THE UNIVERSITY *of* EDINBURGH

CiC - Report 1

What happens when I visit a webpage?
A Role-Play Activity

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Contents

1 Introduction

This report elaborates on the background and creation of this unplugged activity. In this report I'll first talk about the audience and learning objectives of my activity. After that, I'll review some current research in the field of CS Unplugged. I'll then go on to talk about some other educational theories that influenced my design decisions. I will also compare my activity to an existing Unplugged activity that has been recommended in the Teach CS Guide for Early Years and Primary Practitioners (Farell et al. 2018). I'll use this comparison to highlight similarities and differences and how these differences justify my contribution to be a useful asset for teaching CS. Lastly, I will provide some general thoughts on evaluating learning methods and materials like the one I created.

2 Audience and Learning Outcomes

The proposed lesson is targeted at Upper Primary and Lower Secondary students. This equates to an age range from around 9-15 which is quite a range. Nevertheless, I recommend using this activity in a roughly homogeneous group of learners - in terms of age - as the activity should be slightly adapted depending on the age of the learners (the lesson plan contains some suggestions on this).

My main learning objective is for students to understand the process behind web-browsing. This includes:

1. Understanding which components are involved
2. Understanding the unique role/function that each component has
3. Understanding the interaction between these components

Generally, my activity fits in with Organiser 2: *Understanding and analysing computing technology* of the Teach CS concept (Farell et al. 2019, 2018) as it helps understanding the technological concepts that allow us to interact with webpages.

For Upper Primary Learners the lesson can be used as part of achieving the level 2 Learning Outcome `TCH 2-14b` from the Curriculum of Excellence, namely:

> *I understand how information is stored and how key components of computing technology connect and interact through networks*

Regarding this, the Teach CS guide (Farell et al. 2018) states:

> *In addition to a greater depth of understanding of how a computer works, pupils will also be aware of the basics of how computer networks operate. Developing this awareness can be set within the wider context of communicating networks from everyday life*

Using the context of everyday life is precisely my intention as most students will click on links and navigate to webpages on a daily basis.

For Lower Secondary Learners the lesson can be used as part of achieving the level 3 Learning Outcome `TCH 3-14b`, namely:

> *Demonstrate an understanding of how computers communicate and share information over networks including the concepts of sender, receiver, address and packets*

Making the use of sender, receiver and packets more explicit can be achieved by extending the proposed activity in different ways, e.g. sending messages in chunks instead of as a whole. Furthermore, in Organiser 3 - level 3 students will learn about web-development in terms of HTML and CSS. Using this knowledge in my proposed lesson would be a great opportunity to recap the material and see how it can be used in a different context. Such alteration are meant when the beginning of this section talks about "slightly adapting the lesson depending on the learners age". Explicitly creating adaptations like this are out of the scope of this project but a valuable extension worth considering for the future.

3 Research Review

The research I looked at to evaluate my activity is a survey about existing research in CS Unplugged (Bell & Vahrenhold 2018). The paper starts with an introduction into the concept of CS Unplugged and its history. The term originates from a number of activities shared in the 1990s which were then collected and published as a free online book, authored by Tim Bell, Mike Fellows and Ian Witten. The term was then picked up by different educators and used in a wider context. Thus, CS Unplugged evolved from describing a specific collection of activities to a general pedagogical approach. Today, one of the most popular collections of CS Unplugged activities is `csunplugged.org` (*CS Unplugged* 2021) which is an open source platform founded by the University of Canterbury, providing free CS Unplugged materials for various topics and ages. CS Unplugged isn't meant to be its own program of study but rather a pedagogical method which can be used in specific situations, e.g.

1. to avoid the misconception that CS is only about programming
2. to allow for teaching of CS concepts where no computers are available
3. remove the barrier of knowing how to program before learning about CS

Even though, in it's early years CS Unplugged was solely meant to be used as an outreach tool, with Computer Science becoming a key part of students' general education it has found its way into lesson plans for use within the curriculum. One example is the Teach Computing Science-Guide (Farell et al. 2018) which links several CS Unplugged resources in their suggested teaching activities. This supports that conceptually my proposed role-play activity can be used in a classroom setting.

The survey contains two sections which aren't particularly related to my project and thus, not discussed in more detailed. These are a section about CS Unplugged activities outside the classroom (Section 3) and a section giving a particular example of a CS Unplugged activity to explain a non-trivial CS concept (Section 5).

Section 4 is about the effectiveness of CS Unplugged for teaching and thus, highly relevant to my project. The section starts off by saying that even though there seems to be an increasing adoption of CS Unplugged activities into teaching, "surprisingly few empirical studies about the use of CS Unplugged activities in a regular classroom setting have been conducted" (Bell & Vahrenhold 2018). The author goes on to talk about examples of such research. I won't go into detail for all the research papers mentioned as this would be out of the scope of this report. I rather want to pick out certain passages and elaborate on them.

Taub et al. (Taub et al. 2012) investigated CS Unplugged activities in middle-schools and found that it changed the students' view of computer science but actually made them feel less attracted to the field. Taub et al. hypothesize that this might be due the activities' loose connection to the central concepts in computer science and not being suitable for the age group worked with. The survey then talks about some suggestions that Taub et al. make to improve CS Unplugged activities. Reflecting on this passage I didn't find much evidence provided for any of the statements made. The metrics used to analyse the level of attraction to the field and students' view of computer science are only described as "mixed-methods approach" (Bell & Vahrenhold 2018). The hypotheses made aren't backed by numbers either. Such vague citation of literature isn't expressive and doesn't help to make an informed decision about the effectiveness of CS Unplugged. This theme of missing rigorous reasoning applies to other research mentioned. E.g. the study by Feaster et al. (Feaster et al. 2011) finds that CS Unplugged materials were not suited for improving content understanding. How they came to this conclusion is omitted.

The section about research by Thies and Vahrenhold (Thies & Vahrenhold 2012) is more expressive as it mentions the use of a controlled study and the outcome that no statistical difference was found in the understanding of students. Thies and Varenhold further did a survey with teachers and found that some teachers state that CS Unplugged does make students curious to learn more about computer science. On the other hand, some teachers voiced that they don't feel comfortable or don't feel that they have the appropriate space to teach kinesthetically. Even though this questionnaire with teachers gives some insights into the use of CS Unplugged in the classroom, it doesn't provide any evidence about its efficiency when used in the classroom.

Wohl et al. (Wohl et al. 2015) did a comparative study on Cubelets, CS Unplugged and Scratch. Students received around 2 hours teaching using one of these tools/methodologies. They were then asked to draw figures and build paper models representing the procedures they developed. This method of evaluation was combined with an interview study and led to the conclusion that CS Unplugged "appeared to generate the highest level of understanding of the concepts of algorithms, logical predictions and debugging" (Bell & Vahrenhold 2018). In this example I appreciate the clear explanation of methodologies used to evaluate the study. Nevertheless, the final statement - "appeared to generate"(Bell & Vahrenhold 2018) - seems very vague again and not something I would use to justify my use of CS Unplugged in a classroom.

To summarise the section about existing research, there are contradictory findings and few rigorous arguments about the efficiency of using CS Unplugged in the classroom.

The survey concludes with advocating that CS Unplugged shouldn't be treated as an either/or issue. Even though it can be ineffective or even cause harm, if used inappropriately, there are "many reports on ways that it can be used to achieve positive results" (Bell & Vahrenhold 2018). This conclusion seems somewhat unreasonable to me. After reading the whole survey I didn't feel like there are "many reports" (Bell & Vahrenhold 2018) confirming the positive results of CS Unplugged. On the contrary, the opinions on its use seem quite contradictory. In my opinion, stating that in certain situations - not limited to the classroom - CS Unplugged has been used to achieve positive results, would be a more accurate conclusion.

Reflecting on this research, I find it difficult to use it to justify the creation of my material. Considering that the introduction states that "CS Unplugged is mentioned in hundreds of papers about CS education, and appears regularly in curriculum recommendations, teacher forums, and social media." (Bell & Vahrenhold 2018) it's surprising to me that this survey list very few reliable arguments for or against the use of CS Unplugged. Assuming that this survey is representative of the literature, the current research neither strongly supports nor strongly opposes the creation of an activity like the role-play activity I created. For this reason I will base my justification of creating an unplugged activity on other educational theories like the conversational framework (Laurillard 2002) as described in the section 4.

Lastly, another aspects that raises my suspicion is the fact that this survey has been co-authored by Tim Bell, who is a pioneer and co-author of the original free online book that started the CS Unplugged-Movement. This in combination with the partly vague argumentation and missing evidence raises the question of a possible author bias. Taking this into account, for the next steps, I advise to consult other resources and compare their findings on CS Unplugged to the ones presented in the survey investigated in this report.

4 Educational Theory

The conversational framework by Diana Laurillard (Laurillard 2002) promotes to think about learning from the student's perspective and splits learning into six different types. Laurillard makes a main distinction between Concepts and Practice which both are considered essential part of the overall learning experience. Another abstraction splits the students interaction into interactions with his/her teacher and interactions with his/her peers. Combining this distinction of interactions with the first distinction between Concepts and Practice there are four main areas in which learning can happen (see diagram 1).

My proposed activity mainly targets the two areas in the bottom half of diagram 1, namely collaboration and practice. The reason I decided to focus on these two learning types is partly a response to my own experience at school where I received lots of upfront teaching, which Laurillard describes as Acquisition Learning. There is nothing inherently wrong with Acquisition Learning but I would like to promote more variety in the learning types used at schools.

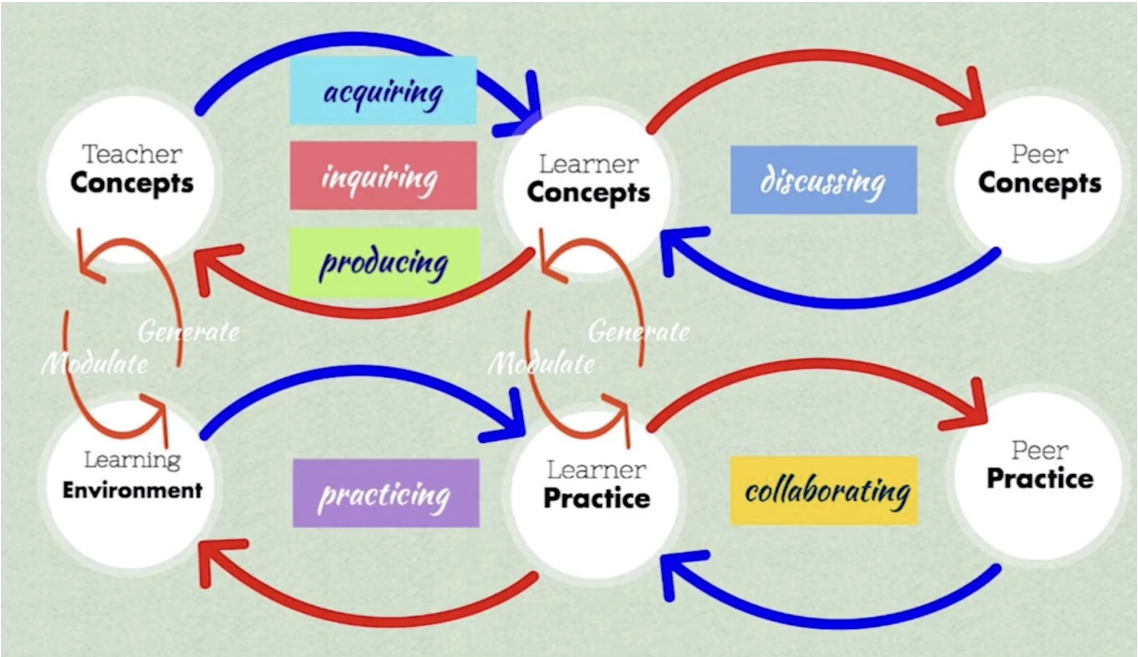

Figure 1: Conversational Framework

The proposed role-play activity is an example of Collaboration Learning as students have to work together as a team to emulate the interactions that happen over the internet. Assuming that the corresponding theoretical background has been taught beforehand (e.g. through Aquisition Learning), students need to apply their knowledge in this new context which also matches the Practice Learning-Type.

In line with Laurillard I am convinced that a variety of learning styles is the best way to learn. This also creates the justification for my unplugged activity. On its own, this role-play activity won't work well and will at most give a superficial level of understanding of the concepts. In combination with suitable preparation lessons - most likely using other learning types - as well as post processing the outcomes of this activity with the students, I am convinced that this activity can be both fun and beneficial for the students learning process. The post processing mentioned includes relating the practical activity back to the theory which is often called "plugging it in" in the CS Unplugged jargon.

My vision for this activity is the use within the curriculum alongside other teaching methods to increase variation in terms of Laurrilard's Learning Types and encourage students to apply their knowledge in a new context. I am convinced that such use will benefit student learning and deepen their understanding. Trying out this activity in practice, getting feedback and adapting it accordingly would be a sensible next step.

5 Similar Teaching Materials

After having finished creating my activity I found that the CS-Teach-guide for Early Years and Primary Practitionors (Farell et al. 2018) includes an activity that has some similarity to mine (*Modelling the Internet* n.d.). On the one hand, this is a good indicator

that the material I created fits in with the Scottish curriculum. On the other hand, it'll be interesting to compare the differences in the activities as they've been develop independently from one another. The next section will do a brief comparison of the two activities and explain some of my design decisions.

The activity *Modelling the Internet* is also an Unplugged activity. The idea of abstraction is similar in a sense that students take on the role of a certain internet component and act out the interactions that happen over the internet. One key difference is the specified learning outcome. The objectives defined by this activity resolve around the difference between the internet and the *"WWW"*. Further, the desired outcomes state: "I can explain what the internet is" (*Modelling the Internet* n.d.). In contrast, my focus is less on understanding the internet as a whole but understanding the interactions that take place when we use the internet, e.g. when we click on a link. That's also the reason why I called my activity: "What happens when I visit a webpage?".

Another key difference is the roles which take part in the Unplugged activity. In the case of the *Modeling the Internet* activity there are four components: Client, DNS, Router and Server, some of which are replicated such that a group of 9 students carries out the activity. In my activity there are 5 components: User, Browser, Internet Connection, Web-Server and DNS. Each component only has one instance and thus, a group of 5 students is sufficient. My idea behind the roles I've chosen is the following. I wanted to make the abstractions as tangible as possible. Every student has interacted with a browser before and having the distinction between the user who wants to achieve a certain action and the browser that does the heavy lifting behind the scenes seemed like a valuable separation to me.

One could argue that the abstraction provided by the existing activity is sufficient to fulfill the learning outcome `TCH 2-14b`, namely "I understand how information is stored and how key components of computing technology connect and interact through networks" (Farell et al. 2018). The wording of this learning outcome puts an emphasis on the interaction between the "key components of computing technology" (Farell et al. 2018). Thus, including a separation between user and browser isn't strictly necessary. Nevertheless, I deliberately included this distinction to make this activity more tangible to students. This aligns with the principle `Make it Matter` from the Engagement Practices Framework which states that "students are more motivated, perform better and more likely to persist when they can see how a lesson connects to their experiences" NCWIT (n.d.).

The similarity between the activities suggests that it's advisable to chose either one or the other to avoid unnecessary repetition of both content and learning method. Nevertheless, the differences are sufficient to justify for both activities to coexist. A teacher who is aware of the students' prior knowledge and the context in which he/she will use an activity can decide which activity is most suitable depending on the situation.

6 Final Thoughts

Going back to the research about CS Unplugged (Section 3) one thing that struck me was the fact that the main focus of investigation was efficiency. In my opinion efficiency shouldn't be the only metric to judge if a teaching method is suitable or not - the same applies to evaluating teaching materials. For me, a key aspect that is missing in the research presented (Bell & Vahrenhold 2018) is the satisfaction of students. Let's assume that two methods have similar efficiency in terms of the students' level of understanding. For me it's pretty clear that in such a case choosing the method that was more fun for the students is the way to go.

As mentioned earlier, in my own experience at school I received lots of upfront teaching. I'm a successful university student now but this doesn't mean that the teaching methods couldn't have been improved. I would have like to see more variety in learning types used throughout my education at school. Assuming that a similar learning outcome could have been achieved with such methods, I would possibly have a more positive attitude towards school and institutional learning.

Investigating the topic of students' satisfaction and happiness more thoroughly would be needed to support the hypothetical argument made above. It would also be interesting to explore the role that CS Unplugged can play in this. Such research would be a great next step but out of the scope of this report. The main takeaway I want to advocate is that efficiency doesn't have to be, and in my opinion, shouldn't be the only metric considered when evaluating teaching methods/materials. That's also the reason why I tried to design my activity as engaging as possible. I hope the material I created does not only convey knowledge but also shows students that learning can be fun and rewarding.

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