the state accordingly. The UI component dependent on the mentioned position state detects its change and thus gets re-rendered with the new avatar icon's position.

4.3.2 Project structure

```
node_modules ..... libraries downloaded from npm
src ..... source code
    components ..... reusable UI components
        layout
    data ..... dummy json data
    hooks ..... hooks for reusing logic
    pages
    resources .... resources such as images, videos, icons
    style ..... assets like colours, shadows, global css
```

Figure 4.4: Project structure

For the sake of keeping the project simple without redundant nesting, it was decided that the easiest approach to our project structure would be to group similar files together. Thus reusable components such as `Toolbar.ts`, `Sidebar.ts` were placed in the directory `components`. In addition, with this `components` directory, we opted to go further and separate components

according to their role in the application; thus, the `layout` directory was created to store components specifically related to the layout of the app.

As mentioned earlier in the chapter, hooks played a crucial role in our project; therefore, we created a special directory for them. Hooks like `usePan`, `useStreamWebcam`, `useLogin` were all placed inside this directory alongside their respective stores.

The last thing worth mentioning regarding the project structure is the `data` directory, which was accommodated by all JSON-like files to imitate data fetched from the database.

4.4 Conclusion

This chapter has covered the steps of implementing both the low-fidelity prototype and the high-fidelity prototype. First, it discussed the technologies used to implement the prototypes:

- *Adobe XD,* a designing tool used to create individual screens and eventually specific interactions in the low-fidelity prototype.
- *React,* a JavaScript library aiming to create time-efficient user interfaces by utilising reusable components and the virtual DOM.
- *Typescript,* a programming language built on JavaScript to introduce static typing, preventing compilation errors and easier project management.
- *Zustand,* an easy and straightforward state-management library for React.
- *Styled-components,* another React library used to define component-level styles.

Following the technology subsection, the chapter examined how the low-fidelity prototype had been created in Adobe XD making use of its feature to create an interactive prototype. Subsequently, the chapter explored the Flux architecture on which the state-management library Zustand is built, explaining how specific interactions work in the application. Finally, to give an overview of the code base, the chapter described the project structure.

Chapter 5

Evaluation

Bearing the last phase of UCD in mind, this chapter examines the process of evaluating the low-fidelity and high-fidelity prototypes. These prototypes were evaluated through usability testing with real participants from the target user group.

5.1 Evaluation of the low-fidelity prototype

The evaluation of the low-fidelity prototype was mainly concerned with the core concept's usability itself. In other words, we were trying to assess if the idea of creating a virtual space imitating real-life interactions was practical enough. We recruited 5 educators (3 females, average age = 38.8, SD = 16.12, MIN = 25, MAX = 60) and 5 students (3 females, average age = 14,4 SD = 3.44, MIN = 10, MAX=19), some of which had already participated in the initial user research while the rest was recruited through the method *snowball sampling*. We list the details of the participants in the table below.

Participant ID	Sex	Age	Type of school
PE1	female	51–60	high-school
PE2	female	21–30	elementary school
PE3	female	21–30	elementary school
PE4	male	21–30	university
PE5	male	51–60	high-school

Table 5.1: Educator participants of low-fidelity prototype's evaluation

Participant ID	Sex	Age	Type of school
PS1	female	10	elementary school
PS2	male	19	high-school
PS3	female	11	elementary school
PS4	female	17	high-school
PS5	male	15	elementary school

Table 5.2: Student participants of low-fidelity prototype's evaluation

5.1.1 Procedure

The evaluation of the low-fidelity prototype took the form of informal usability tests. By informal, we mean that the tests took place in an environment of the participant's choice. In the case of educators, this mostly meant physically meeting up in the school they worked at during their free time. As for the student participants, the tests were conducted either in a public space or at their home.

Moving to the usability tests themselves, as a moderator, we began by welcoming the participant and introduced them to the program of the upcoming test. After describing the context to better empathise with the test, the participants were presented with a set of tasks to complete. The contents of the tasks are listed below, divided according to the participant group.

Tasks for educator participants.

1. *Please, log into the application with the following account:*
   - *Email: firstname.lastname@email.com*
   - *Password: password123*
2. *An English class you are teaching is starting in 2 minutes in the classroom III.A. Please find the classroom and join it.*
   - Moderator's questions after the task:
     a. *Did you find dragging the avatar icon intuitive?*
     b. *Can you think of alternative ways to join the classroom?*
     c. *Please describe the elements you see on the screen. What do you think they do?*
     d. *Can you think of alternative ways to join the classroom?*
3. *Greet your students and begin explaining the material you want to teach. If any of the students raise their hands, let them speak and answer their questions.*
   - Moderator's questions after the task:
     a. *Was the process of calling on a student intuitive? Why or why not?*

4. *Next, you are planning on assigning a group exercise, and therefore, you would like to randomly create groups of students, each one to consist of 4 people.*

5. *You have realised a group with the students Adam Šlerka and Lukáš Krasňan has been created. These students do not get along. Please, manually move the student Adam Šlerka to another group where he can work.*

6. *It is now time to check up on each group to see how they are doing. Visit the group with the student Tadeáš Kyral and listen to their conversation.*

   - Moderator's questions after the task:
     a. *Can you think of an alternative way to join a group?*

7. *Now, leave the group.*

8. *At the end of the lesson, you are eager to get feedback on the lesson. Create a poll and observe its results.*

9. *Leave the classroom.*

Tasks for student participants.

1. *Please, log into the application with the following account:*

   - *Email: firstname.lastname@email.com*
   - *Password: password123*

2. *Your English class is starting in 2 minutes in the classroom III.A. Please find the classroom and join it.*

3. *You have joined the classroom on time and still have 1 minute left. Try to find your best friend Adam Šlerka and if he is sitting by himself, join him.*

   - Moderator's questions after the task:
     a. *Can you think of an alternative way to join him?*

4. *The educator has explained the basics of the "Past Simple" tense; however, you still do not understand the context you are supposed to use this tense in. Raise your hand and, after being called on, ask a question.*

   - Moderator's questions after the task:
     a. *Did you find the process of being called on intuitive? Why or why not?*

5. *The educator has made a joke, react with a laughing emoticon.*

6. *The educator has decided to assign a group exercise and told the whole class to create groups of 3 people. Wait after everyone has joined a group and join a group that is missing a member afterwards.*

7. *The class has ended; please leave the classroom.*

Following this task set, we attempted to get the participant's overall impression on the prototype.

Post-test interview.

1. *Can you imagine using this tool in your everyday life?*
2. *What did you like about the tool?*
3. *What did you not like about the tool?*
4. *What are your thoughts on the interactivity of the tool (dragging, talking in a desk) ?*
5. *Was there something unpleasant about the process of this usability test?*

5.1.2 Findings

Usability issues

Drag and drop: interaction not visible.

- *Significance:* high
- *Description:* Upon first interaction with the drag and drop functionality — specifically, when prompted to enter a classroom, 6 (PE1, PE3, PE5, PS1, PS2, PS3) out of 10 participants did not realise they could drag their icon into the virtual room representing a classroom even though there was a considerable popup instructing users to do so. A vast majority of participants chose an alternative way to enter the classroom — either through clicking on a button "Enter" or through directly clicking on the classroom. It is also important to note that once they were introduced to the possibility of dragging, it became very intuitive in the following tasks where they were prompted to visit a group of students or move students from one group to another.

Screen sharing: loss of context.

- *Significance:* high
- *Description:* Due to the nature of the prototype (whole concept) being vastly more interactive than other videoconferencing apps, 5 (PE1, PE2, PE3, PE4, PS2) out of 10 participants were confused as to how the screen sharing functionality worked. Since if they shared a screen, they would lose context of the whole video conferencing app, which generally would not be such an issue in other videoconferencing apps, however in our case, it could be detrimental — educators would not be able to see when their students talk in their groups, whether they are raising their hands etc. Moreover, they would not be able to move their icons or other students' icons.

Hand raising: redundant steps.

- *Significance:* medium
- *Description:* 2 (PE1, PE2) out of 10 participants expressed dissatisfaction with the redundant steps required for the students to talk to the whole class. By default, only students in a common area (a desk) can hear each other. When they decide to speak to the entire class, they need to raise their hand. The broadcasting functionality is enabled after the educator calls on them, and only then can their voices be heard in the whole class. Some participants seemed to agree with these steps, saying it would keep order in the class. However, it is understandable that users who want to keep things simple would not welcome this particular functionality.

Icons' recognisability .

- *Significance:* medium
- *Description:* 4 (PE1, PE3, PE4, PE5) out of 10 participants had issues identifying some of the icons in the toolbar and the sidebar. Moreover, these icons lacked label descriptions, which the participants expected to appear on mouse hover.

  Arguably, the most problematic functionality was the quiz tab in the sidebar. The icon 5.1 was frequently mistaken for file-sharing or statistics.

  Lastly, an icon representing screen sharing was surprisingly unrecognisable for 2 (PE1, PE5) out of 10 participants.

Figure 5.1: Quizzes icon

Figure 5.2: Screen sharing icon

Other findings

Concept overview.

- *Type:* positive feedback

- *Description:* Remarkably, 8 (PE1, PE2, PE3, PE4, PE5, PS2, PS4, PS5) out of 10 participants expressed their satisfaction with the overall concept of the application. The student participants agreed that the tool felt more engaging and fun than a regular videoconferencing tool. In addition, they welcomed the option to talk to their peers at a desk.

  Educator participants were impressed by the simplicity of creating groups for group assignments. PE3 praised the functionality: *"I feel like the process of creating groups in Google Meet, which is what we use, is unnecessarily complicated. I enjoy how easy it is in this tool just by dragging students' icons"*.

  Furthermore, participants appreciated the concept of simulating the space of a real school, especially the quick transitions between rooms.

Addition of a blackboard.

- *Type:* recommendation

- *Description:* 3 (PE1, PE2, PE4) out of 10 participants would welcome the addition of a blackboard, where they would be able to make notes or scribble.

5.2 Evaluation of the high-fidelity prototype

Whereas the low-fidelity prototype's evaluation assessed the usability of the overall concept, the evaluation of the high-fidelity prototype concerned itself with more nuanced functionalities aimed at educator users (such as screen sharing, free panning and dragging, zoom) and naturally, the usability issues found in the previous testing.

We recruited 5 educators (2 females, average age = 34,6, SD = 9.15, MIN = 26, MAX = 60) in a similar manner to the low-fidelity prototype's evaluation. The details of these participants are listed below.

Participant ID	Sex	Age	Type of school
PE1	female	21–30	elementary school
PE2	male	21–30	university
PE3	female	41–50	elementary school
PE4	male	31–40	high-school
PE5	male	21–30	elementary school

Table 5.3: Educator participants of high-fidelity prototype's evaluation

5.2.1 Procedure

The structure of the usability tests followed the same procedure as the evaluation of the low-fidelity prototype (see 5.1.1) except for the main set of tasks itself. The contents of the tasks can be seen below.

Tasks for educator participants.

1. *Please, log into the application with the following account:*
   - *Email: firstname.lastname@email.com*
   - *Password: password123*
2. *Go through the initial tutorial and try out the basic controls.*
3. Moderator's questions after the task:
   a. *Did you find the tutorial comprehensive? Why or why not?*
   b. *Did you find the basic controls intuitive? Why or why not?*
4. *An English class you are teaching is starting in 2 minutes in classroom VII.BG. Please find the classroom and join it.*
   - Moderator's questions after the task:
     a. *Please describe the environment of the user interface. In your opinion, what are the rectangle areas and why are they divided in this manner?*
     b. *What do the avatar icons in each area represent?*
     c. *Can you describe the functionalities of the icons in the toolbar and the sidebar?*
5. *You have joined the classroom and would like to take attendance. Is any of your students missing?*
6. *Please, begin your class by greeting the students and outline the structure of today's lesson.*
   a. *How did you know you were talking to the whole class?*
   b. *Did you find the broadcasting functionality intuitive? Why or why not?*
7. *You have prepared an educational video in another tab of your browser beforehand, share your screen with the students and place the screen appropriately.*
8. *The shared screen seems to be too small. Enter the full-screen mode for sharing and check which students are also present.*
9. *Next, you are planning on assigning a group exercise, and therefore, you would like to randomly create groups of students, each one to consist of 4 people.*

10. *You have realised a group with the students Adam Šlerka and Lukáš Krasňan has been created. These students do not get along. Please, manually move the student Adam Šlerka to another group where he can work.*

11. *It is now time to check up on each group to see how they are doing. Visit the group with the student Tadeáš Kyral and ask whether they need any assistance.*

12. *Now, leave the group.*

13. *During your explanation, check if any of your students are talking at their desks. If anyone is indeed disrupting your class, reprimand them.*

14. *After the lesson ends, turn off your camera and leave the classroom.*

5.2.2 Findings

Usability issues

Room transition recognisibility.

- *Significance:* high
- *Description:* It was found that 3 (PE1, PE2, PE2) out of 5 participants had trouble noticing the transition from a school space to a classroom in task 4 (see 5.2.1). Essentially, both of these spaces contain similar objects in the form of grey rectangles representing rooms in the case of school space and desks in classrooms, which naturally lead to hesitation as to what has changed. On top of that, the transition lacked any information indicating a successful action, causing even more confusion. PE1 and PE2 even continued the task without realising and had to be informed by the moderator about the successful transition.
- *Solution:* This issue could be solved by adding a loading animation indicating an undergoing transition between two spaces. Moreover, visually distinguishing desks and rooms would prove to be beneficial.

Icons' ambiguous active state.

- *Significance:* high
- *Description:* A further novel finding was that the colour of an icon did not suffice to describe an active state. 3 (PE2, PE3, PE4) out of 5 participants admitted not knowing whether their webcam and microphone were on or off. This also caused issues when dealing with the broadcast functionality as the PE3 did not know if they could start speaking or not.
- *Solution:* Modifying an icon along with changing its colour would increase the usability of the prototype. For instance, a turned-off camera would be symbolised by a red crossed camera.

Broadcasting: default state.

- *Significance:* high
- *Description:* Even when participants were familiar with the broadcasting functionality, there were still considerable complications while using it — 3 (PE1, PE2, PE4) out of 5 participants kept forgetting that they had to switch the feature on and off when talking to the whole class and one group only. This would potentially lead to private conversations being heard by the whole class if not addressed appropriately.
- *Solution:* One way of dealing with this issue would be to switch the default states based on the context. If the educator's avatar icon was in a desk area, the broadcasting would be turned off by default since the educator most likely wants to talk only to the group. On the other hand, it is often the case that an educator wants to talk to the whole class when they are outside of the desk area, which is why the broadcasting would be turned on here.

Broadcasting: unknown functionality.

- *Significance:* medium
- *Description:* Arguably, the most confusing functionality for the participants was broadcasting, which happens to be somewhat of an unusual tool in other videoconferencing tools. Upon first interaction with the prototype, 2 (PE3, PE5) out of 5 participants were familiar with the concept of broadcasting and, therefore, did not know they had to turn it on when talking to the whole class while solving task 6 (see 5.2.1).
- *Solution: To address this issue, we could create a tutorial (similar to the tutorial for basic controls) introducing the broadcasting functionality.*

5.3 Conclusion

In conclusion, this chapter has described the evaluation of both the low-fidelity and high-fidelity prototypes. The results from the low-fidelity prototype demonstrated that our concept had indeed improved the distance education's experience for most of the participants and thus should be further worked on. The high-fidelity prototype's evaluation section has pointed out lacking parts of the prototype and presented possible solutions for these usability issues.

Chapter 6

Conclusion and future work

This thesis has provided a detailed account of a development process with a design of an application for distance education as its end product. In order to summarise this process, let us revisit the thesis's goals introduced earlier in section 1.3 and examine how they were met.

- Goal 1: **Conduct user research with both educators and students.** We cover the topic of the conducted user research in section 2.3. The user research was realised through semi-structured interviews with the target group; its contents are discussed in the subsection 2.3.2. In total, 15 participants took part in the user research, based on which we identified the findings in subsection 2.3.3.

- Goal 2: **Analyze educators' and students' needs and issues they face regarding distance education.** Taking the new knowledge obtained from the literature review 2.2 and the findings from user research 2.3.3 into consideration, we define the crucial needs of educators and students in section 2.4. Subsequently, we decided to only focus on a subset of these needs:

  - *EN1: Feedback* (2.4.1)
  - *EN7: Social interaction with students* (2.4.1)
  - *SN1: Social interaction with peers* (2.4.2)
  - *SN2: Social interaction with educators* (2.4.2)

  To justify the choice of these particular needs, we lead a discussion in section 2.5.

- Goal 3: **Analyze applications and tools used for communication between students and educators.** Section 2.2.4 is devoted to the analysis of existing tools. More than specific applications, we examine general tools and techniques such as *videoconferencing tools, virtual boards, breakout rooms, LMSs and MOOCs.* Despite not directly targeting distance education, we analyse two interesting applications — *Kahoot! and Gather Town* in 2.2.4 that could offer an added value to distance education.

- Goal 4: **Follow the UCD methodology and propose a set of designs that will resolve issues currently connected to distance education based on the learnings.** Chapter 3 is dedicated to the design of the final solution. First, the conduction of the design studio utilised to generate as many ideas as possible and eventually converge to a single idea that may inspire the final solution is described in 3.2. Based on the final concept discussed in 3.2.3 we formally describe the user interface through user scenarios in 3.4.1 and then build on these to create the low-fidelity and high-fidelity prototypes explored in section 3.5.

- Goal 5: **Evaluate the designs with the target audience in each iteration.** Chapter 5 provides in-depth information about the evaluation of both prototypes through informal usability tests. The low-fidelity prototype (discussed in section 5.1) was evaluated on 10 participants (5 students, 5 educators). It can be inferred from the results that the concept did indeed improve the experience of distance education for most of the participants and thus should be further worked on. Regarding the high-fidelity prototype's evaluation, 5 educator participants took part in the usability tests. Subsection 5.2.2 present the usability issues of the high-fidelity prototype and suggests possible solutions to increase its usability.

In regards to future work, we recommend addressing the high-fidelity prototype's usability issues by putting the solutions presented in section 5.2.2 into practice. Furthermore, the next iteration should be re-evaluated to find plausible usability issues, and if proved successful, a full-fledged back-end of the application should be implemented. While the concept of our solution proved to elevate the experience of synchronous distance education, it did not tackle features essential for asynchronous distance education (as it was not the goal of this work) — storing learning materials at one place, creating online assignments, collecting data to analyse students etc. Thus, further investigation in this area is required to determine which features should be added to our solution for a complete distance education tool.

Appendix A

Persona A: Eve — a high-school educator

Quote

> "Interaction with my students is almost non-existent, I do not see them, I do not know if they are working or falling asleep in their room, nobody answers my questions." — Eve

Story

Eve is an older teacher who has been teaching at a high school most of her career. With her experience she has a very traditional style of teaching. She doesn't use a computer very often and only does so when it's necessary. She has been having trouble adapting to online classes and frequently requires help with technical stuff.

Needs

- ❤️ Need quote from research comes here — Source
- ❤️ Needs to socially interact with her students
- ❤️ Needs feedback from her students in all forms - verbal and non-verbal

Goals

- 🎯 To not feel isolated during a an online class and make it more enjoyable.
- 🎯 To make sure that students understand the material being taught.
- 🎯 To make sure that students are paying attention.

Fears

- 😱 Fears that she might encounter a technical issue.

Pains

- 😢 Lacks nonverbal communication which would be present during a normal class.
- 😢 Feedback from her students is very poor.
- 😢 Doesn't see her students' faces and don't know what they're doing during an online class.

Figure A.1: Template was created by Daniele Catalanotto from [8]

Appendix B

Persona B: Alina — a high-school student

Quote

> "Almost all of my educators approach distance education as a reading contest, meaning that they usually just read notes for us to copy, which is obviously really boring. From my point of view, online communication is impersonal and unpleasant." — Alina

Story

Alina is a 17-year old high school student in Prague. She is graduating from high school in 1 year and therefore has been focusing on her studies more. She has been struggling with productivity and material retention during online classes and overall how they are taught at her school.

Needs

- Needs better interaction with her teachers
- Needs a more interactive online class

Goals

- To feel reassured by a teacher during an online class.
- To understand the material being taught.
- To have her teachers available when needed for any questions.

Fears

- Fear quote from research comes here — Source

Pains

- Feels like online classes are not interactive enough.
- Communication with her teachers doesn't feel personal.

Figure B.1: Template was created by Daniele Catalanotto [8]

Appendix C

Persona C: Thomas — an elementary school student

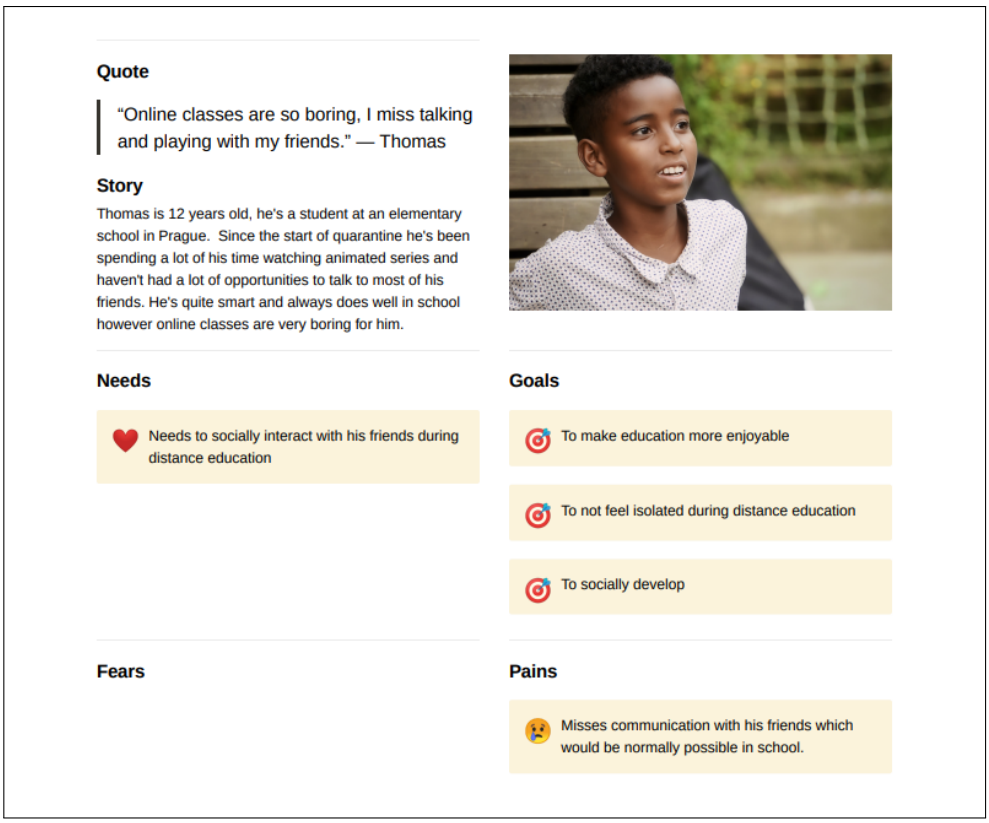

Figure C.1: Template was created by Daniele Catalanotto from [8]

Appendix D

Bibliography

[1] Adobe xd. https://www.adobe.com/cz/products/xd.html. Accessed: 2021-15-12.

[2] Facilitating an effective design studio workshop. https://www.nngroup.com/articles/facilitating-design-studio-workshop/. Accessed: 2021-09-12.

[3] Figma. https://www.figma.com/. Accessed: 2021-15-12.

[4] Flux: In-depth overview. https://facebook.github.io/flux/docs/in-depth-overview/. Accessed: 2021-16-12.

[5] Gather town. https://gather.town/app. Accessed: 2021-06-12.

[6] Ideo designkit. https://www.designkit.org/methods. Accessed: 2021-09-12.

[7] Javascript. https://www.javascript.com/. Accessed: 2021-16-12.

[8] Minimal persona (notion template). https://store.swissinnovation.academy/minimal-persona-notion-template. Accessed: 2022-02-01.

[9] React. https://reactjs.org/. Accessed: 2021-16-12.

[10] Sketch. https://www.sketch.com/. Accessed: 2021-15-12.

[11] Styled-components. https://styled-components.com/docs/basics#motivation. Accessed: 2021-18-12.

[12] Typescript. https://www.typescriptlang.org/. Accessed: 2021-16-12.

[13] Zustand. https://github.com/pmndrs/zustand. Accessed: 2021-16-12.

[14] G. Di Pietro, F. Biagi, P. Costa, Z. Karpinski, J. Mazza, et al. The likely impact of covid-19 on education: Reflections based on the existing literature and recent international datasets. *JT Report, Ed*, 2020.

[15] I. D. Foundation. User centered design. 2020.

[16] P. Gorsky and A. Caspi. A critical analysis of transactional distance theory. *Quarterly review of distance education*, 6(1), 2005.

[17] C. N. Gunawardena and M. S. McIsaac. Distance education. In *Handbook of research on educational communications and technology*, pages 361–401. Routledge, 2013.

[18] D. W. Janiess Sallee. Transactional distance or community of inquiry: A need for a theory of focus in online learning. *Russian-American Education Forum: An Online Journal*, 2011.

[19] C. D. McClure and P. N. Williams. Gather. town: An opportunity for self-paced learning in a synchronous, distance-learning environment. *Compass: Journal of Learning and Teaching*, 14(2), 2021.

[20] M. G. Moore. *Handbook of distance education*. Routledge, 2019.

[21] M. G. Moore and G. Kearsley. *Distance education: A systems view of online learning*. Cengage Learning, 2011.

[22] U. Nations. Adverse consequences of school closures. *United Nations*, 2020.

[23] U. Nations. Education during covid-19 and beyond. *United Nations*, 2020.

[24] J. Nielsen. Usability 101: Introduction to usability. 2012.

[25] A. O'Brien. *An investigation of live-virtual synchronous teaching demonstrated by highly-qualified virtual high school teachers: Tools and techniques*. PhD thesis, Robert Morris University, 2015.

[26] F. Saba. *Methods of Study in Distance Education: A Critical Review of Selected Recent Literature*, pages 152–171. 06 2014.

[27] A. Saykili. Distance education: Definitions, generations, key concepts and future directions. *International Journal of Contemporary Educational Research*, 5(1):2–17, 2018.

[28] M. školství, mládeže a tělovýchovy. Metodické doporučení pro vzdělávání distančním způsobem. 2020.

[29] D. Vlachopoulos and A. Makri. Online communication and interaction in distance higher education: A framework study of good practice. *International Review of Education*, 65(4):605–632, 2019.

[30] A. I. Wang and R. Tahir. The effect of using kahoot! for learning – a literature review. *Computers Education*, 149:103818, 2020.