An investigation of secondary school students’ conceptions on how the Internet works

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ABSTRACT

The Internet has become an important part of everyday life. But what conceptions do secondary school students have of the way the Internet functions? How do they explain the phenomena they experience while using email, chat or video streaming? Although the usage and applications of the Internet are part of the UNESCO curriculum and although the underlying concepts definitely belong to the subject of computer science these questions are not yet in the focus of current research of CSE. This paper presents a brief overview of an empirical qualitative study of secondary school students’ conceptions of how the Internet works. For this study we interviewed 23 students who were 13 and 14 years old and analyzed the transcripts using qualitative content analysis. The results show differences between the students’ conceptions (like the Internet as one big computer) and the scientific view and give us a list of recognizable patterns which might be helpful for teaching, e.g. to imagine YouTube videos as snakes of play dough.

Categories and Subject Descriptors

K.3.2 [Computer and Information Science Education]: Computer Science Education, Curriculum

General Terms

Experimentation, Human Factors

Keywords

Computer Science in Secondary Education, Students’ Conceptions, Phenomena, Internet, Qualitative Content Analysis, K-12

1. MOTIVATION

Most CS textbooks and teachers try to present a complex topic from the scientific point of view. Our experience in classrooms is that students have great difficulties in understanding this scientific approach. But they are quite capable of describing complex topics in their own words. In these descriptions they often use interesting depictions and examples which could be helpful for explaining the topics to other students.

The Internet is not only part of our everyday life, it has also become a tool for teaching and is or should be a topic in CS lessons in many countries and curricula. Many committees and educational councils demand to teach "the most important conceptual foundations of information technology contributing to FITness", like the Committee on Information Technology Literacy [12]. For Networks they list on p. 29: "Key attributes and aspects of information networks, including their physical structure (messages, packets, switching, routing, addressing, [...] ), and logical structure (client/server, interfaces, layered protocols, standards, network services)."

The UNESCO state in their curriculum [1] on p. 67f. "Students should be able to: [...] demonstrate an understanding of the local network in use in relation to the external network (e.g. Internet) and the use of email [...] They should be aware of the connectivity of computers in a local and an external network and be familiar with the appropriate functions of such networks." and later on p. 79: "Students should understand the various means of electronic communication such as electronic mail, chatting and mailing list, use of Internet and the World Wide Web".

From the constructivistic point of view, see e.g. [2], students create their own conceptions to explain the phenomena they perceive while acting in different contexts. This does not mean that they learn how the Internet works just by using it, but these conceptions are determined by the use of the Internet. Therefore the applications used most frequently and their phenomena became the subject of our investigation. Studies like the German JIM-study [10] in which adolescents were questioned about their daily use of media and computers show that they spend a lot of time on the Internet: more than 2 hours a day, and unattended. According to this study the three applications of the Internet used most frequently are email, chat and video streaming.

We think it would be helpful for teachers wanting to explain the Internet in CS lessons to be aware of the conceptions (compatible with the scientific view or not) that the students bring into the classroom. The aim of this research project was therefore to find out the nature of these conceptions and possibly discover models which could be used for
the planning of lessons. Some of our results correspond to earlier findings. But the main outcome is that and also in what way these conceptions differ from the scientific view.

This article\(^1\) is divided in 6 chapters: After a brief summary of related work, chapter 3 gives an overview of the setting of the interview. This includes the decision for a guided interview technique and the interview guide itself. In a next step in chapter 4, the qualitative content analysis of Mayring [9] will be described which has been used for the evaluation of the interviews in two independent evaluations of the same interviews. The results and a list of the models we found will be described in chapter 5. We close with a summary and an outlook on possible further research and the development of courses.

2. CONCEPTIONS OF THE INTERNET

In the information age, the Internet influences the lives of many students. This is proved by the German KIM- and JIM-studies of the about children’s use of media, see [11, 10]. They show that the topic “Internet” becomes more and more important for children from the age of 10 to 11 (see [11], p. 38). At the age of 13, already 93% of them are using the Internet, see [10], p. 46). Their main focus is on services like E-Mail, Instant Messaging and music / video. These topics are also part of the suggestions for curricula like the one from the UNESCO mentioned above or educational standards of the German Computer Association (GI) (see [5]) in different sections like “Informatics Systems” or “Languages and Algorithms”.

2.1 Students’ Perspectives in the Model of Educational Reconstruction

The model of “Educational Reconstruction” (see e.g. [8]) for design and arrangement of lessons and courses emphasizes the importance of students’ perspectives by considering students’ conceptions as equal to statements by the scientific community. An adaption for CSE is shown in fig. 1 and will be described more in detail in [3] at the same conference like this paper.

Following this model where each corner has to be taken into account equally for the design and arrangement of lessons and courses, one cannot speak about misconceptions because “mis” already judges on what might be wrong or worthwhile and what not. Here, one can only speak about preconceptions of the students and regard them as fruitful in every case, suitable to the scientific view or not. So, in order to use this model for research or just to plan lessons more student-oriented it is necessary to know about the students’ conceptions of the various topics of CS. This makes it important to do more research in this field not only to support CS teaching at secondary schools but also to support introductory courses in higher education.

2.2 Related work

Many studies of students’ conceptions in CS refer to adult students at universities. But more close to us, Hammond and Rogers investigated children’s conceptualizations of computers and how they work and give an overview of other studies in this field in [7]. There they sum up their review that “children’s understanding of computer concepts will be complex and that children have ample scope for generating intuitive, but limited conceptions, or plain misconceptions, of how computers work”, see [7, p. 6].

They also dealt with the question whether more frequent use of ICT – outside school – creates a deeper understanding of it or not. They conclude that “children will not develop more scientific explanations of computer concepts by themselves”, [7, p. 13].

Hammond and Rogers found that all pupils had an awareness of the basic computer devices and tended to be confined to what they had acquired through experience, which did not change remarkably over time. They also gave a list of conceptions for themes like logging on (“the computer gives you a code”), storing devices (“all work needs to be saved on a floppy disk”) or surfing the Internet (“web pages are stored in the modem”) ascertained by their interviews, see [7, p. 11].

The study most closely related to ours is Papastergiou’s study from 2005 which showed in [13], on the basis of a questionnaire and drawing tasks set to 340 Greek high school students, that "Internet experience indeed is not a sufficient condition [to refer to more abstract concepts] and that appropriate learning experiences are always needed as conceptual support to the student. This is reinforced by the fact that even the limited instruction of relevant subject matter and limited use of the Internet within the Informatics course have significantly helped students in mentally representing the Internet in terms of connections”, see [13, p. 358]. It also showed "that high school students form simplistic, utilitarian rather than structural mental models of the Internet, which would provide them with an adequate explanatory system of what the Internet actually is and the processes underlying its use. [...] Although students can easily attribute some general function to the Internet (i.e. what purpose it serves), they do not form clear conceptions, or have misconceptions, of what the Internet is as a physical entity. In students’ thoughts, the Internet seems to be identified with its most widespread service, the Web and with Web content. Although aware of the universality of the Internet, students encounter difficulty in conceiving the existence and necessity of an – invisible to them – underlying physical infrastructure, and few students mentally represent the Internet in terms of connections among networks or even

\(^1\)This article is an enlarged version of the German article [4] where we reported on the interviews briefly already.

Figure 1: Model of Educational Reconstruction for CSE, [3]
among computers. Subsequently, most students encounter difficulties in conceiving basic Internet characteristics (e.g. that information on the Internet is stored on many different computers, that there is no single authority that controls the operation of the Internet) and perceive the Internet rather as a centralized system than a distributed one”, see [13, p. 356].

2.3 Research questions

In Papastergiou’s questionnaire the students could choose from given answers. But there are no research results on how students explain the function of the Internet and particularly the most popular applications (email, chat, video streaming) in their own words, yet. To achieve the basis for helping teachers plan their lessons, the following research questions have been developed:

1. How do secondary school students explain the functioning of services of the Internet?

2. How far do students use models from their everyday life to explain the functioning of the Internet?

A condition for doing research on students’ conceptions is that these conceptions either exist already or are in the process of being developed. Therefore it is necessary to choose a topic, which is strongly connected to the reality of the students. As shown in [10] this requirement is met for Internet services at the age of 13.

3. THE SETTING OF THE INTERVIEWS

For answering our research questions 13- and 14-year-old students from grades 7 and 8 of two different schools were interviewed. In order to get a heterogeneous group we chose two schools explicitly for their different locations: one school from a city center and one from a rural area. We also chose equal numbers of boys and girls for the interviews and also students with and students without CS lessons. All of them participated voluntarily and with their parents’ permission.

3.1 The Basis of the Interviews

Students' conceptions can be investigated using a dialogue-hermeneutic method [6] like an interview. The method we used was a semi-structured guided interview. This gave us the opportunity to react to answers and to find models which were unexpected.

The interviews took place at the schools. Apart from the organizational advantage this method guarantees high external validity. By staying in familiar surroundings the students were able to concentrate on the interview and were not distracted by external factors. The loss of internal validity due to the fact that you cannot influence all the factors inside a school context may be neglected. We were able to compensate that to some degree by the chance arrangement of the group.

The time component is also important for this research. The interviews were designed as a horizontal survey. This means that all data is taken in one interview within a short period of time. We planned to do 15 interviews with two students at a time. This approach was chosen to make the interviewed students feel comfortable. On the other hand, such an approach also gives the opportunity to the two students to motivate each other. They can interact and react to each other’s answers and thereby create a communicative atmosphere. To support the students’ creativity different materials were laid out like Lego stones, play dough, paper and pens.

3.2 Construction of the interview guide

The interview guide describes a course of action, which is the same in every interview. Thereby the results are comparable at the end. The developed interview guide consists of five blocks of questions each containing a different amount of questions. This guide reflects the three topics e-mail, chat and streaming technology. In addition there is an introductory and a concluding block of questions. These two blocks have a fixed position within the interview whereas the other three can change places according to the course of the interview. To change the order within these three blocks is allowed but should be avoided. This structure is meant to give students as much leeway as possible.

The purpose of the introduction block is to create a relaxed and trusting atmosphere. Asking the students about their internet habits helps to get them talking and lose inhibitions. A typical question was: "What do you do on the Internet?" One focus of this block is on getting information about the user behavior - which then will be used as a basis for the following questions.

In the concluding block we gain information about previous knowledge in the field of CS and general interest in it, like "Did you pick CS voluntarily? And why?" or "What topics to you like best?". This information can be used to evaluate the given answers of the three middle blocks. The answers can be seen as a kind of "social statistics", which are collected at the end of qualitative interviews. Information however, like nationality, cultural interests or religion, is not relevant for this research, and the social statistics can therefore be kept short.

The three blocks in the middle are the main part of the interview. They are vital for answering our research questions. The structure of the blocks is similar: To begin with a reference is made to the Internet habits the student had described in the introductory block of questions. In the block "Instant Messaging" for example the first question is "Which chat program do you use?" Then the students are asked to describe their ideas of how this service works. Another question in this block is: "Describe how a message gets from one computer to another." More questions are asked to deepen and clarify he students' ideas of the phenomena they perceive while using the system. The aim of these questions is to keep the focus of the interview close to the research questions. Guideline times were set for all blocks to keep the interviews within a 40 minutes limit. The introductory and the concluding block got 5 minutes each, the three middle blocks 10 minutes each. For a detailed view at the interview guide see the appendix.

3.3 Pretest

The pretest was run with nine students to test the method and the surrounding setting. It is important to check if the questions were chosen correctly and if the time limit was realistic. Also the different materials used by the students for their explanations and depictions had to be tested: Is the material being used during the interview at all and if so which of the materials is being used? It had to be ruled out that material was chosen that was too difficult to handle during the interview.
The pretest showed that the guideline for the interview was well-structured. Only some of the questions were put in a different order during the interviews and modified a little later on. None of the students had a problem in answering our questions and we were able to improve on our questions. Not all the material we offered was used: The Lego stones and the play dough were seldom used. Another result was: The amount of material was confusing rather than helpful. Only paper and pen were really considered helpful and often used to sketch and explain thoughts.

It also showed that individual interviews could lead to unexpected problems. Answers were much shorter than in the two-students-setting and the answer “I don’t know” was given more often. This happened much less frequently in the two-students-setting, and if it did the other one was mostly able to provide an answer.

The time 40 minutes for each interview was realistic: 35-40 minutes was the approximate time needed. If an interview took longer the students’ concentration deteriorated. This resulted in more unstructured and contradicting answers - which makes evaluation more difficult.

3.4 Carrying out the Interviews

After contacts with the headmasters, the teachers and the educational authorities, we got the chance to introduce our research idea to the classes. It was very important not to mention our specific topic to make sure that no student would try to collect information about it before the interview. Students who were interested in our project were given documents for their parents to sign their permission. The teachers were given a list of dates for the students to choose from. This system worked out very well, which is also due to the teachers’ support.

4. EVALUATION

In total, 11 interviews with 23 students were used for the evaluation. The other four interviews were dismissed for various reasons like illness of a student or a problem with an audio file. All interviews were recorded with a voice recorder, saved as mp3-files and then transcribed.

For the evaluation of the transcribed interviews Mayring’s model of qualitative data analysis was used, see [9]. This is a summarizing data analysis which can be used for deductive category-building derived directly from the material at hand, [9].

The building of categories is done in several steps: First the texts are inserted into the software “maxQDA”. This helps us to connect categories to specific text passages. In a first round the interviews are viewed line by line and text passages are marked with rough descriptions like structure and model characterization. After 50% of the material has been dealt with the process is repeated. Thereby a consistent categorization and level of abstraction is assured. In a second round the material is viewed again as long as no new categories, or at least not many of them, are found. Then the complete material is viewed once again by connecting the relevant text passages to the found categories. After this step it is possible to take a look at the single categories. It has to be checked that the text passages are really connected to the right categories and that everything is coherent. The first results are the single categories with the text passages.

For allowing an evaluation the text passages of a given category were grouped. By doing this we got subcategories, which covered a certain aspect of the main category. E.g. the subcategory “addressing” was grouped into residence, password, addresses of computers / routers, uniqueness of names, E-mail-address, and given name. These subcategories represent special features or characteristics of the particular main category.

This evaluation was done totally independent by two persons that had no contact to each other during this.

The final category system of the first evaluator was built by thematic grouping and includes four areas:

- Conceptions of transmission techniques
- Conceptions of the structure of the Internet
- Conceptions of Internet services
- Use of models in different areas of application

The category system of the second evaluator consists of the main area with categories for functioning of the Internet services e-mail, YouTube, CS lessons and general structure and another area for categories of the used models. The categories and models that were found by the different evaluators were very similar and will now be described in detail.

4.1 Conceptions of transmission techniques

The interviews also showed students’ ideas about the transmission of data on the bit layer. These conceptions can be described as follows:

**Addressing**: Students have conceptions of addresses and the need for a unique address to send and receive information via the Internet. Almost 40% of the interviewed students described a system that could be interpreted as a kind of IP address system:

E.g. student 2 in interview 7: “Well, I think that each user of the Internet is registered at a control room. And they say that particular code and that particular sign and then they say that is your direction and that is the way to take.”

Many students stated that addressing works by using a unique name, the e-mail address or the home address used for registering for an e-mail address.

**Speed and bandwidth**: In the interviews the students were asked to explain why data, messages or videos take some time for transmission and why this sometimes took longer than at other times. Most students (40%) explained this with a limited capacity of a central computer which did not allow to serve all requests at once. The same number of students explained the structure of the Internet as one central computer in a later question. And many students said that more data could be sent through a thick cable than through a thin one.

E.g. student 1 in interview 6: “You also have to consider how thick the cable is. If you have a very thin cable where only 20k fit through it takes longer than if you have a thicker cable where 300k fit through. Then it is faster.”

2 All quotes of students’ answers are translated from German
They also described in their answers that for bigger packets, meaning bigger files and longer text documents, the transmission takes longer. This implies that these students think that files and texts are always transmitted as a whole. The next category shows that this is a frequent conception.

Packeting: The number of students describing the transmission of data as divided into packets equals that of students who do not describe a division of data into packets. It is interesting that the same students change their mind about this in different categories: One student describes for text documents that they are transmitted in individual different waves and can be read as a text again at the other end (like a telegram). For videos the same student states that they are “pushed” through the cable as a whole. One exception to this is one girl who answered:

“It is transmitted in fragments, and then at some point there is one fragment missing. And then it must go back and collect the next fragment.”

There she basically describes the TCP protocol and the possibility of requesting a defective packet to be sent again.

Physical transmission: The interviews showed that students have no detailed conceptions of the physical transmission of data between computers or even talk about a network of networks as in [13]. Only 40% of our students talked about cable or wireless transmission. No student mentioned using a combination of these two. Only 3 of 23 students talked about converting text into some kind of code for transmission.

4.2 Conceptions of the structure

It is extraordinary that about 40% of the students explain the Internet as being managed by one big central computer. Almost 50% think that there are several central computers. We noticed that on this topic students contradicted themselves during the interview. E.g. one student talked about one computer at the beginning of the interview and changed his mind when he became aware that this model did not always work. He then remarked that there must be several central units.

4.3 Conceptions of Internet services

Chat and IM: Here it stands out that about 50% of the students call the posting of messages to blackboards or guestbooks chatting. Only one student distinguished between chat and instant messaging. Therefore we treat these systems as one in our analysis. Only 13% describe that communication by chat or IM uses a server. But 35% talk about a direct connection between the computers. The same number of students state that while using chat or IM they are in a private area of the Internet.

Streaming: Two conflicting conceptions can be found in this category. While 35% believe that a YouTube video is played on their own computer, 26% think that the video is played on the Internet. There are different ideas about how this works: Some students said that the video is played on the server and they are looking at the server through the Internet like at a cinema screen. Two students explained the time it takes between clicking on the video and the video actually starting not with the fact that the video has to be loaded but that their own computer has to send several signals and data for the server to know where to display the video. It is also interesting that 9% of the students said that a video is not deleted after being played but has to be sent back to the server. Very few comments were made on the topic “upload”. We will discuss some of them in the next category.

4.4 Use of models in different areas

We very often found the model of the mail service as an explanation for e-mail. Apart from this there were only a few other models. We will only describe those models that occurred frequently or that we find usable for teaching.

From the category “addressing” the model “lockers at school” was used to explain how a message knows where to be sent and also to explain how e-mails are sent and why the recipient gets only his or her own mails without being able to read all the others.

E.g. student 1 in interview 4: "This is like a huge mail box for many people and with many smaller boxes, like in school where everyone has his own locker and can access it only with a key, like a password.”

Two models seem to be very important for physical transmission: On the one hand there is the model that there are little men or dwarfs running around in the cables carrying data from one point to the other. In another model the students described data, especially videos, moving like snakes through the cable. If there is a bottleneck and too many snakes want to pass through transmission slows down at once. If one snake is too big for the bottleneck the snake is altered so that it becomes thinner and therefore longer (like a snake of play dough).

For the category “Structure of the Internet” there are also two remarkable models: Some students described the Internet like streets with many junctions. At these junctions there are signs to show the way. On the streets there are houses with addresses. And so it is possible to send a message to a certain house. Other students said that there are people working in the Internet at certain points and sort out data and route e-mails or do other important jobs.

Explaining chat as using a telephone is also an interesting model. It is based on a stable connection between two chat partners like in former times when the telephone cables were plugged together.

For streaming there are three models: The model mentioned most frequently uses the metaphor of reading out a book or a letter to someone. The fact that you can repeat the story only as far as you have heard it, explains the transmission of videos and sometimes having to wait if the video has not yet been loaded sufficiently. Student 1 in interview 10: “I think the central computer reads the video and sends the parts to us.” That videos disappear when the browser is closed was explained with the fact that a human being cannot keep everything in mind either.

The second model refers to a video rental store, where you’ll have to wait for your video cassette or DVD while the assistant finds it in the storage. With this model the students also explained that a video can only be played on their home computer up to the point it had been played in the store.

The third, also very interesting model is “stacking sheets”. In this model one single letter is written on each sheet and the sheets are put on a stack. During transmission only one sheet is carried from one stack to the other at a time. If the
process of carrying the sheets from one stack to the other is faster than the writing of the letters on the sheets, the process cannot continue and the video stops for some time.

For E-Mail the model most frequently used was that of the mail service.

More than 50% of the secondary school students made use of such models during the interviews to explain other phenomena. This could be observed in almost all interviews except one. We conclude from this that students who have a model in mind use it also to explain other phenomena. We can therefore assume that they do this on other topics of CS as well.

5. RESULTS

From the categories described above students’ conceptions and explanatory models of the Internet can be summarized as follows:

5.1 Not one model for all

The central result of our research is that it is not possible to describe students’ conceptions of the Internet by a single model or even a few models. The categories we found show a great variety of very interesting ideas about the functioning of the Internet and services like E-mail and chat. As we described in the category “Structure of the Internet” 40% of the students believe there is one central computer somewhere which is the Internet. And half of the students said there are several central computers. This corresponds to the findings of [13]. This conception may be supported by some comics or videos (like Southpark).

In other categories, like addressing, the students’ conceptions come quite close to the scientific view. On the other hand data transmission remains an obscure topic, because no student had developed any real idea of what happens when data are being transmitted. According to [13] this results from the fact that the physical structure is invisible to the students.

5.2 Students’ use of models

The question whether students have formed or use models to understand how the Internet works can be answered with a straight yes. They have very good ideas and try to match them with their everyday experience. All these ideas could be of great value for planning lessons.

One important model seems to be the model of the regular mail service, which is already often used in lessons. This model was used to describe the e-mail service, but also for the topic “addressing” in general. This is not unusual considering the many parallels between these systems.

For video streaming especially there are some very interesting models like the one described as stacking sheets or the one regarding video streams like reading out texts: Reading and watching is only possible, because one paper has already been downloaded (carried to the next stack or read out loud) to the computer. This reminds us of the animation in Windows XP for copying data.

Another interesting model is the one of a big snake which is getting longer and thinner if pressed through a small cable like a snake of play dough. If this snake gets thinner and thinner or the play dough breaks into pieces this might be very suitable to visualize transmission of packages in the classroom.

There is also very often the idea of small people running around in the cables to carry data from one place to another – which is often mentioned – or of people in the Internet sorting out e-mails. Here there may also be a connection to existing videos that try to explain the Internet. Here are the frequently used models listed:

- regular mail service
- streets and junctions
- lockers at school
- fast and slow trains or cars
- little men / persons inside doing all the work
- snakes (of play dough)
- (data in or as) boxes / little bricks
- (1:1) telephone connection
- reading books in library
- video rental store
- moving sheets of paper to stacks
- central computer / big router

Although these models could definitely be useful we agree with Hammond and Rogers in [7] and come to the conclusion that students have not finished building up their models at this age.

In the interviews approximately half of the students tried to use their models to explain other functions. To some degree this attempt could be observed in nearly all the interviews. This allows the conclusion that students tend to reuse their models.

5.3 Conceptions motivate

Another important observation is that students asked a lot of questions about the topics of the interview after they had been interviewed. They wanted to know how the Internet really works and what it is that makes it slow or fast. The interviews stimulated a great interest in the topic – or at least the interest had been increased. This aspect should be taken into account for the development of lessons.

6. CONCLUSION

In summary it may be said that a variety of interesting students’ models were discovered which often differed considerably from scientific views. But it can be assumed that some of these models were actually developed during the interview because the students had never before been able to speak about their ideas on this topic.

The choice of topic and target group proved to be worthwhile. Nearly all the students were using the services selected or knew about them. Because the model building process is not completed at this age, however, and some students showed a rather poor capacity for abstract thinking it might be useful to do research with students who are a little older.

There are two interesting points for teachers of CS in secondary schools:
1. Students’ conceptions can be used for the development of lessons, e.g. for an opening phase of a new topic or to depict certain aspects. These conceptions can also be used to relate them to scientific views and discuss in class how far they agree with the scientific concepts.

2. Students’ conceptions can be used as basic knowledge for teachers. Teachers who are aware of these models will be able to react more easily to students’ questions. This can be of help to encourage learning processes.

To continue this research it would be interesting to examine the categories more closely and thereby create a more clearly defined system of categories. Additional interviews of students of different age-groups could give us some insight into the development of models and how they are influenced by animation, films or lessons. Another interesting topic is the transfer of these ideas into schools and into student-oriented teaching concepts.

APPENDIX

A. INTERVIEW GUIDE

1. Opening questions
   (a) How often do you use the Internet per week?
   (b) Do you use the Internet more often for school (e.g. homework etc.) or for private use?
   (c) What do you do on the Internet?

2. E-mail
   (a) Do you use e-mail? And what for?
   (b) Please describe how an e-mail gets from one computer to another.
   (c) What happens if a file is being sent?

3. Chat
   (a) Which program do you use for chat?
   (b) What is the difference between chat rooms and programs like ICQ or MSN?
   (c) What do you think: How does the system chat function? What is happening when and where?
   (d) How does a message reaches the receiver?
   (e) Is there a difference to e-mail?

4. Video streaming
   (a) Have you been using YouTube?
   (b) Where did you meet something like YouTube elsewhere?
   (c) Please describe how watching a video with YouTube works.
   (d) Where do the data stay between download and playing the video?
   (e) What happens when uploading a video to the server?

5. Closing questions
   (a) Do you have CS lessons at school?
   (b) if yes: What do you do there at the moment? What topics have you been interested in at most? Do you like CS lessons?
   (c) if no: Did you choose another alternative course? Did you have a special reason not to take CS?
   (d) How do you get in the Internet?
   (e) Is there a computer at home that you use for it or do you use computers at school or at a friend’s house?

B. REFERENCES