

Social Construction of Open Source Application for Student Records: The Case of Cape Coast University

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Abstract. *The purpose of this study is to understand the development and use of open source software (OSS) for higher education (HE) administration in a developing country. Research on OSS in developing country HE has thus far focused on teaching and learning. Less attention has been paid to the area of administration. This lack of attention may be due to the back-office nature of the administration function, which makes it less obvious to academics. Nevertheless, HE administration provides significant support for efficient and effective teaching and learning and thus requires equal research attention. To extend the OSS research in developing country HE to the administration domain, this study focuses on the development and use of OSS for student records administration in a higher education institution (HEI) in the developing country context of Ghana. The research question motivating the study concerns why and how a developing country HEI developed an OSS for administration, how the various interest groups shaped the software and how the software shaped them in return. The study follows social construction of technology (SCOT) as a theoretical lens and qualitative, interpretive case study approach to trace the experience of the University of Cape Coast (UCC) in Ghana in developing and using OSS for student records administration. The findings provide rich insight into the various interest groups who shaped the software and how it shaped them in return.*

Keywords: open source software, higher education, social construction of technology, Ghana

1. INTRODUCTION

The aim of this study is to understand the development of open source software (OSS) for developing country higher education (HE) administration. The HE sector is very important for every country to participate and benefit from the growing global knowledge economy (Ismail, 2008). To be effective and efficient, the sector requires accurate and reliable information to support teaching and learning as well as research and administration. The importance of this is signified by the growing research on ICT in higher education (Tatnall et al., 2009). One strand of this research, which is increasingly attracting the attention of academics and governments in developing countries, is OSS application. OSS is a free software distributed at no cost to users with full access to source code for further modifications and redistribution (Khelifi et al., 2009; von Hippel and von Krogh, 2003). Its license grants users the right to copy, modify and redistribute to others with no commercial, legal and technical restrictions. OSS differs from its proprietary software counterpart, which is sold to users with closed source and the license of which commercially, technically and legally restricts the rights of users to copy, modify and redistribute to others (Khelifi et al., 2009).

OSS has been identified as a huge opportunity for the developing country HE sector to address financial, legal and technical constraints due to the use of proprietary software, especially from the developed world (Khelifi et al., 2009). However, research to date has largely been on teaching and learning,

especially e-learning and e-library. Less attention has thus been paid to OSS in administration which serves as the infrastructure for the teaching and learning functions. In view of this research problem, this study intends to extend the research area to HE administration. The key research question that has motivated this study therefore concerns why and how a developing country HEI would develop an OSS for administration, how the various interests groups shaped the software and how the software shaped them in return. To address this, the study follows interpretive case-study approach (Walsham, 1995; 2006) and the social construction of technology theory (Bijker, 2001; Kline and Pinch, 1999; Pinch and Bijker, 1984) to understand OSS development and use for student records administration in the University of Cape Coast in Ghana.

The rest of the paper is organized as follows. The next section reviews the literature on open source, developing countries and the HE sector. After this social construction of technology is introduced and discussed as the theoretical foundation of the study. The research methodology is discussed next. The following section presents the case study report as the research findings. The discussions follow and the paper concludes with its contribution, implications for research and practice and recommendations for future work.

2. OPEN SOURCE, DEVELOPING COUNTRIES AND HIGHER EDUCATION

Open source software (OSS) is offered for use by all at no cost (von Hippel and von Krogh, 2003). OSS is delivered under a license agreement that forces disclosure of source code so that anyone with the appropriate programming skills can freely use, modify and re-distribute the software to others (Neumann, 2005; von Hippel and von Krogh, 2003). Conversely, proprietary software is not only commercial but also licensed to legally and technically restrict the rights of users to copy, modify and redistribute (Lungo and Kaasbøl, 2007). Comparatively, OSS offer users the opportunity to customize the software to fit their specific context while proprietary software forces them to use the software as is or depend on the vendors for any modifications at additional cost.

OSS offers specific benefits to developing countries including Africa. It affords technical and legal freedom from foreign and local vendor lock-ins (Mengesha, 2010c; Khelifi et al., 2009). Developing countries have opportunity to reduce total costs of ownership including licensing fees (Waring and Maddocks, 2005; May, 2006). In the absence of purchasing and licensing cost, they can acquire and try the software before deciding to use it (von Hippel and von Krogh, 2003; Gallego et al., 2008). Getting software developed in the West to work in the developing world remains problematic due to cultural differences (Heeks, 2002; Avgerou, 2000; Avgerou, 2008; Nhampossa, 2005; Braa et al., 2004). However, OSS provides opportunity for them to overcome such challenges by customizing to meet their local needs. The OSS alternative also offers developing countries the potential to develop local expertise in software development by interacting and learning from relevant, global open source communities (Khelifi et al., 2009).

OSS has increasingly become popular among developing country governments (Khelifi et al., 2009). So far, one sector that has benefitted much is health (e.g. Lungo, 2006; Lungo and Kaasbøl, 2007; Bernardi, 2009; Câmara and Fonseca, 2007). Empirical OSS research on HEI in developing countries remains limited. Notable exceptions include: Mengesha (2010b; 2010c; 2010a), Khelifi et al. (2009) and Sanga (2010). OSS offers HEI the opportunity to address their cost and performance concerns with proprietary software (Khelifi et al., 2009). The authors note that much of the proprietary software proposed for the HE sector is adapted from other sectors and not specifically developed for the former. Such situations

however worsen the problem of getting successful customization. In short, OSS offers a more cost-effective and flexible alternative for ICT in HEI, especially in the developing world (Khelifi et al., 2009).

Nevertheless, developing country HE research on OSS has so far focused more on the teaching and learning activities in the HE sector. Consequently, less is known about the OSS in HE administration and management activities. Yet, the latter are equally important to promote the contribution of the HE sector to socio-economic development in every country. In view of this knowledge gap, this study intends to provide insight into the development and use of OSS to support the administrative and management function of HEI in developing countries.

3. THEORETICAL LENS: SOCIAL CONSTRUCTION OF TECHNOLOGY

The theoretical lens underpinning this study is the social construction of technology (SCOT) (Bijker, 2001; Kline and Pinch, 1999; Pinch and Bijker, 1984). SCOT is useful for explaining how social environments shapes the development and content of technology (Howcroft et al., 2004; Howcroft and Light, 2010). As part of the social shaping of technology approach, SCOT emerged as a critique of technological determinism which presumes an autonomous, rational, objective and linear development process (Bijker, 2010). Rather, SCOT aims to demonstrate the complex, unpredictable, and social constructive nature of technology as subject to multiple interpretations and engagement with different social groups (Bijker and Law, 1992).

It therefore argues that technology emerges from interactions among social groups through a stabilization process that involves the convergence of interpretive flexibility of various social groups to achieve closure. By this SCOT helps to reveal the impact of multiple social forces on technology development (Prell, 2009) and how emergent problems get resolved (Howcroft and Light, 2010). Technology is therefore seen as a product of social constructivism through divergent social groups (Kline and Pinch, 1999). The basic concepts of SCOT are described in Table 1 as follows:

Table 1: Basic Concepts of SCOT

Concept	Description
Relevant social groups	Members of each group share the same interpretations of the technology under construction.
Interpretive flexibility	Different relevant social groups have different interpretation of the same technology.
Technological frame	Elements that influence interactions among members in a group and lead to their interpretation of the technology.
Stabilization	Convergence of the different interpretations into shared view of the technology
Closure	The stage where interpretive flexibility vanishes and the technology achieves stability.
Impact on society	How the constructed technology shapes society in return

Adapted from Bijker (1984; 1987) and Edwards (1995)

Interpretive flexibility means interpretation is similar among members of the same group but differ between groups (Kline and Pinch, 1999). Interpretive flexibility can therefore lead to conflicts of understanding resulting from technological frame which comprise the beliefs, values and assumptions that shape the understanding of a group towards the technology under construction. Technological frames can

therefore shape designers' understanding to make required modifications (Sismondo, 2010: 102). Bijker (1995:123) likens technological frame to Kuhn's (1970) notion of research paradigm among communities of researchers. Stabilization explains the process of how conflicts of understanding among various groups get resolved through redesign to achieve closure of shared understanding among the groups for a particular technology to emerge (Pinch and Bijker, 1984). Impact on society (Edwards, 1995) is a later addition to the original SCOT concepts to reveal the consequences of the technology in use in given social context. This addition became important following the criticisms that SCOT fails to move beyond technology development to analyze impacts on society (Winner, 1993). However, Edwards (Edwards, 1995) warns that technologies do not cause direct impact on society as technological determinism wants to believe. Rather, they create pressures and possibilities through interactive processes for social systems to respond.

Beyond just being theory, SCOT offers a methodology of how to study technology development (Winner, 1993; Prell, 2009). The methodology begins with the researcher identifying the relevant social groups, their interpretive flexibility and technological frames (Bijker, 1997). The researcher then needs to detail the stabilization process towards closure and how conflicting interpretations and problems got resolved for the technology to emerge or otherwise. The final stage, which is an extension of the original SCOT framework, is to investigate the impact of embedding the technology in a given social context (Edwards, 1995). It is important however to note that the SCOT process is not deterministic or linear. Rather the process entails controversies and contradictions (Howcroft and Light, 2010). Meanwhile, phases can iterate or overlap. Moreover, closure is not a permanent state since new social groups with different interpretive flexibility can emerge and require further modifications.

We considered SCOT useful for investigating the open source application development because of its capability to study complex technological innovations and multiple stakeholder views and how they shape and are shaped during the innovation processes (Prell, 2009). We also consider the theory useful for helping to uncover problems that emerged during the open source development and how they got resolved (Howcroft and Light, 2010). SCOT has been found useful in similar studies involving technology development and adoption processes (e.g., Howcroft and Light, 2010; Mitev, 2000; Orlikowski and Gash, 1994; Boland and Schultze, 1996; Sahay and Robey, 1996; Prell, 2009).

4. RESEARCH SETTING AND METHODOLOGY

The study forms part of an ongoing multiple-case study into ICT in higher education institutions in developing countries. The current study focuses on the development and use of OSS to support higher education administration in the University of Cape Coast (UCC), situated in the developing country context of Ghana. The study investigates the emergence and development process of an OSS to support student records as part of the administrative activities of the University. The research followed qualitative research approach (Silverman, 2005; Patton, 2002), using interpretive case study (Walsham, 1995; 2006; Klein and Myers, 1999) as the underlying philosophy and methodology.

4.1 Research Setting

The study was conducted in the University of Cape Coast (UCC), one of the three old universities in Ghana. It was established in 1962 as a public university with the mandate to produce highly qualified teaching and administrative professionals for the country's education sector. Since its establishment, it has trained several graduates for second and third cycle institutions such as secondary schools, technical schools and teacher training colleges. Over the years, it has also expanded its programmes into

professional areas including business management and medicine. UCC currently offers various forms of degrees including: bachelors, masters and doctorates. The current population of the University stands at 17,000 full time and 30,000 distance students dispersed across the country.

The University had adopted a South African based software called Inter-Tertiary System (ITS) for its administration information systems. However, due to some challenges which were difficult to resolve, it had to opt for another software particularly for the student records. This led to the adoption of the open source software, which forms the topic for this study.

4.2 Data Gathering

Access to the organization for research was gained through the second author who works with the University as senior systems analyst for the student records and management information systems unit. He also doubles as a part-time lecturer in the department of computer science and information technology. The author has been involved in the open source project from inception, through development to implementation as well as maintenance and support till date. He worked with the development team as the leader of the student records and information system unit. The fieldwork for data gathering occurred between April and September 2012. It was conducted by him in remote collaboration with the first author. During the open source development, the second author worked with the project team, contributing in the areas of systems analysis and design, database design, workflow and testing.

Data was gathered from multiple sources: semi-structured interviews, informal discussions, observations, documents and artifact analysis. Each interview session lasted between 1 and 2 hours. In view of the researcher's familiarity with the people and the subject, interviews were recorded through note-taking and written-up immediately after each discussion. Additional data came from project reports and documents, minutes of meetings, website of the university and the consultant. The researcher also conducted several walkthroughs on software. Follow-up interviews continued via e-mail and telephone when the researcher was off-site. Social groups were identified from project documents, snowballing and following the actors (Bijker, 1995 p.46).

4.3 Data Analysis

Initial data analysis occurred alongside data gathering. Detailed analysis however occurred after the data gathering. This involved the two researchers reading and reflecting on the gathered data iteratively in light of the relevant groups' interpretive flexibility, technological frame and the stabilization process. Detailed analysis involved categorizing the relevant social groups and their interpretive flexibility and technological frame through conceptual analysis (Bijker, 1995; Klein and Kleinman, 2002). The detailed analysis followed the SCOT process to identify problems that emerged and how they were resolved in the stabilization process. Emergent concepts from the conceptual analysis were then used to frame the case study findings as presented in the next section. We evaluated the study using principles proposed for the conduct of interpretive case study (Walsham, 2006; 1995; Klein and Myers, 1999; Barrett and Walsham, 2004).

5. CASE STUDY FINDINGS

This section presents the case study findings. It begins with the previous software in use before the open source application. It then presents the open source development process and the role of the relevant social groups, their interpretive flexibility with emergent issues and how they got resolved. The key relevant social groups encountered in the study are students, lecturers, administration (vice-chancellor and the registrar), administrative staff, IT staff and the consultant who served as the software developer.

5.1 Before the adoption of the open source software

In 1997, UCC implemented a software called integrated tertiary software (ITS) to support its administration activities including student records. The software is developed in South Africa to support the HE sector in Africa. The implementation of ITS in UCC was led by the vendor from South Africa. Due to various challenges with the operation of the ITS, a number of relevant social groups had problems with it. Both the administration and the IT staff were not satisfied with the system because any small technical problem with the software had to be referred to the consultant in South Africa. For example common problems such as getting transcripts and admissions letters to fit A4 size-sheet required could not easily be solved by the IT staff. Because of this problem, examination transcripts and admission letters had to be copied from the ITS and typed into Microsoft Word before they could be issued.

Another problem was that the ITS could not handle the existing student ID format. The original UCC student ID format was faculty/year-of-admission/order of student reporting. For example ED/1992/001 represented a student of the faculty of education admitted in 1992 being the first to have reported while SS/1995/003 was a student of the faculty of social science admitted in 1995 being the third student in order. This format helped lecturers, staff and administration to easily identify students with their faculty, year of admission and order of reporting. However, the ITS generated student ID sequentially without categorizing them into faculty and year of admission. Although the IT staff perceived most of such problems as trivial for them to solve, they could not do so for lack of access to the source code and configuration tables of the ITS system.

Such problems generated some misunderstanding between the administration and the IT staff. The administration and the students blamed the issue on the incompetence of the IT staff. Administration was not happy that every small problem required making contact with the consultant in South Africa. This did cost the University a lot of money. Moreover, there were some issues such as the student ID format which the consultants could not solve. Students also encountered much delay in getting their admission letters and transcripts. It was however difficult for the IT staff to explain to the two groups that solving the problem required access to the source code which they did not have. In 2001, the consultant, IT Consortium (ITC) approached the University and proposed to develop an open source application as a solution to their software and data management problems. The consultant succeeded in convincing management and the IT staff that open source application is free (which will have an effect on the cost of development) and that the IT staff would have unrestricted access to the source code to solve all technical problems. The University would only pay the consultant for the initial development service. In view of the restrictions with the ITS, management and the IT staff bought into the idea of installing a software developed using open-source tools.

5.2 Open Source Development

Once the University's management and the IT staff got convinced about the open source approach, a project team was formed comprising the consultant and the IT staff of the University. The main objective of the project was to develop an open source application for managing students' records. The intended software was named as OSIS (online student information systems). The development team used MySQL, PHP, Apache and Linux as open source tools to develop OSIS. Linux was used as the operating system platform; MySQL was used to create and manage the database; Apache was installed as the webserver; and PHP was used to develop the interface as well as the functions and procedures. Throughout the development and beyond, members of the development team benefitted immensely from the various online open source communities (for MySQL, PHP, Apache and Linux). They posted issues to the various community forums and got suggestions on how to address them. As the leader of the IT staff, the second author's role in the project included requirement analysis and design.

The project team adopted prototyping as the development approach to ensure that the views of the various users groups were captured at the design stage. The team therefore showed prototypes to the various relevant social groups including management, lecturers, students and the administrative staff. The team went through several iterations to ensure that varied views of the relevant social groups had been captured. Although they found this to be tedious, the inflexible experience with the ITS motivated them to do so. After several prototyping cycles, the development team completed the design and proceeded to testing and validation of the software against the requirements of various relevant social groups. In situations where the software was not working to the expectations of a particular group, the development team made the necessary changes to get it to work.

When the development team got convinced through the testing that the software was working as expected, they proceeded to the implementation. Implementation including data migration which involved moving all student records including those of examination from the ITS to the OSIS. Once, this was completed and the users began to use the system, the relevant social groups began to realize its usefulness. For example, the director of academic affairs became really impressed that he could access and monitor students records in real-time during registration. He expressed his excitement as follows: “this is a marked improvement over the previous system [ITS] where registration was done in batch”. Such commendation from the various user groups especially management and the administrative staff motivated the development team to quickly move beyond live testing and deploy the software for use by all the relevant social groups.

5.3 Open Source Application in Use

After the development, IT staff and the consultant migrated the students' records from the ITS to the OSIS. Following the migration, the software was ready for use. In the ITS era, lecturers recorded students marks on paper for administrative staff to key into the software. However, OSIS required lecturers to enter the marks themselves. This generated a huge opposition from the lecturers who saw entering marks as extra work and an attempt to transfer administrative duties to them. They preferred the old way where they would complete the forms for the administrative staff to enter marks. To get the lecturers to accept their new role, the IT staff had to organize seminars to convince them about the benefits of the entering their own marks and ensuring security of their marks. The seminar helped most of the lecturers to appreciate the software and its potential to support quality student records. One influential lecturer who later became the Vice-Chancellor got convinced about the quality of the open source software over the ITS. This lecturer initially opposed the open source software and idea of entering records directly but later supported after realizing that they system could track all marks entered in a secured way. Also, with full backing from management, the lecturers had no option but to use the software to enter marks online.

With the ITS, all bugs and technical problems had to be referred to the consultants in South Africa for solution. For example if the registrar wanted an ad-hoc report they had to get the consultant from South Africa to do that. However, with the OSS the IT staff are able to handle all of such problems. Not too long after the implementation, the IT staff have developed enough experience and capacity to provide full support for the system without resorting to the consultant. The IT staff are able to provide changing information needs of the various users groups due to changes in University policies and procedures. One such example was the change in policy on the number of failures for students to be dismissed. This required redesigning data structures and software procedures, which the IT staff could handle without the support from the consultant.

For over a decade now, the IT staff have obtained enough experience and competence through resolving problems at the source code level and participating in online open source communities, logging problems and receiving feedback to address them. Now the IT staff are able to resolve all problems relating to the

open source software. As a relevant social group, the IT staff are happy and consider the open source a better option than the proprietary ITS because the former enable them to provide all technical support such as reprogramming and redesigning to meet changing information needs of various relevant social groups as result of access to the source code. Beyond, the initial modules they developed with the consultant, the IT staff have added additional modules: online admission, introductory letter generation, certificate requests and tracker. The team is in the process of adding online examination time-table. The IT staff also have the capability to design ad-hoc reports which were not part of the original OSIS software. A member of the IT staff remarked that:

With the previous software, it was impossible for us to develop new reports which were not part of the original [ITS] design... with this software we able to create all new reports requested by users.

With the above positive developments, the open source software has come to be nicknamed as 'agyenkwa' meaning saviour. The problems with the student ID have been resolved. Issues with transcripts and admission letters have been resolved without recourse to any external assistance. In the recent 2012 matriculation ceremony for distance education students, the vice-chancellor confidently announced migration of their records to open source application, noting that the migration "will improve the processing of [their] results so that requests for provisional results and transcripts will be attended more promptly".

6. Discussion

This study sought to find out why and how a developing country HEI developed an OSS for its administration function, how the various interests groups shaped the software and how the software shaped them in return. The findings show that the developing country HEI adopted the OSS application to address the inflexible and closed source nature of the existing proprietary software, which was found to be expensive and too rigid in terms of getting consultants to address emergent problems. By nature, proprietary software is designed to be rigid (Lungo and Kaasbøl, 2007) and thus not easily amenable to changing user needs. It was therefore difficult for the IT staff of the University to address unforeseen problems and information needs of various user groups with the existing proprietary software.

Conversely, the OSS development through prototyping and response to interpretive flexibility of the relevant user groups could accommodate emergent issues and user information needs. Given the dynamic nature of HEI and the variety of user groups, they are bound to have changing information needs. The experience of the University supports the view that OSS may be more appropriate for such institutions than proprietary software. Moreover, by using open source Linux, PHP and MySQL, the development team, comprising the University's IT staff and the consultant, could adopt collaborative efforts and iterative development process to address issues emanating from the interpretive flexibility of the various relevant social groups. The process served as a learning opportunity for the internal IT staff to acquire knowledge on how to provide local support and address the various emergent technical problems which hitherto could not be addressed in the proprietary software.

Eventually, they did not need the consultant any more as the open source approach empowered them enough to be self-sufficient. Moreover, the local IT staff also had ready access to various online open source communities to support them in further development of the software to address emerging issues. This supports the view noted in the literature that open source support creative knowledge (Lungo and Kaasbøl, 2007) as demonstrated in this case. Clearly, by going open source, the institution gained opportunity to reduce the total cost of software ownership (Waring and Maddocks, 2005; May, 2006)

compared to the earlier situation where the University had to fly consultants from abroad to solve any little technical problems, some of them without success.

In sum, the findings show how proprietary software can reduce the power of internal IT staff to address technical issues and how OS rather empowers them to solve technical problems. As demonstrated in the findings, the internal IT staff were often helpless in addressing the information needs of the various user groups due to the closed nature of the proprietary software. The situation led to the user community developing bad attitude about the IT staff. However, by gaining technical control over the software and competence to address the problem through open source, the IT team became empowered and regained their respect.

7. Conclusion

This study investigated the experience of a developing country higher education institution in developing and using open source application for managing student records. Existing research on developing country OSS research in HE has focused largely on the area of teaching and learning. This study contributes to the literature by extending it to the domain of HE administration. The findings demonstrates the interpretive flexibility of various user groups in a higher education institution and such groups can shape a given software during development and how the software can shape them in return during use. Moreover, open source offers opportunity for issues raised by various user groups to be addressed alongside the development process. An important contribution of the research stems from its demonstration of how OSS empowers internal IT staff to address emergent technical problems and information needs of users groups and how proprietary software rather disempowers them.

In terms of practical implication, the study shows that institutions that intend to promote OSS but lack internal capability can collaborate with external consultants and online communities. In view of this, the study recommends open source for higher education in developing country as an opportunity to reduce vendor lock-ins and total cost of software ownership as well as meet rampant ad hoc user information requests. In terms of research implications, the study uncovers an interesting relationship between internal IT staff empowerment and the type software used—proprietary or open source. This relationship however calls for further research and theorization. The study was however limited by its focus on various user groups and their impact on OSS and the vice-versa without attention to the institutional environment. Future research can thus benefit from investigating institutional impact on OSS and vice-versa.

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