VisciPad: Peeking Into a Collaborative Creative Writing Project in Elementary School

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Abstract—We describe an experimental setting of creative collaborative writing in an elementary school in Finland, among a group of 5th and 6th graders. They were provided with small portable computers (“netbooks”) and ubiquitous access through WLAN and 3G to a collaborative writing service based on EtherPad. The computers and service were used for three months to produce manuscripts for a musical. Our work is an exploratory characterization of the usage patterns and customs that emerged, as they can be detected post hoc from the automatically revisioned writings and online discussions.

I. INTRODUCTION

We set up an experiment in a Finnish elementary school during spring semester 2011, where a musical project was underway. One of the working groups was responsible for producing the manuscripts of the musical. Pupils in that group were provided with portable computers, and instructed in the use of our collaborative writing service that is available over the internet. The experiment is part of a larger research project, and in the present work we concentrate on the initial findings of how the service was used and which patterns emerged.

For creation of art, such as the musical in the project we describe, the school setting can pose unnecessary limitations on the expressivity of pupils and hinder the emergence of serendipitous thinking due to place and time restrictions. The pupils were provided with small, lightweight computers to lift some of the limitations by increased mobility. Ubiquitous wireless connectivity helped make this also a practical reality. If we are to study the creative processes, this poses a new challenge. How do we study the actions that take place outside the classroom and thus out of our reach? Our solution to this is to host the service on servers that we have full access to, and study the very detailed logs that the software saves as a by-product of its normal operation.

In a collaborative setting, ideas and criticism have to be conveyed to other participants. The art form itself provides a means of communication, but typically other means are necessary to support work coordination, resolving disputes and so on. In our case the work is also occasionally distributed, limiting communication to technological means like video, audio and textual chat or mail. The first two facilitate expressivity and give a feeling of immediacy. Textual communication is easier to recall for review (at least in our system, as the latest messages are always visible), and tends to be more analytical. We did not directly support audio and video communication, but the pupils were free to use (and install) any software available for the computers. However, for textual communication we provided a chat side-by-side with the actual writing area, where the participants could discuss without adult supervision among their peers. The chat is also extensively logged and we use that data for analysis.

This paper is organized in the following sections. First we look at work previously done to support similar projects, and which methods have been used for analysis in Section II. Then we describe the experiment in detail in Section III, followed by description of the data we collected in Section IV. Results and analysis are presented in Section V, after which we conclude with some leads for future work.

II. RELATED WORK

A number of experiments have brought laptops or similar computing devices (mobile phones, netbooks, etc.) to elementary schools. The United Nations’ led “One Laptop per Child” project is one of the most ambitious ones and definitely the farthest reaching in terms of population affected.1 On the experiences of that project, see for example [1]. Perhaps more relevantly, Holcomb describes a number of initiatives in US elementary schools introducing 1:1 laptops to pupils. [2] Similarly to those, we provided each participating pupil with a laptop.

We build our collaborative writing tool on the software called EtherPad2, which in turn is based on the work of Ellis et al. on operational transformation protocol. [3]. The software was open sourced in 2009 and subsequently used in schools for different purposes, see for example [4] and [5]. Previous work has concentrated on information and knowledge sharing and building aspects of learning, but our experiment employs the software in a creative project.

Our experiment is set in an existing team project that has a large creative writing component, and pupils are familiar with use of technology. A typical example of how pupils communicate verbally and what creative phenomena might emerge in such projects can be found in [6].

WriteProc is a framework for extracting and analysing collaborative writing data, which supports identifying of collaboration processes and writing activities from event logs

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1The project is reported through stories at http://one.laptop.org.
2Created by a company called AppJet, which was later acquired by Google.
as part of a review feedback model. [7] Writing activities are recognized heuristically from text surface and structure changes, and topic overlap and cohesion measurements based on an LSA model. Similarly to them, we use event logs, but instead of identifying higher-level constructs, we measure editing and chatting activity levels, and certain co-occurrences between those. We do not have anything comparable to their review feedback support.

Entropy measures of text have been used to detect bots in online chats. [8] Repetitive or otherwise regular text has low entropy, and was found in their study to be a good classifier for automated bots. We use the same methods to characterize the nature of pupils’ discussion in different teams.

The final works of the pupils were not graded and we rely on methods that do not require qualitative analysis or annotation of source material. In software development context, creativity has been approximated by contrasting the amount of new features implemented to mistakes corrected. [9] We do not have such measures, and thus look at activity as a proxy for creativity.

III. EXPERIMENTAL SETTING

All pupils of a Finnish elementary school (grades one to six, or ages six to thirteen) participated over the school year in creation and performance of a musical. The framework for the project was created and agreed upon during the fall term 2010: time allotted and scheduled, the working groups, the milieu and inspirational melodies, lyrics and visuals and so on. Volunteers were drafted for different project groups. Our experiment was conducted with one of them: the manuscript group had 21 volunteer pupils, who all were fifth and sixth graders (i.e. ages eleven to thirteen). They were responsible for creating manuscripts for the performing groups. Each pupil was provided with a computer on loan until the end of the spring semester 2011. The computers were equipped with Ubuntu Linux and set up with an account based on the first name of the pupil and a password, creating a sense of personal ownership. The guardians of the pupils had signed a form accepting their responsibility for damaged or lost computers, further stressing the ownership aspect, and limiting sharing or loaning of computers among the pupils.

The experiment started in February, when the manuscript group had already started working. During the first session of the experiment their works were copied to our service from a proprietary system temporarily in use, leaving us without data about the earliest creative sessions.

A. Regulation

The Finnish regulation concerning research among elementary school pupils mandates that the guardians sign a form giving the researchers permission to publish works produced by the pupils and media where they are present. In our experiment, the guardians of two pupils agreed only to their participation, but not to releasing media or works, so we are restricting our discussion in the current work to summaries and other indicators that do not identify the pupils or reveal their contributions directly.

B. The Computers

The netbooks were on loan from the Computer Science Department of Helsinki University, having been previously on loan to their students. The choice of Ubuntu Linux depended on the department’s IT administration providing a version that worked on the computers reliably, having been “battle tested” by students during their two to three years of studies. These included two different Asus Eee models, both 22.5 cm x 16.5 cm (8.9in x 6.5in) and weighing about one kilogram (2.2lbs), easily carried in a schoolbag every day. The collaborative writing service was provided as a web application and two browsers (Mozilla Firefox and Google Chrome) were available from the installation. Finally, there is a large collection of software available from the Ubuntu repository for a variety of tasks, including tools for creating art and supporting creativity.

C. VisciPad

The EtherPad source code was obtained by the researchers and modified to (i) better fit the small screen resolution of the computers used in the experiment, (ii) use Finnish language in user interface elements and (iii) support specialist notation in manuscripts. The resulting software was named “VisciPad” and an improved version can be accessed at http://viscipad.hiit.fi/. The manuscript notation has been removed from the current version and instead we now support some automated search services, in support for a different experiment. Visually the service is quite similar to what the pupils used, and can be seen also in Figure 1.

The page layout consists of four main elements. A writing area (highlighted in the picture with the larger red rectangle) occupies most of the page on the left hand side. If the text does not fit in the visible area, the user may scroll freely and indepedent of other users. Manuscript notation support is provided in the musical note, smiling face and sun icons. The right hand side shows the chat (smaller rectangle) and participant list. Above, stretching from side to side are controls for the text (emphasis, lists, export and so on) and general access. In the terminology of the original software and typical users, the page is called a pad.
The overall organization of VisciPad is such that the system supports any number of pads and they are independent of each other. The front page of the service provides a link to create a new pad, which will have a randomly-generated name from letters and numbers. By default new pads writing area contains a short welcome text, which can be removed. A pad can be shared and accessed from other computers through its URL. The URL is simply the service’s URL suffixed by the pad’s name. If a user wishes to create a pad with a name that is easier to recognize and memorize than those created by the service, this can be done by entering its URL, upon which the service verifies that the user indeed wants to create it. We used this method in the experiment: the URLs were provided to the pupils in writing and they created them on their own.

VisciPad supports several people simultaneously visiting the same pad, where they can observe the modifications others make on the pad, and also contribute their own modifications. Each user is assigned a color in which their writings appear, facilitating coordination, workflow and attribution. Propagation of changes from one user to another through the service happens typically in a sub-second time frame, creating a strong feeling of immediacy.

In addition to the main writing area, the service shows other participants, who are currently available through their browsers, and using a name of their own choosing. Choosing a name is not mandatory, but facilitates chatting. Chat messages are contributed by pressing enter, and can not be removed or redacted by the participants, nor the teacher in our experiment. The full discussion history can be shown, with the most recent portion always visible. Each message is accompanied by the participant’s name, who sent the message, along with a time when it was sent.

Some features which are supported by the software were not enabled during the experiment. The service supports a convenient way of sharing a pad through email or instant messaging using the controls visible on the pad’s page, but this feature required email server capabilities that we did not have at the time. Furthermore, this would have created a division between pupils to those who actively use a supported IM system or email, and those who do not. Authentication through username and password is possible, but was not used for the experiment due to costs related to SSL certificates and their availability in browsers. Lacking authentication makes it somewhat easier to start using the system and enables effortless collaboration across teams, but was not without problems (see VI-B).

D. Helpdesk Support Function

In addition to the team-specific pads, we set up a pad for general questions about the computers and VisciPad. A research assistant was tasked to check twice daily (morning and afternoon) for new questions, and answer them or seek help from others in the team answering them. Several researchers visited the pad and some even chatted with the pupils.

E. Questionnaire

The pupils answered a questionnaire at the end of the semester. We only use the answers to support our analysis in two places, and when discussing issues in Section VI, and chose not to present them in more detail.

IV. DESCRIPTION OF DATA

As a final result of the project, the group produced the manuscripts that were an essential part of the musical. The musical performance lasts about an hour and has considerably lengthy dialogue and lyrics. As part of the data, we consider the whole revision history of the different manuscripts (all modifications performed to any pad used in the experiment), and of course the resulting final texts. Each modification is stored in the database of the service, using a variation of operational transformation protocol. [3] The stored format is a compact representation of the 6-tuple (pad, edit type, range, new content, author, time), where edit type is one of addition, change or deletion. The range identifies the position in the existing text where modification takes place. An instructive example of the data format and transformations for adding text “moi” by one participant, followed by removal of the same text by another participant within one second, is shown in Table I.

<table>
<thead>
<tr>
<th>Pad</th>
<th>Edit type</th>
<th>Range</th>
<th>Content</th>
<th>Author</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Addition</td>
<td>1-3</td>
<td>“moi”</td>
<td>g.1234</td>
<td>129967772443</td>
</tr>
<tr>
<td>A</td>
<td>Removal</td>
<td>1-3</td>
<td></td>
<td>g.2345</td>
<td>1299677727034</td>
</tr>
</tbody>
</table>

TABLE I
DATA TYPES USED FOR ANALYSIS OF REVISION HISTORY OF OPERATIONAL TRANSFORMATIONS WITH INSTRUCTIVE EXAMPLES.

<table>
<thead>
<tr>
<th>Pad</th>
<th>Userid</th>
<th>Name</th>
<th>Time</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>g.ckfu9wedjy010bkhf</td>
<td>Jonne</td>
<td>129967772443</td>
<td>Here goes, ok</td>
</tr>
<tr>
<td>A</td>
<td>g.zdnuduffd5z748ms</td>
<td>Osama</td>
<td>1299677730398</td>
<td>NOT ok</td>
</tr>
<tr>
<td>A</td>
<td>g.zdnuduffd5z748ms</td>
<td>Rambo</td>
<td>1299677744129</td>
<td></td>
</tr>
</tbody>
</table>

TABLE II
DATA TYPES USED FOR ANALYSIS OF CHAT WITH INSTRUCTIVE EXAMPLES.

In addition we consider the chat discussions held during the writing process as our primary data. There are 18,676 messages in the following 5-tuple format: (pad, userid, name, time, message). The userid is the service’s construct to keep track of users who change their name during or between sessions. Unless one removes the cookies stored by their browser profile, the userid changes only if a user changes the browser or the account (i.e. the computer). Thus, we expect to see somewhat more than 21 userids, assuming some pupils to use other computers available to them in the school, at the library and home or through friends. The name field contains what the pupils have put in there, and the message is obvious. The service records time using millisecond granularity, for technical purposes, and the timestamps are synchronously.
assigned by the server, greatly facilitating analysis of events later. An instructive example chat is shown in Table II, where user with name “Jonne” sends a message “Here goes.”, followed by user with names “Osama” and “Rambo” sending more messages (note that it is the same user, but a different name).

V. ANALYSIS

We first present analysis of the distinct constructs in the system: user names, team differences, use time patterns and language. That is followed by study of the editing of the manuscripts and how those characterize the uses of the system.

A. Names

As pupils build their online identities, we first look at the names they have chosen to represent themselves. Our data consists of 65 userids 3, and 109 unique names chosen by the pupils. The names include playful variations on the pupil’s name or nick name, a few jokes on general issues or other pupils, and a few mistakes (messages typed into the name field and keyboard-banging gibberish). At most only a few messages have been sent under humorous or mistaken names, emphasising the importance of an online identity. Some names are clear indications of a more established online identity (proper names other than one’s own, consistent mispelling of one’s own name), but as we do not control for the pupils’ use of other online services, we can not distinguish whether these names were specific to this experiment. In total 31 messages have been sent without a name: mostly salutations, a few indications of continuing a discussion from a different computer (presumably forgetting to set their name there) and one where the user clearly wanted to cloak their identity.

B. Teams

The 14 teams produced different kinds of manuscripts, for example some were shorter (in particular those to be performed by second graders), others had more music and lyrics than dialogue. The teams also used chat in wildly different proportions. The team most actively using chat submitted altogether 73% of all the messages (13,688 messages). This was, however, mostly due to 10,013 messages sent on two consecutive days and can be characterized as highly repetitive (one team member called it “spamming”). Our further analysis accounts for this noticeable skew by removing the messages, unless otherwise noted.

C. Time

The schedule of the school had allocated two one-hour weekly sessions for the teams to work on the project: Mondays 9am to 10am and Fridays 11am to noon. The actual usage during nine weeks of more intensive work is shown in Figure 2. On the x-axis we show 61 most active days from near the start of the experiment (a Tuesday). On the y-axis we show 18 hours of the, from 6am to midnight, and no activity happened during night. The shade of each slot corresponds to the amount of text edits according to the scale on the right. One distinctive feature is the dark cluster towards the right side, a time during which the pupils had more opportunities to participate in the writing instead of going to regular classes. After this period the activity levels dropped, as the performing groups started rehearsing the manuscripts, and only very occasional writing or chatting activity was observed. The darker slots of the mandated sessions at Mondays 9am are quite distinctive and easy to spot, the Friday sessions perhaps less so.

In Figure 3 the amount of chat messages during the same 61-day period is shown, along with the summary number of chat messages according to the hour of the day to the left of the labels. Again here we can see the effect of the mandated sessions, with some activity seeping to succeeding hour, and also more frequent chatting after the end of the school day at 2pm. Chatting commences during rest of the afternoon and in the evenings, but in very low numbers, totaling only 83 messages after 4pm during the whole experiment.

We summarize the weekly activity in Table III for the number of chat messages and text edits. Here we see a pattern of use, where there is clearly more activity on days immediately preceding the mandated sessions (Sun, Thu) than on the other “free” days (Tue, Wed, Sat).

D. Chat Contents

The manuscripts were written in Finnish, as that was the language of the musical performance. Also the chat is overwhelmingly Finnish, but we can also detect some English use, mostly words within otherwise Finnish discourse, and occasional complete sentences in English, for example song lyrics. Before analysing further the content, we must note that at several occasions the pupils have used really short messages (one character or slightly longer), to annoy others (judging by the pleas to stop), perhaps to hide what is visible on the screen (embarrassing or otherwise questionable earlier discussion, for example, swear words or name calling), and very likely out of reasons related to boredom or procrastination. As is typical for unrestricted chat [10], we detect a lot of intentional (and unintentional) mispelling, inventive use of letters and other orthography simply for visual or other effect and experimentation on the limitations of the system and the social setting it provides. For example, the longest word we witness has 513 characters.

<table>
<thead>
<tr>
<th>Day of the week</th>
<th># Messages</th>
<th># Transformations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>1612 (4948)</td>
<td>6966 (19799)</td>
</tr>
<tr>
<td>Tuesday</td>
<td>10</td>
<td>1070</td>
</tr>
<tr>
<td>Wednesday</td>
<td>18</td>
<td>5661</td>
</tr>
<tr>
<td>Thursday</td>
<td>2088</td>
<td>12009</td>
</tr>
<tr>
<td>Friday</td>
<td>558 (1092)</td>
<td>4670 (9727)</td>
</tr>
<tr>
<td>Saturday</td>
<td>17</td>
<td>2664</td>
</tr>
<tr>
<td>Sunday</td>
<td>484</td>
<td>5648</td>
</tr>
</tbody>
</table>

3 Of those 65, seven contributed only a single message: six salutations and one lament about an approaching deadline.
letters, there are 790 messages (9% of all) that do not contain any letters or numbers, consisting solely of white space and punctuation (question and exclamation marks, smileys, dots and so on) and even after removing all letters and numbers, white space and punctuation there are still messages containing of arbitrary Unicode characters, the non-combined tremata (U+0308) being most popular such character.

In Table IV we have summarized information about the chatting and editing activity of individual teams. Team names are anonymized to protect the privacy of the pupils. In the column #Messages the total number of messages per team sent is shown and in column Entropy a measurement on the complexity or non-repetitiveness of messages is shown, in columns > 10 min and > 30 min the co-occurrence statistics between chatting and editing, and in column Entropy a measurement of the repetitiveness or complexity of the messages.

The entropy measurement is indicative of the content complexity. For example, a string of messages that is repetitive in nature, has little entropy. As there are lots of very short messages, we report only entropy for the entirety of a team’s chat. More specifically, instead of calculating the actual entropy

\[
H(X) = - \sum_{i=1}^{n} p(x_i) \log_b p(x_i)
\]

directly from our chat data by assigning the probabilities \( p(x_i) \), we approximate it with a compression method, based on run-length encoding and Burrows-Wheeler transformation.
TABLE IV
TEAM-WISE USAGE SUMMARIES: TEXT EDITS, MESSAGES AND CO-OCCURRENCES WITHIN SPECIFIED TIME LIMITS.

| Team | # Edits | Avg. $|\text{Edit}|$ | # Messages | Entropy | $>10\text{ min}$ | $>30\text{ min}$ |
|------|---------|--------|-----------|------------|---------|----------------|----------------|
| A    | 5946    | 28.2   | 51        | 13         | 13      | 13             | 13             |
| B    | 393     | 34.2   | 5         | 0          | 0       | 0              | 0              |
| C    | 3528    | 26.9   | 26        | 2          | 2       | 2              | 2              |
| D    | 5512    | 26.3   | 79        | 19         | 17      | 17             | 17             |
| E    | 4583    | 23.5   | 13688     | 0.98       | 3285    | 32             | 32             |
| F    | 1962    | 31.3   | 18        | 11         | 11      | 11             | 11             |
| G    | 3797    | 31.6   | 201       | 3.66       | 13      | 3              | 3              |
| H    | 1658    | 22.0   | 2121      | 2.46       | 201     | 76             | 76             |
| I    | 473     | 21.2   | 34        | 2          | 2       | 2              | 2              |
| J    | 3125    | 27.2   | 544       | 3.09       | 46      | 13             | 13             |
| K    | 1578    | 25.3   | 36        | 1          | 1       | 1              | 1              |
| L    | 11293   | 29.1   | 863       | 3.34       | 458     | 320            | 320            |
| M    | 8354    | 27.6   | 853       | 3.14       | 348     | 205            | 205            |
| N    | 9004    | 32.0   | 156       | 4.56       | 29      | 0              | 0              |

The approximate method adds extra data to the result and we restrict from showing results for teams which sent less than 100 messages. For reference, our method gives 1.93 bits per byte of entropy for the Finnish 1992 Bible. The messages sent outside editing sessions (i.e. those in the third column) have an overall entropy of 3.22 bits per byte, which is in line with the proportion of teams participating and the corresponding entropy of their messages.

The two most active teams by the chat message count have clearly somewhat inflated numbers, as the message entropy is very low (for team E) and relatively lower than others (for team H). Of the remaining five teams, one shows notably higher entropy (team N) than others, indicating further distinction between the teams’ use of the chat.

E. Editing

While the chat provided a support function for the teams and was completely optional to use, the manuscripts were mandatory to be completed on time for the whole project to proceed. Here we consider all the manuscripts as starting from the same initial state and progressing through a number of text edits (in operational transformation protocol) to the final stage. The operational transformation protocol, as described in Section V-B, is able to capture small changes interleaved between the writers as distinct from larger chunks of text either typed manually or copy-pasted by one individual contributor. To capture such differences, we calculate edit length, $|\text{Edit}|$, from the size of the system’s internal representation of the edits. This measure has two drawbacks, namely that (i) the length of the removal edits is much shorter than corresponding additions and (ii) the lengths have minimum size which depends on other variables (mainly, a higher number of users for a specific pad increases the minimum). Despite these, we think this value is representative of the working mode of the team. Overall, the minimum edit length in our data is 7 and the maximum is 4960, while the average for all the teams is 28.8 (median 23).

The editing activity levels are shown in Table IV. The number of edits show more than one magnitude of difference and there are almost three orders of magnitude difference in the number of chat messages, indicating different usage patterns among the teams. There is some indication of correlation between edit lengths and chatting activity, but this result is not significant ($p > .05$) in our data.

For the co-occurrence statistics we consider messages that have been sent 10 minutes and 30 minutes apart from the team’s closest preceding and succeeding edit events. These cutoffs are chosen arbitrarily with the following rationale: the typical recess time is about 15 minutes, so the second column includes chat messages sent during a recess, but without other activity on the pad. The 30 minute cutoff is indicative of relative quiet on the pad (in some cases the distance is measured in days). Interestingly, two teams (L and M) used the chat proportionally much more than others outside editing sessions. These teams were the most active and third most active according to the number of edits.

VI. ISSUES ENCOUNTERED

We look separately at the challenges presented by technology, those arising from the VisciPad service and issues detected in its use, and finally those that can not be directly attributed to either one. The researchers participated on a pad specifically created for questions about the computers. About 30 questions were asked and answered, both in the pad text and in the chat.

A. Equipment Limitations and Problems

The computers distributed to the pupils were not the most powerful available at the time, instead representing technology that was a considered state of the art two–three years prior to the experiment. The form factor was small enough to easily fit even in the smallest schoolbag. The combined weight of the computer and 3G modem was slightly over one kilogram.

4We also experimented with LZ77, which gave considerably higher entropy approximations.
thus it was accessible at different locations and situations effortlessly. Unfortunately the small size also contributed to two problems the pupils suffered from: for many the keyboard was too small to use comfortably, and some poked the touchpad below the keyboard often by accident, causing confusion by activating arbitrary user interface elements.

The 3G connectivity was less than perfect, but as the researchers provided help only through VisciPad, the root causes were not determined. As a typical solution the pupils were instructed to first unplug and reconnect the modem, forcing it to reset the connection. The reconnection step was quite lengthy, typically 30–60 seconds, perhaps adding to the confusion. Also the availability of wireless networks through the internal adapter at both the school and individual homes may have confused either the pupils or the operating system. It is possible that some workflows did not emerge because of problems in the connectivity, and others were possibly invented because of these limitations.

B. Challenges Related to VisciPad

Technical challenges As a preliminary limitation, the pupils were instructed not to participate in great numbers simultaneously on the same pad, due to reliability issues. As the experiment setup was such that there were already teams of two or three pupils, this was not a limiting factor for the actual work. We did not log whether the pupils created new pads or participated on some that were outside those reserved for manuscripts. A problem we encountered was that due to the long names of some pads, they were prone to mispellings and four teams had two or more similarly named pads, which resulted in some confusion. This was simply an oversight on the researchers part, a simple web page linking to the pads would have helped a lot.

Social challenges The chats revealed one prominent problem: some pupils visited the pads of the other teams only to annoy the team members participating there. As mentioned in Section III-C, we did not require authentication to the service. This enabled some pupils also to visit the pads of other teams for inspiration or comparison, but these visits were not logged if the visitor did not actively participate in discussion or writing. We became aware of this happening only when such visits were discussed in the chat. These visits were not mentioned by the pupils, however, the annoying behaviour of others was mentioned as a problem by one pupil in an answer to the questionnaire. Thus we can perhaps conclude that authentication would have been beneficial.

C. Other Considerations

The pupils' use of the computers was not monitored outside classroom situations, the only limitations being what the teachers and guardians allowed. The pupils self-reported to listening to music, watching videos, playing games, taking notes and various other activities in their questionnaire answers.

VIII. Acknowledgements

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REFERENCES


