

FireFlies: Supporting Primary School Teachers through Open-Ended Interaction Design

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ABSTRACT

Primary school teachers usually perform several tasks simultaneously. Many secondary tasks, such as giving turns or encouraging children to work silently, could be supported by interactive systems, which may lighten the teacher's busy everyday routine. Such systems however, should afford being interacted with while performing another primary task. We call this type of design *peripheral interaction design*. In this paper we present *FireFlies*, an open-ended peripheral interaction design developed for primary schools. Preliminary results of a six week deployment of FireFlies in four classrooms, reveal that teachers used FireFlies to perform secondary tasks and saw it as a valuable addition to the classroom. Though different interactions with FireFlies required different levels of effort, teachers could successfully interact with FireFlies during or in between other tasks.

Author Keywords

Classroom Technology, Peripheral Interaction, User Exploration, Physical Interaction, Open-Ended Design.

ACM Classification Keywords

H.5.2. Information Interfaces and Presentation: User Interfaces – Evaluation/methodology, Interaction styles, Prototyping, User-centered design. K.3.1. Computers and Education: Computer Uses in Education.

INTRODUCTION

During everyday lessons at primary schools, teachers are usually performing numerous tasks and activities. Their main tasks include giving whole-class lessons, leading group discussions and providing individual instructions. During these main activities however, teachers are also performing several small, secondary tasks. For example they need to monitor if children are working well, keep track of which children had their turn, stimulate and correct children as well as keep an eye on the time-schedule. These secondary tasks make up a large part of teachers' everyday routines.

Computing technology is making its way into primary schools, for example in the form of laptop computers and interactive whiteboards. Such technologies can be very valuable in supporting the teacher's primary task of explaining the teaching material. Secondary tasks such as

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keeping track of turns however, are usually not suitable to be supported by these devices. We believe that teachers could benefit from interactive systems that support them in performing their secondary tasks, and aim to evaluate this in the present paper. Such interactive systems might help teachers in smoothly managing the class and potentially lighten their busy everyday routine.

The development of such interactive systems however, requires a different approach from the development of systems that support primary tasks (Bakker et al., 2012b; Hausen et al., 2012). Performing secondary tasks cannot stand in the way of the primary task which is performed simultaneously (also see (Zijlstra, 1993)). Hence, interactive systems that support secondary tasks should easily blend into the user's everyday routine. A potentially suitable approach to the design of such systems is *peripheral interaction design*: interactive technology designed such that minimal attention is required for interaction (Bakker et al., 2012b; Hausen et al., 2012). This way, the interaction may take place in the background or *periphery* of the attention, leaving room for primary tasks to be performed simultaneously. Peripheral interaction design therefore requires interaction to be simple and straightforward, so that it can embed in the everyday routine, rather than having users adapt their routine drastically.

This paper presents a peripheral interaction design called *FireFlies*, aimed to support secondary tasks of school teachers. FireFlies is an open-ended design, meaning that the goal for which teachers use it is open and can be chosen depending on the preferences of the teacher. FireFlies is thereby not focused on supporting a single secondary task, but can support multiple such tasks. An interactive prototype of FireFlies was used in four different primary school classrooms for six weeks each. In this paper we report the preliminary lessons we learned from this user study regarding the extent to which FireFlies supported secondary activities of the teachers.

RELATED WORK

A few examples are known of interactive systems that support secondary tasks. *StaTube* (Hausen et al., 2012) for example uses peripheral interaction to enable users to easily update their instant messaging status and monitor the status of contacts. Edge and Blackwell (2009) presented a peripheral interaction design that uses interactive artefacts on the side of the office work environment to quickly track or update task progress.

Although no specific interaction design is known that aims to support secondary activities of teachers, several

innovative classroom technologies have been developed. *Lantern* (Alavi et al., 2009) is an interactive light-object located on university students' desks, which students can use to indicate which exercise they are working on or to call for help. *vSked* (Hirano et al. 2010) supports primary school children with autism in working independently, by providing an interactive visual way to schedule activities. *Discovery Table* (Bodén et al., 2011) supports school children in learning about numbers and letters by interacting with everyday physical objects.

FIREFLIES DESIGN

The aim of the study described in this paper is to explore the possibility of supporting primary school teachers' secondary tasks through peripheral interaction. To enable this exploration, we developed a dedicated peripheral interaction design called *FireFlies*.

An important requirement of FireFlies was that the goal for which teachers use it is personally relevant to them. Earlier research revealed that this is essential for embedding interactive technology in everyday routines (Bakker et al., 2012a), as interactions that are not seen as relevant will not become automated. Furthermore, the extent to which technology is leveraged in classrooms depends on the teacher's goals and on their personal beliefs about teaching in general (Chen et al., 2009). We therefore decided that our design should be *open-ended*: teachers can specify for which goal and in which manner it is used, so that it will fit their personal way of working.

FireFlies consists of three elements: the light-objects, the teacher-tool and the soundscape. The soundscape is outside the scope of this paper.

When using FireFlies, a *light-object* (see Figure 1) is located on the desk of each child. The light-object can be yellow, blue, green or red, or it can be off. Single light-objects can provide information to or about a single child, while all light-objects together form a distributed display that provides information about the class as a whole.

The teacher can set the colours of the light-objects with the *teacher-tool* (Figure 2). The interaction design of the teacher-tool is intentionally kept as simple as possible: the slider at the top is used to select a colour and when squeezing one of the beads on the bottom of the tool,



Figure 1. FireFlies light-objects in different colours (top), and light-objects in a classroom as a distributed display (bottom).

which each represent one child, the light-object of that child changes to the selected colour. The button labelled 'everyone' can be used to set all light-objects to the same colour at once. The tool can be clipped to one's clothes so that it is at hand without continuously having to hold it.



Figure 2. FireFlies Teacher-Tool: selecting a colour (top left), selecting a child's name (top right) and clipped to the user's clothes (bottom)

To enable a user evaluation of FireFlies, we developed an interactive prototype. The teacher-tool and the light-objects can wirelessly communicate by using JeeNode modules (<http://jeelabs.net/projects/9/wiki/JeeNode>). A demonstration video of the interactive prototype of FireFlies is available at <https://vimeo.com/52218544>.

USER EXPLORATION

To evaluate the extent to which FireFlies can support teacher's secondary tasks of teachers, we implemented our interactive prototype in four different primary school classrooms in the Netherlands, for six weeks each. Given the fact that we intend FireFlies to be used in parallel with other ongoing activities, some time will be required to get used to the interaction and come up with a suitable way of working with FireFlies. We therefore conducted a long-term study in the real context of a classroom. Long-term and in-situ testing is recommended in human-computer interaction (HCI) literature in general (Hazlewood et al., 2011), and specifically for HCI studies in classrooms (Yarosh et al. 2011), ensuring that an innovation remains valuable after its novelty has worn off.

The four participating classrooms consisted of 6 to 9 year-old children. Two of these classes had a full-time teacher, while the other two were each taught by two part-time teachers (one working two days and the other three days per week). In total, six teachers, who were all female, worked with FireFlies for six weeks. All teachers were explained how the teacher-tool and light-objects worked. Although we encouraged them to use it

regularly, we emphasised that they could choose how and when to use FireFlies.

During the deployment of FireFlies, we conducted two open interviews with each teacher: once in the third week and once in the sixth week of the study. We conducted group interviews with the children of the participating classrooms in the sixth week. Additionally the teachers filled out a questionnaire in the final week of the study.

RESULTS AND DISCUSSION

During the user study, FireFlies was used every day in each participating classroom, during regular lessons such as mathematics and language. We will now discuss the preliminary results of the interviews and the questionnaire, regarding FireFlies as a tool to support the teachers' secondary activities.

How the FireFlies light-objects were used

In all four classrooms, the teachers decided to link each colour to a specific rule or event. For example, in two of the classrooms, a red light meant 'try to work in silence', while green meant 'you may discuss'. Sometimes the whole class had a red or a green light. In other cases, most lights were red and some were green, when a few children were allowed help from others. In the other two classrooms, green was used to give children a silent compliment while working. In one class, blue was used to give turns. For example, when children had to read aloud, the teacher would make the light-objects blue one after the other, and any child whose light turned blue would read one sentence. Yellow was used in two classes to tell which children were allowed to work on the computer.

How the FireFlies teacher-tool was used

Usually, the teachers started a lesson by setting all light-objects to one colour, using the button 'everyone'. During the lesson, they then used the beads at the bottom of the teacher-tool to change individual lights, for example to give compliments or turns. The beads were therefore more often used than the button 'everyone'. Although the teacher-tool could be worn on clothes, it was mostly operated while the tool was lying on a table or desk, the teachers found this more convenient.

In the questionnaire we conducted in the last week of the study, we provided 10 examples of everyday actions that may be performed during lessons as well as 10 examples of interactions with the teacher-tool. The teachers were asked to rate how much effort they required to perform these (inter)actions. They indicated this by placing a cross on the visual *Rating Scale Mental Effort* (Zijlstra, 1993). Figure 3 shows this scale (translated from Dutch), the example (inter)actions that were provided as well as the average results of our six participants.

As evident from Figure 3, single interactions with the teacher-tool, such as turning all light-objects off, selecting 'everyone' or selecting a colour, were perceived to require little effort. The effort required for these activities seems comparable to the effort required to tell a child to be silent. The interactions needed to change the light of a single child, were perceived to require rather much effort.

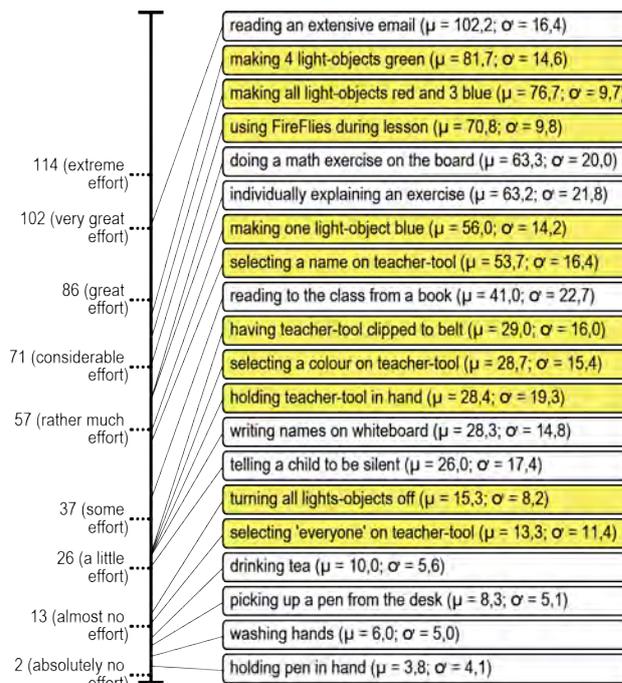


Figure 3. Rating Scale Mental Effort (Zijlstra, 1993) and the average results (μ) and deviation (σ) of our 6 participants, for 10 everyday work actions (white) and 10 interactions with the FireFlies teacher-tool (yellow).

Based on the interview data, we may attribute this to the fact that it took some effort to locate the right bead. Although teachers reported to have automated knowledge of their pupils' names, they had to get used to the order in which the names were listed (alphabetical by first name).

More stacked interactions with the teacher-tool, such as changing the colours of four light-objects, was perceived to require considerable to great effort, comparable to the effort required to do a mathematics exercise on the whiteboard. Although the teachers were positive about the simplicity of the teacher-tool design, two of them mentioned that interaction would be quicker when the two actions required to change the colour of a light-object (selecting a colour and selecting a name) would be combined into one single action. For example the colour may be selected directly on the bead representing a child.

Overall, Figure 3 gives the impression that the effort needed for an (inter)action strongly relates to the amount of thinking required. Smaller interactions with FireFlies seem to require only little thinking and therefore little effort. Stacked interactions require more thinking (e.g. to find multiple names on the teacher-tool) and thus more effort. This is also reflected in the results for the everyday activities. Reading an extensive e-mail involves much thinking, and thus very great effort. Doing or explaining an exercise seems to involve less thinking of the teacher; she has likely explained the same exercise numerous times. As the teacher may not have used all beads on the tool as often, the interaction of locating and selecting a number of beads may have required more effort.

How FireFlies supported secondary activities

While the purpose for which teachers used FireFlies was intentionally left open, all teachers chose to use it for

classroom management activities: secondary activities which are indirectly related to teaching.

Teachers indicated that FireFlies fit well in the classroom, both in terms of the visual appearance of the light-objects, and in terms of being able to interact with the teacher-tool during other activities. Even though considerable effort was required for some interactions, they seemed to be quick enough to do in-between. For example, when the teacher was giving individual instructions to a child and gave this child a small exercise, while this child was performing the exercise, the teacher would be able to give another child a compliment by making his light green. Or, while one student was returning to his desk and another student was on his way to the teacher to get instructions, the teacher was able to send two children to the computer using a yellow light. Such situations occurred frequently in the user study. The teacher-tool seems to afford usage next to or in-between other primary activities.

Teachers indicated that they liked working with FireFlies as it enabled them to communicate to children quickly and silently. The teachers mentioned that they are usually hesitant to make verbal remarks while the children are working, as it distracts those for whom the remark is not intended. Using an interactive system rather than verbal remarks helped overcoming this problem. The interviews with children revealed that they found FireFlies useful, as by looking at their light-object, they always knew what was expected of them (e.g. if they were allowed to discuss, or go to the computer) also when the teacher was currently not available for questions. Additionally, the children mentioned that colour changes sometimes attracted their attention, while they did not even notice it in other cases. The teachers did not see this as a problem as it indicated that the children were very concentrated.

Apart from silent communication, the teachers found a number of ways in which FireFlies provided an added value over traditional ways of working. As the lights were visible from anywhere in the room, it easily reminded the teacher which children had their turn or were given a compliment. This knowledge could be offloaded in the environment and enabled the teacher to equally divide compliments and turns over the children without much mental effort. Additionally, the teachers indicated that children seemed more motivated to focus on their work. They felt 'responsible' for their personal light-object, which could turn green any moment when the indicated rules (e.g. to work silently) were successfully followed.

Clearly, the way in which the teachers chose to use FireFlies was a valuable addition to the existing routine in the classroom. The teachers found relevant ways of using FireFlies and applied this regularly. FireFlies therefore seems effectively usable to support secondary activities.

CONCLUSIONS

In this paper we presented FireFlies, an open-ended interactive system meant to support secondary activities of primary school teachers, by using individual light-objects on the children's desks. An interactive prototype was implemented in four different classrooms for six weeks. In each classroom, FireFlies was used every day

during the experiment. Small interactions with FireFlies, such as turning all light-objects off required only little effort. More stacked actions such as changing multiple individual light-objects were more demanding. Interestingly however, the teachers choose to use the more effortful interactions much more often than the 'easier' interactions. Teachers were able to perform these interactions frequently as well as in-between or during other primary tasks. Using FireFlies was perceived as a valuable addition to existing routine in the classroom. Though based on preliminary results, and realising that the interaction design could be improved, FireFlies seems an effective attempt to develop interactive technology to support secondary tasks of primary school teachers.

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