FireFlies-CFT: A Study On The Emotional Effect Of Feedback Through Classroom Technology

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Abstract
In this paper, further work is conducted on distributed displays that perform in the peripheral interaction continuum in classroom environments. Giving personal feedback is beneficial for the classroom's atmosphere, but can also be interruptive for the workflow of students. This Fireflies-CFT research looks at whether visualizing feedback with distributed displays is a valuable alternative in classroom environments, compared to just having verbal communication. Herewith, not only the cognitive aspect is included, but also the subjective experience of both teachers and pupils. This was done by implementing Fireflies prototypes at a Dutch elementary school. The effect of the prototype was distinguishable in the way the children interpreted the feedback, how they turned off the lights, in their preference in type of feedback, and in the change of work environment in class. The Fireflies were mostly preferred during self-study, when verbal communication was experienced as disturbing. Fireflies-CFT contributes to innovation of classroom technologies, based on teachers' and students' experiences.

Author Keywords
Peripheral interaction; distributed displays; primary education; feedback; human-computer interaction (HCI).

Figure 1: FireFlies prototypes are controlled by the teacher's tablet

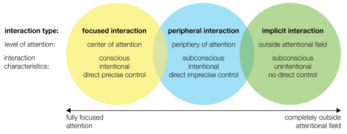

Figure 2: the interaction attention continuum, by Bakker and Niemantsverdriet, 2016 [2]

Introduction

An important task in education is giving personal feedback to the pupils. When a teacher gives compliments, it influences the entire atmosphere of a classroom [8]. This positive and engaging atmosphere will, in turn, contribute to the children's learning.

Distributed displays, which are described as "technological systems that present output to more than one physical display", have been tested as supportive educational tools for elementary school teachers [6]. One of these studies is by Verweij et al. with the FireFlies2 system. The scope of Verweij's research is cognitive offloading for primary school teachers, meaning that "mental resources are freed to focus on other teaching tasks" [10]. On the other hand, these results were mostly focused on the perception and insights of the teacher and thus not necessarily the pupils. In this FireFlies-Classroom Feedback Technology (CFT) research, the focus lies with the emotional aspect of the pupils. Therefore, the following research question was formulated: How do distributed displays of positive reinforcements support the way in which primary school teachers give compliments to their pupils?

The current problem with personal feedback in a classroom is that it is considered as disturbing. Especially during self-study, verbal communication could be interruptive for the workflow of students. Furthermore, pupils find it humiliating when the teacher gives them a warning in front of their peers. Distributed displays can meaningfully enrich and complement the way feedback is currently given between teachers and pupils. For example, the feedback is now more targeted and individual. Additionally, the compliments are now visualized. This will result in more convenience for the teachers, as an illuminating overview of compliments is displayed in class. This study implements the Fireflies prototypes in the classroom, to research students' experiences about receiving feedback through distributed displays.

With the promising results in favor of the pupil and teacher, this research could contribute to the further improvement of innovation within classroom technologies as well as social behaviorism.

Related Work

In recent years, there are a number of novel HCI systems developed for improving teaching and learning in the educational context. One of such technologies is FireFlies, developed by Bakker et al. [1]. The design consists of a set of small lights for each child, controlled by the teacher (Figure 1). The aim of the design was to study the effectiveness of a peripheral interaction technology for teachers in becoming a part of everyday routines. This theory was based on the Interaction-Attention Continuum (Figure 2) [2]. With the success of the study and opportunity left open, a continuation study was made. Verweij et al. conducted research "to lower the teacher's cognitive load on information by replacing present information within the classroom, with a distributed representation." [10]. Verweij et al. implemented Fireflies2 system, which added the ability for children to communicate with the system as well. The aforementioned studies similarly research how a distributed display can aid a teacher with cognitive offloading through their periphery of attention. However, most FireFlies studies have been focused on teachers' experiences, and few of them have analyzed students' experiences in detail.

Design

For this study, the FireFlies2 prototypes have been used. The FireFlies2 is a set of tangible pixels designed

Figure 3: the interface of the teacher's tablet, controlling each individual pixel

Figure 4: Pressing the FireFlies turns the light off

for use in primary education. Each pupil receives a personal pixel, which is mainly controlled by the teacher. The teacher can send compliments (green) and warnings (red) to an individual through a tablet app (Figure 3). The child can turn off the display by pressing the pixel itself (Figure 4). Therefore, only one-way communication from the tablet to the pixels was possible, in contradiction to Verweij's et al. research. The colors green (compliment) and red (warning) for the feedback are chosen because of the connotation with positive and negative behavior [9]. This research was not open-ended compared to Fireflies2, meaning that the teacher did not get to choose the meaning of each color. Taking away this variable led to more qualitative findings of the pupils.

Methodology

In this research, elementary school pupils at the age of 9-12 have been studied on how distributed displays influence the learning performance of pupils. This target group was chosen because children of this age are in the middle of their development process to work independently, in which they need extra guidance. Yet, this group is able to formulate arguments on their own and are highly technological adaptable [3].

In order to make the outcome representative, the study took place at a regular public elementary school in the Netherlands. Two classes participated, where both consisted of two teachers and approximately thirty students. The study was conducted on regular school days (Monday till Friday, 09:00-15:00) for a period of two weeks.

Firstly, an observation without the prototype was held. During this observation, an informal interview was conducted with the teacher for an in-depth understanding of the current situation. Weekly observations were held during the implementation of the Fireflies to juxtapose the classroom environment before and after the user study. In both cases, notes were taken to record those changes.

During the usage of the prototypes, quantitative data was collected from the log of the FireFlies. This data was filtered based on the frequency of use of the FireFlies. Based on this information, four focus groups with three or four children were formed. The discussion groups are divided in such a way that all students within a group had distinctly different amounts of interactions. The difference between individuals was aimed to increase the chance of having an engaging discussion between the interviewer and students [7].

An interview was held at the endpoint of the study, meaning that the quantitative data was leading for the discussion questions and making it an explanatory sequential approach [4]. The researchers took the role of discussion leader and asked questions related to the frequency of interactions and personal experiences. During these interviews, audio recordings and notes were made, with the approval of the pupils' parents. It was assumed that the children would be more confident to talk in a group with peers. Additionally, separate interviews were held with the teachers. This way, the opinions of both parties could be validated, and a review of the overall results could be collected. After collecting all data, the data was analyzed with the affinity diagram [5] method.

Findings

The interactions with the Fireflies prototypes were recorded and graphed (Figure 5). These graphs were determinative for forming discussion groups. For example, child sixteen had pressed the prototype 28 times over a period of two weeks, whereas child six had

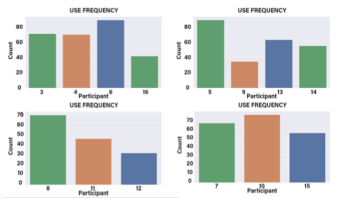

Figure 5: The discussion groups for one of the classes, based on the quantitative data

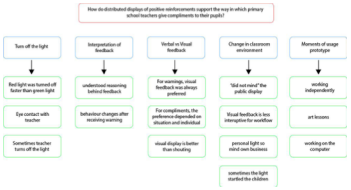

Figure 6: Affinity diagram of the qualitative data

202 interactions. Based on this contrast, the two children were placed in the same group (group 1).

After the interviews were held with teachers and pupils, all topics and quotes were categorized. The focus laid mostly on the children's answers, but the interviews of the teachers were used to put these answers into perspective. Based on this qualitative data, it was possible to distinguish five major themes that are relevant to the pupils' experiences of receiving feedback: 1. turning off the light of the prototype; 2. interpretation of the feedback; 3. receiving verbal vs visual feedback; 4. classroom environment; 5. during which moments the prototype was used (Figure 6). All these elements are supportive arguments for the conclusions of the research question.

Turning off the light

Firstly, the way in which the children turned off the light depended on the type of feedback. If a warning was sent to the children, the prototype was pressed sooner than if the pupils received a compliment. During the interview, the pupils commented: "I kept the [green] light on because that made me feel good", and, "I do turn it off if it is red". In most cases, the children would make eye contact with the teacher before turning it off. This way, pupils better understood the meaning of the light because of the teacher's facial expression. All the teachers mentioned this in their personal interviews as well.

Self-awareness of feedback

Furthermore, several questions on the interpretation of the feedback were asked. In order to test how the pupils' comprehension of feedback was reflected in the prototype, questions were asked about the meaning of these colored lights. The children were able to self-reflect and understand the reasoning behind the feedback. Besides knowing the associations of the green and red light, the students could also explain why they received that type of feedback in the context of one particular moment. Moreover, the received feedback led to behavior changes among the pupils, especially with warnings. If a pupil received a warning, he/she would adapt his/her behavior to the expectations of the teacher: "Sometimes I get a red light when I am talking with someone. But when I do, I stop and continue with my work." For the compliments, one child specifically mentioned that "receiving a green light when working hard was good for [his] self-esteem".

Preference in visual feedback

Thirdly, it was researched whether there was a preference for verbal or visual feedback among pupils. For warnings, visual feedback was always preferred, because compared with a verbal warning, a red light was considered as less embarrassing and drew less attention from peers. During the interview, it was mentioned that "Not everyone pays attention to the lights but if the teacher tells it [the warning], they start to. Because then everyone can hear it." For compliments, the preference depended upon the situation and the individual. Most pupils considered a green light as enough recognition for their good work. In one discussion group, all children (n=3) agreed on one pupil's remark, who said: "If the teacher tells it [a compliment], I am not quite sure how to react, but with a green light I do." On the other hand, others preferred a verbal compliment from the teacher because it was considered as more personal.

Improved work environment

For this study, the possible change in atmosphere in class and the social behaviorism among pupils were observed. Although the feedback was displayed publicly, most pupils "did not mind" or "did not care" that other classmates could see their feedback received from the teacher. Because of the personal FireFlies assigned to the students, the children were more focused on their own tasks and interfered less with the work of their peers. During the interviews, three out of four teachers and 85% of the pupils also addressed that the amount of verbal communication decreased. Overall, the visual feedback was considered to reduce the disturbance of the workflow.

Self-study and other moments of prototype usage

Lastly, the teachers and children were asked when the prototype was used in class. This mainly happened while the pupils were working either self-study, watching videos, doing a test or were following art lessons.

Discussion

This section describes how the quantitative and qualitative findings led to final conclusions and which factors might have influenced the results of this study.

Insights from findings

The way in which the pupils turned off their lights partly reflected the emotional response on the feedback of the children. One example of such a response is that pupils kept their lights on. Sometimes because they just did not realize that their lamp turned on, but mostly to "show off" their green light to the rest of the class. In both cases, the teacher had to turn off the lights with the tablet. Additionally, the pupils always made eye contact with the teacher before turning off the light. This is interesting yet not surprising, as someone's facial expression tells a lot about the reasoning behind the feedback, therefore, making it is easier to interpret the feedback and beneficial for self-reflection.

The interpretation of feedback was important for determining if the children understood the reasoning behind the feedback and if they would change their behavior accordingly. If not interpreted correctly by the students, teachers' feedback through the system would not lead to appropriate effects on students' behavior. It was, therefore, a positive result that children would correct their behavior when they received a red light. This also coincided with the results of Verweij's et al. research [10].

When comparing verbal feedback and visual feedback, it became clear that visual was preferred more often, specifically for red lights. This was because the public display of warnings was considered to be less humiliating for the pupils, than when these comments were made verbally. It is believed that this fact has been important for the general experience of the children, because it involves the social acceptance of the prototype. Furthermore, the prototypes were most often used during self-study activity rather than regular teaching. During these moments, verbal communication was not allowed. Thus, visual feedback was considered to be less disturbing for the workflow of the students.

Finally, a considerable change in the classroom environment has taken place. Previous studies have examined how to make a secondary task less attention focused so that teachers can focus better on their primary tasks. On the other hand, FireFlies-CFT examines how to perform primary tasks in the periphery of attention so that the classroom environment can be improved. The personal Fireflies

ensured that the pupils were less distracted from their own work. Moreover, the number of verbal communication decreased. Due to this, the workflow of the children was less often interrupted.

Limitations

The research duration is relatively short. This was because the end of the school year was approaching, which means that there were a lot of breaks, rapport reviewing days, but also musical preparations and camp for the eighth graders. Looking for a second class was challenging, because of the aforementioned reasons, and the high workload teachers already have combined with the exam period (mainly Cito and Iep exams) that were held at that time. This research was done in two classrooms. Because four educators and 24 students were interviewed, the research was done on a small scale. Even so, the test revealed interesting insights that would be worth to look further into.

An influence on the results that should be taken into consideration, is the attitude of the teacher towards the design. Half of the teachers were enthusiastic about classroom technologies in general, which could lead to a biased opinion on the prototype and this study.

To conclude, the interviews and quantitative data revealed insights on the learning performance, change in the classroom environment and the preference in receiving feedback. These results contribute to research on the effect of technology in a classroom environment. Current studies have been primarily focusing on the teacher's perspective, whereas FireFlies-CFT researched pupils' experiences. The results reveal social psychological and human-technology insights that are beneficial for the understanding of child education and classroom technology.

Conclusion

This paper showed the results of the emotional effect of feedback through classroom technology. The user study focused on experiences of teachers and pupils with distributed displays. The Fireflies were exploited at an elementary school. The quantitative and qualitative data revealed insights on the working performance, a changing working environment and preferred ways of giving feedback. Most children said that receiving a red light was more favorable since they felt less embarrassed. Also, children kept the green lights on to "show them off" to their peers. Both teachers and pupils preferred visual feedback, as the students' workflow was not being disrupted by sound.

During the course of this project, three related topics were noticed that are of interest for future research. Firstly, different kinds of education in elementary education should be taken into consideration. More schools have recently developed a more pedagogic approach with more focus on emotional development in children. Secondly, some schools are specialized in the development of special needs children. These schools often use a more visual approach to their teaching methods, in which products like FireFlies might be a more beneficial addition. Lastly, an aspect that could be further researched is the ability of the students to see each others' feedback through the lights. Some results can be drawn from the interviews held in this study, but a more thorough research on social psychological effects is still lacking.

The results presented in this paper show how HCI can contribute to improve classroom environments and the way children react to these technologies. Fireflies-CFT research also contributes to the further development of classroom innovation and social behaviorism.

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