Supportive learning during lectures using mobile services

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Abstract

Optimizing learning processes at university lectures is a challenging task. Many approaches can be taken and they have varying results depending on the context and individuals involved. In some situations, technology is an advantage - for instance, it is often used for lecture slides, note-taking, online discussions and handing in assignments. In this project, it is leveraged that technology has become increasingly more accessible and accepted as a tool to consider in teaching contexts.

This project describes the research and development of the mobile service *LectureLive*, a service to support student learning during university lectures. Based on feedback from university students and teachers, the LectureLive service allows students to provide anonymous real-time feedback to teachers on their understanding of the material, their motivational level, their confidence and on their need for a moment to take notes. The service is divided into a student application and a teacher application. The student application includes an interface for the students to provide feedback and the teacher application displays statistics on this feedback. The student feedback is provided using existing validated scales on understanding, motivation and confidence but the scales are slightly modified for self-assessment and to fit the mobile format.

Evaluation of the service indicates that the service can be useful under the right conditions but that it requires adjustments and proper introduction to both teachers and students. The biggest challenge is that the service can be distracting and cause information overload for the students. Further research and development of the service is needed to verify if the service is generally beneficial for students' learning during lectures or if it is too distracting.

Contents

1 Introduction

1.1 Context and Problem Definition

The question of what teaching methods and learning environments best support students' learning are often debated and a lot of research has been done in the area. In the research paper *Active learning increases student performance in science, engineering, and mathematics* [11], the authors compare the learning outcomes of traditional learning versus active learning in technical fields at the university level and they argue that there is a significant advantage of active learning. Active learning can be described as any teaching method different from the student passively listening to the teacher's lecture [1]. There is also a lot of discussions when it comes to the advantages and disadvantages of using technology as part of lectures. Some research shows that technology can help improve the students' motivation and that students more often prefer courses that uses interactive technology such as clickers over courses that does not [14]. Even though some research indicates that there are advantages of using interactive technology others argue that it can be distracting and time-consuming [25].

While trying to find a compromise between the two sides of the discussion, the focus of this project is to conceptualize students' learning at university lectures and create *LectureLive* - a mobile service and web service aiming to support the communication between students and teachers during a lecture; thus supporting the students' learning. A substantial part of the project is the supporting research and development of the *LectureLive* service that includes real-time feedback and anonymous communication from the students to the teacher.

The project is an attempt to research how technology can be used to support learning processes at the university level and falls into the Quality of Life psychological health domain 'Thinking, learning, memory and concentration' [24]. The larger context is research on Information and Communications Technology (ICT) solutions supporting the individual's thinking, learning, memory and concentration processes.

1.2 Approach and Thesis Structure

The availability of smartphones and the fact that students and teachers in most western countries own at least one [20] adds new opportunities to the classroom. Smartphones are often kept close to the individual [8] which makes it possible to assume that many students and teachers will also bring them to class. The approach taken in this project is to research and develop an operational mobile service, to be evaluated in real conditions with real users, as opposite to simulating or modelling the context and outcomes. The LectureLive service development is assumed to be a user-centric and iterative development process where requirements, design, implementation and evaluation steps are repeated along the feedback provided by potential users of the system.

To get an overview of the current state of the art (SOA), several existing tools to support student and teacher communication are presented and compared to *LectureLive*

(see section 2). Along with the SOA, different research methods like interviews and a survey was used to understand the problems experienced during lectures from both teacher and student perspective and to delineate the requirements for the LectureLive service (see section 3). Surveys and interviews as methods are commonly used for getting a better understanding of problems within a specific area. While a survey often focuses on getting written quantitative feedback from multiple participants, interviews can help getting a better understanding of the individual's mind and find nuances on a topic through verbal conversation.

One requirement found during requirements elicitation was the need of scales to measure understanding, motivation and confidence. A description of these scales is presented in section 4. After defining the requirements for the project, the analysis model of the project is presented which will give an overview of the LectureLive service as a whole (see section 5). The service is implemented using Cordova, Ionic and Firebase. The implementation is motivated and described in section 6 along with a discussion of the problems met while implementing. The implementation was modified after the first test session. The system evaluation tests are described in section 7 along with their results. Finally, the project outcome and results are discussed in section 8.

The service LectureLive consists of both a student application and a teacher application. Throughout this report, LectureLive will refer to the entire service, and it will be explicitly specified when talking about the teacher or student application.

2   State Of the Art (SOA)

The research paper *Enriching face-to-face and digital interaction with SpeakUp: challenges & lessons learned* [12] describes the experience gained from developing the mobile application *SpeakUp* which purpose is to support student-teacher communication in learning situations. Some questions discussed in the article are:
1. How to best interweave digital and face-to-face interactions?
2. How to improve participation?
3. How to avoid information overload?
4. How to find a balance between attention, distraction and awareness?

These four questions have also been in mind while developing LectureLive and using the experience from SpeakUp it is clear that supporting real life interaction with technology is a difficult task which requires simplicity and carefulness when choosing functionalities. Too many features might distract the students instead of supporting their learning. It can also cause information overload when the students need to be aware of both the lecture content as well as interact with the application (see subsection 3.3 on nonfunctional requirements).

Besides SpeakUp, several other applications exists that can be used to support student/teacher communication during lectures. Their main features are compared in Table 1 and Table 2. The solutions compared are:

- SpeakUp, a research based application where students can join a room based on

their physical location and can ask anonymous questions.

- Socrative, a learning platform with multiple choice questions among many other features.

- PollDaddy, an online tool for creating polls and surveys. It also allows the teacher to create a quiz.

- PollEverywhere, an interactive and live poll tool that can be used with an audience in business, classrooms or other situations to gather answers or opinions from a large crowd.

- Kahoot, a live tool that can be used for polls and questions using gamification such that contestants get points for correct answers.

- Informa Web, a research project with focus on making traditional clicker hardware into a web based application.

- LectureLive, the application researched and developed in this project.

The existing applications and LectureLive are compared on the following parameters:

Reference: Name or website of the application.

Research Reference: References to research papers about the application.

Platform: Platforms supported by the application. The platforms are categorized either as mobile applications (Mobile) which can be installed directly on a phone or as web applications (Web) which are accessible from a browser on a laptop or phone.

Max Students: Maximum amount of students that can be online in the application simultaneously.

Anonymous: Indication of whether or not the students are anonymous in the application.

Teacher Defined Questions: Indication of whether or not teachers can define questions for the students to answer.

Up/down Voting Of User Content: Indication of whether or not users can up-vote or down-vote content provided by other users.

Registration: Indication of whether or not users are required to register before using the application.

Real-time: Indication of whether or not the application includes real-time features.

Teacher Interface: Indication of whether or not the application have a dedicated teacher interface.

Room Definition: Technique used to connect students and teacher. For instance it could be by using a room ID or the users' geographical location.

Pricing Strategy: Pricing strategy of the application.

Pre-lecture Preparations: Indicates whether or not the application requires preparations by the students or teacher.

Reference	Research References	Platform	Max Students	Anonymous	Teacher Defined Questions	Up/down Voting Of User Content
speakup.info	[12]	Mobile+Web	NA	Yes	Yes	Yes
socrative.com	[4]	Mobile+Web	150	Optional (Teacher decides)	Yes	No
polldaddy.com	NA	Mobile+Web	Any(not real time)	Yes	Yes	No
polleverywhere.com	[21]	Mobile+Web	Price dependent	Optional	Yes	Yes
getkahoot.com	[13]	Mobile+Web	4000	Optional	Yes	Yes
Informa Web	[19]	Web	NA(14 in test)	Optional	Yes	No
LectureLive	NA	Mobile+Web	99	Yes	No	No

Table 1: First half of solution comparison.

Reference	Registration	Real-time	Teacher Interface	Room Definition	Pricing Strategy	Pre-lecture Preparations
http://speakup.info/	None	Yes	Yes	Geographical location	Free	None
https://www.socrative.com/	Teacher	Yes	Yes	By name	Freemium	Teacher
https://polldaddy.com/	Teacher	No	Yes	Email	Freemium	Teacher
https://www.polleverywhere.com/	Teacher	Yes	Yes	By SMS or URL	Freemium	Teacher
https://getkahoot.com/	Yes	Yes	Yes	By ID	Free	Teacher
Informa Web	Optional	Yes	Yes	By ID	Free	Teacher
LectureLive	None	Yes	Yes	By ID	Free	None

Table 2: Second half of solution comparison.

In Table 1 and Table 2 the applications are compared on several different features. The tables only display core factors that can be directly compared to LectureLive and thus leaving out many additional features that the applications might have. Compared to the other solutions, LectureLive stands out on the following features: No registration is required, the application does not support teacher defined questions and it does not require any pre-lecture preparations. The reasoning behind the importance of the latter comes from interviewing four teachers at the University of Copenhagen. Details on these interviews can be found in section 3.1.1.

3 Requirements Elicitation

This section describes the requirements defined for the service. The requirements are divided into functional and nonfunctional requirements and a short explanation of why each requirement was chosen will be given.

3.1 Finding the Requirements

Instead of having one client to help defining the requirements, the clients for this project were considered to be the end-users - university teachers and students. For that reason, the requirements are defined using the interview answers from students and teachers, the survey answers from students, research papers and the projects described in the SOA section.

3.1.1   Teacher Interviews Results

Four teachers (T1,T2,T3,T4) from the University of Copenhagen (UCPH) were interviewed in February and March 2017. The participants were from different departments of UCPH: "The Royal School of Library and Information Science" (T1), "The Department of Computer Science" (T2), "The Department of Science Education" (T3) and "The Department of Arts and Cultural Studies" (T4). The purpose of the interviews was to find any frustrations or problems that the teachers experienced when giving lectures and to discuss possible solutions. The interviews mainly focused on issues regarding communication between students and teachers. The teachers were also asked about their opinion on using technology in class. The interview questions can be found in Appendix B. The interviews took from 15 to 40 minutes. A set of questions were formulated as a basis for the interview, but it was not followed strictly, and the participants were asked many follow-up questions on the topics they brought up. This was to explore those issues in depth that the teachers thought most severe.

Use of technology

Three out of four teachers had some experience using mobile or web applications (Socrative (T1,T2,T3) and Padlet (T3)) as part of their lectures. The last teacher wanted to include more technology in lectures but did not know of any good applications. All of the teachers found that using technology as part of their lectures took up preparation time which was not always worth spending.

Questions in class

The teachers found that students are often too shy to ask questions and three out of four wanted more questions from students. T2 pointed out that there was a big difference in how much students participated in elective courses and in mandatory courses. In elective courses student participated a lot more in discussions and asked more questions in general. Another teacher (T1) found that most questions asked were about assignments and exams. All four teachers agreed that there was a big difference between teaching small classes with few students and in big lecture halls with many students. Having less students often meant that it was easier to get an idea of which students were getting behind and which students were up to speed. Teaching large courses often made it difficult to identify students having trouble understanding the course content.

Envisioned features

At the end of each interview, questions on two envisioned features for LectureLive were discussed(see Appendix B).

- Anonymous questions during lectures.

- Anonymous feedback from students during lectures indicating if they understand the current content.

The idea of allowing anonymous questions was met with some scepticism from the teachers. For instance anonymous questions or comments would allow the students to write less serious questions, distract the students or it could be a stress factor for the

teacher if too many questions were send at the same time.

The idea of getting anonymous feedback from students indicating if they were up to speed was also discussed with the teachers. T1,T2 and T4 liked this idea because they could get a notification if a certain percentage of the students did not understand the topic. One issue that was discussed was that the teachers might feel monitored with such a feature if it also allowed others to see the student feedback.

3.1.2 Student Interviews Results

Three computer science students (S1,S2,S3) from the University of Copenhagen were interviewed in February 2017. S1 and S2 were bachelor level students and S3 a master student. The purpose of the interviews was to find any frustrations or problems that the students experienced when attending lectures and discuss possible solutions. Fourteen exploratory questions were made to find the students' opinions on technology used in class and to find potential problems experienced during lectures (See Appendix A). The interviews took 10-15 minutes.

Three key issues that at least two of the students had were:

- Understanding too little or too much of the lecture content is demotivating.

- Asking questions during lectures can be intimidating.

- Boring lectures result in easy distraction by other things.

Understanding
The students had frustrations when not understanding the lecture content but they also had frustrations when finding the content too easy. For instance S2 mentioned that not understanding the first part of lecture often meant that the rest of the lecture was a waste of time: *"If you don't understand the first part of the lecture the rest often doesn't matter."* (S2)

On the other hand S3 sometimes found the topics covered too easy:

"Sometimes I know the stuff the teacher is telling already and I stop listening." (S3)

Confidence
None of the three students raised their hand very often which was mostly due to lack of confidence: *"I am afraid to ask stupid questions."* (S3).

It could also be because they did not want to make the experience worse to others or the teacher: *"I am afraid that my question will ruin the flow of the lecture"* (S1)

Distraction
There were many ways in which the students got distracted and it usually resulted in using their phone or laptop for something else. For instance S3 mentioned: *"The lack of interaction makes me bored and I look on my phone."* (S3)

All of the three students used their phones during lectures, and not necessarily due to boredom: *"I check my phone every 20-30 minute."* (S2)

The interviews gave a fundamental understanding of what issues might needed to be addressed when developing LectureLive, but to verify these and to get a better understanding of these ideas, an online survey was conducted with students from different educations.

3.1.3 Student Survey Results

The survey responses were collected from the 8th to 10th of March 2017. 26 students (P1-P26) participated in the survey and these were divided into different areas of studies using the University of Copenhagen division of faculties [7]. For the study participants not enrolled at the University of Copenhagen their education has been categorised as found most appropriate.

Category	Number of Answers
Science	9-10
Health and medical	2
Humanities	3-5
Social Science	9-10
Law	1

Table 3: Division of survey participants fields of study. Some participants were enrolled in programs fitting multiple categories

The student survey was made using Survey Monkey [22] and consisted of 11 questions (Q1-Q11). The students were asked which program they were enrolled in, what they liked and disliked about their lectures in general, their participation level during lectures, their contributions to other students' learning and their thoughts on using technology during lectures (See Appendix C for an overview of the questions). The answers gathered and keywords assigned can be found in Appendix D.

Asking questions in class

The students were asked if they usually raised their hand during lectures. The distribution can be found in Figure 1.

The survey showed that 61.5% of the survey participants rarely raise their hand during lectures. The survey showed that the number one reason for the students not raising their hand was lack of confidence. For instance, many students were afraid to say something wrong or afraid that their questions would annoy others.

Using technology in class

The students were in general positive about the use of technology and especially liked the idea of interactive quiz questions during lectures:

"It is good to do these kind of quiz. It is funny and anonymous, so you can see how
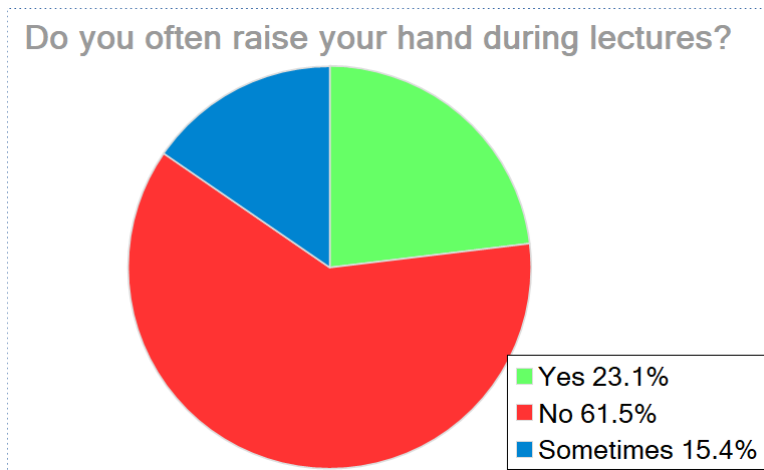
Figure 1: Distribution of the students' answers to the question: "Do you often raise your hand during lectures?"

much you know and the teacher can see the level of the class. It is good to make lectures more interactive."(Appendix D, Q11, P2)

The survey also indicates that the students find it important to let the teacher know how much they understand:

"Interaction through Doodle etc. Sometimes Works well, and gives the professor an overview of what knowledge is lacking" (Appendix D, Q11, P26)

When the students were asked how technology could aid their learning, many of them requested better tools for note-taking. Some students argued that technology often distracted themselves or others while others thought that technology could help avoid distracting themselves by giving them time to take notes.

Contributions to other students' learning

When the students have trouble understanding the lecture they often ask their fellow students for help. Most of the students had tried helping other students by giving a different explanation than the teacher on a topic.

3.2 Functional Requirements

The functional requirements identified from the initial research are found below.

1. The teacher should get statistics on the students' understanding.

   Reason: This requirement was found when interviewing both teachers and students. The teachers were sometimes wondering if the students understood their explanations: *"Many times I get the feeling that something is not clear. But it is hard to figure out what, if no one says it." (T2)*

   The students were also interested in letting the teacher know their level of

understanding.

2. The teacher should get statistics on the students' motivation.

   Reason: In the student interviews and survey, the students indicated that they often felt bored which made them use their laptop or phone for other things instead of listening. Being able to record some statistics for the overall motivational level in the class could help the teacher understand the student mindset and the students could use the self-assessment to be aware of their own mindset and try to think of how they could change it.

3. The teacher should get statistics on the students' confidence.

   Reason: Both students and teachers agreed that it was usually the same few students who raised their hand during lectures. As seen in Figure 1 only 23.1% of the students raised their hand often during lectures. The hypothesis was that the self-assessment would encourage the less confident students to participate if their understanding and motivational levels were high.

4. The teacher should get feedback from students on their struggles after the lecture.

   Reason: The teachers were asked if they would like to get anonymous questions during lectures but they thought that it might be too stressful and that they would get many stupid questions if they were anonymous. "T4" suggested that getting questions before or after the lecture would be much better and less stressful. By allowing the students to anonymously send their struggles after each class the teacher can get a better understanding of where the students have problems throughout the course. This type of feedback could also be an addition to the University of Copenhagen end-of-course feedback survey which "T4" mentioned was very influenced by how the students felt about their final grade.

5. The student should be able to self-assess understanding, motivation and confidence anonymously.

   Reason: To make all students confident enough to send feedback and use the service their feedback is anonymous.

6. Scales in the service for measuring understanding, motivation and confidence should be supported by research or the scales should have been used in other research.

   Reason: This requirement was requested by the supervisor of this project, who is also a university lecturer, to ensure academic quality of the project.

7. The service should include a feature supporting note-taking for students.

   Reason: Some students were frustrated that taking notes took so much time and often made it hard to listen to everything the teacher said. One student mentioned that technology could help with note-taking and help avoid getting distracted: *"Making personalized notes quicker and without taking attention away from the*

lecture while writing them" (Appendix D, q11, P20)

3.3   Nonfunctional Requirements

In addition to the function requirements, a number of nonfunctional requirements were found. The nonfunctional requirements can be found below.

Usability	*LectureLive should require none or very little pre-lecture preparation time.* **Reason:** All four teachers interviewed thought that using technology required a lot of preparation time which was one of the main reasons why they did not use technology more often. *LectureLive should distract as little as possible.* **Reason:** Both teachers and students agreed that technology could easily distract themselves and others. Reading the experiences gained from developing the SpeakUp application [12] one of their main issues was that the application distracted the students instead of supporting the face-to-face interactions. *LectureLive should only require short interactions by the student.* **Reason:** Too long interactions would be distracting. The student should be able to use the application quickly and then get back to listening to the lecture content. *The data gathered in LectureLive should easily be understood by the teacher.* **Reason:** Spending too much time understanding the data would waste lecture time. *LectureLive should have a simple interface that is small enough to fit a mobile screen with minimal scrolling needed.* **Reason:** LectureLive should work on mobile phones which small screen sizes requires them to have few elements in each view.
Reliability	*The teacher application should always display the accurate and up-to-date statistics.* **Reason:** The teacher should get up-to-date feedback in real-time, otherwise the service would not be very useful. *The service should not crash while being in use in real-time.* **Reason:** The teacher and students should be able to rely on the application such that data can be gathered and displayed consistently.

Performance	*The service should have a real-time interactivity to it, such that the time from the student updates a parameter until it appears in the teacher view is less than 3 seconds.* **Reason:** If the delay is longer the teacher might doubt which topic the students have trouble understanding. *The service should be able to handle as many students as there are attending the lecture.* **Reason:** LectureLive should not exclude some students from using it due to a maximum cap. (The current cap of the service is 99 students but can be increased if upgrading to a paid version of Firebase (See section 7.3.2 for details)). *LectureLive should try to minimize battery usage.* **Reason:** If the phones or laptop run out of battery during the lecture, the students will not be able to give feedback or the teacher not able to see it.
Portability	*The service should support multiple platforms including iOS, Android and Web and the web application should work in all major browsers (Chrome, Firefox, Edge, Safari).* **Reason:** Supporting many platforms is important to allow all students and teachers to access the applications independent of what device they have.
Implementation Requirements	There were no direct requirements for implementation. Due to the requirement on supporting multiple platforms, the service is implemented using JavaScript: Angular version 1 and corresponding versions of Cordova, Ionic and the Firebase API (See section 6).
Operations Requirements	*LectureLive requires the users to have internet access* **Reason:** Otherwise the teacher will not get the students' feedback in real-time.
Packaging Requirements	Not applicable.
Legal Requirements	Common laws on data handling and privacy.

Table 4: Nonfunctional requirements identified during requirements elicitation for `LectureLive`.

4 Self-assessment Scales

Three validated scales for measuring understanding, motivation and confidence which were used in LectureLive are presented in this section. Finding ways for the students to self-assess their level of understanding, motivation and confidence was not a trivial task. Many scales and ways of measuring understanding, motivation and confidence exists but they usually include several parameters or questions. LectureLive needed a simple interface, should be easy to use, easy to understand and it should fit on a small screen. These requirements made it much more difficult to find suitable scales. This meant that the scales in the service omits aspects of their original intentions. Using them differently in LectureLive can be justified for two reasons: **1.** They are used for self-assessment. **2.** They are compared relatively to the same students' self-assessment over time.

4.1 Understanding Scale

The scale used to self-assess understanding was developed by Robert Marzano and presented in the book *The Art and Science of Teaching* [**p.19**, 18] from 2007. In Table 5 the scale is presented and compared to the modification used in LectureLive.

Score	Marzano Scale [**p.19**, 18]	Rewritten for self-assessment
0.0	Even with help, no understanding or skill demonstrated.	Even with help I would not understand this.
1.0	With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.	With a little help I would understand the overall concept.
2.0	No major errors or omissions regarding the simpler details and processes but major errors or omissions regarding the more complex ideas and processes.	I understand the overall idea, but not everything.
3.0	No major errors or omissions regarding any of the information and/or processes(simple or complex) that were explicitly taught.	I understand this to the extend expected for this course.
4.0	In addition to Score 3.0, in-depth inference and applications that go beyond what was taught.	I have a better understanding than what is expected.

Table 5: Understanding Scale: A comparison of the Marzano scale and the scale used in this project.

4.2 Motivation Scale

The scale used for measuring motivation is the *Positive and Negative Affect Schedule* (PANAS) [26] [**P.52**, 17]. The question should have the format: *At this moment, how <adjective> do you feel?* using this five step scale to answer:

0. Very slightly, or not at all **1.** A little **2.** Moderately **3.** Quite a bit **4.** Extremely

The scale was originally used to measure positive and negative affects by combining the self-assessed scores on all the positive emotions and the scores on all the negative emotions. 10 negative and 10 positive emotions were used. Examples on emotions mentioned in PANAS are interest, attentiveness and nervousness. However, to make LectureLive as simple as possible only one emotion was chosen - *interest*. The question embedded in LectureLive is: *At this moment, how interested do you feel in the current topic?* and is answered by the scale presented above (from 0-4).

4.3 Confidence Scale

The confidence scale used is *the Rosenberg Self-esteem Scale* [5]. The Rosenberg Self-esteem Scale measures self-esteem by combining the scores of ten statements that all get answered using a 4 point Likert Scale [16]:

0. Strongly Disagree **1.** Disagree **2.** Agree **3.** Strongly Agree

To keep the interface of LectureLive simple the students' confidence is measured using only one statement. The statement added to LectureLive is: *I currently feel confident participating verbally*, which is then answered using the 4 point Likert Scale above.

5 Service Analysis

To allow communication between students and teacher in LectureLive, some kind of data-flow between them was necessary. A top level diagram of the communication links needed is shown in Figure 2. The students and teacher are required to have an internet-connected device that uses either a Wi-Fi connection or a connection to a mobile cellular network. The data is then transferred to or from the server using the internet.
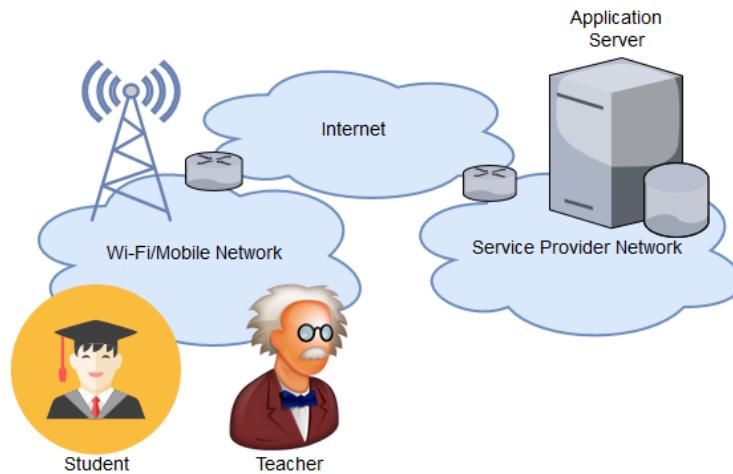

Figure 2: Network communication in the LectureLive service

On application level the service should be structured as shown in the System Overview Diagram presented in Figure 3.
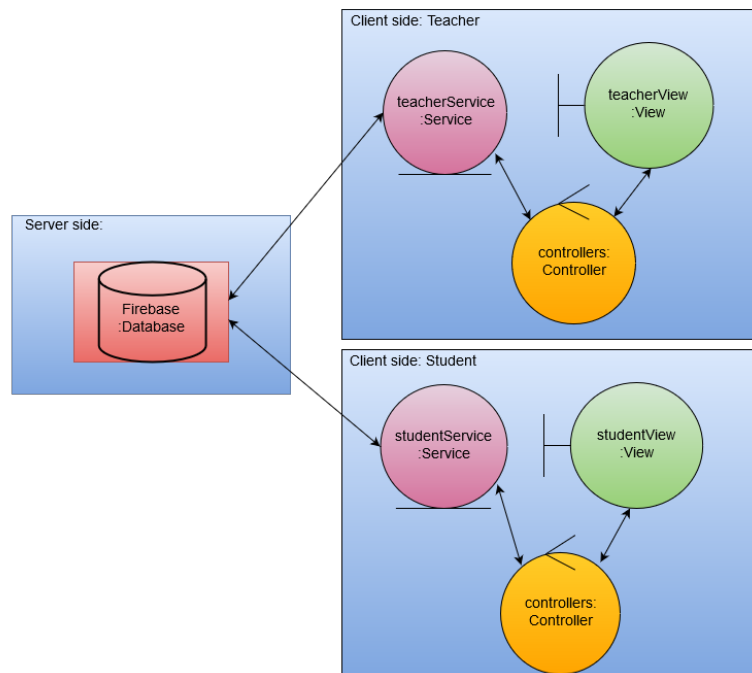

Figure 3: System Overview Diagram of LectureLive

The System Overview Diagram uses UML elements but it is not a standard UML

diagram. It displays the relation between the student application, database and teacher application as well as the basic AngularJS elements: View, Controllers and Services. The database server should be the link between the teacher application and the student application such that both applications pushes data to the database and listens for specific changes in the database.

5.1 Functional Model

The functional model consists of a use case model. The use case model in Figure 4 shows the top level use cases of the student application:

- **FindRoom:** The student uses a room ID to access the lecture room.

- **SubmitFeedback:** The student adjusts motivation, understanding or confidence or requests a moment to take notes.

- **SendEndOfLectureFeedback:** At the end of the lecture the student sends a comment on current struggles or other thoughts on the course.

- **CreateRoom:** The teacher creates a new lecture room in the teacher application and gets access to a room ID.

- **SeeFeedback:** The teacher receives the student feedback and statistics in the teacher application.
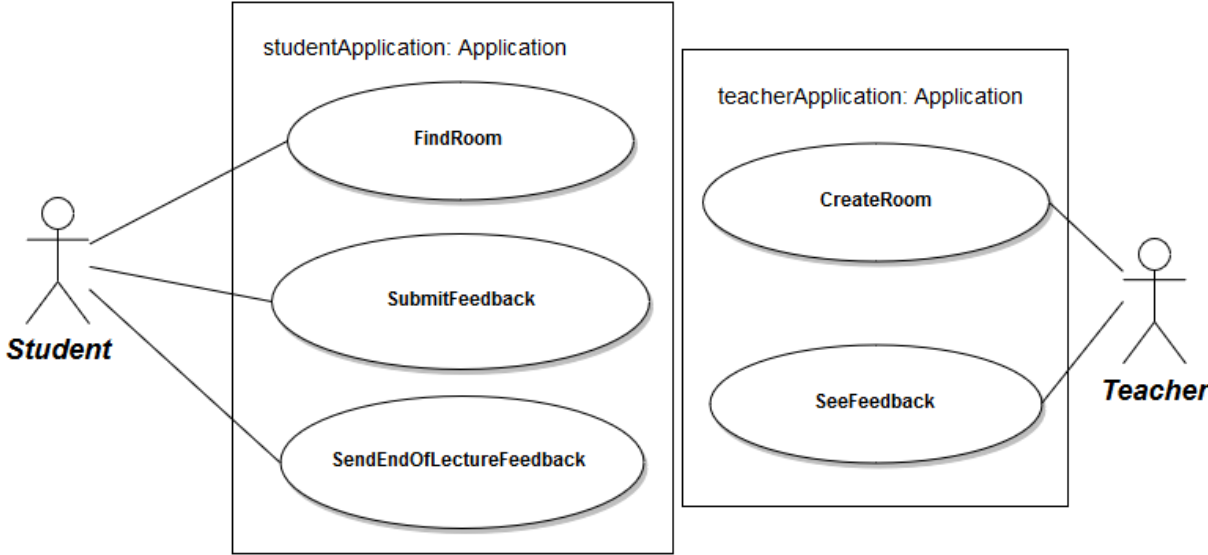

Figure 4: Use Case Model of LectureLive

One of the use cases **SubmitFeedback** is described in more detail below. This use case was selected as it shows the core concept of the LectureLive service - that students can provide real-time feedback.

Use case name	**SubmitFeedback**

Participating actor instances	student:Student, database:Database	studentApplication:Application,
Flow of events	1. `student` makes an interaction with a feedback element. 2. `studentApplication` sends a request to the database. 3. `database` updates.	
Entry conditions	The student application is opened by the student.	
Exit conditions	Data update is registered in the database.	
Exceptions	ConnectionToDatabaseFailed - database is unreachable.	
Performance requirements	Update should happen within 3 seconds.	

5.2   Object Model

An initial class diagram using UML was difficult to make for this project for two main reasons:

1. It was decided to use AngularJS and Ionic to implement the service for easy deployment on multiple platforms (See section 6). AngularJS is a web development framework in JavaScript. JavaScript is a loosely typed language that defines objects as a mapping between property names and values similar to HashTables in Java [**P.1**, 10].

2. In JavaScript almost everything is considered objects. For instance functions are objects [**P.124**, 10].

For these reasons no class diagram was made before implementation and the service was developed using the functional model, dynamic model and the System Overview Model. To get an overview of the final implementation an alternative class diagram is used in section 6.

5.3   Dynamic Model

To model the flow of the service, two sequence diagrams displaying the service from both student and teacher perspective are shown in Figure 5 and Figure 6.

In Figure 5 the student modifies an element in the student application GUI. The controller registers the change and asks the databaseService to update it. The databaseService then sends a request to the database to update the value. When the database is done updating it will notify the databaseService.

Meanwhile the teacher application listens for changes in the database as shown in
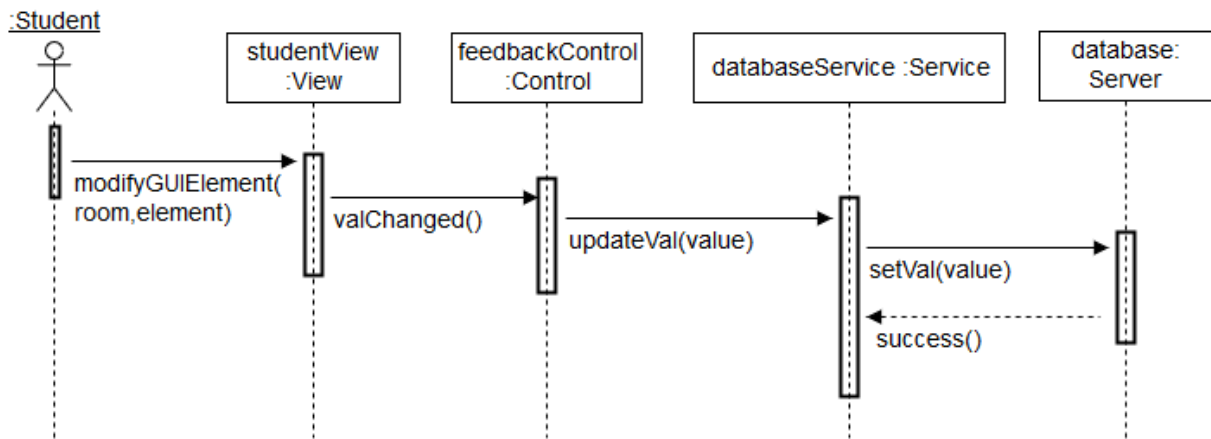
Figure 5: Sequence diagram: Top level student interaction with the student application.
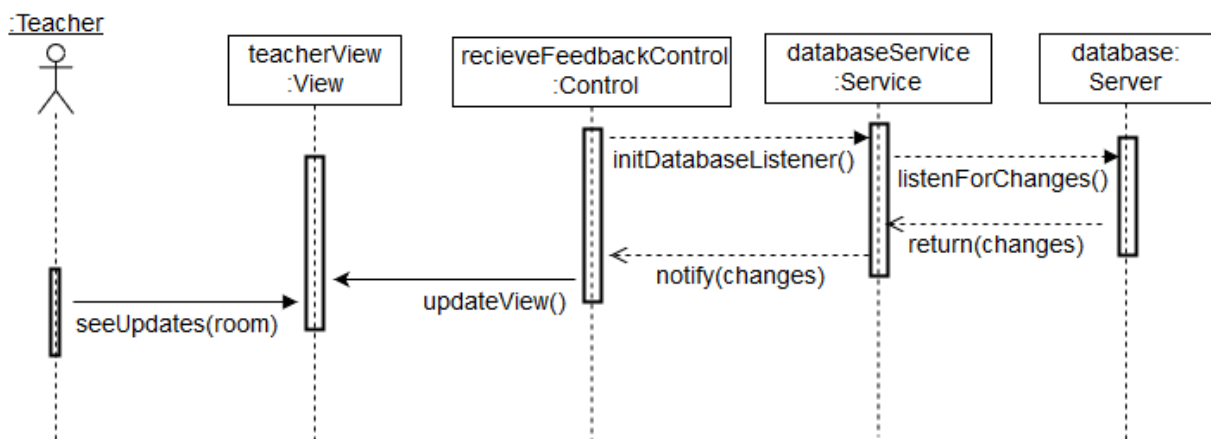

Figure 6: Sequence diagram: Top level teacher interaction with the teacher application.

Figure 6. When a value in the database is updated, the databaseService in the teacher application receives the updated value from the database. The databaseService then notify the controller which updates the teacherView. The teacher will now be able to see the changes.

6 Implementation

In this section technology and implementation of LectureLive will be described. The implementation was an iterative process done alongside requirement elicitation, analysis and testing. First the technologies are presented and then a description of the implementation and the challenges met during the implementation are discussed.

6.1 Choice of Technology

The service is implemented using JavaScript, CSS and HTML. *Apache Cordova* [3] was selected for easy deployment to multiple devices and the *Ionic Framework* [6] was added on top to get a native looking design for mobile devices. *Google Firebase* [9] is used for database storage and was selected because it supports real-time updates between database and devices. Firebase also outperformes similar services such as MongoDB, DynamoDB and CouchDB, when it comes to response times and scalability [2].

6.2 The System

LectureLive was implemented in two separate applications; the teacher application and the student application. Both applications are implemented using AngularJS and they are both structured similarly using the Model-View-Control (MVC) pattern.

- **The Model:** The model is where the data is stored. AngularJS uses two-way data-binding between the view and controllers. The data is stored in an object called *$scope*. The two-way data-binding means that the $scope object is accessible for reading and writing from both the view and controllers.

- **The View:** The view part of the angular project is responsible for displaying the GUI. The view is implemented in html files named *Templates* and designed using CSS.

- **The Controller** The controller is responsible for all logic of the application, such as updating values for the View to display and updating values in the Model.

LectureLive is implemented such that the controllers handle any functionality that does not require database access. The controller needs to call an AngularJS Service, the *databaseService*, to get access to values in the Firebase database. The relations between the Templates, Scopes, Controllers and Services can be found in Figure 7 which shows a class-diagram-like model of the teacher application. The diagram is not a class diagram

in the traditional sense because of the way JavaScript handles types and classes [10].
The student application has a very similar structure and the source code for both
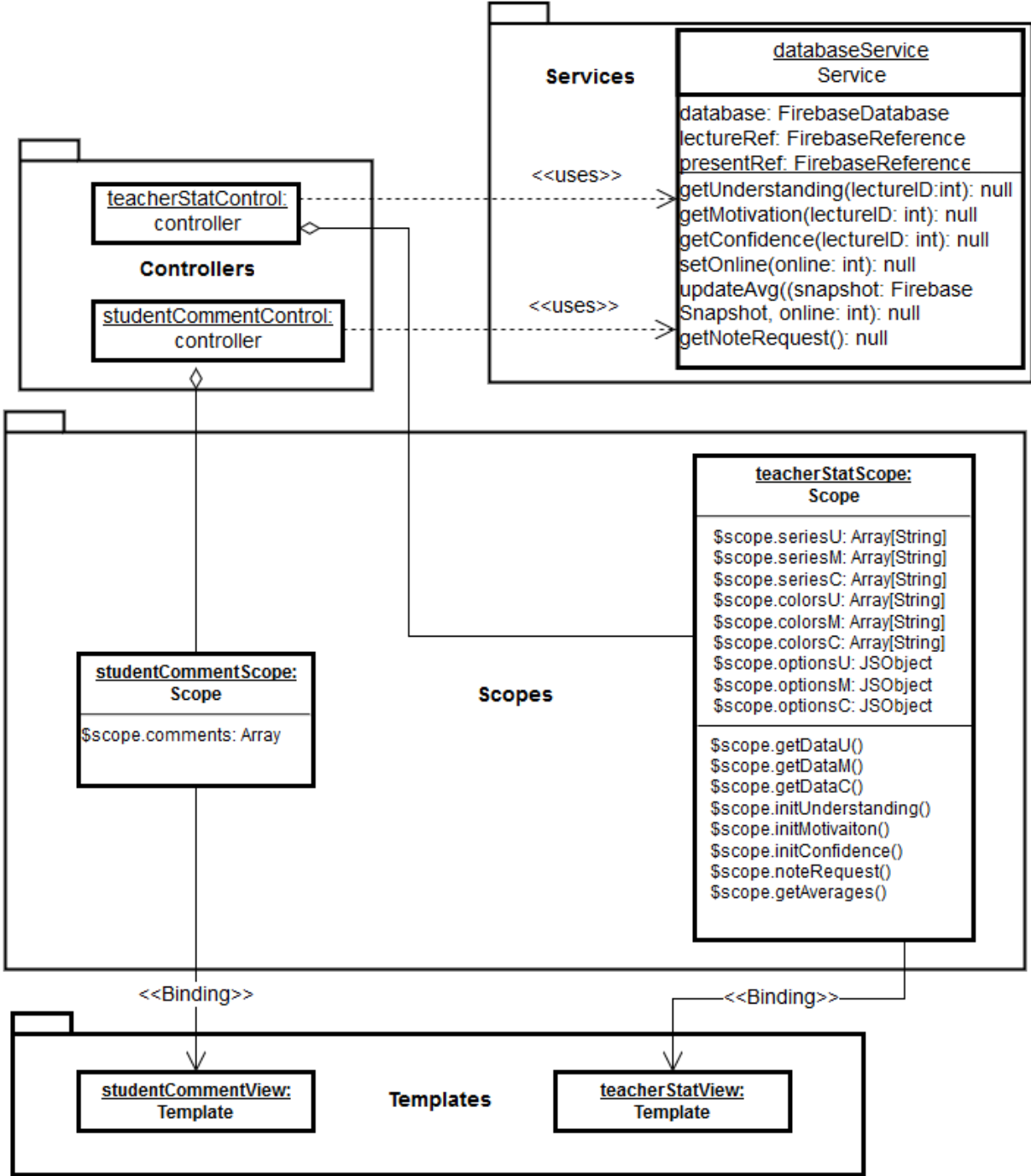applications can be found on Github at: `https://github.com/schnoor/LectureLive`.

Figure 7: Class diagram showing services, controllers, scopes and templates for the teacher
application of Lecture Live.

6.3 Implementation Issues

6.3.1 Student Anonymity

One challenge that occurred during implementation was how to implement anonymity and still know which user updated a value. The students should not have to register their personal information and it would also be too personal to collect their IP-address. This challenge was solved by registering instances of the student application running and deleting the instance as soon as the application is closed. Every time a new student access the application a new ID token will be generated in the database. This token will be deleted again when the student exits the application. This solution works but it also makes it very easy for the student to access the application on multiple devices and pretend to be multiple students. Therefore this solution will need to be tested and requires some level of trust between the students and teacher.

6.3.2 The Graphical User Interface (GUI)
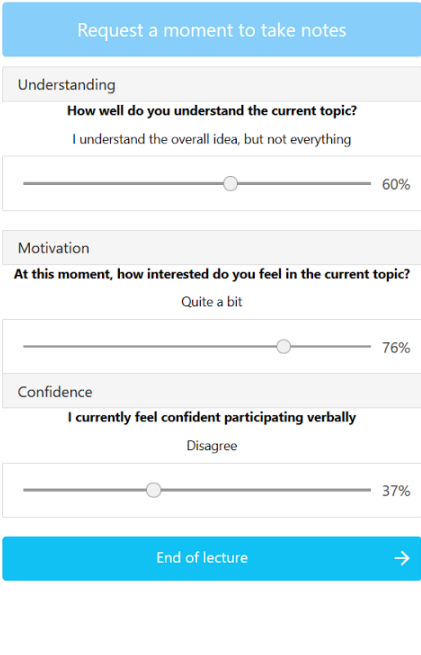
The requirements elicitation did not result in many clear ideas on how the GUI should be structured. This gave some freedom to how the interface elements should look but it was also a challenge to find the right layout. Some design challenges that arose were:

What is the best order in which to put understanding, motivation and confidence?
How should the students update understanding, motivation and confidence?
How should the students indicate that they need time for note-taking?

The student application GUI can be seen in Figure 8.

Figure 8: Student Application GUI

The order of understanding, motivation and confidence was selected on pure intuition on what would make most sense. The students using a slider and buttons to adjust the parameters was based on trying different ideas and using the one that felt most intuitive. Feedback from potential users on the GUI was collected later during usability-testing and in a lab simulation test (see section 7).

7 Evaluation

To be able to easily test the service it was pushed as a web application to www.madsshansen.dk/student and www.madsshansen.dk/teacher, where the former is the student application and the latter is the teacher application. Using the Cordova Framework [3] and Ionic [6] to compile the project to both web and to native iOS and Android (using WebViews) can be done using the terminal command:

$$ionic\ build\ platform\_name$$

where the platform name could be *browser, ios or android*.

7.1 Lab Simulation Testing

An initial test-session of the LectureLive service was made with researchers and teachers at the University of Geneva (Switzerland). No actual lecture took place, but the test participants were asked to imagine that they were at a lecture. The test participants were asked to use the service as they found suitable while trying to find usability issues and bugs. The session ran for 15 minutes on the 22nd of May 2017. During the test session a maximum of seven participants acting as students were online simultaneously. One person was acting as teacher by having the teacher application open. A text area was added to the student application for the test participants to provide feedback concerning the service. Similar to the end-of-lecture feedback feature in LectureLive, the feedback was given anonymously. The main issue found was that the feedback should not be given in ranges from 0%-100%:

"The slider should only have a fixed position when a comment is made and not be available for a range. A checkbox type would be preferable." (Anonymous participant #1)

"Great job, Multiple choice questions could be interesting instead of numbers :)" (Anonymous participant #2)

Another participant found that the service required too much attention if you should also try to follow a lecture:

"The app works well. But it absorbs my attention too much." (Anonymous participant #3)

After this initial test some changes were made to the teacher GUI. The changes are shown in Figure 9. Instead of showing the average of the motivation, understanding and
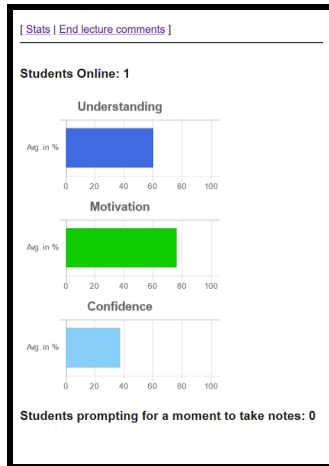
(a) GUI version 1.
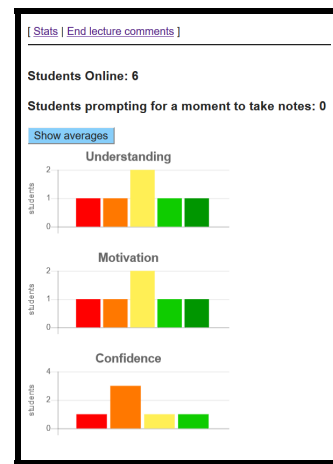
(b) GUI version 2.

Figure 9: The teacher application GUI before and after changes

confidence, a distribution bar chart is displayed. The averages can still be found by pressing the "Show averages" button. The distribution chart should give a more precise overview of the students' feedback.

7.2 Usability Testing

To find usability issues a usability test was conducted with three test participants in Copenhagen in June 2017. Two of the participants are students(U1,U2) at the University of Copenhagen and the last is a lecturer(U3) at the University College Copenhagen (UCC). The *Usability Test Document* displaying the test scenarios can be found in Appendix E. To simulate a real lecture situation, one task included watching a TED Talk [23] for three minutes while using the LectureLive student application. The findings addressed during the usability tests will be categorised into *Positive Feedback, Small Problems, Big Problems and Ideas.*

> ♻**Positive Feedback**
> *Description:* The participant reacted positive towards a feature in LectureLive. This feature should be kept and potentially reused other places in the system.

> 🔧**Small Problems**
> *Description:* This problem was found by at least one test participant but the participants did still complete the task.

⛔ Big Problems

Description: The problem was found by at least two participants and influenced their overall experience of the service.

💡 Ideas

Description: These are possible solutions suggested by the test participants that addresses the problems they experienced while testing LectureLive.

7.2.1 The Student Application

⛔ The application required too much attention when trying to understand a lecture at the same time.

While watching the TED talk, none of the three test participants used the student application. U1 found the TED talk very easy to understand and said that the application was more tempting to use for negative feedback than for positive feedback. U2 and U3 did not use the application because it took their attention away from the lecture content.

💡 Make changes to the application during breaks to avoid distraction.

U2 suggested that the teacher gave the students a moment to adjust the parameters a few times during the lecture to avoid using the application while trying to listen. Another idea was to adjust the parameters during the regular breaks when attending longer lectures.

🔧 The "Request a moment to take notes" button was not intuitive.

All three participants had trouble understanding the button and tried to indicate that they needed a moment to take notes by adjusting understanding, motivation and confidence instead. Eventually U1 and U2 understood the button. U3 never used the button.

💡 Make the "Request a moment to take notes" button into two radio buttons instead.

U2 suggested that the button was made into two buttons or into a toggle on/off button to make the purpose more obvious.

♻️**Interacting with the few parameters understanding, motivation and confidence was nice.**

U1 and U3 liked that the student application only had three parameters to adjust and found it easy to use. U2 mentioned that the sliders were nice to use.

7.2.2 The Teacher Application

🔧**The end-of-lecture comments should not be anonymous.**

U1 and U2 wanted to know who made each comment to be able to help the student if he/she had problems.

🔧**The end-of-lecture comments are messy.**

U1 said that there was too much text to read on the page and if 100 students all commented the teacher would never read them. U2 found the text too large.

🔧**Averages are ambiguous.**

U2 was confused to whether the averages meant the *average amount of students that were understanding/motivated/confident*
or the *average of the combined percentages in understanding/motivated/confident submitted by the students.* It is the latter that is implemented.

♻️**The colors are nice.**

U1 and U2 commented that they liked the colors on the charts.

7.2.3 General Feedback

🔧**Percentages do not correspond to the scales.**

U2 did not think that 75% motivation corresponded to the text "Quite a bit". U3 said it was hard to distinguish 75% motivation and 100% motivation.

🔧**The confidence scale should have a neutral element.**

U2 wanted a neutral element in the confidence scale. The reason was also that the other scales for understanding and motivation both had 5 elements.

> 💡 **The use of the application should be made clear.**
>
> U3 thought that it was very important for the students and teacher to agree upon how the service was used. He mentioned that the students needed to trust that the teacher would actually use the feedback. He also mentioned that the teacher needed to trust that the students used the service for serious and honest feedback only. To assist this, the possible use cases should be presented to the teacher before using the application.

7.3   Performance Testing

7.3.1   Response Time

To test if the requirement of real-time feedback was met, the time to access the database was measured using the Windows program Tracert [15]. The last 3 steps of the Tracert can be found in Figure 10.


```
17    125 ms    124 ms    127 ms   216.239.51.157
18     *         *         *       Request timed out.
19    126 ms    127 ms    126 ms   226.130.154.104.bc.googleusercontent.com [104.154.130.226]

Trace complete.

C:\>
```

Figure 10: Example Tracert from client to database in California (USA)

Using Tracert it was found that accessing the database from Copenhagen requires 19 jumps and it takes about 126 ms. to get a response from the final IP address visited. Using the final IP address it can be confirmed that the database cloud is located in California (USA). To optimize performance a cloud provider in Europe would be an option.

The actual time from the student changes something in the application until it appears in the teacher application was tested using Google Chrome Developer Tools to log the time stamps of specific changes in the applications. A simple test of dragging the confidence bar in the student application gave the following logged times:
Student application confidence change: 17:49:49.205

Teacher application received response: 17:49:49.386

Which gives a difference of 181 ms. This meets the 3 second criteria defined in the requirements.

7.3.2 Concurrent Students

To test how many students can use LectureLive simultaneously a test of opening the student application multiple times in a browser was made. When all connections were established they were shut down simultaneously which made 99 database requests. The service could handle the requests without significant changes to the real-time experience. Screen-shots from the test are shown in Figure 11. In Figure 11a the Firebase statistics show that the service is very close to the connection limit for the free Firebase pricing plan. In Figure 11b a screenshot of the teacher application during the test is shown.
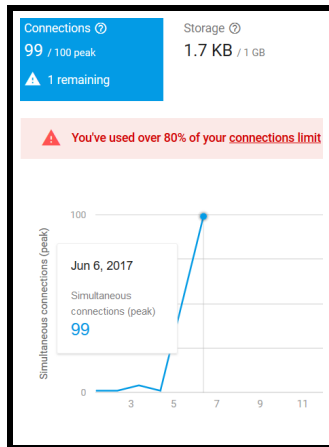
(a) Firebase connection statistics
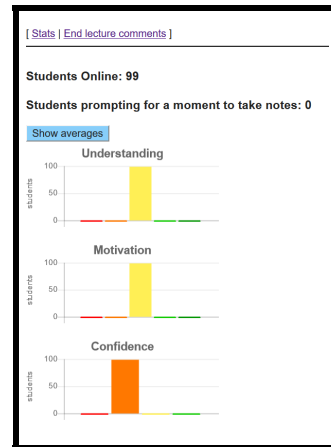
(b) Teacher view during test

Figure 11: Test results of maximum concurrent students test

8 Discussion

The SpeakUp paper [12] discussed four challenges met when developing the SpeakUp application:
1. How to best interweave digital and face-to-face interactions?
2. How to improve participation?
3. How to avoid information overload?
4. How to find a balance between attention, distraction and awareness?.

Similar issues were found when evaluating the LectureLive service. In this section these questions will be discussed with respect to the LectureLive service and the results found from testing it.

8.1 Interweaving Digital and Face-To-Face Interactions

Interweaving digital and face-to-face interactions is a challenge because it requires that the technology supports the face-to-face interaction instead of being a distraction. During the evaluation of LectureLive in Copenhagen described in subsection 7.2 the usability test showed that participants did not use the student application while

watching a TED Talk for three minutes. Even though they did not use the application during the task, the test participants found that the application could be useful if brief breaks were added to the lecture to make adjustments to the student application. They also suggested that if they were more familiar with the features of LectureLive, they might use it.

There are several possible solutions that could potentially transform the application from a distraction to a supportive tool. One option is to make the user interface even simpler and maybe remove one of the parameters *understanding, motivation or confidence*. Another option is to test if the application is still a distraction when users become more familiar with the application. This could be by using it continuously in a series of lectures. In the usability test the participants only watched a video lecture for 3 minutes while using the application as they found fitting. There are several question that would be interesting to study if the application should be applied to a real lecture: *Will students use the application more or less depending on how much the teacher uses the feedback during the lecture? Will the application be used more if used through an entire lecture and not just 3 minutes? Does the teacher's introduction to the application influence how and how much the students will use it?*

8.2   Improving Participation

A clear goal from the beginning of the LectureLive project was to improve the students' participation during lectures. This was identified as an issue both from the teacher and student interviews as well as from the student survey. The LectureLive application tried to solve this problem by allowing anonymous feedback to the teacher. The intention of the feedback was that it should function as a conversation starter that would help less confident students participate more. For instance if 50% of the students did not understand a topic, the teacher would get an indication of this and could ask the students to clarify where they had trouble. Testing if LectureLive would benefit less confident students could not be captured in the current evaluation and would need to be tested during a real lecture.

8.3   Information Overload

The usability evaluation of LectureLive showed that two out of three participants experienced information overload, when having to use the application while watching an online lecture for three minutes. This was categorized as a big problem during evaluation. One test participant suggested that the problem could be solved by allowing students a brief break to adjust the parameters or by telling the students to make adjustments during planned breaks in the lecture. Another test participant suggested that it would feel less like information overload when the students had used the application a few times. These solutions might solve one problem but they introduce others. For instance it will consume lecture time if the teacher needs to pause the lecture several times to allow the students to provide feedback during the lecture. If the students were asked to adjust the feedback during the planned break it requires that the

lecture is long enough to include a planned break at all. It would also remove the whole real-time experience of using LectureLive. Losing the real-time feature would mean that the teacher could talk for half a lecture before getting an indication that the students had struggles.

8.4 Balance between Attention, Distraction and Awareness

One issue that can arise when using technology to support face-to-face interaction is *the fear of missing out.* The fear that the student would miss important parts of the lecture by using LectureLive might lead to the student not using it at all. One important aspect of the student application is that the GUI only displays the student's own changes. Thus the student will not get as distracted or feel that he/she is missing out on something by not using the application. This is important because LectureLive should support the lecture and allow students to prioritize the lecture over the application. During the Copenhagen usability testing described in subsection 7.2 the participants also prioritized listening to the lecture over using the application.

9 Conclusions and Future Work Areas

This project focused on research, development and evaluation of a mobile service to support learning during lectures. The resulting service called LectureLive is a real-time system that allow students to provide anonymous feedback to the teacher during lectures by submitting their level of understanding, motivation, confidence and their need for a moment to take notes to the teacher. The requirements of the service were found by looking at the current state of the art and by interviewing students and teachers at the University of Copenhagen along with an online student survey. The main issue found when evaluating the LectureLive service was that it was a distraction and difficult to use while watching a lecture but the problem does not appear unsolvable and requires further testing.

Developing LectureLive is an ongoing and iterative process which require continuous testing and adjusting of the service. In particular, it will be important to test the service during a real lecture and ideally with the same students and teacher several times, while getting feedback on their experiences. Evaluation of the service indicated that the service requires trust between students and teacher, meaning that students should trust that the teacher will actually use their feedback and teachers should trust that students make honest feedback. To support the mutual level of trust, some clearly defined scenarios on when the service can be beneficial should be specified and presented to both students and the teacher. These scenarios should be found in close cooperation with students and teachers.

To sum up future work with the LectureLive service will include:
1. Adjusting the service according to the latest evaluation results.
2. Test the service in a real world setting and run more usability tests.
3. Continuous improvements of LectureLive through analysis, design, implementation and evaluation.

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Appendices

Appendix A: Interview Questions for Students

What are you studying?

Are you a bachelor or a masters student?

Describe the last lecture you had?

Was there something really nice about this lecture?

Did you have any frustrations during the lecture?

Do you often raise you hand to give comments or questions when attending lectures?

Have you ever kept quiet during lecture even though you had a question or comment for your teacher? Why?

Have you ever used mobile applications or web applications as part of a lecture? Which ones?

Did you like using these?

Have you ever used your phone or laptop for something unrelated during lecture? Give an example on when this happens.

If there was a mobile application that could make it easier to communicate with your teacher or the other students during lectures, what features would be cool to have, if anything was possible?

What features in such an app would be annoying to have?

What are some advantages of using mobile phones as part of university lectures?

What are some disadvantages of using mobile phones as part of university lectures?

Appendix B: Interview Questions for Teachers

Initial interview questions for teachers:

How long have you been teaching?

What courses have you been teaching?

Which ones are you teaching now? Is it the first time your teach this course?

How many students are usually enrolled in the courses you have been teaching?

Have you ever asked students to use a mobile application as part of a lecture? If yes – how was it used?

Are there any frustrations that you experience when giving lectures when it comes to communicating with your students or understanding their needs?

How do you think that mobile phones can be used as an advantage in a teaching situation?

If an advantage is given: If anything was possible, what feature would be fantastic to have in a mobile application for teaching situations?

How would you benefit from an app like this?

Can you think of a feature that should not be in such an app?

How do you think that the students would benefit from an app like this?

Would you use a mobile application like this in a teaching situation? Why?/Why Not?

If no advantage is given: Why are mobile phones a bad tool to use in a teaching situation?

Do you use any other technologies besides mobile phones in lectures? Why are these good?

Do you think that students ask enough questions during lectures? How do you think this could be improved?

Finally: If there existed a mobile app where the students could send anonymous questions and give feedback during lectures would you use it? Why?/Why not?

If there existed an app where the students could anonymously indicate if they felt lost and you got a notification of this during lectures, would you use it? Why?/Why not?

Do you have any other thought or ideas after our discussion?

Appendix C: Survey Monkey Questions

This survey is part of a bachelor project in Computer Science at the University of Copenhagen conducted by Mads Schnoor Hansen.

Purpose of this survey
To get an initial understanding of student's perception of university lectures and how mobile technology might be able to support the learning processes during lectures.
The project is an attempt to research how technology can be used to support a learning situation at university level and falls into the Quality of Life psychological health domain 'Thinking, learning, memory and concentration'.
The larger context is research on ICT solutions supporting the individual's thinking, learning, memory and concentration processes.

Procedures
The survey has 11 questions and will take approximately 5-10 minutes.

Participant Requirements
The survey is targeting all students studying at university level.

Risk and Benefits
The survey is anonymous.
The results of this research will be used as part of my bachelor project report and may be presented at scientific or professional meetings or published in scientific journals.
I cannot and do not guarantee or promise that you will receive any benefits from this study.

Compensations & Costs
There is no compensation on completing this study and there will be no cost to you if you participate in this study.

Confidentiality
The data captured for the research does not include any personally identifiable information about you.

Voluntary Participation
If you have read this form and decided to participate in this survey, please understand your participation is voluntary and you have the right to withdraw consent or discontinue participation at any time without penalty or loss.
You have the right to refuse to answer particular questions. Your individual privacy will be maintained in all published and written data resulting from this study.

Right to Ask Questions & Contact information
If you have any questions, concerns or complaints about this research, its procedures, risks and benefits, contact Mads Schnoor Hansen <qdp777@alumni.ku.dk>

* 1. Please indicate if you agree to the following:

☐   I have read and understand the information above.

☐   I want to participate in this research and continue with the survey

* 2. What are you studying?

[   ]

* 3. Level of your studies

( ) Bachelor

( ) Master

( ) Other (please specify)

[   ]

4. Try to think of the last lecture you attended. Was there anything you really liked/disliked about this lecture?
Is there something you like dislike about the lectures that you attend in general?

[   ]

5. Have you ever kept quiet during lecture even though you had a question or a comment? If yes - What kept you from raising your hand?

[   ]

6. Do you often raise your hand during lectures?

( ) Yes

( ) No

( ) Other (please specify)

[   ]

7. Do you recall a case in which you have helped other students during lectures? If yes - Describe what happened and how you helped.

[   ]

8. Do you recall a lecture where you contributed to other students learning in a negative way? If yes - Describe what happened.

9. Have you ever used mobile applications or web applications as part of a lecture?

○ Yes

○ No

10. If yes - Which ones and what did you think of using these?

11. If anything was possible - how do you think that mobile phones or laptops could improve your learning during lectures?

Appendix D: Survey Monkey Answers

q2

What are you studying?	Keywords
Environmental Sciences	Science
MSc in Environmental Science	Science
Bachelor in Nutrition	Health and medical
Biology	Science
pathology	Health and medical
History	Humanities
MSc (Hons) Mathematical Modelling and Computation	Science
Global Business and Digital Arts	Social science
Intercultural Communications and Marketing	Social science
comunication	Humanities
Linguistics	Humanities
Mathematics	Science
Economics and Business administration	Social science
Law	Law
Psychology	Social science
	Humanities
Communication and IT	Science
Physics	Science
Computer Science	Science
Anthropology	Social science
Computer Science	Science
Interkulturel markeds-kommunikation på CBS	Social science
International Marketing and Management	Social science
Europæisk etnologi	Social science
Mathematics-economics	Science
Pedagogy	Social science
	Social science
Business administration and communication	Humanities

Category	Quantity
Science	10
Health and medical	2
Humanities	5
Social Science	10
Law	1

Level of your studies

Answer Options	Response Percent	Response Count
Bachelor	76,9%	20
Master	23,1%	6
Other (please specify)	0,0%	0
answered question		26
skipped question		0

Level of your studies

- Bachelor
- Master
- Other (please specify)
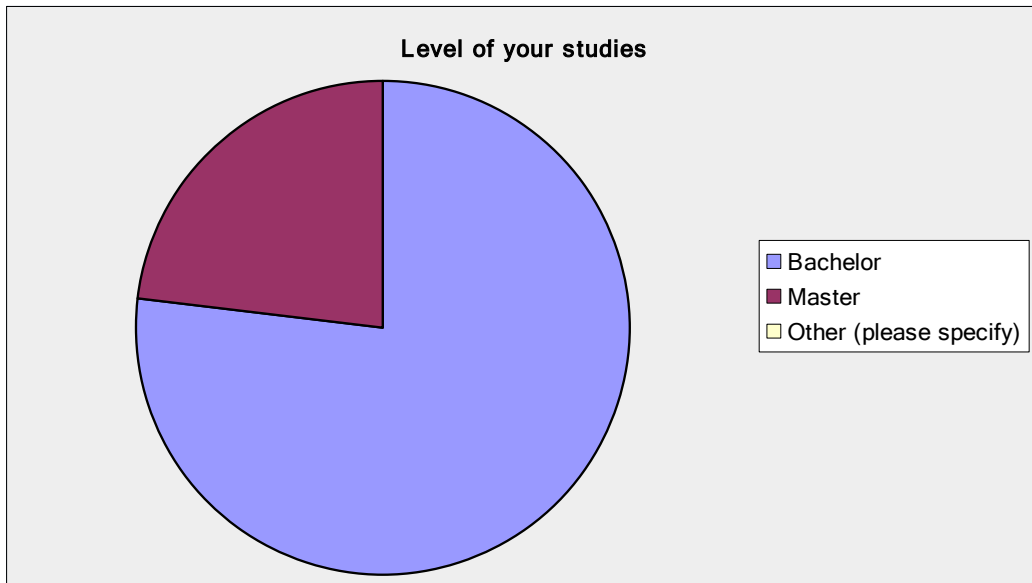
Q4 Try to think of the last lecture you attended.
Was there anything you really liked/disliked about this lecture?
Is there something you like dislike about the lectures that you attend in general?   **Keywords**

We repeated in general the same thing we
Did for the past 3 weeks instead of learning new stuff — Level low

I liked that we commented an article and interpreted some of the considerations and calculations they did.
The problem is that sometimes it goes too slow to comment it. What I don't like in general is when the rithm is slow.
I hate having the feeling I'm llsing my time. I like to be challenged. — Interaction / Level low

I liked that my lecturer is energetic and good at explaining the content we have to learn.
I dislike when my lecturer is unstructured and jumps around the lecture slides — Teacher energetic / Lecture unstructured

boring lol — Boredom

I liked the interaction with our professor during the lecture, which made the intended
Subjects of the lecture expand into a more broad context — Interaction

Not in particular. I'm generally very satisfied with my studies and find the lectures satisfactory. — Satisfaction

Sometimes what we're being taught doesn't seem relevant to the overall course. — Materials

Graphics of the power points are often quite boring and monotonous — Materials

Not really except for the bad timing our lectures are located this semester (from 3-6 pm mostly). — Schedule

Like: the lectures are lively and full of interaction
Dislike: lecturer simply reads lecture notes and English pronunciation is unbearable. — Teacher energetic / Interaction / Language

I dislike the way the professor acts towards students who are making annoying smalltalk, which removes his focus of the subjects — Teacher distracted / Boredom / Learning Environment / Communication

Dislike: Boring lecturers, level auditorium (instead of raised seating),
And when a lecturer says things like "as you know" or "you already know this" instead of actually providing information — Language / Materials / Communication

He didnt articulate the words well enough, and he didnt put the powerpoint on Absalon before the lecture.
If the lecturer doesnt put the powerpoint on Absalon before the lecture,
All the students write down everything on the powerpoint, and then forget to listen to what is said. — Note-taking

The discussion we have are too easy...too "low".
The questions are easy, in the sense that they can be answered in 2 seconds.
But the issue is that, the students often do not participate in the discussion and there will be like an awkward pause.
So, the problem is not only the lecturer but the students. However,
I believe if the discussion were more interesting, then I would enjoy the lectures more.
One important thing to have in mind is that student (and me sometimes) are tired and have a lot on their mind.
Sometimes they have not read the texts and therefore, it is difficult to participate and concentrate. — Level low / Student engagement / Preparation

Many a times, the material being taught is generally not entirely comprehensible during the duration o fthe lecture.
It is difficult to make the logical connections in the time we have during the lecture. — Lecture length

There was a very low level of interaction. Many times lectures try to fit too much into
The lecture and end up skipping important parts that I in turn have to try and understand anyway. — Interaction . / Materials

I like that my lecturer is very lively and engaged, but she tends to get off track with cute little
Stories and then haste through the important parts - which isn't really good for the understanding. — Teacher energetic / Materials

They are rarely directly connected to the actual assignment. — Materials

The lecturer was really bad at conveying the material in an interesting way. His teaching skills are bad even though he is a very wise guy — Boredom / Communication

Lectures are based off of PowerPoints with very little information given that is not already on the screen and could be read at home. — Materials

No

Sure i liked it. The dias are black on white and loads of text, pretty boring could be fixed up a bit — Materials

Storytelling Works well. Interaction rarely Works — Storytelling . / Interaction

Positive	
Keyword	Quantity
Interaction	3
Teacher energetic	3
Satisfaction	1
Story telling	1

Negative	

Keyword	Quantity
Level low	3
Person dependent	
Lecture unstructured	1
Boredom	3
Materials	8
Schedule	1
Language	2
Teacher distracted	1
Communication	3
Note-taking	1
Student engagement	1
Preparation	1
Lecture length	1
Interaction	2
Learning Environment	1

**Have you ever kept quiet during lecture even though you had
a question or a comment?**
If yes - What kept you from raising your hand?   **Keywords**

Yes, I don't want to stop the flow of the lecture   Lecture flow

I usually ask a lot in the class. If I didn't ask, it is because
I saw that the teacher is going fast because it is not important,   Student confidence
or because he already explained 1-2 times and I didn't understand,   Question unimportant
Or because I didn't feel confident enough with a new teacher.   Teacher dependent

Yes - too many people in the room.   Student confidence

yes shy   Student confidence

Yes. Mostly the fear of being inarticulate or incorrect   Student confidence

No. The lecturers at DTU are generally very welcoming of questions.   Teacher dependent

In some instances I'm preoccupied with taking notes, in others someone else
has asked the question, and sometimes it's just a matter of something   Note-taking
I know I'll be able to figure out at home when I re-read my notes.   Question unimportant

Shyness   Student confidence

Because I was afraid it was a too stupid question to ask about   Student confidence.
And maybe the teacher wasn't that encouraging to get us to ask.   Teacher attitude

Yes, the lecture is too spiritless.   Motivation

Mostly due to the fact that it is minor questions,
That I believe I can either ask my group or find out myself.   Question unimportant

Yes. Different things on different occasions. Sometimes nervousness,   Student confidence.
Sometimes not really seeing an opening.   Lecture flow

Yes, many times. Afraid of have misunderstood what I would ask about,
afraid of maybe not have heard that the answer had already been given,
afraid that the answer is in one of the articles to the lecture   Student confidence.
If I havent read all of them. All in all, afraid of askin a "stupid" question.   Student unpreparedness

It happens sometimes. Mostly in relation to comments for example
if we are having a good discussion in class. I stop because I can sense that
there is not enough time for the comment (prolonging the discussion).   Lecture flow
But I always raise my hand if I have a question.

                                                                         Student confidence
-Maybe I thought the doubt was elementary and will stop the progress of the class.   Lecture flow
 -I got distracted at some earlier time during the lecture.   Student distraction

Yes. Usually because I know that asking a question will take time
Away from the lecture and parts will be skipped.   Lecture flow
                                                                         Others learning
I felt my question wouldn't help the others learn, so I simply asked afterwards.

No

Lots of people in the room. Not sure that my question was relevant for the whole room   Student confidence

Fear of being wrong and fear of follow-up questions that I may not know the answer to   Student confidence

Yes, embarassement from looking stupid. Applies to everyone who studies math at ku   Student confidence

A few times, wanted to wait to see if my question got answered later on

Yes. Because i hadnt read   Student unpreparedness

Keyword	Quantitiy
Lecture flow	5
Student confidence	12
Question unimportant	3
Teacher dependent	2
Note-taking	1
Teacher attitude	1
Motiviation	1
Student unpreparedness	2
Student distraction	1
Others learning	1

Do you often raise your hand during lectures?

Answer Options	Response Percent	Response Count	
Yes	23,1%	6	
No	61,5%	16	
Sometimes	15,4%	4	Sometimes
answered question		26	
skipped question		0	

Do you often raise your hand during lectures?

Yes 23.1%
No 61.5%
Sometimes 15.4%
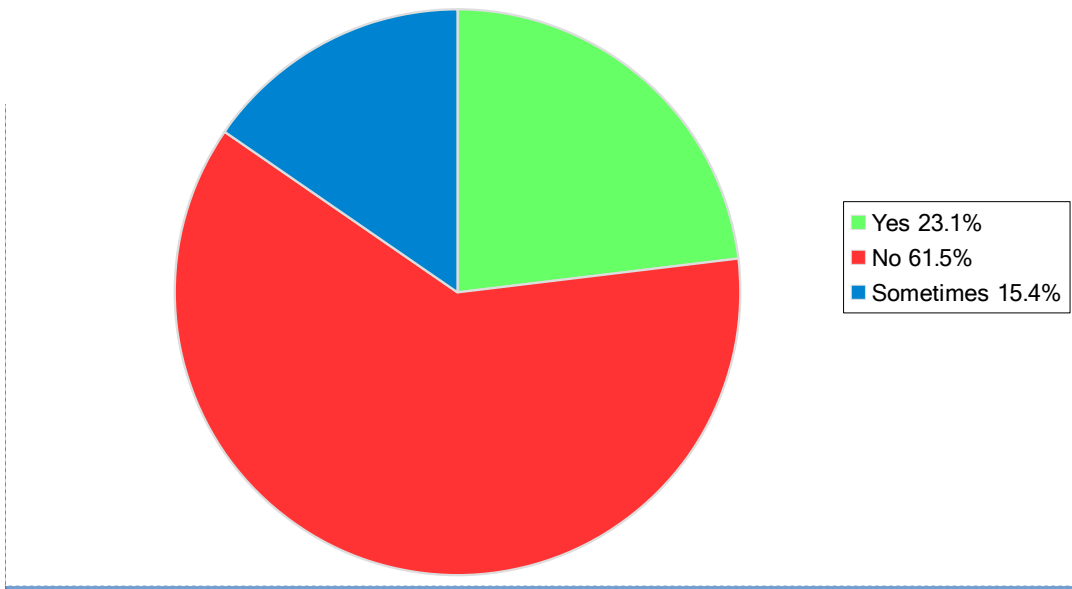
Do you recall a case in which you have helped other students during lectures?
If yes - Describe what happened and how you helped. **Keywords**

Yes, I understood what the teachers explained but it he explained it very vague.
So I explained in more detail what he meant. Explain differently

It is easy for me to understand what the teachers mean.
Sometimes some kollegues don't understand it, so I try to explain it
in another way, usually a simple way.
Sometimes the teachers are not good at keeping the things simple. Explain differently

I dont remember a specific event, but if a friend in my lecture
Has trouble understanding the subject I will try to explain it in my own words. Explain differently

It's hard to be sure, but I think that several times I asked our professor to clarify a point,
Or explain a term, out of which the outcome was at least possibly helpful for others than me
Question asked

Sometimes I get poked on the shoulder and asked why a teacher could go from A to B.
Often they have just missed a minor detail and get the picture rather quickly. Explain differently

Sometimes I've had professors that will ask a student's question to the whole class, and I have responded. Question answered

Only persons sitting next to me. Helping them understand a concept or something like that Explain differently

I sometimes help my classmates with their computer software we're using in class.
Then I just showed them how to use that program or software. Software explained

Yes. A very quick question that he failed to catch what the lecturer said or wrote on the board. Explain differently

I've helped people from my studygroup and my program by answering similar minor questions. Explain differently

Helped people understand or remember what the lecturer said Explain differently

I raised my hand and asked a question, which someone said "good question" to afterwards. People often tell me that I ask good questions. Question asked

Do not recall.

Yes, during my undergraduate years, this was indeed a very regular practice. Some professors were okay with it. But for a major chunk, they were offended by it as they thought we were not paying attention. Explain differently

Yes. Instead of asking the lecturer they asked me. I then quickly try to explain or say wait til the break. Explain differently

There aren't much occasion for 'helping' eachother, but we frequently exchange notes. Note exchanging

I have overheard people misunderstanding certain lecture related topics and helped them explain it. Explain differently

If my friends don't understand they often just look at my notes Note exchanging

Yes, explained quietly what was going on Explain differently

Explained some new and different methods Explain differently

Explained simple Excel actions Software explained

Keyword	Quantitiy
Explain differently	13
Question asked	2
Question answered	1
Software explained	2
Note exchanging	2

Do you recall a lecture where you contributed to other students learning in a negative way? If yes - Describe what happened. **Keywords**

No

No

No

I remember arguing in a lecture that R.E.M. wrote 'Mad World', and actually ending up convincing most people. I later found out this was not true (this was before smartphones)   Fact

Not that I can think of.

I do not

Not really.

No

I dont believe it has happend, no.

Probably distracted others by being on facebook etc.   Distraction

If so, no one ever told me.

Do not recall.

The above practice of discussing in the class did create inconvenience for some students.   Class discussion

Not that I recall.

No, not that I'm aware of.

No

If I'm not listening it's hard for my friends to concentrate too.   Distraction

Talked to much   Distraction

dont think so

No, but recall many lectures where stupid questions was asked   Questions stupid

Keyword	Quantitiy
Fact	1
Distraction	3
Class discussion	1
Questions stupid	1

Have you ever used mobile applications or web applications as part of a lecture?		
Answer Options	Response Percent	Response Count
Yes	72,0%	18
No	28,0%	7
answered question		25
skipped question		1

Have you ever used mobile applications or web applications as part of a lecture?

Yes
No
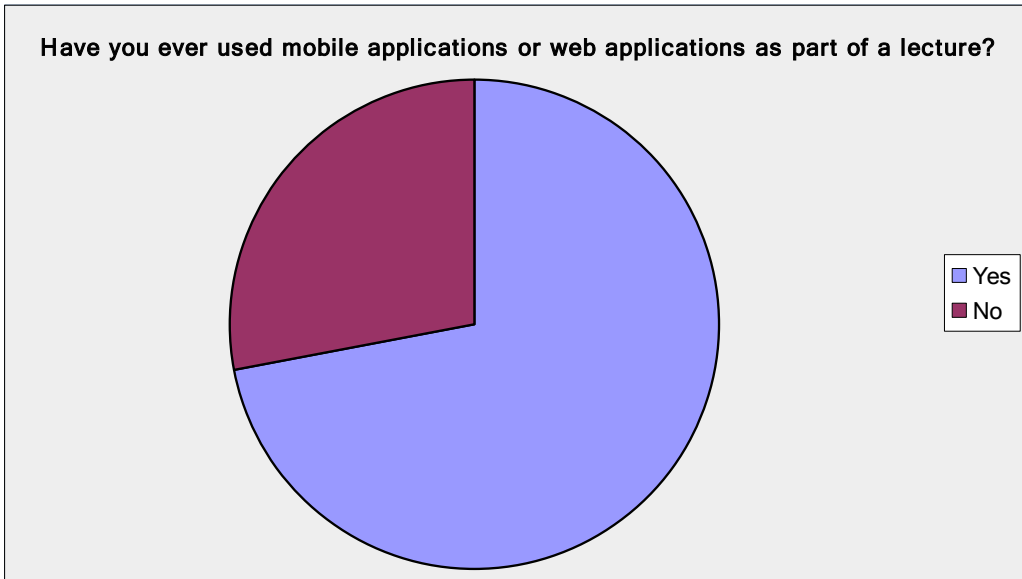
Questions stupid

If yes - Which ones and what did you think of using these? | **Keywords**

Forgot the name, but during my bachelor there was a website to make quizzes on, based on questions made by students | Quiz

These applications where the teacher asks one question and you can choose or write an answer, and the answer or the result appears to the screen. | Quiz

Socrative. It was nice to incorporate in the lecture. | Quiz

clicker questions as participation mark | Quiz

Quite common at DTU. They have they pros and cons... | Pros and cons

We have used in class survey or quiz tools, but I don't recall their titles. We have used Google and other resources when compiling lists or graphs of information, as well as apps like Fritzing to solidify knowledge (though not at the urging of the professor). | Quiz Google Fritzing

Kahoot for some quizzes which was a great way to be interactive in the class. | Quiz

It can be benificial in some cases

Some quiz-ones which the lecturers sometimes ask. | Quiz

We mainly used web application is relation to the lecture, as it is related to IT. I did not have an issue with it.

It is both a distraction and a creative tool. iPad is better if there are no distractions such as WhatsApp and FB | Distraction Creativity

I liked using them. Cannot remember specific names, but one was a mobile app where the professor could quiz or poll the students then show the results in real time or afterwards. The other was a large notepad where students were given a link and they could then create a sticky note box on the canvas and write thoughts. The last one worked well for brainstorming I felt. | Quiz Notepad

We were learning about a statistics program, so we were using our own laptops to follow the instruction steps - it helped a lot instead of just watching the himself confused lecturer. But otherwise, we never really use technology anything but taking notes and every once in a while looking up stuff online, if you need maybe to get some notes about a specific theory, your lecturer mentions. | Recording lectures Google

Searching the web for clarification and camera app mostly | Camera

Web aplications to mind map, it was ok. | Mind map OK

Socrative, it was awesome! | Quiz

.

Børsen. During a stupid question i might aswell read news | News

Keyword	Quantity
Quiz	9
Pros and cons	1
Google	2
Fritzing	1
Distraction	1
Creativitiy	1
Notepad	1
Recording lectures	1
Camera	1
Mind map OK	1
News	1

If anything was possible - how do you think that mobile phones or laptops could improve your learning during lectures?

Keywords

-

It is good to do these kind of quiz. It is funny and anonymus, so you can see how muvh you know and the teacher can see the level of the class. It is good to make lectures nore interactive.	Student confidence Anonymous Interactivity Quiz
Not sure. I think it works pretty good as it is	
useful but depends on person. I always see some students keep browsing on facebook or else	Distraction Person dependent
To have an interactive board onto which anyone could be allowed to draw or write from their smartphone or computer. And maybe with a built in question log for the professor to look through during the break	Interactive board Questions
It would provide additional knowledge to bolster the lecture content. If a professor provides links with more information, it is easier than them trying to summarize and losing part of the message.	Material extras
Follow up questionnaires would be cool	Follow up
Maybe if you could be more interactive with the mobile phone without disturbing the actual class it would be great.	Interactivity Distraction
Higher efficiency and no need to put down too much notes.	Note-taking
Maybe a bigger connection between phone and computer, kinda like Microsoft and their programs, but maybe an even greater and easier connection. Making notes easier to make.	Phone/laptop connection Note-taking
Other than being able to take notes etc. I don't think phones or laptops provide anything positive – rather it's a much too easy form of distraction.	Note-taking Distraction
If it could type down everything the lecturer said, so I could sit back and listen and reflect on what is being told, then maybe write down some thoughts about what is said myself.	Note-taking
I actually find the use of mobile phones and laptops in lectures as a distraction as I find myself doing other things such as planning my day (schedule) or Internet browsing. But this mainly happens if I find the lecture to be boring or a waste of time.	Distraction Boredom
Google Searches!! That's the most important thing.	Google
Don't know.	
My friends sometimes record the lectures on either smartphones or voice recorders, which is nice for students unable to attend. But we don't need technology otherwise, since it's mostly just discussions.	Record lectures
Making personalized notes quicker and without taking attention away from the lecture while writing them	Note-taking Distraction
I have never thought about that	
Stuff on the blackboard could magically show up on my device, so that i never had to take notes	Note-taking
livestreaming from teachers lectures if you are home sick. or taping said lectures for later use	Live streaming
Interaction through Doodle etc. Sometimes Works well, and gives the professor an overview of what knowledge is lacking	Doodle Teacher feedback

Keyword	Quantity
Student confidence	1
Questions	1
Phone/laptop connection	1
Anonymous	1
Interactivity	2
Quiz	1

Distraction	5
Person dependent	1
Interactive board	1
Material extras	1
Follow up	1
Distraction	1
Note-taking	6
Boredom	1
Google	1
Record lectures	1
Live streaming	1
Doodle	1
Teacher feedback	1

Appendix E: Usability Test Instructions for Copenhagen Tests

Thank you for wanting to test the application LectureLive.
The test will take about 30 minutes and its purpose is to find issues with the application and to improve the application such that it is easier to use and understand. We are testing the system, not you. All your thoughts and ideas are of great value in the future work on improving the application. Please don't hesitate to say your honest opinion at all times and please think out loud as much as possible. All kinds of feedback is very much appreciated. I will act as your test leader and will hand you the 11 different tasks but I will not answer questions on how to solve the tasks unless absolutely necessary. This is because we are testing if the system can be used intuitively.
Do you have any questions before we begin?

1. Try to access the website www.madsshansen.dk/student on your phone.

You are now a student attending a lecture and your teacher has asked you to use this application.

2. Indicate that you are not afraid of saying something at the lecture.

3. Set motivation to 75 % and try to explain what this mean to you.

4. You need to write down something important that your teacher said but don't have the time, because you also want to listen to the next thing the teacher is about to say. What do you do?

5. I now present a page that includes small videos explaining different topics on a site called Ted Talks. Pick a video that you find interesting.

6. Now pretend that you are attending a lecture where this topic is explained. Use the mobile application as you find suitable while watching the video for 3 minutes.

7. Now the lecture is done and you would like to inform the teacher that you have problems with assignment 1. What do you do?

8. Please access the website www.madsshansen.dk/teacher

9. Imagine now that you are a teacher giving lecture to a class and you have just explained them something very complex. You would like to know how well the students understood your explanation. What do you do?

10. You would also like to know if the students find interest in the current topic.

11. You are now done giving the lecture and would like to know if the students have send you any feedback. What feedback did you get?

12. The test scenarios are now all completed. Before we end the test please try to think of 3 things that you disliked about the application.

13. Now think of 3 things that you liked about the application.