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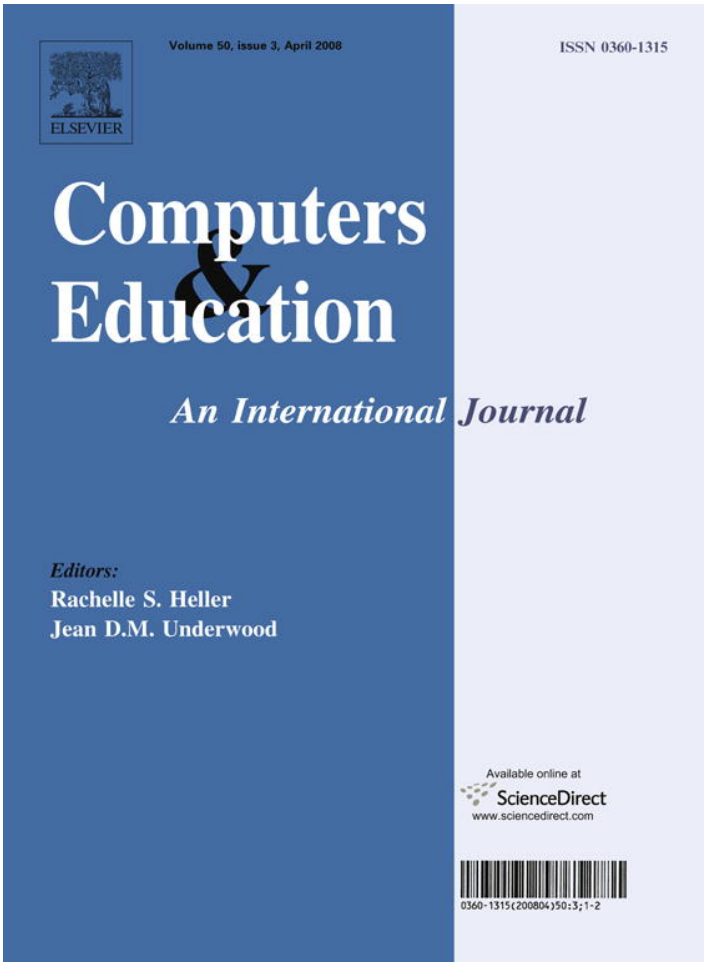

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Free/libre open source software implementation in schools: Evidence from the field and implications for the future

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Abstract

This empirical paper shows how free/libre open source software (FLOSS) contributes to mutual and collaborative learning in an educational environment. Unlike proprietary software, FLOSS allows extensive customisation of software to support the needs of local users better. This also allows users to participate more proactively in the development and implementation process of a FLOSS-based system. In this paper, we observes how implementing FLOSS in an Italian high school challenges the conventional relationship between end users themselves (e.g. teachers and students) and that between users and developers. The findings will shed some light on the social aspects of FLOSS-based computerization – including the role of FLOSS in social and organizational change in educational environments and the ways that the social organization of FLOSS are influenced by social forces and social practices.
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1. Introduction

Many recent studies have pointed out that the relationships between lay and expert, users and developers, knowledge consumers and producers can be greatly challenged in a computer-supported knowledge-based society. Such a complicated knowledge system where mutual learning is a prominent phenomenon can be observed in various sectors (e.g. Hine, 2001, 2002; Millen & Muller, 2001; Tuomi, 2002; von Hippel, 2005). And educational sector is one of them that has been experiencing digital transformation.

In this paper, we observe such digital transformation in schools fostered by the implementation of free/libre open source software (FLOSS). We argue that FLOSS-based educational infrastructure[1] (e.g. Moodle[2]),

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[1] A FLOSS-based educational infrastructure is broadly defined in this paper including open content and open course.
[2] http://moodle.org/

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unlike many other educational institutes that use proprietary software such as WebCT[3] to facilitate the teaching and learning in schools (e.g. Pearson & Koppi, 2002), has greater potentials of stimulating cross-boundary learning, and of shaping the technologies into the desires of users.

Istituto Statale di Istruzione Superiore J.M. Keynes (hereafter 'the Keynes High School' or 'the School'), located in the outskirts of the city Bologna in north Italy, initiated the implementation of FLOSS-based Information and Communication Technology (ICT) to facilitate e-learning in the late 90s'. Given the transparency of the technology itself with openly available source code (Feller & Fitzgerald, 2002; Perens, 1999), the schools not only has the School reduced management costs of existing ICT systems (e.g. licensing fees of proprietary software, the cost for periodical update to fix vulnerability, and the fare for improvement of capability), but this FLOSS-based infrastructure also has enabled software customisation based on the School's specific local needs. Working closely with the technicians and the system designer, the teachers and students at the Keynes High School have also contributed to the construction of the system and the software they consume.

These experiences are valuable for the development of effective environments for learning, and more importantly, they shed light on how FLOSS can be implemented in schools, and benefit both the users and developers. This example also denotes a celebrated chapter about how social actors can take part in the technological development and configure the technologies to meet their demands (Fleck, 1993, 1994). While earlier work on e-learning and Computer Supported Cooperative Work (CSCW) has attempted to use ICTs as effective medium for interactive teaching and learning, few of them have discussed the possibility of including learners and teachers in the design process of the learning technologies. Thus, this paper will be one of the most novel papers about how to design learning technologies with the participation of users in the design process.

2. Research methods

We employ both qualitative ethnographic observation (Silverman, 2004, 2005, 2006) and participatory action-oriented research (Baskerville & Pries-Heje, 1999; Baskerville & Wood-Harper, 1996; Miskovic & Hoop, 2006) methodologies for this study. The former is to get a fuller picture of what users at the field actually do (instead of using prefabricated quantitative questionnaire to collect user requirements), and the latter is to reflect what we have observed and translate that knowledge into useful information for further development of the school ICT infrastructure.

The second author was a student at the Keynes high school 15 years ago, and is now both the developer of the system and a teacher of computer courses. His multiple roles as a student, a teacher, and developer of the ICT system have given him an opportunity to see the use of new technologies in education from a variety of perspectives. His experience of being a student there made him informed of the history of computerisation in the Keynes High School. This is helpful in two ways: (1) the developer can have a better understanding of the capability of the users without imposing too many challenges on them; (2) discrete ICT development could be avoided without having to revamp the system radically. His teaching role allowed him to have more frequent interactions with the users of the system (i.e. the students and other colleagues). Altogether these experiences in turn served as valuable information for him to understand the user needs better, and then he could take actions of evaluating the existing system, planning and developing the next version.

It was noted that the process of getting feedback from users through teaching and talking with the users, and taking actions to revamp the system was a contingent and recurrent loop. During our research course, the second author was aware of the co-shaping relation between his teaching and system development activities. Having involved in both teaching and system development activities makes it easier for him to observe and investigate the learner/user perspectives on e-learning, rather than simply replicating the general promising functions envisaged by normal system builders/providers.

Participatory action research is often criticised of being too operative, too flexible, and too situated to be turned into consistent research results. In order to more systematically document and conceptualise these experiences, the two authors decided to conduct an in-depth case study enriched by multiple sources of data

[3] http://www.webct.com/

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(Yin, 2002). Alongside the second author's participatory observation, we employed other qualitative research methods including content analysis and (unstructured and informal) interview. We use qualitative analytical tools to interpret the documents (e.g. students' and teachers' on-line discussions and off-line presentations and reports) and informal interview with the students, teachers and technicians.

The first author's role in this project is of peculiar importance. She joined the research project as an 'objective outsider' to help analyse and interpret the second author's fresh and first-hand accounts of what happened. In the process of co-authoring this paper, the practitioner-researcher (i.e. the second author) was given an opportunity to step back to reflect and share his decision-makings and experiences of designing architectures for educational technology system and planning learning and teaching strategies. In so doing, we attempt to bridge the limitations of the action research approach, bringing the practitioner-researcher back to the academic world through viewing the 'consulting-type performance' of the practitioner-researcher from an analytical perspective (Baskerville, 1999).

3. The Keynes High School and its information system

3.1. The Keynes High School and its information system

The Keynes High School is a cluster of different high schools with distributed campuses located in a district in the city Bologna including a scientific lyceum, a technical business high school, a geometer technical high school and a tourism-oriented professional high school.

Currently the school has 6 computer labs with 140 computers and 4 servers (based on the GNU/Linux operating system) supported by 5 technical staffs to serve 607 students, 96 teachers. The 4 Linux servers provide services such as routing the laboratories to the Internet, firewall with possibility of isolating different computer rooms in case the Internet is not in use, LDAP[4] centralised user management, file sharing including shared space and personal space and desktop accessible from every computer, DHCP[5] services, local Debian mirror for faster upgrading of Linux machines, web server with school portal, school wiki and personal web space for teachers and students, webmail, mail server with virus scanning and spam filtering, mailing list services, IMAP[6] server, print server, HTTP proxy cache[7] to speed up the lessons where 20–30 computers connect to the same website at the same time. Some facilities, such as the webmail or internal communications, are also available remotely from home (see Table 1).

Amongst these six computer labs, four of them are located at the Castel Maggiore campus and the other two are located at the San Pietro in Casale campus. Amongst those four labs at the Castel Maggiore campus, one is with Linux-only thin clients[8] with recycled old computers; one can boot either Linux thin clients or an old stand-alone Windows 98 operating system;[9] the other two are dual boot Edubuntu Linux[10] and Windows 98. Both labs at the San Pietro in Casale campus are Windows-only. Although Windows remains to be a major operating system at the Keynes computer labs, all computers are installed with OpenOffice.org (a FLOSS office suite composed of a word processor, spreadsheet, presentation, database applications, equivalent to Windows Office), Firefox browser, Thunderbird mail client, and nvu (a web authoring application which is the successor of Mozilla Composer).

[4] Lightweight Directory Access Protocol, a powerful system to centrally manage user accounts and to provide a shared user directory across a network.

[5] Dynamic Host Configuration Protocol, allowing any computer to be plugged into the network and work without any further configuration.

[6] Internet Message Access Protocol, allowing users to access their mailboxes from everywhere in the local network and also, through the Internet, from outside the school.

[7] A system that makes multiple accesses to a same web page faster by saving a local copy of the page. It is very important in a school where it often happens that all the students in the lab are directed to the same web page, and it also helps to optimise the use of network bandwidth, which is still a limited commodity in nowadays Italy.

[8] A thin client is a computer (i.e. client) in client-server architecture networks which depends primarily on the central server for processing activities.

[9] A stand-alone computer means a computer that is not on a network.

[10] http://www.edubuntu.org/

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Table 1
Comparison between the pre- and post-FLOSS implementation at the Keynes High School

	Pre-FLOSS implementation	Post-FLOSS implementation
Hardware	In year 1996, the School was equipped with 3 labs with 50 computers all with Windows operating systems.	In the mid of year 2006, the School was equipped with 2 labs with Windows-only machines, 3 labs with dual boot Linux and Windows, 1 lab with Linux-only thin clients (recycled hardware)
Software	Windows operating system, Microsoft Office, Internet Explorer only in all labs; not all software was licensed;	All computers with OpenOffice.org, Firefox Browser and nvu (web authoring application, the successor of Mozilla Composer) installed; all software is licensed, including proprietary software
Teaching materials	Hardcopy textbooks, proprietary e-learning applications e.g. *Derive* (for studying math functions), proprietary software development tools e.g. *Turbo Pascal*	Some proprietary software such as *Derive*is still in use, but teachers start to use open content on the Internet e.g. Wikipedia, FLOSS e-learning applications e.g. *Analysis* (for studying math functions), FLOSS software development tools e.g. *FreePascal/Lazarus*
Management	Decisions are made by the Institute Council, composed of the head of the school and representatives from teachers, students, technicians, parents and the rest of the staff	No change
Expenses	Higher software license fees	Largely reduced license fees, and the budget saved has been invested in updating infrastructure and acquiring new hardware and know-how
Pedagogical dynamics	Teachers provide authoritative teaching/learning materials	Students could be involved in producing the teaching/learning materials (e.g. contributions to wikipedia), students and teachers could share views via weblog
Relationship with the outside world	Few interactions	Collaborate to contribute to FLOSS projects, share experience with students from other schools, web authoring
Rate of software piracy	High	Approaching zero: proprietary software is not essential any longer for most school tasks and the school legally provides a CD to teachers and students containing all free software they need
Digital literacy	Low	Improved – students can adjust to a variety of different applications to complete tasks, and they can voice their views on the Internet actively (although the latter might be tied to a more generic Internet phenomenon in today's society)

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3.2. ICT management in the Keynes High School

In Italian schools, the Institute Council, composed of the head of the school and representatives from teachers, students, technicians, parents and the rest of the staff, is the decision-making body for school information systems. They then delegate the decisions to the staff managing the information system. At the time of this writing, the teacher for Italian, Latin, History and Geography Mrs. Daniela Volta was the one in charge of the ICT infrastructure at the Keynes High School. She worked with three full-time technicians (and sometimes with external consultants).

ICT-related decision-making in Italian schools are mainly limited by two factors: budget and digital literacy. Budget in Italian public schools is normally limited, but the main obstacle in ICT choices is the limited digital literacy of the decision makers, who tend to fallback choosing mainstream products in the market rather than what is really needed by the school. Because many alumni are involved in computer industry, the Keynes High School seems to endow with higher than average ICT know-how from its social network. Some alumni work as external consultant for the School. The School enjoys a reputation for good management of school information systems. Budget has been used wisely and efficiently for acquiring a wider range of software and (sometimes) taking a pioneer role (in Italy) experimenting with new technology. As a result, for instance, given that the Keynes High School is very equipped with GNU/Linux machines and experience with Linux teaching, it has been chosen as a test centre of the European Computer Driving Licence (ECDL) doing Linux-based ECDL training and testing.[11]

3.3. Linux migration at the Keynes High School

The computer laboratory has been established since 1985 to support computer lessons in the practical business courses, and the initial equipment of Olivetty M20 has been slowly upgraded and expanded. FLOSS was introduced to the School in summer 1998, when the technicians decided to try and install Linux on a testing computer. At the beginning of 1999, a Linux server was deployed to share the dial-up internet connection and provide shared disk space over the network. The server has kept continuously upgrading since then, partly due to the needs of the school (such as working as a print server) and partly due to the interest of the technicians to learn and experiment with new technology (such as installing a web server and CMS,[12] or a VPN[13] across the two campuses).

In 1999 the school was given a budget of about 35,000,000 lire (ca. 18075 euros) to buy Microsoft Windows Office licenses for a new laboratory.[14] Since the school staff had already experience with Linux and FLOSS, facing such a big cost, the school decided to try other office replacements. At that time, Sun had just acquired Star Division and released Star Office 5.1 under a FLOSS license. So the school decided to install Sun's Star Office (which later on became OpenOffice.org), instead of Microsoft Office, in the new laboratory.

This migration decision encountered a strong resistance from many teachers, who feared of having to be re-educated to acquire new skills. The students, instead, had few problems with the change. The migration experiment ended up in a bargain, where only about 13,000,000 lire (ca. 6710 euros) were spent on Microsoft Office licenses. The rest of the budget was used to buy new hardware.

3.4. FLOSS and teaching/learning strategies at the Keynes High School

Traditionally, ICT training in Italian high schools has been an optional rather than a compulsory part of the curriculum. Meanwhile, ICT does not normally belong to the teacher skillset, except when it is the core of

[11] European Computer Driving Licence is a standard certification for computer end-users. Certification of ECDL test procedures and training centres is delegated to different local organisations in each country. In Italy, it is the Italian Association for Automatic Calculus (AICA). In October 2003, AICA released the specifications for Open Source versions of all the training modules. These are based on KDE (2 or 3), OpenOffice.org 1.1, Mozilla, Evolution, and MySQL. According to NewsForge, at the end of year 2004, 237 Italian test centres offer these modules (Fioretti, 2005).

[12] Content Management System: a system that makes it easy to collect, organise and present multimedia information over the web.

[13] Virtual Private Network,allowing secure interconnection of different separate local networks across the Internet.

[14] At that time, the budget to buy hardware for a brand new laboratory was around 30,000,000 lire (ca. 15500 EUR).

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their teaching topic, as is the case with text processing or basic Pascal programming. Some teachers do try to learn extra IT skills, either on their own or through some small school-funded training: the most common of these extra IT skills is web authoring, which enables teachers of humanities to teach students how to present their work as a website as well as an interactive CD.

After the installation of Star Office, new FLOSS-related services were deployed in the servers and the school staffs started to have more contacts with the developers' community. With the increasing awareness about FLOSS, the school started to learn how to utilise the FLOSS-based infrastructure they have built – not only passively use the system but also more proactively participate in the design and development process. The concept of user inclusion in participatory design has been gradually grounded in Keynes High School. For instance, they started to have students moderating mailing lists to provide mutual help. The mailing lists were also an open list which is publicly accessible, thereby prospect students could subscribe to the mailing lists and ask about the future school environment. Through the communication on the mailing lists, not only could prospect students start having contacts in the social network they were going to be a part of, but the moderators – the senior high school students – could also have more advanced computer experience of moderating and facilitating an on-line community.

Using FLOSS at school also helps reduce software piracy. The students were issued a Compact Disc (CD) with the applications used at school (e.g. OpenOffice.org, Mozilla Composer, Free Pascal) to install in their home computers. Students could also download them legally from the Internet. They learned not to pirate proprietary software if they did not pay licence fees. They also learned that there could be alternative applications for completing the same tasks (e.g. instead of using Windows Office to write an essay, OpenOffice.org Word Processor is equally useful). In so doing, the students experimented different operating systems and software applications. Such pedagogical experience was expressed in one of Mrs. Volta's talks.[15]

In using free software, our students realise that working with computers does not mean working with a single software. [...] They understand that it is possible to switch easily from one software to another [to complete a task]. When sitting in front of computers, they do not search for "Word", but they look at what software is installed and what can be useful to them.

Apart from starting implementing open source technologies, open contents, which share the same philosophy with the FLOSS movement, were also employed in the daily teaching and learning. The teachers and students started to use information on Wikipedia[16] for extensive teaching/learning materials. Meanwhile, some of them also contributed to translating webpages on Wikipedia or adding new contents to the on-line encyclopaedia shared openly by Internet users around the world. That said, through localising online resources, the teachers and the students at the Keynes High School are included in and participating in a globalised digital world.

Furthermore, a FLOSS-based educational infrastructure encourages the teachers to reconsider their teaching materials and adopting free contents rather than strictly copyrighted ones. For instance, the materials used for teaching Pascal programming have been switched from Turbo Pascal (running mainly on Microsoft Disk Operating System (MS-DOS) and developed by Borland) to FreePascal/Lazarus (released under the GNU General Publica License (GPL) and runs cross-platform including Linux, Win32, Mac OS/2).[17] For teaching and learning mathematical functions, alongside the existing computer program *Derive*,[18] a proprietary software owned by the company Texas Instruments in the USA for doing symbolic and numeric mathematics, the math teachers at the Keynes High School were considering introducing another FLOSS alternative application named *Analysis*.[19] Equivalent to *Photoshop*,[20] the free software *GIMP*[21] is also installed in the school computers. Overall, one main point in the School's ICT teaching and learning strategy is to provide users with

[15] This paragraph is translated from Mrs. Volta's presentation at the seminar 'Software Libero – Un'opportunitá per la pubblica amministrazione e il sistema economico regionale', June 16, 2003, Emilia Romagna Regional Administration.
[16] http://wikipedia.org
[17] http://www.freepascal.org/ and http://www.lazarus.freepascal.org/
[18] http://www.derive-europe.com/
[19] http://www.geocities.com/leibowitz.geo/analysis_en.html
[20] http://www.adobe.com/products/photoshop/
[21] http://www.gimp.org/

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alternative FLOSS applications for more flexible use (e.g. in case the students and teachers would like to use them at home or share with or redistribute to other people).

The information system at the Keynes High School fosters a greater learning environments for both students and teachers at the Keynes high school with more interactive activities locally and globally, and more importantly, with the FLOSS-based educational infrastructure, the school members are empowered to shape and contribute to the technological design and implementation potently. Their participation in the design and knowledge-making process changes not only the relationship between users and developers, but also that between students and teachers.

In the following, we will present a couple of examples how their uses of FLOSS-based technologies transform local pedagogical and computer usage experiences, understandings and social formations. We will focus on particular digital practices – developing the OpenOffice.org Italian thesaurus and creating a school weblog – and analyse representations of these technologies in discourses.

4. Two examples of collaborative learning

4.1. The OpenOffice.org Italian Thesaurus

Hitherto, we have described the current computer-supported learning environment at the Keynes High School and the motivation for them to switch to a FLOSS-based educational infrastructure. Additionally, open contents are also employed in the daily teaching and learning. Both open source technologies and contents on the one hand enable the teachers and students to take more active part in the technological design and implementation process and on the other hand also shape their learning behaviours and activities. In so doing, technological design and pedagogy have the potential of being integrated and co-evolving in the new medium (Bruckman, 2003). This is illuminated in the following case on OpenOffice.org.

OpenOffice.org is an open source office software suite for processing text documents, spreadsheets, presentations, drawings and databases. The language customisation of this software usually is developed and maintained by a local community of volunteers, though Sun Microsystems Inc. provides occasional funding for the OpenOffice.org project. The Progetto Linguistico Italiano Openoffice.org (PLIO), the Italian OpenOffice.org project, develops, maintains and distributes the localised Italian version of OpenOffice.org. And the source code is freely available for interested people to download, modify, study and redistribute.

In year 2004, students of the class III H (26 3rd grade 16-year-old students from the Scientific Lyceum branch of the Keynes High School amongst whom 21 were female and 5 were male) were asked by their Italian teacher, Mrs. Volta, who was also responsible for the computer infrastructure, to write up synonyms and antonyms as an outcome of learning linguistic and lexical skills. Because the OpenOffice.org they were using did not have an Italian thesaurus, the teacher thought it would be a good idea to collect students' work on synonyms and submit it to the Italian OpenOffice.org development team PLIO as an enhancement.

However, bringing students into the development of free software requires some basic training. To prepare the students to work on a FLOSS project, the second author was invited to give an introductory lesson about the concepts and mundane practices of developing FLOSS. The lesson also included a short history of the OpenOffice.org project as a background to improve students' understanding of the free software project they were going to get involve. The students at the Keynes High School contributed the vocabularies starting with letters A and B. This work attracted other people outside the Keynes High School to help, including students from other high schools and users from the wider Internet world. Later on, Mrs. Volta collected, edited and coordinated all the collaborative work, and handed it over to the second author to package as a software application. And then the packaged software was uploaded in the Debian GNU/Linux system and can be picked up by other FLOSS developers (e.g. the OpenOffice.org project).

The creation and development of Italian OpenOffice.org thesaurus shows active cross-boundary learning and developing activities based on social networking and mutual support. Because of the teacher's link with other high schools, she can call more people to participate in this project. Students, crossing the school boundary, contribute their learning results to one of the biggest FLOSS projects in the world that can be used by many others coming from different social worlds (Strauss, 1987). Drawing on heterogeneous knowledge from diverse actors, the thesaurus of the Italian OpenOffice.org resembles a boundary object (Star, 1989) that has

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been and will be constantly shaped by people who share the software. The construction of the technological artefact (i.e. the Italian OpenOffice.org thesaurus) embeds and embodies students' learning experiences and results. Technological innovation is no longer just within the strong expert-led industrial-supported research environment; learning is no longer just within schools. Instead, this case shows how learning is fostered by a 'community' (Lave & Wenger, 1991) including diverse actors travelling across multiple boundaries and users play an eminent role in the development and implementation process.

As written in the Debian package documentation *openoffice.org-thesaurus-it*, the students reflected what they have learned: 'This experience shows that in the school it is possible to adopt an active and experimental approach to the computer technologies, with the aid of competences concerning different subjects, in this specific case of the Italian language.' Such interactive, community-based and cross-boundary learning proves to be more effective than other one-way passive Internet-based learning with websites providing course resources (text, graphics, maybe audio, video). It also entails that such a learning community based on FLOSS technologies is more dynamic. It is worth noting that further studies are required in order to understand why some tools are chosen over others, and how are they implemented in a context determined by the teachers, the subject matters, and the social, cultural and political environment of the institution.

4.2. Weblog: A collaborative instrument

The weblog is another facility that fosters a collaborative learning environment at the Keynes High School. Moreover, it also shows how students build both the learning community and their collective identity based on the shared learning experiences.

The initiation of the Keynes weblog was motivated by two main reasons. The first reason was to provide a platform for interactions. Students come from various backgrounds and therefore have various learning styles. Their knowledge is heterogeneous, dynamic and situated (Gomez, Bouty, & Drucker-Godard, 2003; Lave & Wenger, 1991). It would be effective if their different knowings and learning experiences can be shared through the rapidly developed ICT (Abrioux, 1989).

The second reason was to raise students' ''electracy'', a new form of literacy in a digital era (Ulmer, 2003). One of the objectives of the new media education at Keynes is to help students to reflect critically on their media experiences, telling what they have seen – rather than just absorbing media messages passively and unconsciously. To develop digital literacy in schools, the Keynes High School initiated a new module on ICT covering issues such as how to provide and present information on the Internet. The pedagogical meaning behind this is to construct students' self identities in an era of mass media through filtering a massive amount of information they get everyday and reflecting their relations with dominant discourses and institutions. This will teach students to be neither passive information receivers or disinterested knowledge consumers. Learning basic web authoring skills enable them to play a more active role in the Internet-based Society.

Twenty-four second grade students from the Scientific Lyceum branch of the Keynes High School (22 of them were female and 2 of them were male) took the module. In the class, examples such as Internet news websites Slashdot.org or Indymedia.org were presented to the students. Moreover, as a practical ground for experiencing independent information providers, a FLOSS-based weblog infrastructure using technologies such as pyblosxom[22], apache[23], planet[24], weblog-add[25] was set up in early 2005.

This weblog system can aggregate all individual blogs of students and staffs automatically and turn them into a community blog (e.g. a class blog collecting all teachers and students' blogs from the class II H, and a school blog collecting all blogs of staffs and students). In so doing, information collected from different sources and contexts can be rearranged and presented for different purposes and shared amongst wider interested audiences. Compared with other Internet technologies, this blog system contains the following advantages:

[22] http://pyblosxom.sourceforge.net/
[23] http://www.apache.org/
[24] http://www.planetplanet.org/
[25] http://pyblosxom.sourceforge.net/blog/registry/input/weblog-add

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1. With a simplified interface, the blog is comparatively easier to use than web pages or wiki pages because the weblog only allows posts in plain text, and then the content will be automatically edited, displayed and archived. Before applying this means, a careful evaluation of the educational needs in a specific situation has been made (Fox, 1998; Huysman & de Wit, 2002). Without many fancy features, this means is truly customised for the users' requirements and thereby the technologies were less likely to discourage participation of teachers and students (Dougiamas, 1999; Dougiamas & Taylor, 2003; Shirky, 2004). In this sense, the school did not just blindly accept any 'cool' new technologies; the School has acted as a smart consumer knowing how to choose the most suitable software for its local needs.
2. Unlike on-line forums, no topic needs to be assigned on a blog for discussion. The interface was clean and easy; users could insert free text not bound by pre-given format. Thus, users are offered great freedom (except for the rule that the blog is not used to insult people) expressing themselves in whatever content, and whatever style they want.
3. Unlike a mailing list that can be exclusive to a closed group, a weblog is universally accessible by any user on the Internet. The information can be disseminated further and network more actors (including information providers, mediums and receivers).

It is worth noting that this technique of linking different blogs together was technically trivial (easy and simple), yet socially very effective. It is also a common practice amongst FLOSS developers to create an aggregation of the blogs of all the developers working on the same project (e.g. Planet Debian for Debian GNU/Linux[26]; Planet Ubuntuix for Ubuntu GNU/Linux[27]). The technology was introduced to the Keynes High School because the developer (who is also the second author) was an experienced Debian FLOSS developer and deeply connected with the rest of the FLOSS community. Conforming to this common practice in the FLOSS community embodies the link between the local (the Keynes High School) and the global (the wider FLOSS community). The creation of Planet Keynes[28] with the blogs of everyone in the Keynes High School fosters a greater learning community where mutual learning takes place not only between students themselves but also between students, teachers and technicians.

For example, when learning about a Greek epic poem, one student had been posting the lyrics of a pop song that was inspired by this ancient Greek poem onto the class webblog. The teacher indicated in her follow-up message that this lyrics would be discussed at the next lesson for drawing parallels between ancient narrative artwork and modern pop music. In this case, the teacher learned from the students about the current teen culture. In sharing the lyrics, it shortened the gap between the teacher and the students. Being applied in the teaching in the class, the information shared on-line had become useful materials to reflect something taught in the textbook, and common topics shared amongst the teacher and students. This instance illustrates how ICTs are used to integrate the physical off-line life and the digital on-line life, and more importantly, to motivate the students to reflect and share what they've learnt with each other and the rest of the world. Such a community-based blog system not only enhances peer-support but also hinders the hierarchy in a traditionally educational environment where teachers own the power to deliver knowledge and students passively receive the information given. Their involvement in virtual space also bridges learners around the world. Moreover, although not yet prominently observed, the technicians could also learn from the activities of their users and design better devices and services for them. A learning community with active exchanges between diverse actors thus is built and so is their collective identity based on the shared learning experiences.

Another observation acquired from the implementation of weblog technology was related to the maintenance and the feature of FLOSS. The system designer, who is also the second author of this paper, had been paying extra attention on minimizing the divergence of the customised software from the upstream parent project for easier maintenance and better integration. He also created new features to automatically install (and mass-install) the pyblosxom weblog in any user's webspace. The bugs found and fixed in the customisation and implementation process together with the new features added were reported back to the original developers of the parent project. Since this is the first of such a FLOSS-based weblog system implemented in a school,

[26] http://planet.debian.org/
[27] http://planet.ubuntu.com/
[28] http://keynes.scuole.bo.it/planet/

Author's personal copy

a documentation[29] was also produced to share this experience of customising and implementing FLOSS-based weblogs at schools. This confirms the function of connecting the local users community with the global.

5. Conclusion and future research

Throughout the paper, we have introduced the story about implementing cost-saving and effective FLOSS-based technologies in the Keynes High School. This system not only fosters a local learning community integrating the physical school and on-line learning environment, but also bridges the local knowledge-sharing and learning with the global Internet society. We also show that development and implementation of ICT in schools is a socio-technical process involving interactions between diverse actors (e.g. users, developers, and decision-makers) and artefacts. We have presented two eminent examples showing how FLOSS-based technologies improve the current e-learning technological development in encompassing both students and teachers in the development process at the Keynes High School. The first example is the usage of OpenOffice.org, one FLOSS office suite. Apart from being software users, the students are also developers contributing their lists of Italian synonyms to the Italian thesaurus. In this process, the students not only learned Italian synonyms, but also actively participated in the free software development and made contact with the outside world. Their learning across the boundaries between users and developers brings socio-technical dynamics into both the free software development and school education. Another example on using FLOSS-based weblog technologies also shows how on-line knowledge-sharing subverts the traditional power relationship between teachers and students in an educational environment, and empowers all actors to learn from each other. Software bugs found and new features developed in the customisation and implementation process were also reported back to the software developers of the parent project.

To sum up, the Kenyes High School benefits from the FLOSS development for having cost-saving and customisable e-learning software, and the FLOSS development benefits from the Keynes High School for having users feedback and contributions. Compared with similar proprietary software, the FLOSS technologies can be tailored to suit the users' specific requirements and therefore empower users to play a more participatory role in the design process.

In this paper, we have examined the highly dynamic and socially complex processes of collaborative learning at the Keynes High School bolstered by the FLOSS-based technologies. We have also investigated the changed role of teachers and students in such a community-oriented educational settings from an integrated socio-technical perspective, taking socio-cultural processes as well as technical infrastructures into account. Moreover, FLOSS could serve as an effective way of raising and improving digital literacy through actively including users in development and implementation processes.

However, we have also observed some phenomenon that require further studies. For example, we found that not every student had dedicated the same amount of time to blogging, and that the teacher played an important role of leading, making decisions, and motivating students' learning activities on-line in the uptake of the FLOSS technologies. Once the involved students graduated and the teachers retired, the FLOSS implementation might not be sustained. To get a better understanding of the impact of such temporality in a FLOSS-based learning community, consistent investigation is needed in order to understand how the experience earned with a long period of blogging can be leveraged, how shared interests can be built and enhanced amongst all participants, and how to motivate students to continue blogging and involving in the FLOSS development after graduating from the high school. Additionally, in the future, we are also expecting to study whether implementing FLOSS and using non-proprietary data formats indeed helps teaching pupils about exactly how computers operate, making them learn about the formats and the tools by letting them experiment (Marson, 2004). Finally, we would like to strengthen that such an implementation process should never be considered as smooth and straightforward as socio-political factors (particularly human factors) are always involved in the implementation process (such as the resistance and disfavouring of some math and science teachers at the school in the beginning). These socio-political factors should always be taken into account when planning such implementation or future Linux migration in other countries or sectors.

[29] The documentation is available at the Keynes wiki page at <http://keynes.scuole.bo.it/phpwiki>.

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