

HAVING FUN IN PHYSICS WITH SECRETS AND SPIES

REVISED VERSION AFTER DEFENSE OF MASTER'S DEGREE IN SCIENCE EDUCATION.

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Abstract

The future of quantum technology depends on a skilled workforce, but both the number of high school students and their interest in physics are declining. Hence, a focused large-scale effort is required to maintain Denmark's internationally leading position in quantum research and industry. This work presents a novel teaching course on quantum communication, developed for potential nationwide implementation in Danish high schools. The course engages students through spy narratives, hands-on activities, digital learning games, and debates on socio-scientific issues about technology access. To avoid disengagement from unconventional teaching methods, well known elements like calculations, data analysis, reports, and exam training were included. A pilot test with one high school class showed emotional engagement. However, some students experienced the fun elements as time inefficient teaching, while calculations and data analysis were experienced as more engaging than exam training. An outline of the entire project is illustrated in Fig.1.

Acknowledgment

I, the author of this work, sincerely thank The LIFE Foundation for supporting my journey in completing this master's degree. Special gratitude goes to Henrik Busch for initiating this opportunity, Marie Danø and Ditte Linde Thomsen for their unwavering support over the years, and Kim Splittorff, along with the Novo Nordisk Quantum Computation Programme, for making time and flexibility available during the final sprint. I am also deeply grateful to Pernille Vils Rasmussen, Gry Riemann, Malene Hjortboe Andersen, Mårten Flø Jørgensen, and Cathrine Terkelsen for their invaluable partnership in our development work and for their contributions as observers and interviewers. Above all, my deepest thanks go to my wife and our four children for making room in our family life for dad's insane hobby project.

PHASE A: IDENTIFICATION OF FRAMEWORK FOR DEVELOPMENT**DEVELOPMENT FOCUS**

- Topic relevant for exam curriculum.
- Engaging SSL.
- Appropriate level
- Design principles

DECISIONS

- Topic: Quantum communication
- SSL:
- Spies and secrets
- Difficulty: B level physics
- Design principles

DATA COLLECTION**METHODS**

Memory game

Ranging of articles

Prototype activities

Group interviews of students

Solo interviews of teachers

Interview of reference teacher group

DATA TYPES (NOT IN APPENDIX)Results of memory game
Recording of conversations during gameResults of ranging of articles
Recording of conversations during rangingObservation notes
Recording of conversations during activityInterview notes
Recording of interviewsInterview notes
Recording of interviewsInterview notes
Recording of interviews

Memory game



Ranging of articles



Prototype activity

PHASE B: DEVELOPMENT OF COURSE DESIGN AND ACTIVITIES**DEVELOPMENT FOCUS**

- Course design
- Engaging activities.
- Digital learning game.
- Quantitative experiment

PRODUCTS

- Activities with:
- Fictional video
 - Secrets & Spies
 - Calculations and data analysis
 - Digital learning game
 - Report Hand-in
 - Exam training

DATA COLLECTION**METHODS**

Prototype activities

Group interviews of students

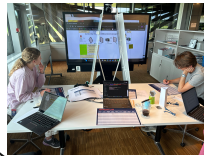
Solo interviews of teachers

Co-creation workshops with experts and teachers

Interview of reference teacher group

DATA TYPES (NOT IN APPENDIX)Observation notes
Recording of conversations during activityInterview notes
Recording of interviewsInterview notes
Recording of interviews

Workshop notes

Interview notes
Recording of interviews

Prototype activity



Co-creation workshop



Prototype activity

PHASE C: TEST OF ENTIRE COURSE**DEVELOPMENT FOCUS**

- Evaluation of engagement
- Answer research question

RESULTS

- "Unbreakable" is engaging.
- Students suspect time-inefficiency.
- Calculation exerc. are engaging
- No engagement by exam training.
- Sufficient support to teach new topic.

DATA COLLECTION**METHODS**

Student tests of all activities

Group interviews of students

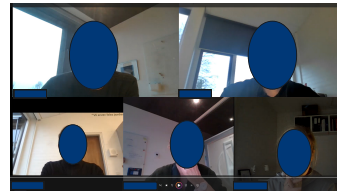
Group interview of teachers after teacher trials

DATA TYPES (IN APPENDIX)

Observation notes

Interview notes
Recording of interviewsInterview notes
Recording of interview

Test of all activities with students



Group interview of teachers after teacher trials

Figure 1. Outline of the entire project, development process, data collection, and outcome.

SECTION 1

Phase A: Identification of framework for development

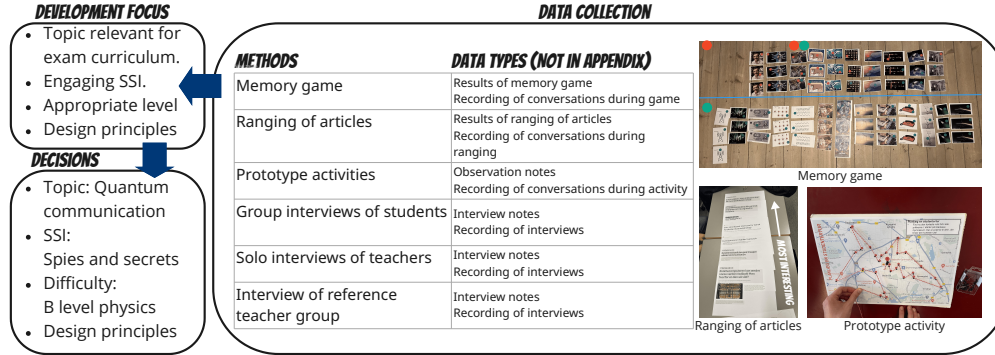


Figure 2. Outline of how development focus and data collection lead to decisions in Phase A.

SUBSECTION 1.1

Outline of this work

Fig. 1 presents an outline of this entire work. Phases A and B outline the processes and methods used to develop a teaching course on quantum technology. Phase B specifically focuses on designing activities to engage students, while the didactical design, learning goals and evaluation of the course are outside the scope of this work. Phase C studies this teaching course through testing to address the research question of this work.

Although Phases A and B are less central to the research question, they present research-relevant methods and analyses that underpin this study, and they are included in the hope of inspiring other educational development projects.

SUBSECTION 1.2

Background: Education in quantum technology

The need of an effort to secure both quality and quantity of the future quantum work force has become evident as quantum technology advances, matures and approaches transition to commercial applications [1]. In a Danish context, this need of an focused effort is strengthened by the fact that the number of high school students choosing advanced physics has steadily declined since 2019ⁱ. Additionally, the high school-aged population is expected to shrink between 2025–2031 due to demographic trends [2]. Actors from both universities and industries are calling for action with policy papers [3, 4] and tools for assessing and supporting the future quantum workforce [5]. Strategies for how to implement quantum technology in the high school curriculum are also under discussion [6, 7], where one of the challenges is how to support the teachers to integrate quantum technology in their teaching [8]. In parallel, educators have for decades attempted to develop novel teaching in quantum mechanics and quantum technology [9, 10], which are traditionally perceived by students as mathematically difficult and inaccessible [11]. While awareness of the future career opportunities in the quantum industry is awakening for current university students [12, 13], new students may be prevented from engaging in a career in quantum technology because they believe that

ⁱData presented in January 2025 by the Ministry of Children and Education’s “FiP” meetings for Danish high school physics teachers.

quantum physics is exclusive to certain types of students [14, 15]. “Seeing” quantum mechanics in experimental exercises are perceived by many educators as an important tool to excite students [16, 17]. However, these experiments are only available at few universities as these experiments are technically complex and resource expensive. However, an attempt to disseminate and study teaching about quantum key distribution to high schools have been studied in [18]. Much in line with [18], this work presents a teaching course on quantum key distribution for high school students.

Phase A and B of this work present the development of this teaching course on quantum key distribution developed on behalf of the LIFE Foundationⁱⁱ and The Novo Nordisk Quantum Computation Programmeⁱⁱⁱ (NQCP). Phase C focuses on a case study of a high school class that tested this teaching course, aiming to answer the research question of this work, which will be presented later in Phase A.

SUBSECTION 1.3

Actions in Phase A: Topic, SSI and difficulty

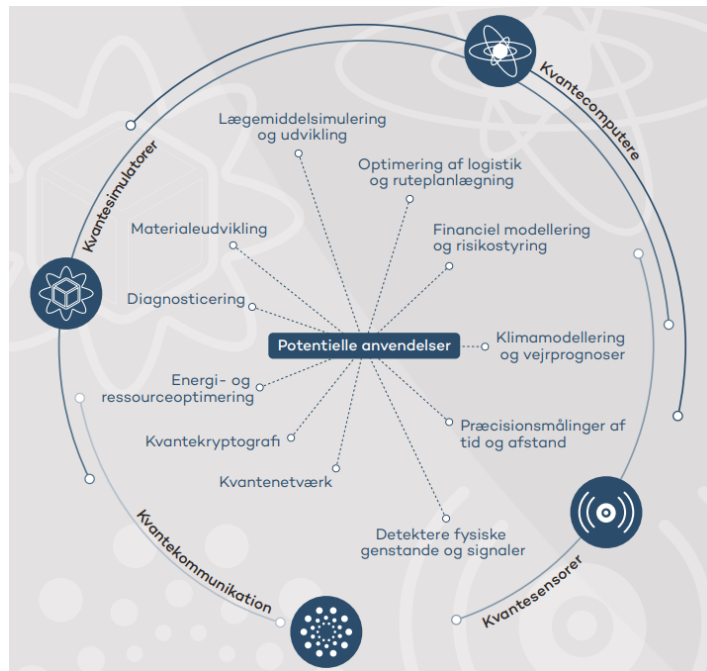


Figure 3. Illustration of the four main categories of sub-technologies within quantum technology and their potential applications (in Danish). From [19].

The LIFE Foundation and NQCP had decided to develop a teaching course about quantum technology and to base this teaching course on a socio-scientific issue (SSI) [20] with the aim to engage high school students. However, quantum technology covers four main topics of sub-technologies, quantum computing, quantum simulation, quantum sensing and quantum communication, as shown in Fig. 3. The specific topic and SSI for the teaching course were initially not decided.

The following activities and interviews were carried out with six high school classes and their five teachers from three different Danish high schools in order to investigate the needs of the students and the teachers and to investigate what motivates them. These

ⁱⁱ<https://life.dk/>

ⁱⁱⁱ<https://nqcp.ku.dk/our-work/education-team/>

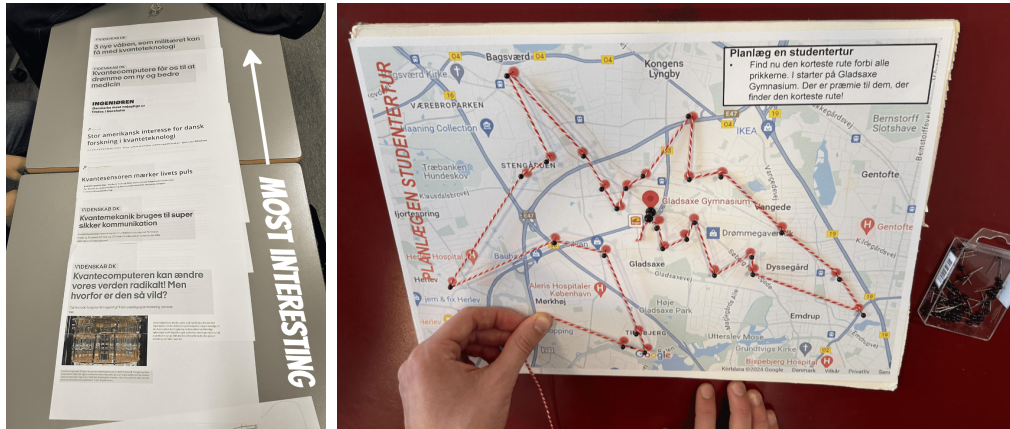
six high school classes were selected from schools across Zealand, one of Denmark's main islands. The selection included institutions both within and outside the central Copenhagen area, representing a diverse range of fields of study and socioeconomic backgrounds. The students' conversations during all activities and all interviews were recorded as data^{iv}:

- **Memory game:** Small student groups were presented with 23 different pictures related to quantum technology. First, the students got 30 s to memorize the pictures. The pictures were then hidden and the students were asked to mention all the pictures they could remember with their own words. Secondly, the pictures were shown again and the students were asked to label the pictures green if they knew something about the motive on the picture and red if they knew nothing about the motive on the picture. Examples of such labeled pictures are shown in Fig. 4a. The students' conversations during this memory game were recorded as data.
- **Ranging of articles:** The same small student groups were presented with 7 short popular science news articles. The students were asked to discuss and range the articles from most to least interesting. An example of one group's ranging of articles are shown in Fig. 4b. The students' conversation during this ranging activity were recorded as data.
- **Prototype teaching activities:** The same small student groups were instructed to carry out some hands-on prototype teaching activities. These prototype teaching activities dealt with applications of quantum communication and quantum computers. Fig. 4c shows an example of a prototype teaching activity about application of quantum computers for route optimization. The students' conversation during this ranging activity were recorded as data.
- **Group interviews of students:** Semi-structured group interviews were carried out with the student groups immediately after the activities mentioned above. The focus of these group interviews were the students' engagement in the different topics within quantum technology and the students' response to the different teaching styles of the prototype activities.
- **Solo interviews of teachers:** Individual semi-structured interviews with students' daily physics teachers were conducted and audiorecorded before or after the activities mentioned above. These interviews focused on determining the appropriate level for teaching quantum technology for high school students, as well as the challenges teachers face when introducing a new topic in their teaching.
- **Group interviews of reference teacher group:** A reference group, consisting of five outstanding teachers from various regions of Denmark, was assembled to follow the entire development process through a series of group interviews. Here, this reference teacher group was divided into two smaller groups, each participating in a separate group interviews to evaluate the decisions made during Phase A.

^{iv}The data and transcripts from recordings in Phase A are not included in the appendix as these are not used directly to answer the main research question of this work.



(a) Picture of the labeled pictures from the memory games of three student groups. The students labeled the pictures with red dots if they knew nothing about the motive on the picture and with green dots if they knew something about the motive on the picture.



(b) Picture of one student group's ranging of popular science news articles. (c) Picture of a prototype exercise where students tried to find the shortest possible route for their future graduation trip past all classmates' homes.

Figure 4. Pictures showing examples of student activities used to identify the needs of students and to identify what motivates them.

1.3.1 Identification of topic and SSI

The investigation mentioned above revealed a very broad range of reaction from the students when they were presented for quantum technologies. Both highly curious students, cautiously curious and absolutely uninterested students were observed. However, a large group of students seemed particularly interested when they were told that the quantum technologies will be of great importance in their grown up life and professional life as illustrated in this quote:

*The fact that quantum communication will become relevant in the future is exciting.
I would like to work on that a little more.^v*

The students already have a language to talk about communication and Quantum communication seemed to activate the students as suggested in [18]. Issues concerning

^vOriginal quote in Danish: "At kvantekommunikation bliver aktuelt i fremtiden, er spændende. Det vil jeg gerne arbejde lidt mere med."

secure communication for private communication did not seem to catch the students' interest. However, the students were more engaged when discussing complex issues on national or industry level concerning secure communication and risk for espionage. Based on this, the following SSI was formulated as the core issue for the teaching course:

How will quantum communication change digital communication in the future, and should everyone have access to it?^{vi}

One aim of this SSI was to engage students in working with the core curriculum on the properties of light as waves and photons. This SSI also allowed students to discuss the development of current and future communication technologies and to take personal stances on a complex issue without clear answers.

1.3.2 Identification of appropriate difficulty

Initially, the LIFE Foundation and NQCP wished to develop a teaching course for the broadest and largest possible target group. Hence, the focus of the solo interviews of teachers and the group interviews of the reference teacher group was to determine if this teaching course about quantum communication can be taught on the lowest and mandatory C level in the Danish high schools. All interviewed teachers welcomed the proposal for a quantum communication course, appreciating its ability to complement the existing curriculum on light. This is illustrated by this quote by one of the teachers from the reference teacher group:

Communication is a new punchline in my teaching!!^{vii}

However, all teachers also agreed that it was difficult for them to imagine how quantum communication could be taught at the lowest C level. Still, this does not mean that it is impossible to develop a relevant teaching course on quantum communication for C level physics. In this work, a difficulty corresponding to the elective B level was chosen instead, making it more likely that a large group of Danish physics teachers will use and adopt the teaching course.

Many of the interviewed teachers were concerned that a large scale adoption of a new teaching course on a new topic would be limited by the limited preparation time of the teachers as illustrated by this quote:

If it is difficult for the teacher to understand, then it has been opted out of in advance.^{viii}

This gave reason to focus on ensuring sufficient teacher support. However, a few of the teachers also recognized the value of investing time in adapting new teaching materials:

Familiarizing yourself with other people's materials is a huge investment, ... but it can become a lifelong companion.^{ix}

^{vi}Original SSI in Danish: "Hvordan vil kvantekommunikation ændre digital kommunikation i fremtiden, og skal alle have adgang til den?"

^{vii}Original quote in Danish: "Kommunikation er en ny punchline i min undervisning!"

^{viii}Original quote in Danish: "Hvis det er svært for læreren at sætte sig ind i, så har man valgt det fra på forhånd."

^{ix}Original quote in Danish: "At sætte sig ind i andres materialer er en kæmpe investering, ... men det kan blive en livslang følgesvend."

SUBSECTION 1.4

Design principles and research question

The initial focus of the prototype teaching activities and the group interviews of the students were to study the students' engagement in topics within quantum technologies. An unintended result was that the students were broadly enthusiastic about the prototypes' activating and inquiry based teaching style. This is illustrated in particular by the following quote:

I'm turning on my brain more than I usually do because we have to do something ourselves.^x

This differed from their usual lecture-focused teaching in physics which a student described as:

In physics we usually sit and listen...^{xi}

The students found the activating and inquiry-based teaching style fun and enjoyable. However, they also worried about whether they were learning what they were expected to:

It's been fun doing these exercises, but if you have to learn a curriculum this way, I think it might be a bit difficult.^{xii}

Two design principles were chosen as guides to develop an engaging teaching course with the potential for large-scale adoption, based on the input from students and teachers:

1. In this course, students need to be active, engaged and have fun in the teaching while also feeling that they are learning what is expected of them.
2. Teachers must be supported such that they feel that they are qualified to teach the new scientific topic quantum technology.

This work will examine the first design principle in detail, framing it as the following research question to be explored:

- **Research question:** How can quantum communication be taught in a way that engages students while minimizing disengagement when the teaching deviates from their expectations of teaching in physics?

^xOriginal quote in Danish: "Jeg tænder hjernen mere end jeg plejer, fordi vi selv skal lave noget."

^{xi}Original quote in Danish: "I fysik sidder vi normalt og lytter..."

^{xii}Original quote in Danish: "Det har været sjovt at lave de her øvelser, men hvis man skal lære et pensum på denne her måde, så tror jeg måske det vil være lidt svært."

SECTION 2

Phase B: Development of course design and activities

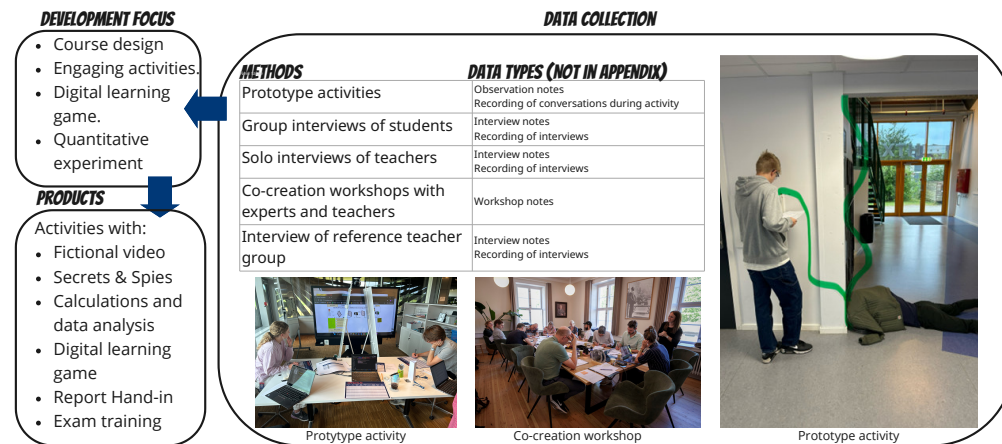


Figure 5. Outline of how development focus and data collection lead to products in Phase B.

SUBSECTION 2.1

Title of the course: Unbreakable

The user research in Phase A (presented in Sec. 1) indicated that students were equally interested (and uninterested) in topics within quantum technologies. Most importantly, the students showed interest and engagement to all topics within quantum technologies if the prototype teaching activities were hands-on, activating, and differed from their usual lecture-focused physics teaching. However, both students and teachers expressed concerns about whether the students were learning what they were supposed to, given that it was different from the usual teaching. These important findings lead to the following design principle as guide for the development of the teaching course:

In this course, students need to be active, engaged and finding enjoyment in the teaching while also feeling that they are learning what is expected of them.

Student engagement was hence a key focus in Phase B, leading to the teaching course being titled “UNBREAKABLE”. This title was chosen for its dramatic impact and because it defied conventional expectations for a physics course. The LIFE Foundation distributes both physical and digital materials for the “Unbreakable” teaching course free of charge. This course has been available for booking^{xiii} since March 2025.

^{xiii}Link for booking: <https://booking.life.dk/booking/forloeb/unbreakable>

SUBSECTION 2.2

Background: Engagement in science education

It is a widespread understanding among education researchers that engaged students are likely to participate actively in teaching activities and that they are likely to achieve higher achievement at school [21]. However, engagement complex and malleable. By following [22], engagement can be modeled as consisting of:

- Behavioral engagement associated with students' actions and behaviors.
- Emotional engagement associated with attitudes, interests and enjoyment.
- Cognitive engagement associated with students' instrumental motivation, future orientation towards science and willingness to self-regulate.

Engagement is situational and is operationalized by [23] as *optimal learning moments*^{xiv} where students experience high level of interest, skill and challenge. For example, a student is more likely to participate actively (behavioral engagement), enjoy the activity (emotional engagement) and meet requirements (cognitive engagement) if the student feel interested and confident in a situation. Furthermore, student engagement can be collective [21]. For instance, when students see their peers actively participating in a class discussion, they may feel more engaged to join in as well.

Empirical research has affirmed that students' engagement varies with different science classroom activities. These studies indicate that students' engagement is positively correlated with the frequency of student interaction, hands-on activities, student investigations and relating science to real-world applications [25]. However, other studies found that some students view "*practical work as nothing more than a welcome break from other teaching approaches*"^{xv} [26] and that lab work only increase student engagement when associated with contemporary problems. Students are also reported to be less engaged when listening to a teacher lecture [27].

SUBSECTION 2.3

Actions in phase B: Development and testing

2.3.1 Development choices

The following elements related to student engagement were implemented during Phase B of the development of the "Unbreakable" course:

- The entire course is based on a socio-scientific issue (SSI) [20] where students are solving meaningful and contemporary problems.
- The teaching activities were designed to secure the three preconditions - interest, skill and challenge - to support creating optimal learning moments:
 - The students' interest is supported by developing the activities following the "6F" model with emphasis on the engage-phase^{xvi}.
 - The activities were designed with appropriate threshold for entry and high level of support in order to making sure that all students have the proper skills and knowledge to initiate and complete the main tasks.

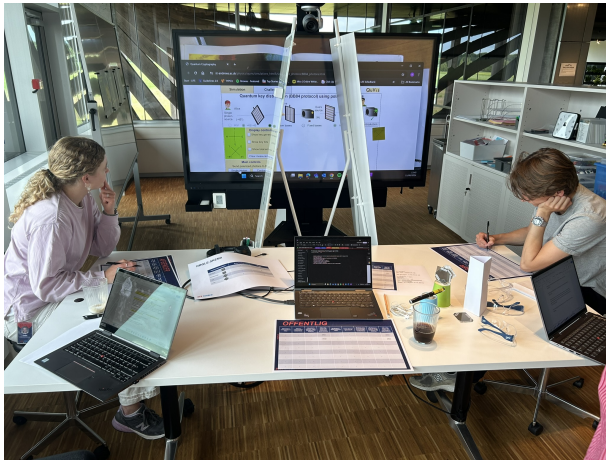
^{xiv}Optimal learning moment is very similar to the concept *flow* [24].

^{xv}Direct quote from [25]

^{xvi}"Fang" in Danish [28]. The "6F" model is similar to the "5E" model [29].

- The progression of the developed activities also offered opportunities for challenges and elaborations. These elaborations can be theoretical questions and calculation exercises in order to meet the students’ expectations to the traditional physics teaching.
- All activities were designed to include brief assessments or quizzes that connect to future hand-in reports or training of future exams. This approach aims to help students staying cognitively engaged and recognizing the activity’s importance, even though they do not find the assessment itself enjoyable [30].

2.3.2 Methods in user research and prototype testing



(a) Prototype testing during development of the digital learning game “Quantum Keys” (see Sec. 2.5.3). This prototype test was based on a *simulation* by University of St. Andrews and tested with two students.



(b) Prototype testing during development of “Part 1: Optical fibers” (see Sec. 2.5.1). An optical fiber is marked with green.

Figure 6. Example photographs from prototype testing.

All teaching activities developed in Phase B were prototype tested with students. Examples of photographs from prototype testing situations are shown in Fig.6. The following methods were used for gathering data and insight:

- All prototype testing included group observations to examine the situational engagement while students are involved in the tasks. Observation focused on investigating the students’ behavioral and collective engagement. Observation was chosen to overcome the retrospective problem of questionnaires.
- All prototype tests were immediately followed up by group interviews of the students to get qualitative insight in the students’ emotional and cognitive engagement. These interviews are retrospective but they were used to support the observations.

SUBSECTION 2.4

Course design

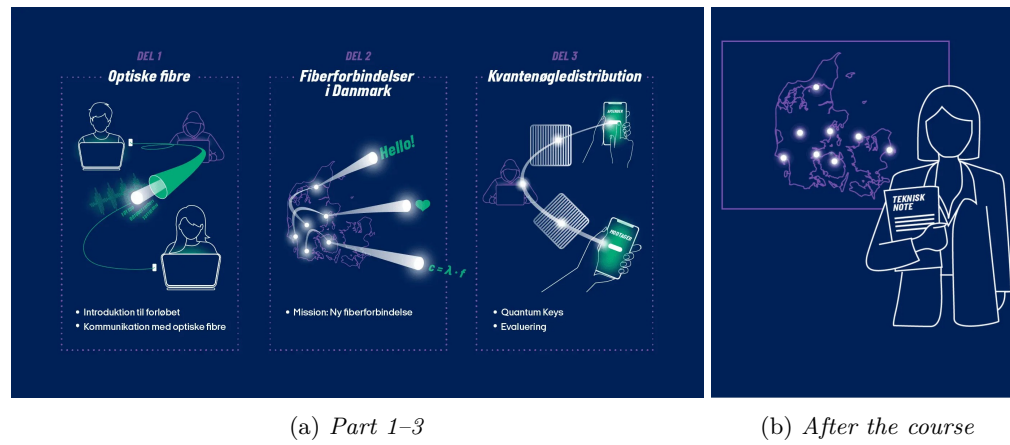


Figure 7. Illustrations of the course outline with Danish descriptions used in the published material of the “Unbreakable” teaching course. The Course is divided in 3 main parts. The following are the titles of the three parts translated into English: “Part 1 – Optical fibers”, “Part 2 – Fiber connections in Denmark” and “Part 3 – Quantum key distribution”. ©LIFE

The course outline was developed based on the students’ interests, which were explored in Phase A. An illustration of the course outline is shown in Figure 7. This “Unbreakable” course consisted of 3 main parts:

- Part 1 – Optical fibers: The students are introduced to the course’s central SSI and learning objectives. Then the students investigate how light propagates in optical fibers by sending and spying secret words through an optical fiber.
- Part 2 – Fiber connections in Denmark: The students build their own light sensors and investigate the attenuation of light in optical fibers. The students then apply their results to the real-world internet by calculating and analyzing the risk of espionage.
- Part 3 – Quantum key Distribution: The students play a digital learning game titled “Quantum Keys”. In this game, the students perform physical and digital experiments in order to investigate the technology of quantum key distribution. The students send and receive encrypted messages in the game and apply this technology in real-life cases.
- After the course: The students can study a scientific text on quantum key distribution, written at a high school level and specifically designed for this course. The teacher can also chose to let the students work on a technical report hand-in written for a fictional Danish minister for societal resilience and contingency.

SUBSECTION 2.5

Engaging teaching activities

2.5.1 Part 1: Optical fibers

The central SSI of the “Unbreakable” teaching course is introduced for the students with a short fictional video where a spy is sabotaging the Danish national electricity infrastructure. A screenshot from this video is shown in Fig. 8. The students then



Figure 8. Screenshot from a fictional video where a spy sabotages the Danish national electricity infrastructure. The spy uses a fiber optical device to connect to some central hardware for fiber networks. The video can be seen in the following link: [BLACKOUT ©LIFE](#)

receive short optical plastic fibers in their hands. First, the students perform some qualitative investigations of the properties of the optical fibers. The students will then work in groups of three, each sending, receiving and spying on secret words using a longer 25 m optical fiber and by using a binary system. Excerpts from the printed instruction booklet for this activity are shown in the Fig. 9. The students work in groups and take on very clear roles, which can potentially stimulate collective engagement[21]. The students have degrees of freedom to be creative with how they encode the binary system in their laser light and with what secret words they want to send.

This exercise is extended by a theoretical exercise on how amplitude, frequency and pulse modulation can be used to transmit a binary code. Part 1 is then concluded by a summary exercise where the format of the oral exam is trained. These theoretical and exam training exercises aim to enhance cognitive engagement by aligning with students' expectations of physics teaching, especially after the previous play-like activities.

2.5.2 Part 2: Fiber connections in Denmark

The main activity of Part 2 is an experimental mission related to the SSI of the “Unbreakable” teaching course. The mission is to select two Danish cities (shown on a map in Fig. 11a) and assess the espionage risk associated with fiber-optic communication between those cities. The students are provided with the fact that the risk of espionage in optical networks is greatest in connection with existing infrastructure such as amplifier stations. The students will then experimentally measure and determine the attenuation of light in optical plastic fibers in different lengths by assembling and using the setup illustrated in Fig. 10.

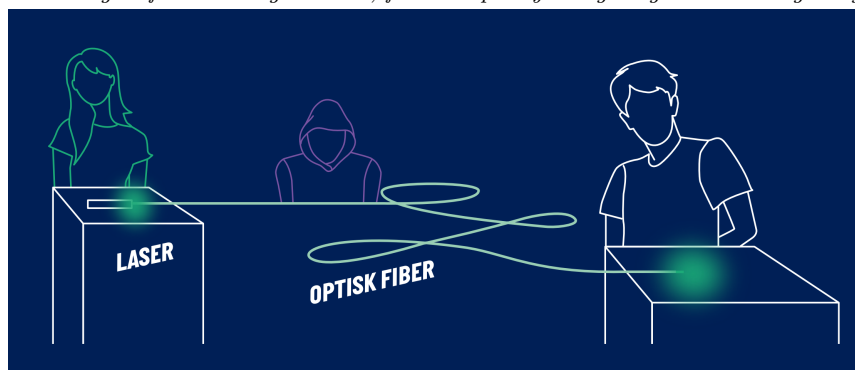
The laser light transmitted through the optical plastic fibers are measured in the unit of mV using optical diodes. The students will then need to calculate the results to the unit of μW using a calibration plot (shown in Fig. 11b). Their analysis will reveal that the attenuation in optical plastic fibers is too high for connecting Danish cities. Plastic fibers will require too many amplifier stations and result in high risk of espionage. The students will then receive data on optical glass fibers used in the real fiber-optic internet and extend their calculations to determine attenuation levels and amplification requirements. The results from the students' experiments and calculations are then used in a technical report hand-in (illustrated in Fig. 7b) after the “Unbreakable” teaching course.

1 Læs sammen i jeres gruppe tekstboksen om binær kode:

Binær kode er et system, hvor information kodes som enten 0 eller 1. Det bruges til at sende og lagre digital information.

A 00001	E 00101	I 01001	P 10000	W 10111
B 00010	F 00110	J 01010	Q 10001	X 11000
C 00011	G 00111	K 01011	R 10010	Y 11001
D 00100	H 01000	L 01100	S 10011	Z 11010
		M 01101	T 10100	Æ 11011
		N 01110	U 10101	Ø 11100
		O 01111	V 10110	Å 11101

(a) The students use a binary system to code secret words. Students have the freedom to devise their own strategies for encoding 0 and 1, for example by using long and short light signals.



(b) Groups of three students take on the roles of sender, receiver and spy. The light signal can be spied on by covering the fiber and watching the light escaping from all sides of the fiber.

Figure 9. Excerpts from the instruction booklet used in Part 1. This booklet is supplemented with the following instructional videos (in Danish): *Instruction video 1* ©LIFE

This experimental exercise is put in a narrative/SSI about assessing risk of espionage with the aim to stimulate emotional engagement. The thorough quantitative data analysis, calculation exercises and technical report hand-in aims on the other hand to enhance cognitive engagement by aligning with students' expectations of physics teaching.

2.5.3 Part 3: Quantum Key Distribution

The students are investigating a technology called quantum key distribution [31] in the third and final part of the “Unbreakable” teaching course. The main activity is carried out using a browser based digital learning game titled “Quantum Keys” developed to this course.

As part of the development of this learning game, an intuitive formalism was developed to explain quantum key distribution without using expert terminology with terms such as bits, superposition, basis, state collapse, or the standard names Alice/Bob/Eve commonly used in cryptography.

The students sit in pairs with their own computers and take on the roles of sender and receiver of individual photons (Screenshots seen from the sender and receiver are shown in Fig. 12a–12b). The sender and receiver each change the orientation of virtual polarization filters randomly and are guided through the different steps of quantum key distribution such that they can encrypt and decrypt a secret message by using the photons to distribute an encryption key.

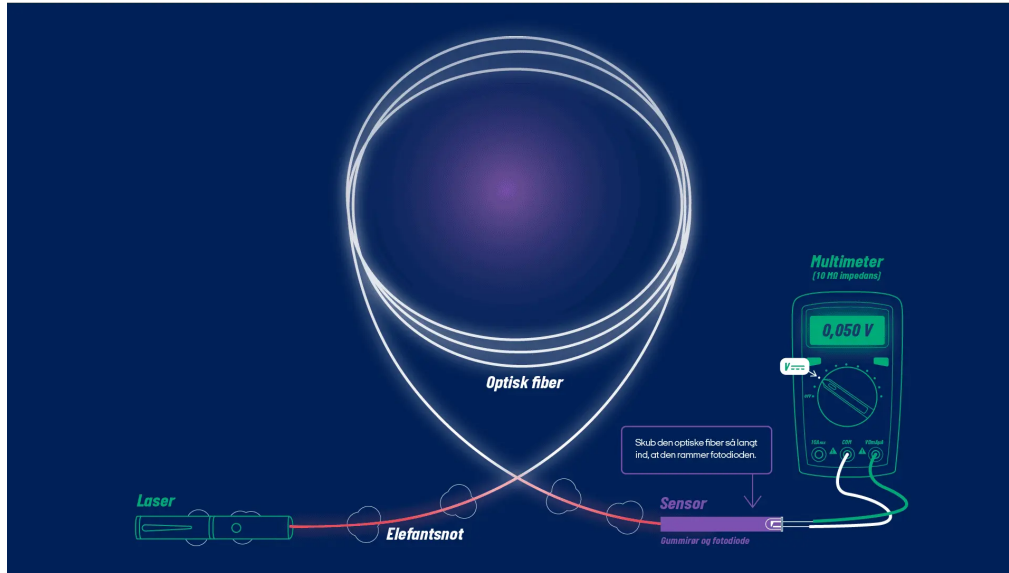
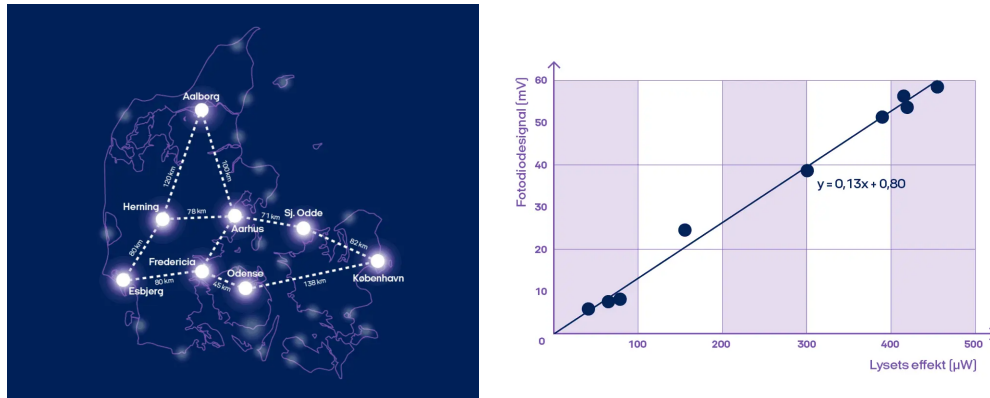


Figure 10. Instructional illustration of the quantitative experiment for determining attenuation of light in optical plastic fibers. This illustration is shown in the online instructional material supplemented with the following instructional videos (in Danish): *Instruction video 2* and *Instruction video 3* ©LIFE



(a) Map used in a mission where students determine the need for signal amplification in optical fibers to connect cities in Denmark. (b) Calibration plot used by students to calculate the measured light from optical fibers in from [mV] to [μW]

Figure 11. Excerpts of illustrations in the online instruction material for Part 2. ©LIFE

Both these different steps and the intuitive formalism without expert language are presented in Danish in a simple scientific text [32] written for the students and an advanced scientific text [33] written for the teachers and for skilled students. Both scientific texts are written as part of the development of the “Unbreakable” teaching course.

Finally, the Students use their newly acquired knowledge of quantum key distribution to choose a realistic case where confidential information needs to be sent between two locations in Denmark. During this mission, students must be aware of whether their photons are received as expected, or whether the photons are affected by spies on the communication lines.

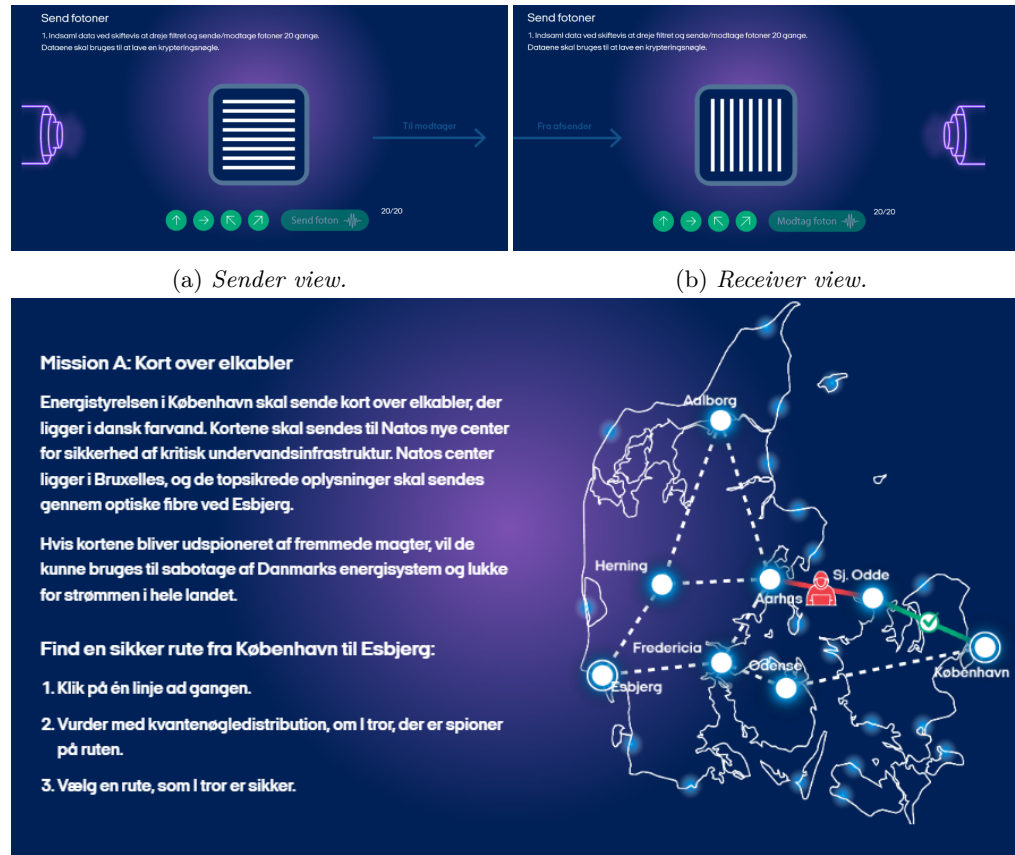


Figure 12. Screenshots from the digital learning game “Quantum Keys”. ©LIFE

A game like format is chosen for “Quantum Keys” where the students can write secrets to each other and “catch” spies. The aim of this is to stimulate emotional engagement while teaching a highly abstract subject as quantum key distribution. The missions in Quantum Keys are designed so that the sender and receiver of confidential information can choose to take on the role of either an authority responsible for key societal functions or a criminal operating outside the law. A screenshot of one of these missions, concerning transfer of confidential information about power cables in Danish waters is shown in Fig. 12c with Danish descriptions. These missions are extended with a final discussion where the students can discuss and take a stance on whether everyone should have access to quantum communication technologies, with the aim to emotionally engage the students by aligning their discussion with the core SSI of this course (presented earlier in Sec. 1.3.1). The data from “Quantum Keys” is also utilized in the final technical report hand-in at the end of the course. To support students in their writing process, a Danish scientific text [33] was developed, providing theoretical background on quantum key distribution at an appropriate difficulty level.

2.5.4 Overview of engaging activities in “Unbreakable”

All activities presented in Sec. 2.5.1–2.5.3 were individually prototype tested with methods described in Sec. 2.3.2 and improved based on the test results. An overview of engaging activities in the “Unbreakable” teaching course are shown in Table 1. Table 1 categorizes the activities by their intended type of engagement, which served both development and testing purposes. This classification ensured that the teaching activities were designed to encompass a broad range of engagement types while also guiding the selection of test methods in Phase C (presented in Section 3) .

Part	Activity	Intended type of engagement
Part 1:	Fictional video about espionage	Emotional engagement
	Sending and spying secrets	Emotional & behavioral engagement
	Theoretical exercise	Behavioral engagement
	Exam-like summary	Cognitive engagement
Part 2:	Narrative about risk of espionage	Emotional engagement
	Quantitative experiment	Behavioral engagement
	Calculation exercises	Behavioral engagement
	Technical report hand-in	Cognitive engagement
Part 3:	Digital learning game	Behavioral engagement
	Narrative about risk of espionage	Emotional engagement
	Sending secrets and catching spies	Emotional engagement
	Discussion of SSI	Emotional engagement
	Technical report hand-in	Cognitive engagement
After the course	Technical background text	Behavioral engagement
	Technical report hand-in	Cognitive engagement

Table 1. Overview of the main activities with the intention of engaging students.

SECTION 3

Phase C: Test of entire teaching course

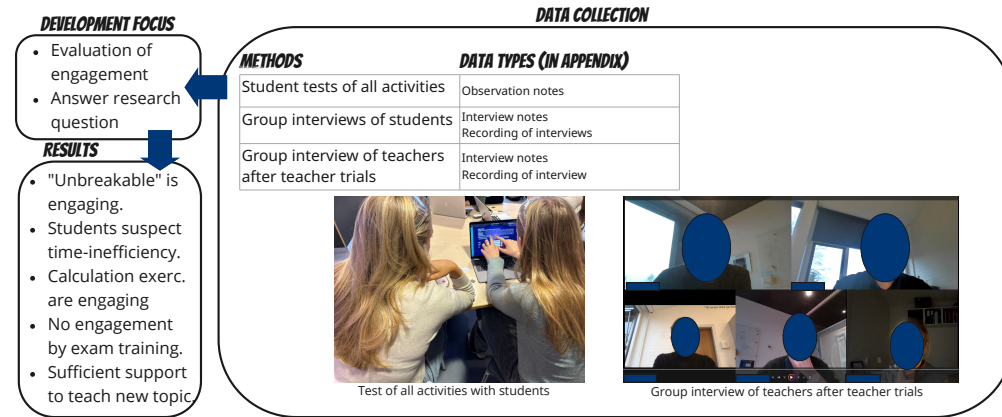


Figure 13. Outline of how development focus and data collection lead to results in Phase C.

The entire “Unbreakable” teaching course as described in Sec. 2.4 was tested in the following ways in chronological order. All tests were carried out before the publication and the opening of bookings for the teaching course:

1. **Student tests:** The author of this thesis taught the part 1~3 of the “Unbreakable” course (illustrated in Fig. 7(a)) for a 2nd year high school class in the capital area of Copenhagen during November 2024. The scientific text [32] and hand-in (illustrated in Fig. 7(b)) were not tested.
 - Observational data were collected by 3 non-interacting observers during the teaching activities.
 - The observational data were supported by semi-structured group interviews immediately following the teaching.

A combination of observations and interviews was selected, recognizing that behavioral engagement could be assessed through observation, while emotional and cognitive engagement required both observation and insights gathered through student interviews^{xvii}. These data from these student tests are the main focus for the data analysis presented in Sec. 3.1.

2. **Teacher trial:** The “Unbreakable” teaching course was conducted by two high school teachers in Copenhagen’s capital region, without the presence of observers. The teachers participated in semi-structured interviews after completing the course. The insights from which are briefly analyzed in Sec. 3.3 to complement findings derived from student observations and interviews.

^{xvii}An overview of the intended types of engagement is shown in Table 1.

SUBSECTION 3.1

Student tests of “Unbreakable”**3.1.1 Observation and interview methods**

Teaching of part 1~3 of the “Unbreakable” course was observed by three non-interacting observers. 4×90 min lessons of one high school class were observed over three days. The observers filled out a table with observation notes by following a description of the teaching activity and focus points. The focus points were mainly concerned:

- Levels of student activity.
- Levels of student engagement.
- The students’ reactions to the course’ narrative and socio-scientific issue (SSI).

A representative section of the observation table is cut out and shown in translated form in Fig. 15^{xviii}. A picture from one of the observed lessons is shown in Fig. 14.

Semi-structured group interviews were conducted immediately after each lesson. The observers conducted these interviews of three groups after each lesson by following focus points concerning the students’ experience of:

- Engagement.
- The course’ narrative and SSI.
- Learning outcome.

Selected quotes from these interviews are presented in the following Sec. 3.1.2^{xix}.



Figure 14. Picture from student test of Part 3 of the ‘Unbreakable’ teaching course. Two students are playing the digital learning game, “Quantum Keys”.

^{xviii}The complete observation table with observation notes in Danish can be found in Appendix B.

^{xix}Selected interview transcripts in Danish can be found in Appendix A

Time	Activity	Observation focus points	Observation notes 1 point per note
30 min	Send a secret (Engage/Explore) Secret words are sent, received and spied by student groups in- and outside the classroom. New technical term: "Binary code"	- Are they successful in sending & decoding the message and intercepting it? - Are students engaged in sending/receiving/spying secrets and in making their own code? - Collaboration - Curiosity - Use of instruction booklet Labels: - Having fun - Being creative - Having a clear role in investigation - Sending & spying secrets - Technical challenges - Surprised by hands-on experience	The sticky notes are organized into several categories: "Fun": Includes notes about the fun of the activity, such as "Det er sjovt at sende og modtage hemmelige beskeder" (It is fun to send and receive secret messages) and "Jeg synes det er sjovt at prøve at bryde koden" (I think it is fun to try to break the code). Topic: Notes about the technical aspects of the activity, such as "Hvad er en hemmelig kode?" (What is a secret code?) and "Hvad er en hemmelig kode?" (What is a secret code?). Materialer: Notes about the materials used, such as "Vi brugte papir og blyant" (We used paper and pencil) and "Vi brugte papir og blyant" (We used paper and pencil). Level of activity and collaboration: Notes about the level of activity and collaboration, such as "Vi arbejdede sammen" (We worked together) and "Vi arbejdede sammen" (We worked together). Instruktion - roller: Notes about the instruction and roles, such as "Vi brugte instruktion" (We used instruction) and "Vi brugte instruktion" (We used instruction).

Figure 15. A representative section of the observation table is cut out and shown here in translated form. The complete observation table with observation notes in Danish can be found in Appendix B

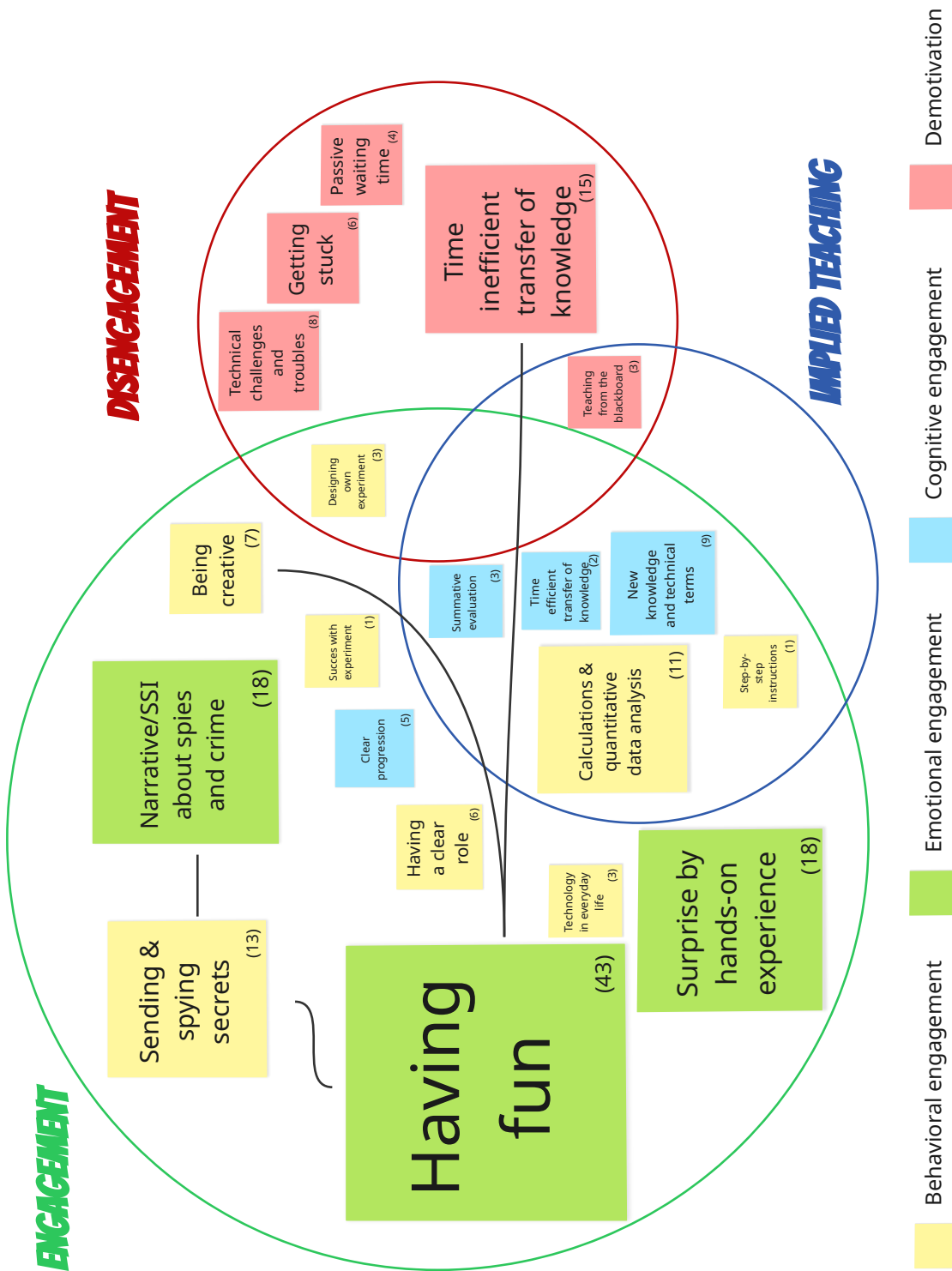


Figure 16. Visualization of confirmed themes associated with engagement and disengagement. The size of each theme reflects the number of observations and interview quotes supporting its connection to engagement or disengagement, with the exact counts provided in parentheses.

3.1.2 Analysis and labeling of data from student tests

Fig. 16 visualizes the themes associated with engagement derived from the observations and the student interviews. These themes were derived by categorizing the observers' notes thematically. Notes from interviews were also included in the observation tables and in this categorizing. Notes related to engagement and disengagement were labeled and quantified by the author of this work. The thematic categories and labeling of the observation notes are illustrated in Fig. 15. The number of labeled observation and interview notes supporting are visualized as the size of the boxes in Fig. 16.

The categorizing was mainly inductive with a view to the research question of this work. For example, an interview quote was categorized under the theme "Fun" and later labeled as "Having fun" and "Being creative" (Interview 1G in Appendix A - 00:08:32):

It was really fun that we had to code for each other... It was also a bit about making our own systems... and we also had to try to figure out each other's systems. I think that's really fun.^{xx}

The following excerpt is an other example. This quote is labeled as "Having fun" and "Time inefficient transfer of knowledge" (Interview 1P in Appendix A - 00:05:27):

It wasn't something I needed to do. It was a fun experiment. That thing about decoding the binary. It wasn't difficult.^{xxi}

Both the two quotes presented above have two labels. Dual labeling was common through the analysis and the most common matches of labeling are illustrated by solid black lines connecting the boxes in Fig. 16. For example, activity designs where students get engaged in actually sending and spying secrets seem to be coupled to the students' engagement in the course' SSI about spies and crime.

SUBSECTION 3.2

Results and discussion from student tests

This section presents and discusses the main results from the student tests in relation to the research question of this work.

3.2.1 Is having fun time inefficient?

It is clear from Fig. 16 that the students were greatly emotionally engaged by having fun in the "Unbreakable" course. Observation notes about students laughing, giggling, smiling and joking were labeled as "Having fun" as well as interview quotes stating explicitly that they were having fun. This quote from one of the group interviews illustrates this (Interview 1G in Appendix A - 00:01:48):

It's been like normal physics, but maybe a little more fun, a little playful in some way... Well, the thing about it being a whole case of us being a spy... It's been very exciting to follow (a little story).^{xxii}

^{xx}Original quote in Danish: "Mega grineren det der med at man skulle kode til hinanden... Det handlede også lidt om at lave sine egne systemer... og vi også skulle prøve at regne hinandens systemer ud. Det synes Jeg er meget sjovt."

^{xxi}Original quote in Danish: "Jeg havde nok ikke behøvet at lave det. Det var et sjovt forsøg. Det der med sådan at afkode det der binære... Det var ikke fordi, det var svært."

^{xxii}Original quote in Danish: "Det har været ligesom normal fysik, men måske lidt sjovere, lidt mere legende på en eller anden måde... Jamen, det der med at det har været sådan en hel case med at vi er spion... Det har været meget spændende at følge (en historie)."

Both this quote and the solid lines in Fig. 16 indicate that the SSI about spies and secrets were emotionally engaging for the students. Observations also showed that the students were emotionally engaged in being creative with formulating secrets and designing various setups for sending and spying secrets through optical plastic fibers. For instance, one group rolled the fiber down a spiral staircase and all groups devised numerous creative solutions to block background light for the spy, such as draping them in jackets and scarfs. For example, a student lying on the floor under a jacket is shown in Fig. 6b. Some groups repeated the exercise about sending a secret through optical fibers (illustrated in Fig. 9) in “Part 1: Optical fibers” (illustrated in Fig. 7(a)) so that each member could engage in the creative process of thinking up a secret word, even though the rest of the class had already moved on to the next exercise.

Part 3 of the “Unbreakable” course concerns a technology called quantum key distribution. The students are asked to devise methods for distributing encryption keys as an introduction to this part. Once again, the students were having fun being creative in their thinking of methods for distributing keys^{xxiii}. Later in Part 3, the digital learning game “Quantum Keys” allowed the students to experience and explore the very abstract quantum key distribution set in a narrative where public authorities and criminal organizations must send sensitive and confidential information. Both observations and group interview also showed that the students were emotionally engaged in having fun with this digital learning game. A student from one of the focus group interviews expressed how the digital learning game was experienced as both fun and helpful for learning (Interview 2G in Appendix A - 00:02:56):

The last part (the game) is super fun. That thing that we were allowed to guess. I feel you learn more when you have made your thoughts first.^{xxiv}

However, many observation and interview notes labeled as “Having fun” were also labeled as “Time inefficient transfer of knowledge”. Many students felt disengaged because they perceived the learning outcomes of these fun teaching activities to be lower than those of their regular lessons, as illustrated with this group interview quote (Interview 3P in Appendix A - 00:00:09):

It’s been quite fun... maybe more fun than educational.^{xxv}

The students still experienced this, despite positive evaluative summaries indicating they met the learning goals of the “Unbreakable” teaching course and trial teachers deeming the course high quality (presented in Sec. 3.3). By reviewing the student quotes in more detail, students show a focus on gaining new knowledge and learning new technical terms. For example, one of the students focused on the amount of new technical terms (Interview 1G in Appendix A - 00:07:26):

I don’t feel like I’ve progressed (corresponding to) two modules. I don’t feel like I have learned any new technical terms.^{xxvi}

^{xxiii}Example of methods for distribution encryption keys mentioned by students: Postal service, paper planes, message in a bottle, sign language, encrypting a key in a cow’s calling, hiding a message in a song etc.

^{xxiv}Original quote in Danish: “Den sidste del er jo mega sjovt. Det der med at man fik lov og gætte sig lidt frem og Sådan noget. For så føler jeg at man lærer mere, når man selv ligesom har lavet tankerne først.”

^{xxv}Original quote in Danish: “Det har været ret sjovt... måske mere sjovt, end Det har været lærerigt.

^{xxvi}Original quote in Danish: “Jeg føler ikke, at jeg har rykket mig to moduler. Jeg føler ikke, at jeg har fået nogen nye fagbegreber.”

Another student gave this comment about learning and knowledge (Interview 3G in Appendix A - 00:00:21):

I've learned this much (points to an illustration of the course structure^{xxvii}), because I didn't know all that. But I could have learned it all in one module... two modules... (one other student agrees).^{xxviii}

One way to understand this match of “having fun” and the perceived “time inefficient transfer of knowledge” is to consider what the students expect from typical teaching in physics. In this work, the students’ expectations are described by using the concept of the implied physics teaching from [15] as a tool. In short, this implied physics teaching^{xxix} is teacher-centered and transmissive, emphasizing content, knowledge, and calculations over context, history, philosophy, and application. Fig 16 shows the different types of engagement categorized as either within or outside the implied physics teaching (indicated by a blue circle). This figure reveals that students taught in the “Unbreakable” course are primarily engaged in ways that lies outside the implied physics teaching. It is also clear that the most commonly observed type of engagement in Fig. 16 is emotional engagement (shown with green color) while only the behavioral and cognitive engagement (shown with yellow and blue color) are represented in the implied teaching. This mismatch of the emphasis on emotional engagement and the implied teaching might shed light on why the students perceive the teaching as time inefficient and get disengaged.

3.2.2 Shut up and calculate

The most common types of observed engagement were emotional and did not align with the implied physics teaching. However, the blue circle in Fig. 16 shows that many students were cognitively engaged in activities such as calculations and quantitative data analysis, which did match the implied physics teaching. This might show that high school students appear to be already socialized into a culture where physics is for the students who can adopt the traditional “shut up and calculate” teaching style in physics [11]. This opens up for both a potential to engage students with well known and expected calculation exercises but there is also a risk of cultivating the “Shut up and calculate” culture which is reported to lead to disappointment and excluding a group of students who do not get engaged by this teaching style [14].

Interestingly, no observations or group interviews showed students being engaged by the summary and evaluation activities, which were designed to mimic and train exam formats and highlight the exam relevance of the teaching. Hence, engagement from the exam training is not included in Fig. 16 as this was simply not observed.

^{xxvii}Corresponding to Fig. 7.

^{xxviii}Original quote in Danish: “Jeg har lært hertil, for alt det vidste jeg ikke, men jeg kunne godt have lært det hele på et modul... to moduler. (En anden elev er enig.)”

^{xxix}Described in details in [15, Table 1].

SUBSECTION 3.3

Teacher trial

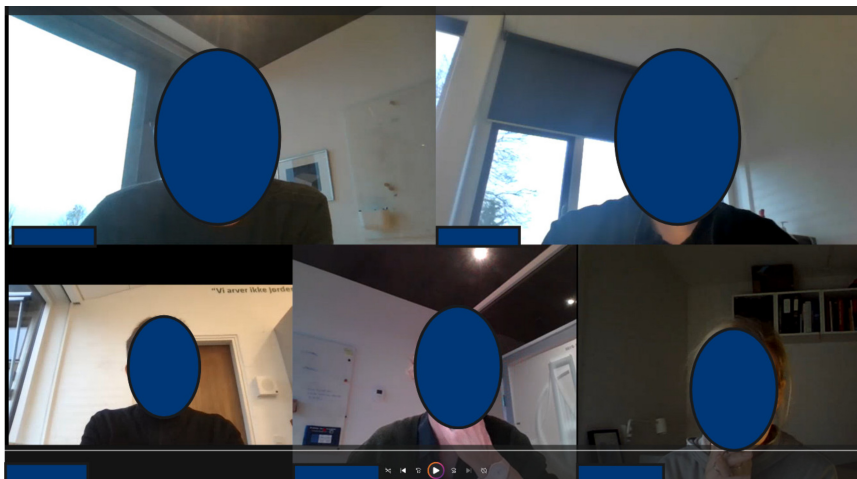


Figure 17. A picture from the online group interview of the two trial teachers.

The students tests were followed by a teacher trial were two high schools teachers taught the “Unbreakable” course on their own without observers. A class with math-physics-chemistry-specialization and a class with biotechnology-specialization were taught in this teacher trial. A semi-structured group interview was performed with the two trial teachers^{xxx}. The teachers were generally satisfied with the quality of the course material:

It is quite clear to those who are going to carry this out that it (“Unbreakable”) has actually been thought through and that it actually works.^{xxxi}

However, the teachers were aligned with the students expectations from the implied physics teaching and requested more theory and calculation exercises which they were familiar with:

A bit more academic challenge... they might have to read something more, which they would then have to relate to. So either differentiate more or at least make it more complex... Maybe some more calculations, maybe more of what they are familiar with.^{xxxii}

This request for more well known elements from the implied physics teaching is aligned with the results from the student tests and is not affecting the answer to the research question of this work. Also, most of the group interview ended up focusing on how the teachers were supported by the course material material which is not the scope of this work. However, a number of interesting topics arose which can be of interest in future works.

For example, the teachers expressed that the course material helped them to teach a novel topic they did not know before:

^{xxx}The transcript from the interview of these two trial teachers are not included in the appendix as they do not focus on the research question of this work, but the transcript is available upon request.

^{xxxi}Original quote in Danish: “Det er helt tydeligt for dem, der skal afvikle det her, at det er faktisk tænkt igennem, og at det virker faktisk.”

^{xxxii}Original quote in Danish: “Noget mere faglig udfordring ... at de måske skulle læse et eller andet mere, som de så skulle forholde sig til. Altså enten differentiere mere eller i hvert fald gøre det mere komplekst ... Måske noget mere regning, måske mere det de kender.”

I haven't really looked up knowledge about quantum encryption either, so it was actually nice that I've gotten some idea about what kind of a concept it is. So yes, I've also learned something...^{xxxiii}

The teachers also got new experiences with didactical designs following the “6F” model [28] where students are exploring before getting an explanation:

In the first module I just gave such an intro because I usually do it... But I found out that you shouldn't do that... It's simply about just trying to sit on your hands and not say too much.^{xxxiv}

These quotes indicates that the “Unbreakable” course fulfills the second design principle about supporting teachers in teaching about the new topic quantum technology (presented in Sec. 1.4). This course might even also support teachers to implement inquiry based approaches in their teaching. This second design principle was not the scope of the research question of this work. However, a more thorough analysis of the audio recording of this group interview with the two trial teachers might lead to new insights related to this second design principle.

SUBSECTION 3.4

Conclusion and discussion

3.4.1 Phase A and B

Part A and B of this work have presented the development process of the “Unbreakable” teaching course concerning quantum communication. Prototype testing and group interviews have been used extensively to gain insight about what will engage the students and about how teachers can be supported. The topic of quantum communication was chosen for the course and a SSI concerning secrets and spies was formulated. The course was entitled “Unbreakable” with a difficulty appropriate for B level physics in Danish high schools. “Unbreakable” has been designed to match the core curriculum of the physics teaching and to meet the needs of both students and teachers. The course has been available nationally in Denmark for booking since March 2025 and it has been booked for 93 classes corresponding to 2255 students as recorded on the 30th of April 2025 (shown in Fig. 18).

3.4.2 Phase C

Phase C of this work concerned tests of the entire “Unbreakable” teaching course. A single high school class was taught in “Unbreakable” while class room observations were carried out. This teaching was followed by focus group interviews of the taught students. These student tests were supported by a group interview of two trial teachers who had taught “Unbreakable” for two classes without class room observation.

The student tests of the entire “Unbreakable” course intended to answer the research question of this work:

- **Research question:** How can quantum communication be taught in a way that engages students while minimizing disengagement when the teaching deviates from their expectations of teaching in physics?

^{xxxiii}Original quote in Danish: “Jeg har ikke sådan opsøgt viden om kvantekryptering, så det var egentlig fint nok, at jeg har fået en eller anden idé om hvad er det egentlig for en for en størrelse. Så ja, Jeg har også lært noget.”

^{xxxiv}Original quote in Danish: “I første modul der gav jeg lige sådan en intro fordi det plejer at gøre... Men det fandt jeg ud af det skal man ikke gøre... Det er simpelthen det der med lige at prøve at sidde på hænderne og lade være med at sige for meget.”

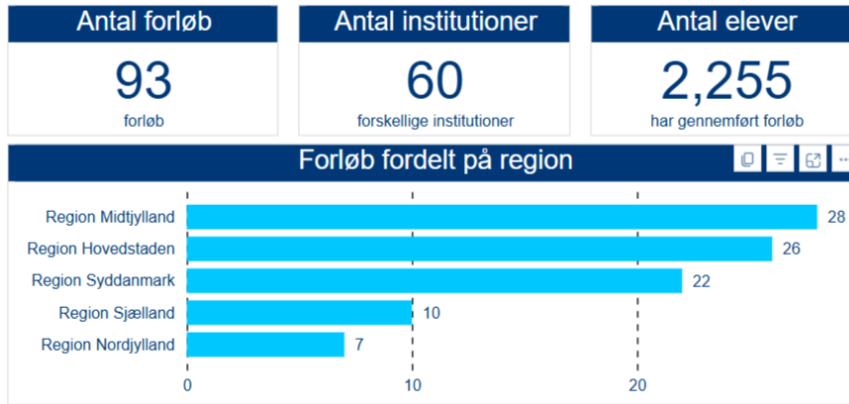


Figure 18. Booking data of the “Unbreakable” teaching course with descriptions in Danish. The number and national distribution of the bookings are shown as recorded on 30th of April 2025. Data is kindly shared by the *LIFE Foundation*.

The student tests presented in Sec. 3.1 showed that the test students were clearly emotionally engaged and were having fun with hands-on teaching activities following a SSI narrative about spies and secrets. The Part 1 of the course consisted mainly of activating inquiry based teaching activities following the “6F” model[28] with mainly qualitative analyses. Furthermore, the core of Part 3 consisted of a digital learning game. The SSI narrative, the inquiry based teaching activities and the game-like teaching activity aimed to exploit the potential to engage students in quantum technology[14]. In the student tests, students did react to the inquiry-focused and game-like elements of “Unbreakable” by having fun and being emotionally engaged. However, some students also found the same parts of the course to be an inefficient use of time compared to traditional physics teaching. One possible explanation for this is that the fun parts of “Unbreakable” deviated from their implied expectations to the teaching style in physics[15].

To prevent disengagement caused by an unfamiliar teaching style, the course design incorporated various activities with the intention to fit the students’ expectations. These activities included calculation exercises, quantitative data analysis, scientific background readings and exam training. Students showed engagement with the calculation exercises, quantitative data analysis, and the acquisition of new knowledge. However, none displayed any engagement with the exam training formats. In conclusion, this work presents a teaching course on quantum communication that has been shown in tests to engage students through hands-on, inquiry-based teaching, framed within an SSI narrative of spies and secrets. However, if the course relies solely on this approach, some students may perceive it as time-inefficient teaching. Hence, an appropriate amount of well known calculation exercises and quantitative data analysis can meet the students’ expectation to the implied physics teaching[15]. The optimal balance is most likely to have a high frequency and variation of teaching activities [25] with the aim to stimulate both emotional, behavioral and cognitive engagement [22].

Contrary to the intentions of the course design, exam training exercises did not seem to engage students in the student tests. These student tests were however performed in the Fall semester many months before the Summer exams. For future studies, it may be relevant to examine if exam-like teaching exercises can meet the students expectations to the implied physics teaching at different times of the school year.

As shown in Fig. 16, observations of emotional engagement outside the implied physics teaching were far more frequent than those of behavioral and cognitive engagement within it. Hence, the “Unbreakable” teaching course seems to be efficient at

engaging students in a specific way. Efficient teaching courses like “Unbreakable” could be valuable for future recruitment in quantum technology and other fields in physics, if it could play a role in shaping students’ perceptions of implied physics teaching. With ‘Unbreakable’ set to be taught to thousands of students nationwide, it presents an opportunity for large-scale studies on how students’ views of implied physics teaching can be affected and potentially change over time.

It is also worth noticing, that the implied physics teaching in Fig. 16 is highly specific to physics. Student expectations may differ in other natural sciences, and different teaching methods may be needed to engage them compared to those used in the “Unbreakable” course (methods shown in Table 1)). Similar studies on engagement and expectations in various natural sciences, or even interdisciplinary teaching, could be both challenging and highly valuable for science education.

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SECTION A

Appendix A – Selected interview transcripts

In the following are selected machine transcripts of group interviews from the student tests in Phase C of this work (presented in Sec. 3.1). All transcripts are in Danish as the interviews were performed in Danish. Only transcripts containing direct quotes used in this work are included. Additional group interviews were conducted, but their transcripts are not listed here. To access these, please contact the author.

Likewise, teacher interview transcripts from the teacher trial (presented in Sec. 3.3) have been omitted, but they are available upon request.

Interview – 1G

Audio recording transcribed by transcription function of Microsoft Word and manually corrected.

Transcript

00:00:00 Speaker 1

... Når og skrive alt det ned i siger.

Ikke fordi så får jeg virkelig, virkelig travlt

Nå, vi skal lave en lille øvelse.

00:00:07 Speaker 1

Der er hel masse billeder her, og i skal faktisk op at stå.

00:00:11 Speaker 1

Så i skal kigge på de her billeder.

Jeg deler bare lige nogle af dem ud.

Og så skal i vælge et billede, som i synes beskriver den oplevelse i har haft i dag.

Det vi har lavet sammen.

00:00:24 Speaker 1

Og vi må ikke tale nu i kigger bare og tager et kort som I selv synes passer til det i har oplevet.

00:00:40 Speaker 1

Og så tager i bare det kort, I synes passer.

00:00:50 Speaker 4

Sådan her.

00:01:08 Speaker 1

Så må i gerne sidde ned igen. Nu spørger jeg en af en hvorfor i har valgt det på i har valgt, og vi vil virkelig gerne have I er ærlige fordi så kan vi gå hjem og gøre det her bedre som Vi har. Vi har oplevet i dag, så i må meget gerne sige jeres ærlige mening. Vi kan godt tåle det.

00:01:25 Speaker 1

M, kan du starte med at fortælle hvorfor du valgt?

00:01:26 Speaker 5

Ja. Jamen Jeg har valgt. Hende her eller ham her. Han tager billeder fordi jeg føler Jeg har
Sådan en observeret og noteret ja i dag. Ja.

00:01:44 Speaker 1

Du har observeret. Er det noget I Plejer at gøre i fysik?

00:01:47 Speaker 5

Ja. Fordi Jeg synes Det har været ligesom normal fysik, men måske lidt sjovere, lidt mere
Sådan legende på en eller anden måde.

00:01:56 Speaker 1

Hvordan har det været anderledes, når du siger sjovere?

00:01:59 Speaker 5

Jamen det der med at det har været sådan en hel case med at vi sådan man er spion.
Det har været meget spændende at følge sådan en.

00:02:10 Speaker 1

Sådan at der var en historie. Ja.

00:02:15 Speaker 5

Ja En lille leg.

00:02:17 Speaker 7

Jeg har valgt det her billede. Jeg tror at jeg tænker bare vi allerede har været til noget
samarbejde i dag. Sådan vi har hele tiden været en grupp. og talt ting eller... lavet og
undersøgt med andre folk og diskuteret.

00:02:30 Speaker 1

Det der med grupper, er det noget i gør normalt?

00:02:33 Speaker 7

Ja vi laver ret meget opgaver i grupper.

00:02:37 Speaker 1

Og hvordan, hvad synes du om det?

00:02:39 Speaker 7

Det synes jeg er meget fint, sådan hvis man ikke kan finde ud af det, så kan man jo spørge den anden.

00:02:46 Speaker 4

Tak. S?

00:02:49 Speaker 8

Altså lidt det samme som M, faktisk. Jeg har valgt den her og Sådan lidt også der Sådan absorberer. Det er også og Sådan tager det til os, og Sådan at den er så stor foran. Fordi der var ligesom mange ting, vi skulle teste, så men Jeg synes der har været Sådan rigtig mange ting til og Sådan øvelserne har været lidt for mange måske.

00:03:06 Speaker 1

Der har været for mange øvelser? Så har det været lidt svært at overskue?

00:03:11 Speaker 8

Ja, Jeg tror også det hænger lidt sammen med, at det har været lidt

altså Sådan Vi har været Sådan forskellige og det er noget vi første gang prøver.

00:03:21 Speaker 1

Hvad hedder du?

00:03:25 Speaker 6

Julie

00:03:27 Speaker 6

Lidt i forlængelse med, hvad lige hvad de også sagde, men også lidt med det S sagde.

Det er ikke fordi der har været mange ting synes jeg. Det er mere fordi Vores sidste forsøg det gik galt. Det fungerede ikke, så der var meget ventetid. Så sidder man og venter på den der ene...

00:03:43 Speaker 1

Den der fiber.

00:03:44 Speaker 6

Ja som skal gå på tur og Sådan. Der er meget tid hvor man måske man føler man spilder.

Og så er der også der Vi skal ud på gangen Sådan de der 25 m. Det kan godt være fordi at der bare var mange elever lige der hvor vi stod men der var Jeg tror der var 8.

Kom og væltede og rev det fra hinanden, så.

Det var også først Sådan, så skulle man lige samle den op. Du ved Det var Sådan.

Lidt upraktisk.

00:04:07 Speaker 1

Ja ja.

00:04:08 Speaker 6

Men Det er meget spændende emnemæssigt.

00:04:10 Speaker 1

Hvad mener man ser spændende, hvad Der er spændende.

00:04:15 Speaker 6

Ja ja altså Det er lidt et nyt emne.

Altså Der er mange – Det ved jeg ikke – nye begreber samtidigt med, at der er begreber man kender.

Og så er det jo også noget, man kan relatere til dagligdagen, altså hver dag. Det der med Wifi fibernet Sådan.

00:04:39 Speaker 1

Var der noget af det, som i hørte hinanden sige som I var uenige eller enige i? og hvorfor det? Hvad var du enig i?

00:04:47 Speaker 5

Det J sagde ikke.

00:04:51 Speaker 5

Det der med at det ligesom var nyt, og der var meget at skulle Sådan se til, men alligevel så var det også gjort på Sådan en måde. Det var ikke helt uoverskueligt. Altså fordi der var stadig noget vi kendte, som vi kunne bruge til ligesom at ja lære noget nyt også det der med at vi Sådan blev ført igennem den her historie, gjort det også lidt nemmere som at forholde sig til.

00:05:11 Speaker 1

Er der noget andet, som nogen har sagt, som i er enige eller uenige.

00:05:19 Speaker 8

Altså Jeg er enig i det. Ida sagde med grupperne, at vi ligesom sammen så i fællesskabet. Sådan laver noget sammen.

00:05:26 Speaker 1

Var det noget godt eller dårligt? Det var godt?

00:05:27 Speaker 8

Ja altså måske det. Jeg ved ikke helt måske brugte vi lidt tiden også på lidt andet.

Sådan overordnet set var det ret godt.

00:05:35 Speaker 5

Det er også fjerde modul.

00:05:37 Speaker 5

Jeg tror faktisk lige en. Det er jo nok ikke mere. Nu havde vi jo 2 moduler i streg. Det er måske lidt meget. Det er det jo i alt altså. Jeg synes 100 minutter er meget. Men Det er jo ikke jeres skyld. Det er bare sådan det var.

00:05:51 Speaker 1

Det er sidst på dagen og det er andet modul ja.

00:05:56 Speaker 1

Det her, Det er jo et undervisningsforløb til fysik Som jo gerne skulle hjælpe med at sætte elever med at lære noget fagligt indhold og denne jeres oplevelse af at have lært noget i dag.

00:06:10 Speaker 1

Hvad tænker du har lært noget om?

00:06:14 Speaker 5

Altså. Jeg havde ingen ide om hvad noget af Det var, men nu tror jeg Jeg har en ret god forståelse for det. I hvert fald også det der med Sådan. Der er mange af de her ting man har hørt om før, for eksempel med Sådan nogle spioner, som jeg aldrig har tænkt mere end Sådan. Der er nogen der kan gøre et eller andet som som kan et eller andet. Men altså nu tror jeg Der er lidt mere Sådan en forståelse for hvad Det er de egentlig kan, og hvad Det er de finder ud af og så videre.

00:06:38 Speaker 1

Og tænker i andre? Hvad er jeres oplevelse at have lært meget.

I må gerne være ærlig. J hvorfor griner du?

00:06:47 Speaker 6

Ja måske lidt begrænset Sådan.

Jeg tror mange af tingene føler jeg lidt. Jeg har vidst i forvejen, og det jeg ikke har vidst mangler jeg vidst lidt kontekst. Sådan altså Jeg tror ikke helt jeg ved at jeg skal bruge det til?

00:06:59 Speaker 1

Hvad er det for nogle ting du har haft om i forvejen?

00:07:02 Speaker 6

Altså det her med bølgelængder og frekvens, og så ved jeg ikke om det bare er mig. Men det der med altså de der etter og nultaller Det er Sådan det føler Jeg har haft om før.

00:07:09 Speaker 1

Ja.

00:07:12 Speaker 6

Så det Sådan. Det var der ikke noget nyt i.

00:07:18 Speaker 1

Så Det har lidt svært ved at se hvad du skulle få Ud af eller hvordan?

00:07:20 Speaker 6

Ja. Jeg føler ikke. Måske at Jeg har

00:07:26 Speaker 6

Jeg ved ikke, om man kan sige Sådan rykket mig 2 moduler. Sådan Jeg føler ikke Jeg har fået Sådan nogen nye fagbegreber endnu. Det kan godt være det kommer senere på ugen.

00:07:39 Speaker 1

Det er godt du siger det. Hvad tænker i 2?

00:07:43 Speaker 7

Jaeg har det samme som J. Sådan altså. Vi har jo lært Sådan de her fagord, som Vi har haft i dag. Sådan også har vi lært alting Sådan bag dem agtigt på det så Sådan. Det er ikke fordi Jeg har fået så meget viden ind, men altså Det er jo meget spændende.

00:08:03 Speaker 1

Så hvad tænker du?

00:08:04 Speaker 8

Det er også lidt det samme, men Sådan altså. Vi har jo lidt haft om det som du siger, men Vi har ikke rigtig Sådan prøve og sætte det i praktisk på Sådan noget. Altså Sådan arbejde med det.

00:08:17 Speaker 1

Var der noget, som i vil supplere med her til sidst. Noget i synes der var kedeligt. Noget i var overrasket over noget der fungerede godt. Eller Det kan være i sidder med nogle idéer og tænker, hvorfor gjorde i ikke Sådan og Sådan? Det har virket bedre, eller?

Sådan lidt frit slag.

00:08:32 Speaker 5

Det var mega grineren det der med at man skulle Sådan kode til hinanden og man lige altså. Det handlede også lidt om at lave sine egne systemer altså hvordan Jeg vil tegne Sådan at nul er måske går ned og et går op eller et eller andet og vi også skulle prøve at regne hinandens systemer ud. Det synes Jeg er meget sjovt.

00:08:51 Speaker 1

Er der noget andet I andre sidder med, som i tænker, Det var særligt godt særligt dårligt det nok hvad i har nogle forslag.

00:09:01 Speaker 8

Altså jeg tænker at det måske Sådan kunne have været godt, hvis Bjarne havde Sådan sagt lidt mere fordi jeg føler Sådan vi fik på en eller anden måde Sådan at vide vi skulle bare komme Videre til næste Sådan øvelse, og så skal vi Selv finde ud af det henne på vejen.

00:09:12 Speaker 1

Og hvad kunne du have ønsket?

00:09:13 Speaker 8

Måske Sådan bare lidt mere Informationer Sådan fra den side af.

00:09:17 Speaker 1

At han fortalte noget mere, altså om det faglige eller hvad?

00:09:20 Speaker 8

Ja altså begge Sådan ting fordi vi ligesom stod i øvelsen, og hvis det først gik galt.

Så fik man jo kaldt på lidt hjælp.

00:09:25 Speaker 1

Du vil gerne have haft Sådan en introduktion, hvor han havde fortalt jer om hvad skal I gøre?

00:09:30 Speaker 6

Ja, eller bare en skriftlig altså en eller anden form for opgaveformulering eller fremgangsmåde.

00:09:33 Speaker 1

En hvordan ser. Hvordan ser Sådan en om ud normalt?

00:09:39 Speaker 5

Bare Sådan noget med at tingene skal sættes op Sådan her og man skal gøre det her.

00:09:43 Speaker 1

Ja OK og det savner du her.

00:09:45 Speaker 6

Jeg stod heller ikke der, hvor jeg skulle dække det til.

00:09:48 Speaker 6

Nej.

00:09:49 Speaker 6

Det kan være det, der har gjort det, men det havde vi misset. Det tror jeg også I havde også.

00:09:53 Speaker 1

Ja, men der er i vant til at få noget mere Sådan så hvordan I skal gøre.

00:09:55 Speaker 6

Altså ja. Det er Sådan. Så skal man gøre det her og ud fra det så får du de her tal.

00:09:58 Speaker 2

Og så skal du beregne det.

00:10:00 Speaker 5

Og så skal man beregne dem på den her måde.

00:10:00 Speaker 6

men så står der måske ikke lige hvilken måde du skal beregne det på, men.

00:10:04 Speaker 6

Mere det der med at. Når det er noget man ikke har gjort før, så tror jeg Det er sådan man kigger på hvad de andre gør. Så tror. Jeg bare Det er Sådan lidt Sådan lidt gætteri.

00:10:17 Speaker 1

Og er i vant til, når i også når i har det på skrift, at i så også er vant til at starter med at fortælle, hvad Det er, man skal.

00:10:18 Speaker 4

Ja

00:10:24 Speaker 5

Jeg tror det Det er lidt blandet. Det kommer lidt an på hvem man har. Det kommer an på læreren.

00:10:32 Speaker 5

Men Jeg tror også måske godt vi kunne have brugt Sådan nogle, ligesom vi gjorde helt i starten Sådan nogle spørgsmål man kunne sidde og Sådan undre sig over at snakke om man godt kunne have det Sådan efterfulgt af nogle af øvelserne. Altså hvordan kunne det se ud i den virkelige verden eller Sådan et eller andet?

Så man lige kunne tænke en gang mere over det.

00:10:53 Speaker 1

Super godt – kan vi lige lukke døren?

00:11:00 Speaker 8

Altså det med at vi både skulle forholde os til papir og på hjemmesiden jamen det synes jeg var lidt forvirrende, fordi så sidder jeg pludseligt inde på hjemmesiden, hvor jeg rent faktisk skulle være ved papiret.

00:11:09 Speaker 1

Ja, Det var svært.

00:11:12 Speaker 1

Er der andet i synes Vi skal tage ned.

00:11:15 Speaker 5

God hjemmeside, den kunne jeg godt lide.

00:11:18 Speaker 1

Hvorfor kunne du godt lide?

00:11:19 Speaker 4

Den var overskuelig

00:11:21 Speaker 6

Altså. Der var ikke særlig mange ting at klikke på.

00:11:24 Speaker 1

Ok, og det er en god ting?

00:11:26 Speaker 5

Ja, nogle gange. Det kommer an på hvad man skal, men Jeg synes sagtens, at alt det her godt kunne have været inde på hjemmesiden. Altså det ved jeg ikke om Det er ja.

00:11:31 Speaker 6

Der var også noget der var inde på hjemmesiden.

00:11:33 Speaker 5

Jeg føler at den der så slipper man også for at printe det hele ud.

Så hvis nu man kunne besvare det hele på hjemmesiden, så vil det gøre det lidt nemmere, tror jeg.

00:11:45 Speaker 6

Eller ej? Det ved jeg ikke, men downloade nogle dokumenter fra hjemmesiden

Eller et eller andet. Fordi at de der (papirer) de er her ikke næste gang.

00:12:00 Speaker 1

Altså 1000 tak Det er så brugbart alt det I har sagt. og vi kommer jo igen også onsdag og torsdag. Vi når ikke at være noget som helst til i for eksempel torsdag, så der kommer vi med det Vi har. Og så tror jeg faktisk Vi skal interviewe jer igen bagefter, så Det har været virkelig fedt at i havde lyst til at sige hvad i tænkte meget brugbart for os.

00:12:12 Speaker 4

Det var så lidt.

Interview - 1P

Audio recording transcribed by transcription function of Microsoft Word and manually corrected

Transcript

00:00:06 Speaker 1

Har i taget et alle sammen.

00:00:11 Speaker 1

Så skal i hver især. Vi tager lige Sådan en runde, så skal I fortælle hvorfor i har valgt det kort i har valgt og Vi er meget nysgerrige på hvordan i oplever det her. Jo og vi Jeg kan tåle at Høre alt. Så i skal virkelig bare være ærlige, ikke?

Ja, er der en der har lyst til at starte?

00:00:33 Speaker 3

Ja Det er Sådan.

Altså sværhedsgraden. Det er Sådan noget af. Det var meget Sådan lidt og meget nemt og Sådan noget, så var der andet, der var lidt sværere.

Og så også det lilla på de der papirer. Det var lidt for Sådan mørkt. Jeg kunne ikke. Vi kunne ikke tegne på det og Sådan se hvad Det var man skrev i hvert fald ja.

00:00:52 Speaker 1

Ja. og hvad... Kan du sige lidt mere om det der let og så svært og?

00:01:02 Speaker 3

Altså Jeg synes det første. Det var meget Sådan nemt at forsøge noget. Det var meget Sådan ret enkle. Det var mere databeregning, der var Sådan en lille smule sværere, men alligevel er det lidt under vores niveau. Jeg siger måske.

00:01:19 Speaker 2

Ja.

00:01:20 Speaker 2

Ja tak vil du fortsætte?

00:01:23 Speaker 4

Ja, Jeg har valgt vejarbejde kortet fordi vi ja har arbejdet med lidt forskellige ting og så stødte vi også på problemer. Specielt med det der vi skulle lave på det lilla papir det store lilla papir hvor vi sendte laseren igennem de forskellige længder og den der.

Hvad hedder det?

00:01:45 Speaker 2

Optisk fiber

00:01:45 Speaker 4

Optisk fiber og Det var lidt irriterende fordi Det er jo altså. Det er jo egentlig en ret nem del af det som bare skal overstås. Altså det. Vi skal jo bare have nogle målinger og det vi kunne ligesom ikke rigtigt få nogle ordentlige tal.

00:01:57 Speaker 4

Så vi kunne...Vi nåede aldrig videre til at regne på dataen

00:01:58 Speaker 1

Men det kommer næste gang. Og hvad... var det bare noget praktik der var bøvlet eller?

00:02:04 Speaker 2

Jeg ved det egentlig altså ikke fordi vi altså. Jeg ved ikke hvad Det var, fordi vi dækkede det til med jakker og halstørklæde, og så der ikke kunne komme noget lys ind, der påvirkede. Og så fik vi også skiftet den der måleling multimeret der, men det det fungerede bare ikke, men Det kan alt muligt ja.

00:02:25 Speaker 5

Ja, Jeg har taget denne her mand der sidder og tænker lidt efter, og Det var også det som lige er kommet lidt ind på det her med at Jeg synes at Det er meget godt at lave Sådan nogle forsøg og så til sidst ligesom skulle sidde og bruge hovedet eller regne lidt den der behandling som vi i hvert fald nåede ind til.

00:02:42 Speaker 1

Og hvordan er den rækkefølge? Er det Sådan, det plejer at være, eller er det noget andet eller?

00:02:45 Speaker 5

Altså, vi plejer nok også at lave forsøg og så bagefter databehandle.

00:02:49 Speaker 1

Ja ja ja.

00:02:53 Speaker 6

Nå så jo jeg skiftede faktisk ja, fordi jeg kom til at tænke på noget andet. Jeg vil gerne Jeg har valgt. Jeg har valgt den her med edderkoppen fordi at Jeg synes at noget af Det var Sådan Det var meget spændende og meget Sådan sjovt ligesom at edderkoppen den Sådan nok synes Det er ret fedt at have et spind men så vil jeg også sige at der var noget af det der var Sådan. Nogle af tingene var ret uklare Sådan besværligt at hvad man egentlig skulle ligesom der nok synes Det er ret svært nogle gange, og så var det Sådan. Det var meget af det samme.

00:03:21 Speaker 1

Kan du huske, hvad Det var, der var?

00:03:23 Speaker 6

Ja det var meget det der måden nogle af tingene formulerede, hvad man skulle gøre. Der var det Sådan lidt. Jeg føler der var lidt i tvivl om, hvad jeg egentlig skulle gøre.

Så Det var en af de mest formulationerne på nogle af opgaverne, og så var det meget det samme ligesom edderkoppen nok også kun bygger en slags spind.

00:03:40 Speaker 1

Og hvad var det, der var det samme?

00:03:42 Speaker 6

Det var mere opgaverne. De var Sådan lidt ensrettede. Det var Sådan jeg havde godt et forstået princippet efter den første opgave med de optiske fiber Sådan så forstod jeg godt princippet er det også.

Så var det ikke nødvendigt, så det blev flere.

00:03:53 Speaker 1

Og så var jeg bare helt nysgerrig efter hvad man ville sige til den her.

00:03:55 Speaker 6

Men Det var fordi at Sådan Jeg synes også Jeg er også Sådan lidt neutral omkring det hele. Det var ikke fordi Det var Sådan forfærdeligt, men Jeg synes da ikke Det var Sådan mega spændende, så derfor så røg jeg op neutr.

00:04:08 Speaker 1

Ja og så har jeg lidt ekstra spørgsmål.

Og Det er det her med, at Det er jo et undervisningsforløb til fysik som gerne skulle. Ja Det er noget, som der er mange der gerne skulle lære noget af.

Så vi ville gerne høre hvad hvad er jeres oplevelse af at have lært noget i dag?

I har jo været lidt inde på det nogle af jer.

Men hvad tænker I hver især?

00:04:34 Speaker 3

Altså Jeg synes måske Det er meget godt, at I har valgt Sådan et emne. Der er meget Sådan aktuelt der med Spionage og sådan noget.

Og at vi så sådan lidt lære omkring det. Det var meget fint.

00:04:47 Speaker 4

Ja Jeg synes også det hænger godt sammen med, hvad vi allerede har lært om lys og bølger og Sådan noget, så Det er godt at begge oven på det på det på den måde.

00:04:57 Speaker 5

Ja at Det er Sådan lidt repeterende, men også at der kommer noget nyt ind i forhold til det med fiber og spionage.

00:05:06 Speaker 1

Hvad med dig, Anders?

00:05:06 Speaker 6

Tjoe, jeg... Jeg har ikke Sådan rigtigt noget at tilføje udover det.

00:05:14 Speaker 1

Var der noget, som i synes var kedeligt? Eller Sådan mindre godt?

00:05:23 Speaker 1

Havde i andre det også Sådan, at der var mange gentagelser ligesom A?

00:05:27 Speaker 3

Jeg havde nok ikke behøvet at lave det der det første altså. Det var et sjovt forsøg. Det der med sådan at afkode det der binære. Men Det var ikke fordi. Det var svært på den måde. Nej.

00:05:44 Speaker 1

Gør det det kedeligt eller hvad?

00:05:46 Speaker 5

Det ved jeg ikke. Jeg tror bare godt vi kunne. Måske Jeg tror godt vi kunne have nået at lave mere agtigt. Altså det går ikke så hurtigt. Så man kan nok godt have nået at lave noget mere på den tid vi har brugt i dag.

00:05:57 Speaker 1

Ja det giver mening. Var der noget i Sådan var overrasket over.

00:06:06 Speaker 3

Altså Jeg synes Det var fedt at sidde og lege med den der optisk fiber til at starte med, fordi jeg vidste ikke hvad Det var eller også så Det var fint lige at opdage det.

00:06:17 Speaker 1

Men Det var også den der var meget simpel, ikke?

00:06:19 Speaker 3

Jo, men Det var jo Det er til at starte med. Så den havde jeg ligesom Det var den jeg havde brug for, tror jeg i forhold til de andre ja.

00:06:25 Speaker 1

Ja bare lige se hvad Det var ja.

00:06:30 Speaker 3

Ja.

00:06:34 Speaker 1

Hvad synes i om filmen?

00:06:37 Speaker 3

Altså Det var sjovt nok Det var. Det var godt lavet.

Der var jo ikke nogen slutning.

00:06:44 Speaker 3

Den tænker jeg vi snart når til.

00:06:48 Speaker 1

Jeg tror ikke, at der findes nogen slutning.

00:06:51 Speaker 5

Jeg tænker den. Det er meget Sådan. Det er nok meget sjovt Sådan en start eller introduktion i at lave fordi så ved man ligesom hvad baggrundens-ideen bag Det er agtigt i forhold til, hvis vi bare havde sat os ned og leget med en optisk fiber, så på den måde

synes jeg det giver en meget god Sådan start for ligesom at få en historie lidt med ind over det.

00:07:13 Speaker 1

Har i nogle idéer til ændringer?

00:07:21 Speaker 3

Måske gå hurtigere igennem det.

00:07:23 Speaker 1

Ja

00:07:25 Speaker 3

Det kommer jo an på Sådan det niveau, som klassen er på.

00:07:27 Speaker 1

Ja men altså ja, for jer plejer det at gå hurtigere?

00:07:32 Speaker 1

Ja ja ja.

00:07:37 Speaker 1

Er der andet brænder inde med? Nej altså jeg var faktisk. Jeg har faktisk et lidt teknisk spørgsmål, fordi I brugte slet ikke det der elefantslot. Er det helt bevidst, eller er det bare fordi I aldrig rigtig opdagede det?

00:07:49 Speaker 6

Jamen jeg var også lidt i tvivl om, hvad det skulle bruges til.

00:07:51 Speaker 4

Vores gruppe brugte til at sætte laser og de der optiske ting fast.

00:07:56 Speaker 3

Den var der ja, den var jo på den video med QR-kode der så jeg så den godt og jeg ved ikke, om Det er noget jeg føler Jeg er vildt meget brug for, men Det kan godt være.

00:08:06 Speaker 5

Jeg lagde ikke lige mærke til, når det skulle bruges til.

00:08:07 Speaker 3

Brugte I den, fordi I så den på papiret, eller var det Bjarke, der...

00:08:12 Speaker 4

Ja, men Det er også fordi vi ikke altså så så den bare helt fast i stedet for vi.

00:08:18 Speaker 4

Også når vi lagde jakker ovenpå for at sørge for at der ikke kommer lys ind, så kan man ligesom sørge for, at Det er ikke ryggen på noget, så det hele bare sidder bedre fast.

00:08:28 Speaker 1

Og i var bare mega gode til at samarbejde om det der.

00:08:30 Speaker 5

Ja.

00:08:32 Speaker 1

Ja OK jamen 1000 tak for jeres hjælp

Interview – 2G

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Transcript

00:00:28 Speaker 2

Altså ligesom i går gælder det jo, at vi vil jo virkelig gerne have jeres ærlige feedback, og Det kan vi bruge til mest, så vi kan gå hjem og. Rette alt det der måske skal rettes, så nu vil jeg rigtig gerne have i ligesom i går. Vi tager en runde, hvor i fortæller hvorfor er i valgt som i har valgt.

00:00:43 Speaker 1

Ja

00:00:45 Speaker 2

Vil du starte?

00:00:46 Speaker 1

Ja.

Det har været.

Altså Jeg synes Det var Sådan ret spændende dag og jeg fik Lidt mere ud af det end i går og fik mere baggrundsviden i det. Altså Sådan. Ja, man lærte mere i dag.

00:00:58 Speaker 2

Sådan ja okay, var der noget særligt du følte du du fik med i dag som du ikke vidste før?

00:01:06 Speaker 1

Sådan lidt baggrunden for, hvordan de der fibre virker også.

00:01:14 Speaker 1

Ja Jeg har valgt den her, fordi jeg tænkte at jeg godt kunne lide den tilgang vi sådan tog til opgaverne med at vi sådan fik meget lidt informationer som vi selv skulle eksperimentere med og kom frem til et eller andet, så der var noget der var Sådan skjult for os. Eksempel kom frem til noget.

00:01:32 Speaker 2

Er I vant til det?

00:01:33 Speaker 1

Det synes jeg ikke.

Synes altså nogle gange det kommer lidt an på underviseren og faget, men Det er Sådan meget sjovt nogle gange selv at få lov til at vi selv er i gang med at eksperimentere og undersøge og så. Selv kunne drage nogle konklusioner.

00:01:46 Speaker 2

Var det både den del, hvor i skal sidde og regne sammen og spillet. Eller var det den ene af delene?

00:01:51 Speaker 1

Begge dele

00:01:51 Speaker 2

okay fedt

00:01:55 Speaker 4

ja Jeg har valgt den her. Jeg synes den ser lidt Sådan. Undrende og interesseret ud, for Jeg synes det vi lavede i dag, var spændende.

00:02:02 Speaker 4

Og så sjove opgaver man kunne sidde og arbejde med Sådan her i et par hvor man ligesom. Det der med fotonerne, hvor der ligesom er en afsender og modtager, hvor at man kunne se om. De går igennem eller ikke?

00:02:18 Speaker 2

Du fremhæver mest det der med par. Hvordan med den der del hvis I sidder og regner i Tremandsgrupper

00:02:23 Speaker 4

det synes jeg også... Det var.. synes jeg det kunne jeg også godt lide. Eller det det synes jeg også fungerer godt.

00:02:30 Speaker 3

Dejligt ja. Jeg har faktisk valgt 2.

Jeg har valgt ham her.

Fordi han er Sådan mega overrasket og lidt Sådan det samme som A. Det er meget spændende. Vi lærte noget nyt, men Jeg synes dog godt vi kunne have fået lidt mere

instruks til den første. Altså jeg ved ikke om det bare var os, men vi var lidt forvirrede om Sådan hvor og hvad? Det var sådan lige pludselig. Jeg tror vi skulle lidt ind i det.

00:02:56 Speaker 3

Men Sådan den sidste del Det er jo mega sjovt det der med at man fik lov selv og gætte sig lidt frem og Sådan noget, for så føler jeg at man lærer mere, når man selv ligesom har lavet tankerne først. Og så har jeg valgt den her Fordi hun kunne jo faktisk godt lidt være Sådan et der de der spioner der for det synes jeg også Sådan lidt Vi har lavet af i dag igen. Jeg tror han sagde i går eller mandag eller hvornår Det var det der med at Det er meget fedt. Vi har Sådan en Tema vi følger altså Sådan, at det handler om at være Sådan en spion eller Sådan et eller andet. Det synes Jeg er meget sjovt, at Der er noget at ja at følge.

00:03:31 Speaker 2

Hvordan i forhold til den der matematik vi ikke laver en del matematik i dag, hvor i skulle sidde og bruge en form eller en relation så hvordan hvordan har det været?

Siger du I?

00:03:43 Speaker 1

Altså vi havde problemer til at starte med. Efter vi lige havde fået Bjarke henne nogle gange, synes jeg det fungerede til sidst eller vi fandt ud af det på en måde og så gav det mening.

00:03:53 Speaker 3

Tror lige vi skulle i gang. Ja.

00:03:57 Speaker 1

Jeg Jeg synes egentlig egentlig meget godt og måske også vi var i grupper, så kunne man jo snakke sammen om hvordan man skulle løse opgaven, hvis matematik ikke er ens stærke eller en af ens spidskompetencer.

Så det synes jeg egentlig fungerer meget godt, og hvis man var i tvivl, så var der også ret nemt at få hjælp. Det lignede også det. Altså det Vi har lavet i andre fag, altså det der med at man får en Formel og så. Skal man finde en ubekendt, så Det er noget man kender, så Det er meget fint at sidde med sammen.

00:04:28 Speaker 2

Yes altså ligesom jeg spurgte her sidst, så det her er jo et undervisningsforløb, hvor vi jo gerne vil lære nogle Gymnasieelever noget.

Ja så så hvad har i lige Sådan? Hvad tænker i hvad jeres oplevelse af at have lært noget i dag?

00:04:41 Speaker 3

Altså alt det der med de der filtre. Det havde jeg i hvert fald ingen ide om i går, og jeg ved ikke engang om vi lagde. Altså vi tænkte 2 gange over hvordan vi lagde filteret i går. Jeg tror bare Det er meget fint. Vi Sådan dykker lidt ind i alle de ting, man ikke rigtigt skulle tro der var så meget til, og det er der jo alligevel.

00:04:44 Speaker 2

Ja.

00:05:03 Speaker 1

Ja Det er en meget fin måde Sådan at bygge ovenpå det vi ligesom lærer undervejs, så nå OK så det er også noget vi kan bygge videre på.

00:05:12 Speaker 2

Hvad tænker i om at vi kommer igen i morgen og i skal arbejde videre? Det der spil hvad er mavefornemmelsen omkring det?

00:05:18 Speaker 3

Det er mega sjovt.

00:05:20 Speaker 1

Jeg glæder mig, det glæder jeg mig til.

00:05:20 Speaker 4

Det kan jeg godt lide.

00:05:23 Speaker 2

Er der noget, som i tænker i dag? Åh, det fungerede ikke så godt, eller det skal i lige se på om i kan gøre lidt anderledes eller noget eller nogle gode råd til os.

00:05:31 Speaker 3

Jeg synes ikke Det var så tydeligt i Vores spil at den kun gik Sådan 50% igennem, men vi synes enten så gik den igennem eller gik den ikke igennem den. Der var ikke noget Sådan utydeligt om det.

00:05:41 Speaker 2

Digital eller der hvor I sad med laseren?

00:05:42 Speaker 3

Digitalt digitalt.

00:05:44 Speaker 3

Også i forhold til den digitale. Jeg ved ikke om det bare var os, der ligesom ikke tænkte os om, men vi fik overhovedet ikke arbejdet sådan systematisk med det.

Smitte vi testede ligesom bare alt muligt, så når vi kiggede på resultaterne vi havde fået, så var der nogen vi havde været 2 gange og så er der nogen vi slet ikke havde lavet.

så det skulle der måske have stået noget med at altså man ligesom skal få testet så mange mulige kombinationer som muligt. Ellers så får man Sådan noget som hvor ost der ikke var særlig god. Altså Det er ikke særlig god data.

00:06:11 Speaker 1

Jamen Jeg er også enig.

Jeg havde ikke lige forstået hvordan man skulle aflæse det der data bagefter med at Det var Sådan 50% af tilfældene efter fotonerne gik igennem når der var Sådan 45 graders vinkel.

00:06:16 Speaker 2

Nej.

00:06:25 Speaker 1

Så Det var først da Bjarke fortalte mig så tænkte jeg nå OK det er sådan det hænger sammen.

00:06:27 Speaker 2

Ja.

00:06:29 Speaker 1

Fordi først var jeg forvirret over, hvordan det hænger sammen, men så gav det mening.

00:06:36 Speaker 2

Og I også der gik der lidt tid før Bjarke fortalte jer. Det er jeres data der står her.

Sådan nå OK.

00:06:42 Speaker 3

Ja, Jeg tror lige man skulle forstå Sådan en sammenhængende.

00:06:47 Speaker 2

Ja. Det er godt. Er der noget andet i vil supplerer med?

Så skal i bare 1000. Tak for i dag.

Interview – 3G

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00:00:01 Speaker 1

Værsgo o. k. jeg tænker Sådan. Jeg kunne nok godt have lært lidt mere. Ja, men Sådan Jeg synes stadig Jeg har lært noget.

00:00:08 Speaker 2

Ja Jeg har lært en lille smule, men Det var ikke fordi Det var Sådan.

00:00:11 Speaker 1

OK, men du har vidst. Du ved også meget A.

Jeg vil sige har lært så meget.

00:00:15 Speaker 2

Jamen jeg, men Det har ikke noget med det at gøre. Jeg føler ikke, at Vi har lavet sådan super meget. Vi har bare lavet meget af det samme.

00:00:21 Speaker 1

Jeg synes Jeg har lært hertil for alt det vidste jeg ikke, men jeg kunne godt have lært det hele på et modul - to moduler.

00:00:26 Speaker 2

Ja enig max.

00:00:30 Speaker 1

Men Jeg synes Det har været ret sjovt. Så jeg ville sætte den her,

00:00:34 Speaker 2

du ville sætte din der?

00:00:36 Speaker 1

Ja. Jeg synes, at det var en grineren, men kune godt have gjort det på Sådan den halve mængde tid.

00:00:40 Speaker 2

Jeg synes også Det har været rimelig grineren, men Jeg synes ikke rigtigt, at vi har lært noget.

00:00:43 Speaker 1

Nå? Okay, men på linje med mig.

00:00:44 Speaker 3

... men er det, fordi du vidste det i forvejen eller er det fordi du bare ikke har lært noget?

00:00:47 Speaker 2

Men Jeg synes bare ikke Vi har. Jeg synes Det har været ret ukonkret. Altså Vi har lavet en masse øvelser, men Det har været Sådan. Jamen Vi har ikke rigtig lavet noget konkret hvor vi lært Sådan specifikt om noget. Det har mere bare været mange af de samme øvelser.

00:00:50 Speaker 3

Ja.

00:01:00 Speaker 2

Så jeg ville sætte min... her

00:01:03 Speaker 3

Må jeg spørge, når i har normal undervisning hvordan hvad er det der gør at i en normal undervisning tænker ej der lærte jeg noget? Altså hvordan kan i se det eller mærke det eller hvad gør I i normale undervisning?

00:01:12 Speaker 2

Der føler jeg, at vi går i dybden af noget. Jeg føler ikke rigtig. Vi har gået i dybden med noget specifikt her.

00:01:14 Speaker 3

Nej

Og går i dybden er det ved at i får fortalt noget om eller læser noget om eller I laver eksperimenter, eller hvad gør i?

00:01:20 Speaker 2

Ja, vi får fortalte noget

00:01:24 Speaker 3

Ja ok, Så jeres lærer stiller sig op og fortæller jer noget, så ja, så Det er tydeligt hvad Det er ja.

00:01:27 Speaker 1

Ja Jeg synes måske også godt det kunne have været lidt sværere. Altså fordi jeg vidste ikke rigtig noget af det, men det gjorde jeg efter Sådan noget den første gang, og så kunne man godt have bygget endnu mere ovenpå det i stedet for Sådan køre. Jeg tror jeg havde en meget god forståelse for det hele. Men så kunne man bare godt have gjort det sværere. Ja, så man lærte Sådan endnu mere.

Og så ja eller den mængde Vi har lært nu kan. Godt have gjort på kortere tid, tror jeg.

00:01:54 Speaker 3

Noget af det, Vi har tænkt ret meget og lidt spændt på. Det er at i har siddet på. Nu tænker jeg ikke spillet, men i har siddet inde på en hjemmeside og arbejdet og i har også siddet med nogle papirer hvor i skal udfylde og læse noget på det og Sådan noget. Det der med at man nogle gange er på en hjemmeside og nogle gange arbejder med nogle papirer hånden. Hvordan har i det med det?

00:02:11 Speaker 2

Det synes jeg, det passer mig fint.

00:02:12 Speaker 1

Ja jeg synes også det er fint, men Jeg synes det der i den første dag eller Sådan noget der Der er virkelig meget rod. Der var sygt meget at holde styr på.

00:02:21 Speaker 2

Jeg Synes hjemmessiden er Uoverskuelig. Jeg synes ikke ikke den er så...

00:02:26 Speaker 1

Men Jeg tror måske Det er det der med at Vi har haft en testversion det Jeg tror Det har været meget nemmere hvis den Sådan det lige altså man ikke Sådan kom ind på noget der lignede noget, men at det så var spillet.

00:02:38 Speaker 3

Havde du den samme oplevelse af, at hjemmesiden er de første 2 dage hvor vi ikke var inde i spillet, eller hvor vi ikke kun var på hjemmesiden?

00:02:43 Speaker 2

Ja der synes jeg også Det var Sådan lidt svært at finde rundt, fordi det allesammen lignede hinanden. Der kunne jeg heller ikke skille forskel på hvad Det var.

00:02:49 Speaker 3

Nej.

00:02:50 Speaker 3

Ja hvordan har i det med at sidde med altså arbejde på ark at det ikke er digitalt men at det er analogt.

00:02:57 Speaker 2

Det gør ikke noget.

00:02:57 Speaker 3

Fint er i vant til det.

00:03:00 Speaker 1

Ja.

00:03:00 Speaker 3

Ja.

00:03:01 Speaker 1

Men spillene kunne man selvfølgelig kun lave på computer

00:03:02 Speaker 3

Ja, men så var der nemlig nogen i din gruppe der sagde det der med at det blev bare væk for os de der papirer.

00:03:08 Speaker 1

Ja ja altså, Jeg tror ikke vi ville holde Fast på dem.

00:03:11 Speaker 3

Nej.

00:03:11 Speaker 1

Så Det er meget smart. Det er vigtige data at have det på computeren.

00:03:18 Speaker 3

Så har i prøvet nogle forskellige typer opsamlinger og repetitioner. Jeg ved ikke om i har lagt mærke til at i har skullet sige på nogen billeder i skulle tale om i har lavet Sådan en hurtig skriv hvor i skal skrive et minut. I har haft nogle samme nogle sætninger i skulle færdiggøre et skrivefelt og Sådan noget. Vi har faktisk udsat jer fra en del forskellige ting. Hvordan har det været?

00:03:27 Speaker 1

Ja. Det har også været meget godt.

00:03:37 Speaker 2

Det må også være meget sjovt.

00:03:38 Speaker 1

Jeg kan godt lide når hvis man snakker Om det i klassen.

00:03:40 Speaker 3

Når Det er klassesamtale?

00:03:42 Speaker 1

Ja, når vi opsamler på den måde. Ja.

Det der hurtigt skrev Det var. Kedeligt. Det kan jeg ikke lide.

00:03:49 Speaker 2

Ja, man får ikke rigtigt skrevet noget vigtigt og man tænker mere om at få skrevet noget end at få skrevet noget konkret.

00:04:01 Speaker 1

Og det med billeder. Jamen det synes jeg også var meget OK. Man skulle bare lige forstå det.

00:04:05 Speaker 3

Ja ja.

00:04:07 Speaker 1

Og hvad var den sidste ting vi havde lavet?

00:04:08 Speaker 3

Jamen så så færdiggjorde I nogle sætninger.

00:04:11 Speaker 1

Det var det jeg snakkede om de der billeder.

00:04:14 Speaker 3

Ja ja.

00:04:16 Speaker 2

Det synes jeg også virkede fint nok ja.

00:04:19 Speaker 3

Og når i godt kan lide klassesamtaler, er det klassesamtaler, hvor i fra start af taler sammen alle sammen. Eller er det, hvor i får mulighed for først at tale i jeres gruppe inden klassesamtaler eller.

00:04:29 Speaker 2

Begge dele. Jeg føler ikke den ene udgør den anden eller den ene er vigtig end den anden. Men ligesom Det er Sådan en slags åben diskussion.

00:04:37 Speaker 1

Enig.

00:04:38 Speaker 3

Ved i egentlig efter det her forløb, om man bruger kvantekommunikation i dag?

00:04:43 Speaker 1

Det tænker jeg, da man gør?

00:04:45 Speaker 2

Tror jeg det gør man ikke. Nej.

00:04:46 Speaker 1

Hvad?

00:04:47 Speaker 2

Ikke andet end fibernet. Jeg tror ikke du kunne gøre så meget ud af det i dag.

00:04:49 Speaker 1

Er fibernet ikke nok?

00:04:52 Speaker 2

Eller jo du gør det vel altså du bruger jo mange krypteringsnøgler, især med Sådan kryptovaluta og Sådan noget der så bruger man rigtig meget. Men jeg ved ikke om du bruger det som kommunikation. Det har jeg ikke hørt om.

00:05:06 Speaker 3

Er der noget, der har været særligt sjovt når I husker tilbage på ugen?

00:05:11 Speaker 1

Alle de der lege Vi har lavet eller spillet spil.

00:05:14 Speaker 3

Spillet. Hvad siger du?

00:05:18 Speaker 2

Ikke noget der Sådan tænker.

00:05:19 Speaker 3

Nej.

00:05:21 Speaker 1

Hvad var sjovere end det andet?

00:05:23 Speaker 2

Det ved jeg ikke. Det er altså ikke fordi jeg synes, at der var noget, der var sjovt unde...r

00:05:27 Speaker 3

Er der nogle gode råd? Noget vi skal tage tilbage ud over det I har sagt?

00:05:38 Speaker 1

Måske lidt nogle instrukser til nogle af tingene.

00:05:40 Speaker 3

Ja.

00:05:42 Speaker 1

Spillene kunne vi godt Sådan regne ud, tror jeg, men nogle af de der forsøg blev julen Sådan lidt Sådan. Så blev man lidt forvirret og så brugte man egentlig mere tid på at gætte sig frem til noget dumt i stedet for at lav det rigtige.

00:05:53 Speaker 3

Ja.

00:05:56 Speaker 1

For Jeg synes også Det er godt at skulle Sådan tænke selv, men også til en vis grad tror jeg.

00:06:03 Speaker 3

Du nikker oplevede I det samme?

00:06:05 Speaker 2

Ja, men Jeg er enig.

00:06:06 Speaker 3

Okay okay super godt.

00:06:08 Speaker 3

Er der andet vi tilføjer?

00:06:11 Speaker 3

Så siger jeg bare. Tak for jeres tid. Lad os gå ud inde på det.

Interview – 3P

Audio recording transcribed by transcription function of Microsoft Word and corrected manually.

Transcript

00:00:04 Speaker 1

Vil i forklare hvorfor i har sat jeres prik, der hvor I har sat det?

00:00:09 Speaker 2

Jeg synes egentlig Det har været. Det har været ret sjovt.

Jeg synes også Det har været måske mere sjovt, end Det har været lærerigt. Det var ret fedt med Sådan de der Sådan spil og Sådan noget.

Det har jo også været lærerigt, men jeg føler også noget af det som noget vi vidste i forvejen, men har måske også fået sat lidt mere end Sådan kontekst.

Vi har jo haft og Sådan noget om fotoner og Sådan noget. Men. Det her var en. En ny måde. Sådan at se det på måske.

00:00:35 Speaker 3

Jeg føler måske også at jeg har sat min lidt for langt her henne . Måske skulle jeg have sat den her.

00:00:40 Speaker 3

Det har været meget sjovt. Jeg tror faktisk det Vi har lært eller Sådan fået ud af. Det kunne i godt have lavet på Sådan en eller 2 moduler?

00:00:50 Speaker 3

Men Det var meget sjovt.

00:00:51 Speaker 5

Jeg er også enig altså Jeg synes også at det Har været sjovt og så lave nogle lidt Sådan alternative metoder Lave forsøg og Sådan noget på også det med de online Ting men ja Jeg synes også at man kunne godt have gjort det altså lært det samme på lidt kortere tid.

00:01:14 Speaker 1

Og hvordan synes i dagen i dag har været med spillet?

00:01:18 Speaker 2

Jeg synes Det var sjovt. Det var lidt Sådan en opsamling.

00:01:20 Speaker 5

Og så ja det gav meget god mening at have det til sidst fordi det. Det lidt op på Sådan det dele.

00:01:27 Speaker 1

Ja.

I har Sådan både arbejdet i løbet af det her forløb på platformen med spillet. Og så har I arbejdet med trykserier. Hvad synes I om det som de papirer Vi har udleveret. Hvordan synes I, at det har fungeret?

00:01:50 Speaker 2

Det er meget fedt, og Det var også Sådan lidt fedt med de der spil. Det var Sådan lidt Sådan bare Sådan hardcore undervisning, men Det er Sådan lidt sjovt. Det får man også noget af, så føler jeg spillet mere spændende når det faktisk er sjovt Sådan hvad vi laver.

00:02:10 Speaker 1

Andet?

00:02:14 Speaker 5

Nej ikke andet end at Det er meget godt at kombinere det Sådan også, at man både har det i hænderne og så bagefter Sådan ligesom tager det ind på skærmen, så man. Ligesom. Har en forståelse for det med hvad hedder det nu? Det optiske fibre og Sådan noget, at det ligesom hang Sammen på den måde?

00:02:32 Speaker 1

Og så har I prøvet nogle forskellige former for opsamlinger og repetitionsøvelser og Sådan noget hurtig skrivning og i dag skulle I færdiggøre nogle sætninger og. Hvad synes I om jeg ved ikke om I selv kan huske andre? Hvordan synes I de fungerer? Er I vant til at...

00:02:50 Speaker 3

Fungerer meget fint. Ja ja ja, det føler jeg.

00:02:54 Speaker 5

Det fungerer meget godt.

00:02:54 Speaker 4

Mener jeg så peger til.

00:03:00 Speaker 1

Ja, er der noget I var overrasket over i dag?

00:03:05 Speaker 5

Sådan lidt hvordan altså hvad var det Sådan en krypteringsnøgle var Sådan opstår altså hvordan den kode der Sådan bare opstår. Det var Sådan meget...

00:03:11 Speaker 4

Ja.

00:03:14 Speaker 5

Man skulle lige dreje sin hjerne om, at det ikke var en fast kode, men noget der bare Sådan opstod. Ja.

00:03:17 Speaker 4

Ja.

00:03:22 Speaker 1

Var det svært at forstå?

00:03:29 Speaker 4

Lillesmule synes jeg måske fordi det godt kunne virke en lille smule abstrakt.

00:03:30 Speaker 5

Jeg synes nok det sværeste var nok at forstå det med krypteringskoden fordi Jeg har min hjerne har lyst til Det er Sådan en kode, men Det er bare noget der Sådan opstår eller den kombination synes jeg Sådan.

00:03:34 Speaker 4

Ja.

00:03:42 Speaker 5

Det skulle man lige få drejet sin hjerne omkring.

00:03:47 Speaker 1

Har i nogen forestillinger, om man bruger kvantekommunikation i dag?

00:03:53 Speaker 3

Ja det tror jeg godt man kan gøre hvis der er noget, der skal krypteres ekstra sikkert.

00:04:00 Speaker 5

Ja tænker også det. Hvis det skal være meget sikkert? Ja.

00:04:16 Speaker 1

OK Er der andet I brændere inde med? Ideer til os selv eller noget?

00:04:25 Speaker 3

Der er noget med deres spil, som vi lavede, som Jeg synes nogle af Sådan opgavebeskrivelserne var lidt Sådan lidt utydelige i blandt andet, hvad det var præcis Det var, man skulle gøre.

00:04:39 Speaker 3

Og så også det der med at vi trykker ud på de rigtige steder på det der kort. Altså man skal trykke på linjerne og ikke prikkerne. Det var lidt forvirrende, så lavede vi nogle noget som. Vi ikke havde behøvet at lave.

00:04:49 Speaker 1

Ja ja.

00:04:51 Speaker 5

Altså, jeg ved ikke om det bare var mig, men Det er det første spil, der var den der store blå hvide knap nede i bunden. Der er troede jeg ligesom Det var videreknappen i stedet for den lille knap.

00:04:58 Speaker 1

Ja ja Det er fordi vi ikke har fået det ind i den anden platform endnu. Jeg tænkte lidt på om i faktisk manglede at få at vide at vi var i gang med at lave en krypteringsnøgle i det første i lavede i dag. Giver det mening?

00:05:00 Speaker 2

Ja. Det er måske egentlig rigtigt.

Jeg føler måske også Sådan måske Lidt mere generelt, hvis den gennem en hele forløbet. Det er lidt fedt at få Sådan et konkret Sådan at Bjarke sagde måske enten inden vi gik i gang eller efter Vi er i gang Det er det her vi laver, og det er det her, man kan bruge det til.

00:05:31 Speaker 3

Han sagde, at der bare var de der instruktioner inde i opgaven, og Det er også fint. Men Sådan. Man kunne Bliver sat i gang måske.

00:05:40 Speaker 1

Og når du siger brug skal bruge det til. Hvad tænker du på?

00:05:44 Speaker 2

Altså Sådan der og også hvor vi sidder og laver og hvordan måske hvis man altså Sådan kan bruge det i øjeblikket. Jeg ved godt Det er Sådan. Opgaven giver også noget og man rigtigt Sådan sætter relation til Sådan virkeligheden men måske hvis han Sådan fortalt lidt om det eller uddybet lidt om det. Føler jeg også kunne være lidt fedt.

00:06:02 Speaker 2

Ja.

00:06:02 Speaker 1

1000 tak skal i have tak.

00:06:04 Speaker 6

Det var så lidt.

SECTION B

Appendix B - Observation notes

The following section presents thematically categorized and labeled observation notes in Danish. The text is too small to read in a printed version. However, the notes are provided in a vectorized format, allowing all text to remain readable when zoomed in within a PDF format.

Del 1 - noter og analyse

Tid/min.	Aktivitet	Observationspunkter og aktivitetsformål	Observationsnoter
		Disse har vi i baghovedet når vi skriver observationer. Vi svarer først på dem i analysen.	Under afprøvning: Skriv primært hvad du ser og hører - 1 "pointe" pr post-it. Skriv sekundært også eventuelle vigtige tanker du får. Under opsamlng: Vi laver tematisk analyse og skriver indsigter.
3/5	Bjarke præsenterer LIFE og afprøvningsformål. Pernille præsenterer observationer og hvordan vi agerer.		
2	UNBREAKABLE (forløbsforside)		
10	KOMMUNIKATION MED OPTISKE FIBRE Introduktion til forløbet (Fang)	- Engagement i samtale om video? - Engagement i SSI'en? - Får alle elever får givet udtrykt for, om de ved, hvordan internettet fungerer? - Synes de at blive engagerede i SSI'en? Formål: At fange elevernes opmærksomhed og introducere SSI.	
10	LÆRINGSMÅL (Forudsæt)	- Engagement - Krydder de af og tegner streger i tryksagen med fagbegreber og læringsmål? - Sammenhænge med læringsmål (egen streger) - Fvt. foto Mål: - At elevernes forforståelse aktiveres. - At eleverne bliver bevidste om deres forforståelse med henblik på mulighed for senere selvevaluering. - At eleverne præsenteres for læringsmålene. - At eleverne præsenteres for forløbsoversigten. Formål: Eleverne forholder sig aktivt til læringsmål	
	FORLØBSOVERSIGT	- Hvad taler de om i aktiviteten? - Er der ubesvarede spørgsmål om forløbet længde og produktivitet? - Variere vi for meget? Eller er der for mange gentagelser? - For mange opstartsformer? Formål: Eleverne forholder sig aktivt til læringsmål	
15	OPLEV LYS I OPTISKE FIBRE (Fang)	- Underlæg og beskriv optiske fibres egenskaber. - Forklar lys fra knude ud fra illustration. Mål: Elever får en oplevelse af, at lys kan bevæge sig gennem en fiber. Formål: Eleverne får optiske fibre i hænderne og oplever, hvordan lys bevæger sig gennem dem.	
30	OPTISK FIBERKOMMUNIKATION (Fang/Fælle)	- Lykkes de med at sende & afkode beskeden og af aflytte den? - Er eleverne engagerede i at sende/modtage aflytte og i at lave deres egen kode? - Samarbejde - Nysgerrighed - Hæftet Formål: Eleverne oplever, at binær information kan overføres og modtages i en optisk fiber - og at den kan aflyttes. Elevernes nysgerrighed pirres ved et de skal arbejde med hemmelige ord og opdaget at deres information kan aflyttes - virker aflyttet. Eleverne lærer en logisk opgave - som vi har set de synes er sjov. Eleverne skal bruge den viden om egenskaber de opnår til at forstå hvordan man kan sende beskeder til hinanden via et optisk fiber...	
10	BRUG MODULATION (Forsk/Forklar+Erklær)	- Feedback-øvelsen - Samarbejde - Lykkes eleverne med at tegne egne hemmelige bogstaver med modulation? - Forsikre de sammenhængen med den virkelige verdens internet? Mål: Eleverne er i stand til at koble eksperimentel viden til teoretisk viden om optisk fiberkommunikation. Aktiviteten understøtter forståelsen af modulation igennem elevernes egne forslag samt afkodning af modulateret besked. Formål: Eleverne viden fra de to tidligere aktiviteter holdes op mod hvordan optiske fibre i internettet virker i den rigtige verden. Aktiviteten virker både som et forklar - hvordan virker det rent og et forlæng.	
5	OPSAMLING (Forklar/Feedback)	- Engagement - Er de i stand til at forklare begreber og observationer om optisk fiberkommunikation. Formål: Eleverne repeterer, hvad de har lært og har lært i modulet. Eleverne får koblet det faglige indhold til eksamen.	
	Del 1 overordnet set	- Silber de fanget? - Er den røde tråd tydelig? - Fungerer overgangen mellem modulatorer - Forsikre eleverne rent faktisk de faglige mål? Opsat og opsamlng: - Variere vi for meget? Eller er der for mange gentagelser?	

Tid/min.	Aktivitet	Observationspunkter og aktivitetsformål	Observationsnoter
		Disse har vi i baghovedet når vi skriver observationer. Vi svarer først på dem i analysen.	Under afprøvning: Skriv primært hvad du ser og hører - 1 "pointe" pr post-it. Skriv sekundært også eventuelle vigtige tanker du får. Under opsamling: Vi laver tematisk analyse og skriver indsigter.
2	Kort intro - nu er vi her igen		
15	MISSION NY FIBERFORBINDELSE (Fang/Forudsæt) - Repeterende hurtigskrivning + gruppesamtale - Læs om forstærkning af lys signaler - Tal om figur med forskellige placeringer af forstærkerstationer - Læs og tal om mission og tre undersøgelser - Hent materialer	- Tid - Engagement i SS'en - Kobler de risikoen for spionage i forstærkerstationer med deres erfaringer fra første modul? fx ved at de snakker om at spionen jo kunne aflure beskeden i første modul. - Er de engagerede i at tale om de tre undersøgelser? Og kobler de undersøgelserne til SS'en? Formål: At få eleverne til at koble den undersøgelse de skal lave med SS'en om sikker kommunikation. Fagbegreber: Forstærker Repetition: Optisk fiber	
25	Undersøgelse A: Undersøg en sensors egenskaber (Forsk) - Byg sensor - Undersøg - Optimer til måling af lys fra optisk fiber - Undersøg optimeret sensor - Reflekter - Skriv definition på sensor	- Engagement i konstruktion og undersøgelser - Hvilken samtal har de? - Hvad kan de forklare? - Samarbejde Formål: At give elever en forståelse af hvad en sensor er (herne-stof) og hvorfor der er behov for sensorer for at måle små ændringer af lys. Fagbegreb: Sensor	
40	Undersøgelse B: Bestem, hvor langt lyset kan sendes (Forsk) Brug sensor til at måle lysintensitet ved tre forskellige fiberlængder - følg instruks på tryksag.	- Hvor selvlærende er eleverne med tryksagen? - Hvordan virker forklaringer, fis, QR-koder og visualiseringer på tryksagen? - Engagement og samarbejde - er alle med? Formål: - At eleverne oplever at lys ikke kan passere uendeligt langt gennem en fiber. - At eleverne oplever at lave et konkret fysik eksperiment og derfor føler at de lærer fysik.	
30 (estimat)	Undersøgelse C: Udregn antal forstærkerstationer (Forsk/forklar/forlæng) - Gennem mission - Omræng til mikrowolt - Vælg metode til at udregne maks. længde - ved at bruge formel eller regressionsanalyse - Udregnanal forstærkerstationer - Læs om internet - Udregn længde og antal stationer ift. virkeligt internet - Samtale - vurder sikkerhed	Indikatorer: - Eleverne motiveres af at kunne løse deres mission. - Eleven oplever at de kan koble variabler i eksperimentet til den formel de laver databehandling med. - Eleverne kan udregne et estimat af fiberlængde ud fra den valgte strategi. - Engagement. - Er alle med? Formål: At få eleverne til at forstå koblingen mellem afstanden der kommunikeres over og risikoen for at blive spioneret. At give eleverne en forståelse af hvor langt det er muligt at sende lys i optiske fibre. At få eleverne til at føle at matematik ikke er så forliget.	
30	OPSAMLING PÅ MISSIONEN (Forklar/feedback) - Forberede feedback - Feedback med makkergruppe	Indikatorer: - Eleverne kan forklare deres undersøgelse til hinanden - Eleverne kan diskutere fejlkilder ud fra observationer af at deres resultater er forskellige. - Eleverne engageres af at løse missionen Formål: De vigtigste pointer fra modulet forankres Opsamlingen giver eleverne mulighed for at opdatere og diskutere fejlkilder Data	
	Del 2 overordnet set	- Er eleverne fortsat fangede/engagerede som i del 1? - Er den røde tråd tydelig? - Fungerer overgange mellem modaliteter? - Forstår eleverne rent faktisk de faglige mål? - Er Del 2 blevet nemmere at gennemføre rent praktisk? Opstart og opsamlere: - Varierer vi for meget? Eller er der for mange gentagelser?	

Formålet med tredje del er:
- At introducere teknologien "Kvantegledistribution" til elever på en måde, hvor de kan se, hvilken betydning teknologien har på fremtiden.
- (Måske?) At få elever og lærere til at opleve, at de har fået noget ud af at arbejde med noget, som ved første øjekast virkede som "utilgængeligt svært kvantefysik".

Del 1 - noter og analyse

Tid/min.	Aktivitet	Observationspunkter og aktivitetsformål	Observationsnoter
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30	Undersøg belger og fotoner/Level 1 (Forsk/forklar) Tekst (boks/boks eller trin) med overordnet formål og praktisk information (grupper à 2, 2 levels, download af data) om digital simulation. Digital simulation - Level 1: Undersøg lys - Eleverne logger ind som afsender og modtager. - Eleverne udfører undersøgelse med laserpointer og svarer på sammenhænge med drop-downs. - Eleverne udfører undersøgelse med digitale fotoner og svarer på sammenhænge med drop-downs. Forklar om forudsigtelighed på platform efter level 1. Relevante fagbegreber: - Polariseringsfilter - Belger / Fotoner	Indikatorer: Eleverne gennemfører både eksperiment med laserpointer og simulation med enkelte fotoner. Eleverne bruger deres eksperiment og simulation til at svare korrekt på drop-down-spørgsmål i slutning af level 1. Eleverne vender tilbage til platform efter endt level og klikker videre til næste level. Formål: At eleverne erfarer, hvorfor de skal gennem digital simulation. At eleverne erfarer/forsår, hvordan lys som belger og lys som fotoner passerer forskelligt gennem to polariseringsfilter.	
15	Krytterspørgsmål (Fang/Forsøget) Eleverne skriver i en tabel forskellige metoder for, hvordan nøglen for en kombinationslås kan deles mellem en afsender og modtager, uden at nøglen kan blive spioneret. Eleverne foreslår på skilt på skilt metoder til at dele og spionere krytterspørgsmål. Relevant fagbegreb: Krytterspørgsmål	Indikator: - Eleverne får udfyldt skema, hvori forskellige metoder til fordeling af krytterspørgsmål forklares og argumenteres. Formål: At eleverne forstår, hvad en "krytterspørgsmål" er, og hvorfor det er svært at dele dem sikkert.	
30	Prøv Kvantegledistribution/Level 2: Forsk/forklar Instruktion om at sætte sig hver for sig. Gennemfør digital simulation - Level 2: Kvantegledistribution - Eleverne sender fotoner fra afsender til modtager. - Eleverne kæmper sig igennem tung dataanalyse ud fra skemaer, skriftlige instruktioner og hint. Lav en tegneserie med screenshots som forklarer, hvad i al verden, der er sket. Relevante fagbegreber: - Forudsigtelighed (for fotoner (gennem polariseringsfilter)) - Kvantegledistribution - Krytterspørgsmål - Foton	Indikatorer: Eleverne får diskuteret verbalt om noget fagligt - altså andet end praktisk og logisk i læringsspillet, mens de sidder ved hver deres computer. De får her diskuteret fagbegreber som: - Foton - Krytterspørgsmål - Polariseringsfilter - Forudsigtelighed - Kvantegledistribution Højeste mål er, at de finder frem til den korrekte nøgle baseret på faglige overvejelser (og ikke kun gætt) og at de udviser begejstring over at have løst et svært problem. Formål: At eleverne erfarer, at Kvantegledistribution er en smart måde at fordele krytterspørgsmål på.	
15	Spot Spionen/Level 3 (Forklar/Forsøg) Gennemfører digital simulation level 3: Spot spionen - Eleverne læser instruktioner. - Eleverne læser de tre scenarier/missioner og tager stilling til valg af mission. - Eleverne følger instruktioner, undersøger mindst to linjer på kortet for spionen. Efterfølgende instruktioner på platform: - Tag et screenshot af data fra level 2 eller 3. - Fremhæv/markér dele af skemaerne og brug både illustration og tekst til at argumentere for fordele (og ulemper!) ved kvantekommunikation. Besvarelsen på dette trin kan bruges i afleveringen. (Bov i bunden, der angiver, hvad der er relevant for en aflevering) - Behandl også "skal alle have adgang til det?" her?	Indikatorer: Eleverne gennemfører mindst én mission (uanset om de løser opgaven korrekt). Eleverne tegner noget på et screenshot fra spillet og forsøger sig på skrive en faglig billedtekst. Eleverne får talt sammen om forskellige brug af kvantegledistribution, og de får formuleret mindst et argument for og et argument mod kvantegledistribution. Formål: Eleverne skal opleve kvantegledistribution i "anvendelse". Eleverne skal forholde sig til nogle cases, hvor SS'en kommer i spil.	
15	Opsamling (Forsøg) - Vi giver nogle postulat. - Skriv argumenter (og modargumenter!) der underbygger postulatene (uanset om du er enig eller ej). - Dette kan også inddrages i en aflevering. Ide til instruktion: 1. Fordel roller. 2. Skriv argument for din rolle. 3. Lyt til de andres argumenter og formuler modargumenter. - ... - Fortsæt ved at påtage sig rollen af én af holdningerne.	Indikatorer: - At eleverne skriver argumenter. - At eleverne engageres af både postulat, de er enige og uenige med, og skriver argumenter for/mod i alle tilfælde. Formål: - At eleverne forholder sig til flere perspektiver. - At SS'en kommer i spil igen. - At modulets læringsmål opsummeres/evalueres.	
15	Genbælg parvis illustration af læringsmål, fagbegreber og forløbsoversigt. Evaluering af læringsmål ved at se på billedet af illustration fra modul 1. (Læg en plan) Tal sammen om, hvad de kan gøre for at opnå de læringsmål, de mangler at få opfyldt, hvis de trækker fysik til mundtlig eksamen.	Eleverne finder frem til de gemte billeder/tryksager og taler aktivt om deres nuværende viden og opfyldelse af læringsmål. Eleverne laver en realistisk og sammenhængende plan for eksamensforberedelse. Formål: Selvsøknelse Eleverne giver fornuftig feedback til hinanden (i form af en plan om, hvad de skal gøre for at forberede sig til eksamen).	
Del 3 overordnet set	- Er eleverne fortsat fagdelingsengagerede som i del 1? - Er den røde tråd tydelig? - Fungerer overgangen mellem modaliteter? - Forsår eleverne rent faktisk de faglige mål? Opstart og opsamlere: - Varierer vi for meget? Eller er der for mange gentagelser?	"Kvante"-brevfærdighed? - SS og den røde tråd - Spør / engagement - Læring / Udfordring / Forsøg - Metode - Intentioner vs. realiseret	
Det samlede forløb overordnet set		- Engagement - Læring - Varighed - Metoder og modaliteter - Instruktioner - Perspektivering til virkeligheden	