Friedrich-Alexander-Universität Erlangen-Nürnberg
Technische Fakultät, Department Informatik

Sabrina Jahn
BACHELOR THESIS

Teaching Open Source Competency

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Supervisor:
Prof. Dr. Dirk Riehle, M.B.A.
Ann Barcomb, Msc.
Professur für Open-Source-Software
Department Informatik, Technische Fakultät
Friedrich-Alexander University Erlangen-Nürnberg

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Abstract

The concept of competencies started to grow over the last years and has now arrived in the fast growing field of Free/Libre/Open Source software development (FLOSS). Competencies have been defined, which are necessary for an successful career as an FLOSS developer and also became important to general software development enterprises. To close this gap between FLOSS developers and software developers without experience in FLOSS, a survey was created and conducted, which is described and analyzed in this thesis to see how FLOSS developers have gained their competencies in the past and if there is a difference between FLOSS and non-FLOSS developers. The results show that both groups have learned their competencies mostly through informal methods and that the most important method is “learning by doing”. Also no difference in learning those competencies in the past between FLOSS developers and software developers without participation in FLOSS could be determined, which leads to the conclusion that there are possibilities to develop such competencies outside of FLOSS communities, so software developers in general can keep up with the FLOSS developers.

Acknowledgments

I would like to express my appreciation to Professor Nicole Kimmelmann, whose work inspired the research of this thesis and who introduced me to the field of competencies and supported me in various ways.
Also a thank you to Professor Michael Grottke for providing important information on the different steps of creating and conducting the questionnaire.
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Contents

1 Introduction

1.1 Original thesis goals

In the last few years, the concept of competency has become increasingly important to the working environment. In this context, competency models are used to identify specific competencies that are necessary for an enterprise and therefore essential to the employee. Especially in the fast-growing field of Open Source Software Development, a large set of relevant competencies has emerged and is now important for a successful career as Open Source software developer (Kimmelmann, 2013). But we still do not know how they developed this competencies, if they have learned their competencies through more formal or informal methods or if there is even a difference between FLOSS developers and software developers, without engagement in FLOSS, according to learning.

The goals of this bachelor thesis are to answer this question with the following approach:

The related literature was reviewed to determine if the competencies of Free/Libre/Open Source Software (FLOSS) developers are trainable at all. In addition, an overview of the existing training methods and their effectiveness will be provided.

To detect if the Open Source software developers prefer formal or informal learning, a survey was designed to investigate which learning methods are applied and to what extent. For this survey a group of participants was chosen, which contains software developers who participated in Free/Libre/Open Source Software as well as software developers who did not.

The results of this survey were analyzed afterwards. First, to identify the various teaching methods used by software developers and second, to measure the extent of usage to find out whether formal or informal learning has a greater impact on FLOSS developers compared to software developers, who did not engage in FLOSS.

2 Research Chapter

2.1 Introduction

In the last few years, the concept of competency and competency models has become increasingly important to the working environment. Especially in the fast-growing field of Free/Libre/Open Source Software Development (FLOSS), a large set of relevant competencies has emerged and is now important for a successful career as FLOSS developer (Kimmelmann, 2013). But we still do not know how they developed this competencies, if they have learned their competencies through more formal or informal methods or if there is even a difference between Open Source Software developers and software developers without engagement in FLOSS according to learning.

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2.2 Definitions

Before proceeding to the research approach there has to be a consensus of what is actually meant by the different terms used in this thesis, like Free/Libre/Open Source Software, skills and competencies, and informal and formal learning. This terms are described in the following chapter.

2.2.1 Definition of Free/Libre/Open Source Software (FLOSS)

The term Free/Libre/Open Source Software (FLOSS) is used to summarize the different terms and philosophies existing about software, whose source code is accessible. They can be categorized in two groups – “Free Software” popularized by the Free Software Foundation and “Open Source Software” established by the Open Source initiative. “Free Software”, means that the users can run the software, change it according to their needs and distribute it, almost without any limitations (Free Software Foundation, n. d.). But tactical concerns to this term appeared according to the word “free”, as this often refers more to the monetary aspect than to freedom, which is the actual meaning and why it is often called “Libre”. So the philosophy of “Open Source Software” and with it the term “open” arose, which focuses more on the development of the software than on ideological aspects (Open Source Initiative, n. d.). According to Richard Stallman, in general both terms describe the same community only with two different movements (see Appendix A).

FLOSS is used in this thesis, as a term for software, where users are free to run, alter and distribute the software and even to sell that software with some limitations (Sowe, Stamelos, & Samoladas, 2007), and as a hypernym for both movements and all other abbreviations, like OSS, FOSS or F/OS software.

2.2.2 Skills and Competencies

Nowadays, the term “competency” can be found almost everywhere. There is always talk of competency profiles that have to be fulfilled, or competencies that can be achieved in participating in a workshop, but no one defines this term – so what actually is a competency?

Grundmann (2011) speaks about competencies as related to a job, or better to a special performance of it. Also they are related to general human abilities, what means that there exist abilities needed for basic tasks, which can also explain performance on larger similar tasks. As Erpenbeck and Rosenstiel (2003) explain, a competency is based on its specific performance and can only be evaluated by implementing it. In addition, Kaufhold (2006) summarizes that there does not exist a consistent concept of what competencies are in general, only that a competency is defined by its purpose and the related action requirements.

Skills basically are components, that can be trained to perform them automatically in stereotypical work-related requirement areas and seize the behavior in requirement-based action situations (Erpenbeck & Rosenstiel, 2003).

So competencies and skills are both a term for abilities to perform specific tasks in a job-related environment. As the line between the terms “competency” and “skills” is quite blurred (Erpenbeck & Rosenstiel, 2003) and as there is no consistent concept of competencies, the terms are used interchangeably in this thesis.

2.2.3 Informal and Formal Learning

The terms formal and informal learning describe the environment in which the process of learning proceeds (Straka, 2000).

Formal learning covers all processes of learning, which take place in traditional educational institutions, like schools and universities. Also this kind of learning is methodical, structured by official didactic curricula and executed by professional teaching staff, and aims toward recognized degrees (Straka, 2000). Examples for formal learning are training measures like advanced training, workshops, or courses of instruction (Livingstone, 1999).

Informal learning is learning outside of formal institutions (Faust & Holm, 2001). It is also structured, but not by official curricula. The structure here is based on the demand of learning the learner has. Therefore informal learning is self-organized. Different kinds of informal learning are reading literature or learning from models (Staudt & Kley, 2001).

2.3 Prior Work

2.3.1 Competencies needed for FLOSS: can they be trained, or are they innate?

As this research is intended to declare how FLOSS developers learn and to deliver an impulse for other people who want to develop those competencies, a declaration has to be provided if competencies that are needed in the FLOSS community can be trained at all, or if they are innate.

According to some researchers, competencies are abilities that are neither innate nor a result of maturation processes. Also they are developed by the individual through interaction with its environment and can be cultivated and increased lifelong (White, 1959; Klieme et al., 2007). In summary, a competency is an ability that is developed by the individual itself and contributes to processes of self learning, hence competencies are not innate and can be developed in social reality.

As competencies can be developed lifelong, it is obvious that they can be trained somehow. According to Kaufhold (2006) competencies are bound to a person and therefore it is assumed that they can be developed by the individual itself or by a third party concerning to different

requirements. Grundmann (2011) shows that there are distinctions among competencies, when it comes to training. Competencies that consist primarily of knowledge are highly trainable. Other competencies have a skill component, which can easily be trained, and an ability component that is limited by the degree of talent, which makes them moderately trainable. Last there are the less trainable competencies, which relate to a high amount of personal attributes, and are harder to train (Grundmann, 2011).

Thus, competencies can be evolved by the individual itself in the social reality and are not innate. The trainable competencies can be cultivated and refined lifelong, either by the individual itself or by a third party depending on the different requirements.

2.3.2 Existing Training for FLOSS Competency and the Effectiveness of Training

Based on the previous chapter is resolved that competencies are trainable. Now I provide an overview of the different methods existing for the competencies needed in FLOSS and the effectiveness of those methods.

To train a language, in case of this thesis English, many approaches arose over the years, which are all seen to be as most effective in teaching or training languages. Some examples of those trends are *The Grammar Translation, The Direct Method, a*nd *The Oral Approach and Situational Language Teaching* (Richards & Rodgers, 2001). Today there seems to be no consistent concept of which method is the best to be applied and different approaches are used in combination to teach the different languages in courses or seminars, in institutions or online. Some institutions would be the *Delfin English School*, which offers various different English courses (Delfin English School, 2014), or The London School of English with online courses (The London School of English, 2014). But no further academic research on this topic could be found.

For training the necessary programming and IT-Skills the same issues exist as for the language skills. This area seems to be more practitioner-led than research-led and no scientific research of the training methods applied in this specific field could be found. Many courses are available that teach the different skills via stand-up instruction, discussions or group exercises depending on the topic, in formal courses, workshops or online courses. Some examples would be the *Project Performance International* course “Software Engineering” (Project Performance International, 2014) or the various workshops of the *IEEE Computer Society* (IEEE Computer Society, 2014).

According to Segrin and Givertz (2003) social skills training is seen as most effective when it is started with the assessment phase, to identify the different needs of the participants. The most effective way to train social skills here is the training through social interaction. Different methods like, training through instruction or coaching, modeling, which is seen as the most effective way to teach social behavior, and role playing, where the actual behavior is trained under a controlled setting, are summarized. The training then is completed with homework assignments, where the participants train what they have learned and afterward discuss the situation with the trainer to get advice and learn from their mistakes.

As the skills necessary for a successful career as a FLOSS developer are learned in the FLOSS community, so it is reasonable to see this way of learning as an effective method to train those skills. Weller and Meiszner (2008) show, that work in FLOSS community is like working on a project and that problem-based- (PBL) and case-based- (CBL) and project-based-learning can be applied here. These methods are so effective, because the participants have the responsibility for their own learning, to find different solutions on their own,

while collaborating in groups (Weller & Meiszner, 2008), which represents the process of learning in a FLOSS community.

For a more detailed explanation of the different methods of learning see chapter 3.2.2.

2.4 Related Work

Though competencies have become very important in defining profiles for employees, there is less research in the field of competency assessment. Some of this research was conducted in the medical field to improve the treatment of patients. One approach is the skills training and competency assessment via a simulation technology for medical education (Scalese, Obeso, & Issenberg, 2008). Also in the IT sector some research was conducted, Bassellier, Horner Reich, and Benbasat (2001) provide an theoretical approach on the competency assessment of business managers in the IT sector.

Also surveys have been conducted to evaluate competencies in different sectors. One sector would be the educational sector where different methods on identifying competencies for teachers and educational stuff where used (Thach & Murphy K.L., 1995; Plake, Impara, & Fager, 1993).

In addition, the field of skills or competency training seems to be more practitioner-led than research-led as mentioned in chapter 3.2.2. so there is no additional work, which can be mentioned in this section.

All the above mentioned research only focuses on the assessment of different competencies and not on how different competencies have been or can be developed by others.

Except for the research of Kimmelmann (2013) and the work of Glott and Gosh (2005), on which this theses is based on, no academic research on the topic of assessing and learning competencies in the field of FLOSS development, could be found.

This lack of research in the specific field of FLOSS confirms the need of studies in this field and therefore the approach of this thesis in this special field.

2.5 Research Question

2.5.1 Question

The original research question of this thesis was:
Is open source competency gained largely through self-study, or do more formal teaching methods such as courses, conferences and mentoring play a role? To what extent have open source contributors gained competency through formal teaching methods?

But as the scope of this question was too broad for the scope of this thesis and is not fully addressed by the hypothesis, so the question was scaled down to:
Do FLOSS developers differ from software developers without engagement in FLOSS according to learning the different competencies through formal or informal methods in the past?

2.5.2 Hypothesis

To answer the previous questions, we first have to take a look at the way FLOSS developers think about the different methods of learning based on the literature.

According to Glott and Ghosh (2005), FLOSS developers report that participating in workshops and formal training courses is seen as least useful. Workshops were only rated with 17

percent and formal training courses only reached 12 percent of the participants. In addition to that, fixing bugs is considered as the most useful way, as two thirds of the survey participants found it very useful (Glott & Ghosh, 2005). Furthermore FLOSS development constitutes a model for the creation of self-learning and self-organizing communities, where the core knowledge is acquired through learning by doing (Glott, Meiszner, & Sowe, 2007). This leads to the assertion, that FLOSS developers are more likely to use informal methods of learning, like learning-by-doing, than formal methods of learning. Findings in other areas of volunteer contributions suggest that people, who are likely to be key contributors already possess the attributes, which make them top contributors prior to contributing (Panciera, Halfaker, & Terveen, 2009). FLOSS developers might therefore be different from other software developers. To sum up, FLOSS developers prefer methods of study, which are not favored by the general population, and FLOSS is biased toward these methods of learning, also there has to be a difference between FLOSS developers and the general population. For people who are not engaged on FLOSS it is the opposite. As the work of Grundmann (2011) shows, self-study and learning in a web-based environment are seen as the least effective learning for all classes of competencies for the general population (Grundmann, 2011). So the tendency here is towards formal learning methods. Also the FLOSS community members are not convinced that all skills learned or improved in FLOSS are also better be learned in the community (Glott & Ghosh, 2005). Competencies of FLOSS developers include technical competencies (e.g. programming, quick induction into new projects, implementation of new features without disturbing others), social competencies (e.g. giving constructive feedback, self-organization and presentation skills) and personal competencies, like openness to new things and approaches, time-management and curiosity (Kimmelmann, 2013). Those Competencies and the skills from Glott and Ghosh (2005) can be mapped to the categories Social, Reasoning, Motivation, Knowledge and Mental Style, and also to the categories highly trainable, moderately trainable and less trainable, from Grundmann (2011) (see Appendix B).

So FLOSS competencies can also be developed and trained by other methods. Therefore, I expect that software developers who are not active in FLOSS will have acquired these, or some of these competencies, if they possess them, through more formal methods than FLOSS developers, because the general population prefers these training methods.

So this leads me to the following Hypothesis:

Software developers, who are not active in FLOSS, will report higher levels of learning through formal methods of instruction compared to FLOSS developers for FLOSS competencies they possess.

2.6 Research Approach

2.6.1 Competency Model

The survey uses a combination of the skills by Glott and Ghosh (2005), as they were surveyed before and therefore it is reasonable to repeat them in this survey, and skills based on the original interviews of the research of Kimmelmann (2013), to fill in the gaps where no skills from Glott and Ghosh matched, to keep integrity.

Based on the categorization of Grundmann (2011) those skills were categorized and the skills shaded in green were chosen as items for this survey (see Appendix B). First, the skills were selected by their trainability. The skills in the categories Motivation and Mental Style are less trainable and therefore less interesting to this research approach, to find out if future software developers can be supported in training the competencies necessary for FLOSS. The other skills were chosen to represent the remaining categories at least once and in order to assure an easy understanding to the participant. Also only those skills from Glott and Ghosh (2005) were chosen that match to the competencies of Kimmelmann (2013), because those are indispensable for an successful career as FLOSS developer.

2.6.2 Survey Design

In the following chapters I will explain the construction of the survey I explain the different steps relevant for this thesis.

2.6.2.1 Methodology

For this survey an online questionnaire based on the self-report of the participants was chosen, because a high number of participants can be reached. The selected population, the community of the JDownloader 2 Beta, got access via a link distributed in a client-interface of the JDownloader 2 Beta software.

2.6.2.2 Selection of Items

To answer the research question it is necessary to find out to what extent people learned with each method of learning. So the decision was to formulate the items as questions instead of statements as we here have the possibility to use answers to grade the intensity (Bortz & Döring, 2006).

Also it is necessary to stick to standards, when it comes to formulating the items correctly. The items should not be worded suggestive, they should be written in clear and distinct words and contain only one statement per question. In addition, the phrasing should be clear to all participants and generic, there should be no technical terms if possible (Bortz & Döring, 2006).

2.6.2.3 Format of Answers

The general questions on software development, FLOSS participation, the demographic questions and the questions on the survey are a compound of different answer options like multiple choice questions, deciding questions, and also open formats like short text fields.

To correctly measure the skills, the survey uses graphical rating scales in a slider design. As there should not be any accumulations, the numbers the limesurvey software shows usually above the slider while moving, were hidden with a script. Also the maximum value of the slider was set to 10000 instead of 100. A numeric continuous variable with a ratio scale was

chosen, as more mathematical methods, like calculating the difference or the ratio between groups, are possible. In this way the slider design avoids the problem of the middle value in a Likert-scale with five stages, to decide if the participant did not have a concrete opinion (Bortz & Döring, 2006).

2.6.2.4 Test Falsification

In addition to the possible problems mentioned above, there exist further problems that occur in questionnaires which are based on self-evaluation of the participant. Bühner (2006) summarizes them into social desirability, motivation, sequence effects and response bias.

Social desirability means that the participant tries to emphasize positive values to hide the negative ones, which often occurs in situations where they want to represent themselves in a better light. As this questionnaire is not conducted in a situation of selection, there is no need to test on this problem.

The second problem is the motivation of the participant, as it can decrease while participating, if questionnaires are very long and complex in answering. To avoid this behavior the original survey was split into seven shorter surveys, which is explained in chapter (see chapter 3.5.2.3.) Also the questions are formulated as simple as possible to avoid overwhelming the participants.

Sequence effects relate to the position of the different items, which can affect the way of response. Bühner (2006) suggests, that the sequence of items in questionnaires should be randomized in general, what was taken into account at the creation of this survey.

Last issue of the self-evaluation is the response bias, which means the tendency of the participants to choose yes or no. To measure this tendency a variation of arrangements exists, but it would be necessary to check on a high amount of validity scales, which would exceed the scope of this thesis.

One issue according to conducting the survey is the problem of controlled access. This problem could not be addressed in our case, as anonymity should be established. Therefore the possibility that the survey might be answered by a participant more than once had to be accepted.

2.6.2.5 Sample Selection

The JDownloader 2 Beta community was chosen as it has a big community with about 200 000 users. So a high number of responses were expected. As JDownloader is an open source software, it was reasonable to suggest that a lot of the users are also engaged in FLOSS, as FLOSS developers usually run the software they want to improve. As JDownloader is not a specific tool to FLOSS members, there was also the suggestion that people who are not engaged with FLOSS can be reached. The total number of responses in the seven surveys altogether was 5878 of completed data sets.

2.6.2.6 Description of the Survey

The following chapter provides a short overview of the seven surveys. A full example of the survey structure can be found in Appendix E.

The basic structure is:

1.Questions on software development

2.Questions on participation in FLOSS

3.Skill questions

4.Demographic questions

5.Questions on Survey and JDownloader

The 17 skills are randomly spread across the seven surveys and within them to avoid the sequence effects. Every skill exists twice, for example “to document code” in survey 1 and 2, so every skill has the same chance to get answered and all surveys have nearly the same length. The distribution can be seen in Table 1. The skills are numbered in brackets, the skills shaded in gray, are the control questions.

Question #	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Survey 7
11-13	to evaluate the work of others (1)	to document code (5)	to understand high level structures of software systems (7b)	to communicate without offending others (10)	to coordinate own work with the work of others (15)	to evaluate the work of others (1)	to clearly articulate an argument (6)
14-16	to work on own software module alone (2)	to comprehend technical discussions in English (4b)	to follow discussions on mailing lists (9)	basic/introductory programming skills (12)	to change criticized behavior (16)	intercultural cooperation (17b)	to coordinate own work with the work of others (15)
17-19	to communicate with many different target groups (3)	to clearly articulate an argument (6)	to communicate without offending others (10)	to acquaint yourself with code from others (13)	to acquaint yourself with code from others (13)	to change criticized behavior (16)	basic/introductory programming skills(12)
20-22	to understand English, especially technical discussion (4)	to understand different software architectures (7)	to show respect for the work of others (8)	to write code in a way that it can be re-used (11)	to understand and work with people from different cultures (17)	to work on own software module alone (2)	to express your reasoning so others can easily understand (6b)
23-25	to document code (5)	to show respect for the work of others (8)	to understand different software architectures (7)	to have discussions without upsetting other people (10b)	to make yourself familiar with code from someone else (13b)	to communicate with many different target groups (3)	to follow discussions on mailing lists (9)
26-28	to assess other people's work (1b)	to understand English, especially technical discussion (4)	to write code in a way that it can be re-used (11)	to maintain contact with a community (14)	to maintain contact with a community (14)	to understand and work with people from different cultures (17)	

Table 1: Distribution of Skills

The questionnaire itself was distributed to the participants per link in the JDownloader 2 Beta client-interface.

By clicking on that link some information of the kind of research is provided, that it is conducted by the Friedrich-Alexander University Erlangen-Nürnberg and that there are no financial motivations behind this research (Appendix D).

After starting the survey the first page again provided some information on the research, but in more detail. It also provides the time, 10-15 minutes, the participation will take, information on possibilities to be notified after the publishing the results and on anonymity (Appendix E).

The first part includes questions on the general activity in software development, if people work in software development and if yes since when, to identify the software developers.

Section 2 then identifies the people who engaged in FLOSS, with questions on participation in FLOSS.

The third part, with questions on the skills, is the biggest section of the survey. For every skill there are three questions (see Figure 1). The first asks about how skilled the participants are, the second question asks about how the participants learned their skill, if they possess it, and it provides answers where they can rate the different methods of learning with a slider scale. The third question then asks how the participant would improve the current skill in the future with the same answer options and an "other" category, as multiple choice.

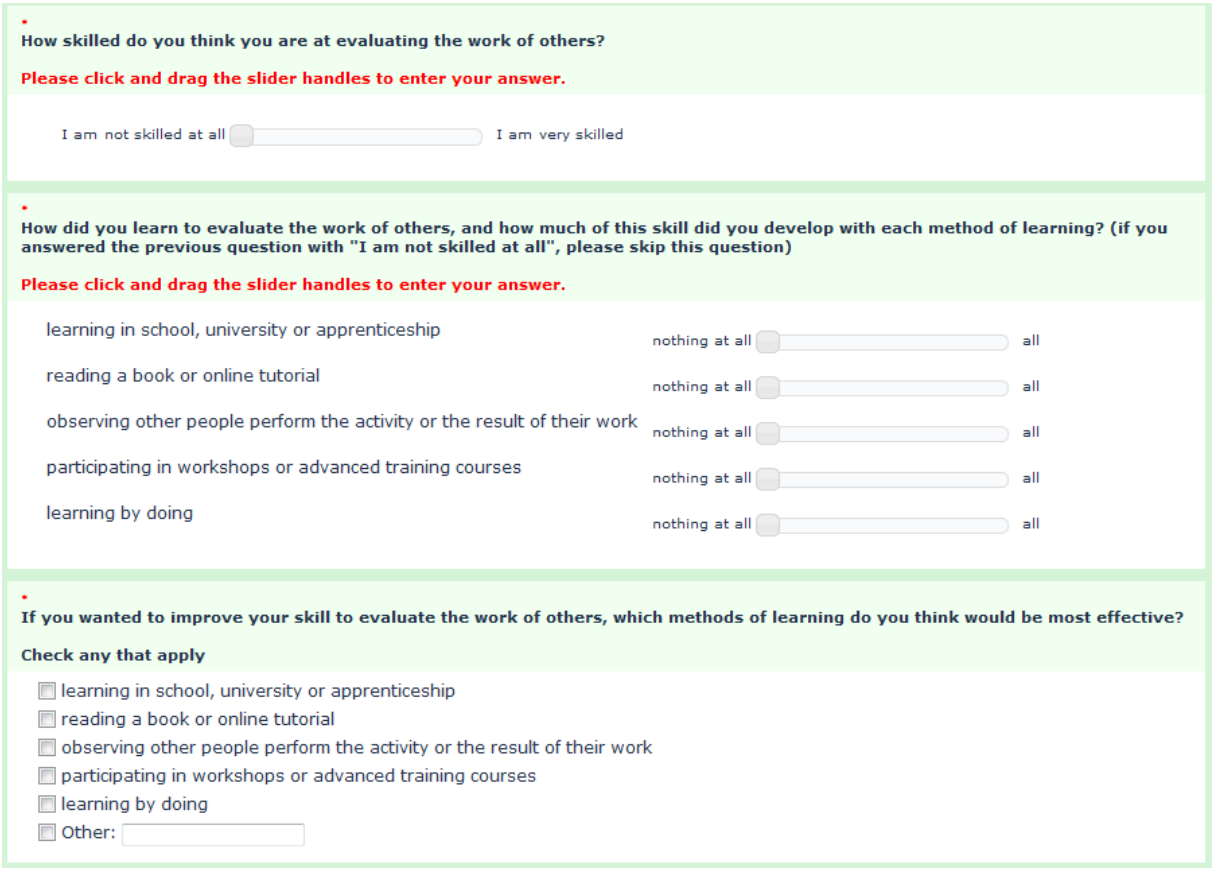

Figure 1: Example of Skill Questions

The next section provides the demographic questions. The first page is an info box which explains the intention of asking these questions to the reader. This section was placed at the end intentionally, to avoid declining the participant's motivation right from the beginning. The demographic questions are about gender, year of birth, current country, employment status and job and income.

At the end, the participants are able to decide if they want to be contacted for further surveys and if they want to be notified after publishing the results. In addition, they were also in-

formed that the results will be announced directly by JDownloader and also on the website of the OSR group.

2.6.2.7 Assessment in detail

In the following chapter I provide the process of assessment in the different steps that have been taken to conduct the survey.

The first step was to test the preliminary version of the survey on a group of people who belong to the desired group of software developers and who also have experience in FLOSS. They were asked to evaluate the survey on clarity and also on the length. As some items were not clear and the length of the survey was considered too long, the survey was revised and split to the final seven surveys.

The final surveys were distributed with the link in the client-interface. The seven links were then randomly assigned to the participants. Also a German version of each survey was available. In this way every user of the JDownloader community was able to enter one of them. The users were not forced to enter, the participation was voluntary.

The survey was completely anonymous, as no information was required to access and also no information on the participant has been saved during the process of answering.

The final surveys were distributed on 12.12. 2013 to the JDownloader community and was open until 15.01.2014.

2.7 Used Data Sources

In addition to the data gathered in this survey, the raw data from the "The FLOSS2013 Free/Libre/Open Source Survey" by Arjona-Reina, Robles, and Dueñas (2014) was used to compare the demographics of the FLOSS developers in this survey with another population of FLOSS developers, to check on the representation.

2.8 Research Results

2.8.1 Mann-Whitney-U-Test

To test the hypothesis that software developers who are not active in FLOSS report higher levels of formal learning than FLOSS developers the Mann-Whitney-U-Test is used. In this case the following hypotheses are tested:

H0: The participants who have not worked in software development report the same level of formal learning as the Non-FLOSS developers

H1: The participants who have not worked in software development report a different level of formal learning as the Non-FLOSS developers

H0: Non-FLOSS developers report the same level of formal learning as FLOSS developers

H1: Non-FLOSS developers report a different level of learning formal learning as FLOSS developers

The same hypotheses were tested for informal learning.

Is the value of significance $p < 0.05$ the null hypothesis will be rejected, otherwise it will be adopted (Bortz & Döring, 2006).

To conduct the U-Test, the answer options of the "How did you learn to...?" questions where grouped into a "formal" and "informal" variable according to the literature (see chapter 3.1.3).

This can be seen in Table 2:

formal	informal
learning in school, university or apprenticeship	reading a book or online tutorial
participating in workshops or advanced training courses	observing other people perform the activity or the result of their work
	learning by doing

Table 2: Grouping of Answer Options

2.8.2 Data Analysis

The raw data was exported directly as SPSS files from limesurvey and analyzed via SPSS 22.0 for Windows. Before starting the answers of the "How skilled do you think you are at…?" questions were normalized to a maximum value of 100 instead of 10000. The answers of "How did you learn to …, and how much of this skill did you develop with each method of learning?" were set to a dependency of 100% as this was intended before, but the limesurvey software does not provide this function in a practical manner. This is the term used to normalize each answer (A) for every participant:

$$A_{new} = \frac{A_n}{\sum_{i=1}^{n} Ai} * 100$$

Subsequently, all data sets got deleted, which did not answer a minimum of one of the "How skilled do you think you are at…?" questions. The amount of the remaining data sets can be seen in Table 3.

Remaining Data sets after Deleting			
	Raw Sets	Deleted	Remaining
Survey 1	815	42	773
Survey 2	889	48	841
Survey 3	913	61	852
Survey 4	906	28	878
Survey 5	753	26	727
Survey 6	734	30	704
Survey 7	868	36	832
Total	5878	271	5607

Table 3: Remaining Data Sets after Deleting

Last the value of correlation of Spearmann between the "How skilled...?" question of the control block and the related skill block was calculated, to examine if the participants followed the survey correctly. All pairs showed a coefficient between $0.5 < r < 0.8$ which represents a

mid- to high-level correlation (Bühl, 2008). Some deviations had to be expected, because of the slider design. So in this case the level of correlation is high enough to conclude that the participants followed the survey correctly. Therefore no further data sets were deleted. After that 5607 data sets remained which are 95.39% of the total.

2.8.3 Results

The following chapter presents the results which are necessary to answer the research question and to examine the constructed hypothesis. The detailed analysis is presented in chapter 3.7.3.

To provide the different results and to compare the groups of participants, each group is named separately. The "non-developers" are all participants who have never worked in software development or FLOSS development, "Non-FLOSS developers" are the software developers without engagement in FLOSS and "FLOSS developers" are the software developers who have experience in FLOSS development.

2.8.3.1 Demographic Questions

Participation in FLOSS

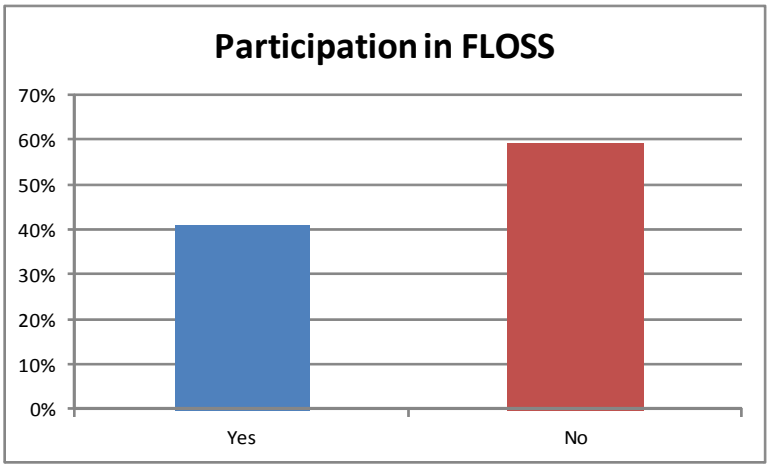

Figure 2: Participation in FLOSS; FLOSS developers (blue), non-FLOSS developers (red)

Figure 2 shows the total amount of all seven surveys of FLOSS developers and software developers without engagement in FLOSS. 41% reported to participate in FLOSS 59% do not (N = 3091).

Gender

1262 participants in the group of FLOSS developers and 1829 Non-FLOSS developers answered this question. FLOSS developers report a very high amount of male developers with 97.64% and 96.97 % of Non-FLOSS developers, 1.55% (FLOSS) and (2,23% Non-FLOSS) are female, the remaining participants chose the option "other".

In the FLOSS2013 survey 86.83% of the FLOSS participants reported to be male, 11.64% are female and 1.53% chose "other" (N = 1632) (Arjona-Reina et al., 2014). In the survey of Glott and Ghosh (2005) only 1.7% were female, so about 98% of the participants were male. So this indicates that our survey is representative in case of the gender of the FLOSS participants.

Year of Birth

The average year of birth in our survey is 1981 for the the FLOSS developers and 1979 for Non-FLOSS developers. So our FLOSS developers are on average 33 years and the Non-FLOSS developers 34 years old ($N_{FLOSS} = 1236$, $N_{non\text{-}FLOSS} = 1772$).

As the average year of birth was calculated with the mean values of the birth years of all seven surveys, seven different values for the standard deviation were calculated. The values vary between 11-15 for the FLOSS developers and between 11-14 for the Non-FLOSS developers.

Country

Almost half of the FLOSS developers (49%) and 40% of the Non-FLOSS developers live in Germany, which might be due to the fact that JDownloader is a German Open Source software. About 5% of FLOSS developers and 9% of Non-FLOSS developers come from Italy, and 4% FLOSS and 5% Non-FLOSS developers from Spain. The remaining countries are only represented with less than about 4% ($N_{FLOSS} = 1251$, $N_{non\text{-}FLOSS} = 1829$).

In the FLOSS2013 Survey the distribution is quite different. Most participants come from the United States of America with 28%, only 8% from Germany, 7% from Spain and about 6% from the United Kingdom (N = 1629). So a representation in case of the countries can not be assumed.

Employment Status

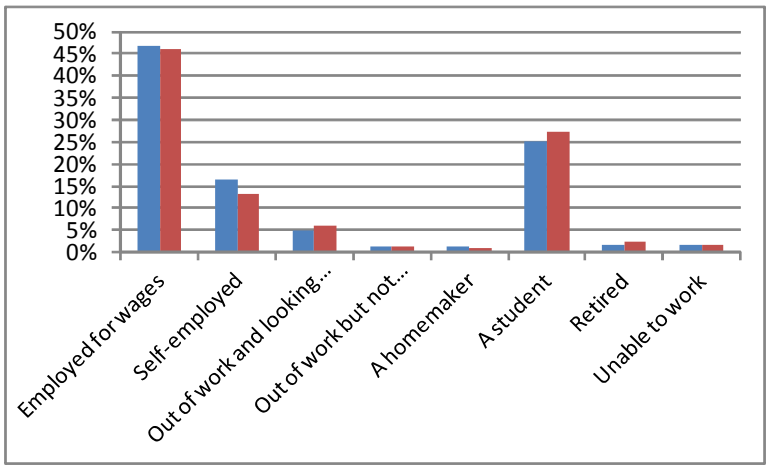

Figure 3: Employment Status; FLOSS (blue), Non-FLOSS (red)

The employment status of the participants in this survey is depicted in Figure 3. Almost a half of the FLOSS (47%) and Non-FLOSS developers (46%) are employed for wages. Second highest are the students with 25% in FLOSS and 27% in Non-FLOSS and then the group of self-employed with 16% of FLOSS developers and 13% of the Non-FLOSS developers ($N_{FLOSS} = 1207$, $N_{non\text{-}FLOSS} = 1728$).

In the FLOSS2013 survey 69% of the FLOSS participants reported to be employed, 20% to be self-employed and 6% to do not paid work as a student (Arjona-Reina et al., 2014).

So this comparison indicates that our survey is representative for the employed and self-employed FLOSS developers.

2.8.3.2 Skill Questions

The next section shows how the participants reported their methods of learning, based on the question "How did you learn to [skill], and how much of this skill did you develop with each method of learning?"

The results of the skills are categorized into Knowledge, Language, Social and Reasoning. One skill of every category was chosen, as the general tendency of learning through the different method is the same in each category, except for Knowledge and Language which include only one skill. The diagrams and the descriptive percentages of the remaining skills are listed in Appendix C.

2.8.3.3 Knowledge

To document code

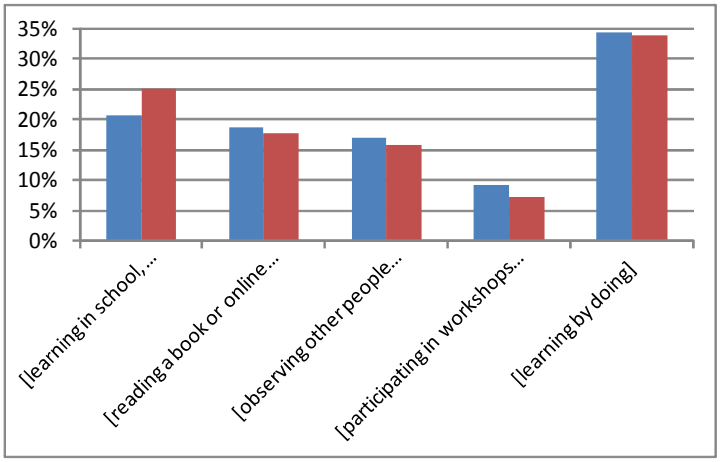

Figure 4: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers (red)

The distribution of the different answer options for learning this skill are shown in Figure 4, the belonging percentages in Table 4.

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	313	20,73%
	[reading a book or	313	18,82%
	[observing other pe	313	16,99%
	[participating in wo	313	9,13%
	[learning by doing]	313	34,33%
	Valid N	313	
No	[learning in school,	484	25,16%
	[reading a book or	484	17,75%
	[observing other pe	484	15,89%
	[participating in wo	484	7,20%
	[learning by doing]	484	33,99%
	Valid N	484	

Table 4: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

The Mann-Whitney-U-Test results in not-significant values (p = 0,346 in survey 1, p = 0,319 in survey 2) for formal and informal learning between FLOSS and non-FLOSS developers. For the comparison of non-developers to non-FLOSS developers the U-test could not be

executed as both values were not variance-homogenous.

2.8.3.4 Language

To understand English, especially in technical discussion

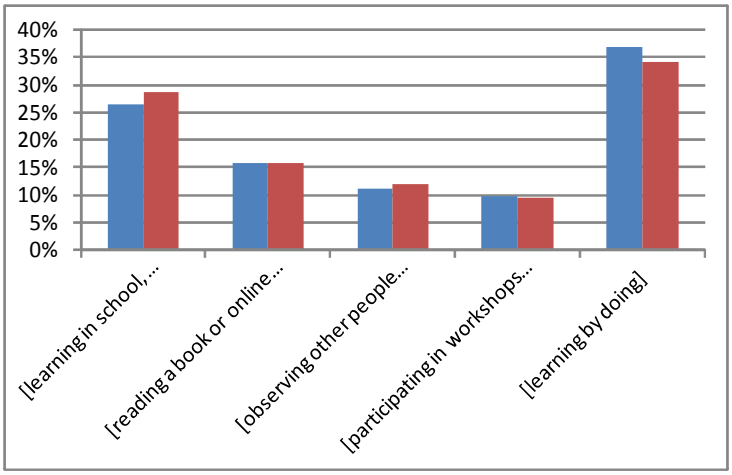

Figure 5: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red))

Figure 5 shows the distribution of learning this skill, the beloging percentages are provided in Table 5.

Descriptive Statistics

		N	Mean
Yes	[learning in school,	329	26,43%
	[reading a book or	329	15,84%
	[observing other pe	329	11,26%
	[participating in wo	329	9,66%
	[learning by doing]	329	36,82%
	Valid N	329	
No	[learning in school,	527	28,64%
	[reading a book or	527	15,88%
	[observing other pe	527	11,87%
	[participating in wo	527	9,53%
	[learning by doing]	527	34,07%
	Valid N	527	

Table 5: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

The Mann-Whitney-U-Test could only be executed for survey 1 where it resulted in a non-significant value ($p = 0{,}190$) for formal and informal learning between FLOSS and non-FLOSS developers. For the non-developers and the non-FLOSS developers both values were not-significant ($p = 0{,}290$ in survey 1, $p = 0{,}506$ in survey 2).

2.8.3.5 Social

In this category “learning in school, university or apprenticeship”, “observing other people perform the activity or the result of their work” and “learning by doing” play the biggest role according to learning this skill in the past. The following skill was chosen to represent the general tendency in the group of social skills.

To communicate with many different target groups

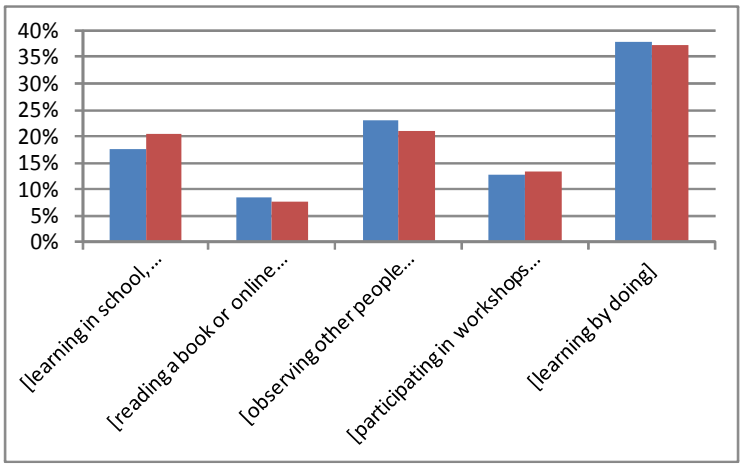

Figure 6: Mean percentage of amount of learning in “How did you learn to ...?”FLOSS developers (blue), Non-FLOSS developers(red)

Figure 6 shows the distribution of the answers for learning this skill, the percentages are provided in Table 6.

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	271	17,72%
	[reading a book or	271	8,52%
	[observing other pe	271	22,93%
	[participating in wo	271	12,87%
	[learning by doing]	271	37,97%
	Valid N	271	
No	[learning in school,	413	20,59%
	[reading a book or	413	7,53%
	[observing other pe	413	21,16%
	[participating in wo	413	13,46%
	[learning by doing]	413	37,27%
	Valid N	413	

Table 6: Mean percentage of amount of learning in “How did you learn to ...?”FLOSS developers (Yes), Non-FLOSS developers(No)

The results of the Mann-Whitney-U-Test for this category can be seen in Table 7 and Table 8.

	formal & informal	
Skill #	Value 1	Value 2
3	0,556	0,219
9	0,134	0,829
15	0,586	0,464
8	0,256	-
1	0,764	-
6	0,257	-
17	0,001*	-
10	0,782	-
16	0,838	0,029*
14	-	-

Table 7: U-Test non-developers and non-FLOSS developers; * = significant

	formal & informal	
Skill #	Value 1	Value 2
3	0,147	0,157
9	-	-
15	0,981	0,940
8	0,700	-
1	0,435	0,000*
6	0,632	0,747
17	0,420	0,986
10	0,304	-
16	0,831	0,146
14	-	0,264

Table 8: U-Test FLOSS developers and non-FLOSS developers; * = significant

2.8.3.6 Reasoning

This category contains the different technical skills. The participants reported that "learning in school...", reading a book..." and "learning by doing" have the highest impact for learning the skills in the past, in this category.

To work on your own software module alone

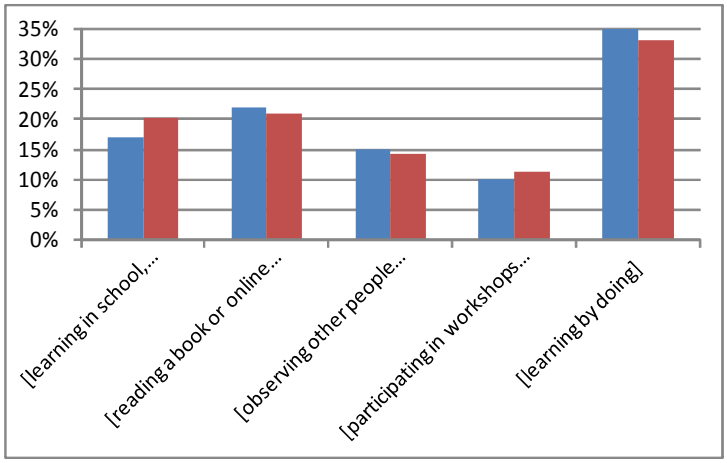

Figure 7: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

For learning this skill the distribution can be seen in Figure 7, the corresponding percentages are provided in Table 9.

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	285	16,94%
	[reading a book or	285	22,10%
	[observing other pe	285	15,11%
	[participating in wo	285	10,07%
	[learning by doing]	285	35,78%
	Valid N	285	
No	[learning in school,	428	20,26%
	[reading a book or	428	20,95%
	[observing other pe	428	14,31%
	[participating in wo	428	11,32%
	[learning by doing]	428	33,16%
	Valid N	428	

Table 9: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

The results of the Mann-Whitney-U-Test in this category can be seen in Table 11 and Table 10.

	formal & informal	
Skill #	Value 1	Value 2
12	-	-
11	-	0,972
7	-	-
13	-	0,051
2	-	-

Table 11: U-Test non-developers and non-FLOSS developers

	formal & informal	
Skill #	Value 1	Value 2
12	0,000*	0,220
11	0,048*	0,008*
7	0,983	0,048*
13	-	-
2	0,115	0,000*

Table 10: U-Test FLOSS developers and non-FLOSS developers; * = significant

2.9 Results Discussion

The following chapter summarizes the important results of this analysis, which are then interpreted according to the hypothesis and the research questions.

The calculated values of the Mann-Whitney-U-Test overall report an high amount of not-significant values in all categories for the comparison between non-developers and non-FLOSS developers, as well as between FLOSS and non-FLOSS developers. Only in the category Reasoning the values for FLOSS and Non-FLOSS developers were often contrary, which might be due to the random distribution of the participants to the different surveys. Also a lot of values between non-developers and FLOSS developers could not be calculated here due to inhomogeneity of variance, as well as in category Knowledge were both values are missing. So no decision can be made according to the values of the U-Test in this categories. As the descriptive values in general only show a small difference of about 5% between formal or informal learning of the different groups, it is reasonable to say that there is no difference in learning formal or informal between non-developers, non-FLOSS developers and FLOSS developers.

As this is the fact for all four categories of skills, the hypothesis that software developers who are not active in FLOSS will report higher levels of learning through formal methods of instruction compared to FLOSS developers for FLOSS competencies they possess, can be refused and it can be said that FLOSS developers and non-FLOSS developers report equal levels of learning through formal methods of instruction . This result as well as the result between the software developers and the participants who never worked in software development, stands in conflict with the findings of the literature in chapter 3.4.2.. An explanation of this on the one hand could be that the literature reviewed was focused on the characteristics of FLOSS developers and less on software developers in general. On the other hand there could be reasons like generational differences or that the sample might be biased. Also the people could have misrepresented how they learn, deliberately or unintended.

The research question if FLOSS developers differ from software developers without engagement in FLOSS according to learning through formal or informal methods in the past, can therefore be answered with no. There is no difference between both groups.

2.10 Conclusions

In this thesis the characteristics of Non-developers, Non-FLOSS developers and FLOSS developers according to formal and informal learning of their competencies were investigated. The result was that the most important method was “learning by doing” for both groups. Also formal methods were only used to 40% in total and learning through informal methods plays the biggest role. Also we found out, that there is no significant difference between Non-developers, Non-FLOSS developers and FLOSS developers according to learning through formal and informal methods. So the hypothesis developed in the beginning could be refused and the question could be answered.

This thesis provides a first fundamental analysis on how FLOSS developers and software developers without engagement in FLOSS have gained their competencies in the past. Both groups learned their skills mostly through informal methods.

As software developers have gained their competencies equal to the FLOSS developers it should therefore be possible to find a concept of training to develop the same competencies by non-FLOSS developers. So there is reason to believe that it would be possible to transfer the concept of learning in FLOSS communities, problem-based-, case-based-learning and project-based-learning, to formal environments to train software developers in such skills successfully outside of FLOSS communities, which might be a interesting substantial scope for research in the future.

3 Elaboration of Research Chapter

This chapter is an elaboration of chapter 2 and explains the different chapters more extensive, to provide additional information.

3.1 Definitions

Before proceeding to the research approach there has to be a consensus of what is actually meant by the different terms used in this thesis, like Free/Libre/Open Source Software, skills and competencies, and informal and formal learning. This terms are described in the following chapter.

3.1.1 Definition of Free/Libre/Open Source Software (FLOSS)

The term Free/Libre/Open Source Software (FLOSS) is used to summarize the many different terms and philosophies existing about software whose source code is accessible, but they can basically be categorized in two groups – "Free Software" popularized by the Free Software Foundation and "Open Source Software" established by the Open Source initiative. "Free Software", which is also known as "Libre Software", means that the users can run the software, change it according to their needs and distribute it, almost without any limitations (Free Software Foundation, n. d.). But tactical concerns to this term appeared according to the word "free", as this often refers more to the monetary aspect than to freedom, which is the actual meaning, therefore it is often called "Libre", too. So the philosophy of "Open Source Software" and with it the term "open" arose, which focuses more on the development of the software than on ideological aspects (Open Source Initiative, n. d.). According to Richard Stallman, in general both terms describe the same community only with two different movements (see Appendix A).

In my Bachelor's Thesis I use FLOSS as a term for software where users are free to run, alter and distribute the software and even to sell that software with some limitations (Sowe, Stamelos, & Samoladas, 2007), and as a hypernym for both movements and all other abbreviations, like OSS, FOSS or F/OS software.

3.1.2 Skills and Competencies

Nowadays, the term "competency" can be found almost everywhere, if it is in school, university or in enterprises. There is always talk of competency profiles that have to be fulfilled, or competencies that can be achieved in participating in a workshop, but no one defines this term – so what actually is a competency?

Grundmann (2011) defines competencies as related to a job, or better to a special performance of it. Also they are related to general human abilities, what means that there exist abilities needed for basic tasks, which can also explain performance on larger similar tasks. As Erpenbeck and Rosenstiel (2003) explain, a competency is based on its specific performance and can only be evaluated by implementing it. Therefore competencies are strongly context-based. In addition, Kaufhold (2006) summarizes that there does not exist a consistent concept of what competencies are in general, only that a competency is defined by its purpose and the related action requirements.

Skills basically are components that can be trained to perform them automatically in stereotypical work-related requirement areas and seize the behavior in requirement-based action situations (Erpenbeck & Rosenstiel, 2003).

So competencies and skills are both a term for abilities to perform specific tasks in a job-related environment. As the line between the terms "competency" and "skills" is quite blurred

(Erpenbeck & Rosenstiel, 2003) and as there is no consistent concept of competencies, the terms are used interchangeably in this thesis.

3.1.3 Informal and Formal Learning

The terms formal and informal learning describe the environment in which the process of learning proceeds (Straka, 2000).

Formal learning covers all processes of learning which take place in traditional educational institutions, like schools and universities. Also this kind of learning is methodical, structured by official didactic curricula and executed by professional teaching staff, and aims toward recognized degrees (Straka, 2000). Examples for formal learning are training measures like advanced training, workshops, or courses of instruction (Livingstone, 1999).

Informal learning is learning outside of formal institutions (Faust & Holm, 2001). It is also structured, but not by official curricula. The structure here is based on the demand of learning the student has. Therefore informal learning is self-organized. Different kinds of informal learning are reading literature or learning from models (Staudt & Kley, 2001).

3.2 Prior Work

3.2.1 Competencies needed for FLOSS: can they be trained, or are they innate?

As this research is intended to declare how FLOSS developers learn, to deliver an impulse for other people who want to develop those competencies, a declaration has to be provided if competencies that are needed in the FLOSS community can be trained at all, or if they are innate.

In his research on competency White (1959) defines a concept that describes the development of basic abilities, which are neither innate nor a result of maturation processes. Those skills are developed self-organized by the individual. To him competency is a precondition of performance, which the individual evolves by self-motivated interaction with its environment (Erpenbeck & Rosenstiel, 2003). The same opinion is provided by the Federal Ministry for Education and Research of Germany. In their work about national standards of education they defined the term competency as follows. Competencies are abilities, which are acquired and not given by nature. Those abilities have been experienced in the social reality and are suitable to its shaping. Additionally, those abilities can be cultivated, increased and refined lifelong and open up a process of self learning (Klieme et al., 2007). In summary, a competency is an ability that is developed by the individual itself and contributes to processes of self learning. Hence competencies are not innate and can be developed in social reality.

As mentioned by Klieme et al. (2007) competencies can be developed lifelong, so it is obvious that they can be trained somehow. Also Kaufhold (2006) speaks about the possibility to alter competencies. As competencies are categorized as bound to a person, it is assumed that they can be developed by this person, wherefore they should not be seen as constant. Therefore competencies are changeable by the individual itself or by a third party concerning to different requirements. In addition, competencies can be lost in case of less to no usage and can also be shifted to another dimension of competency. Also research on competencies and mental abilities shows that there are distinctions among competencies when it comes to developing them through training. “Competencies that consist primarily of knowledge can be improved readily through training and are appropriate training choices for all employees...” (Grundmann, 2011, p. 11) and are therefore rated as highly trainable. Other competencies have a skill component, which can easily be trained, and an ability component that is limited

by the degree of talent, which makes them moderately trainable. Last there are the less trainable competencies which relate to a high amount of personal attributes, and are harder to train, depending on the person (Grundmann, 2011).

Thus, competencies are abilities that are evolved by the individual itself and in the social reality, so competencies are not innate. The trainable competencies can be cultivated and refined lifelong, either by the individual itself or by a third party depending on the different requirements.

3.2.2 Existing Training for FLOSS Competency and the Effectiveness of Training

Based on the previous chapter is resolved that competencies are trainable. Now I provide an overview of the different methods existing for the competencies needed in FLOSS and the effectiveness of those methods.

To train a language, in case of this thesis English, many approaches arose over the years, which are all seen to be as most effective in teaching or training languages. Some examples of those trends are *The Grammar Translation,* where the language is learned by analyzing its grammar through reading literature and applying this knowledge to the translation of different texts. *The Direct Method,* where basic and everyday used sentences and vocabulary is taught with a combination of showing objects, pictures and oral communication. And *The Oral Approach and Situational Language Teaching,* in which the language is learned mainly through the spoken language like in *The Direct Method*, but where grammar plays also an important role and is graded by complexity (Richards & Rodgers, 2001). Today there seems to be no consistent concept of which method is the best to be applied. Instead the different approaches are used in combination to teach the different languages in courses or seminars, in institutions or online. Some institutions would be the *Delfin English School*, which offers various different English courses (Delfin English School, 2014), or The London School of English with online courses (The London School of English, 2014). But no further academic research on this topic could be found.

For training the necessary programming and IT-Skills the same issues exist as for the language skills. This area seems to be more practitioner-led than research-led and no scientific research of the training methods applied in this specific field could be found. Many courses are available that teach the different skills via stand-up instruction, discussions or group exercises depending on the topic, in formal courses, workshops or online courses. Some examples would be the *Project Performance International* course “Software Engineering” (Project Performance International, 2014) or the various workshops of the *IEEE Coumputer Society* (IEEE Computer Society, 2014).

According to Segrin and Givertz (2003) social skills are the ability to interact with other people, for example to express feelings, positive or negative, and to communicate ones interests and desires to other people. Social skills training is seen as most effective when it is started with the assessment phase, because people have different needs which have to be assessed before starting the training. Also it can be examined if the participants are realistic candidates for the training, e.g. if they can or want to follow instructions. The most effective way to train social skills here is the training through social interaction. Different methods are explained in their work. One is training through instruction or coaching, where the core is a set of systematic instructions to communicate more effectively. Those instructions are taught through verbal explanation, which can be a lecture, a group discussion, one-on-one discussions or also written manuals. The participants should learn how to and why to interact with other people in different ways by showing them different examples. Another method is modeling, where the

participants watch other peoples actions and the following consequences, which is seen as the most effective way to teach social behavior. The participants show an increased potential for learning through multiple different models repeating their behavior. Also they start to realize that they are able to learn such behavior, because others can too. This method is based on the fact that if people see rewards, they are more likely to adapt the specific behavior and increase their self-efficacy and response efficacy. In addition to this methods training is conducted through role playing, where the actual behavior is trained under a controlled setting, where the participants can be observed and direct feedback can be given. The training then is completed with homework assignments, where the participants should train in vivo what they have learned and afterward discuss the situation with the trainer to get advice and learn from their mistakes.

As the skills necessary for a successful career as a FLOSS developer are learned in the FLOSS community it is reasonable to see this way of learning also as an effective method to train those skills. In their work Weller and Meiszner (2008) show, that work in FLOSS community is like working on a project and that problem-based- (PBL) and case-based- (CBL) and project-based-learning can be applied here. Savery (2006) defines PBL as an approach that is centered to the learner and is based on instructions. The learners can conduct different research and use their knowledge and skills by combining theory and practice to find a solution to a specific problem, which does not always have a single correct answer. Important for the success of this method is that it is based on an ill-structured problem, because real-world problems are always ill-structured and the participants have to identify the problem and its solution on their own, with guidance of a tutor, to develop their abilities successfully. Often the participants work in collaborative groups to identify what has to be learned, to solve the problem with self-directed learning and then reflect on what has been learned and how effective the applied methods were. CBL is based on a case, which is a written narration of an event, story or experience in the real world and which connects particular situations to more general principles or methods. The case study then simulates part-way the reality which presents problems in the real world in a controlled environment. Based on this case the participants have to identify the characteristics and different problems that appear in it and they have to explore and apply professional knowledge and research (Weller & Meiszner, 2008). Those cases “require student groups to deal with conflicting values and multiple perspectives through collaboration, broadening their own knowledge bases and developing teamwork skills” (Weller & Meiszner, 2008, p. 16). Project-based-learning is similar to PBL as the activities of learning are organized around achieving a specific goal. The participants here get specifications for a desired end product and have to follow correct procedures to achieve this goal. While working on such a project often several new problems are encountered from which they can learn in the process. What makes these learning methods so effective is that the participants have the responsibility for their own learning. They have to find the different solutions on their own, while collaborating in groups, discuss them with their group members and analyze what has been learned in the process. Also they are able to get feedback and give feedback to their group members and therefore reflect on the own behavior.

3.3 Related Work

Though competencies have become very important in defining profiles for employees, there is less research in the field of competency assessment. Some of this research was conducted in the medical field to improve the treatment of patients. One approach is the skills training and competency assessment via a simulation technology for medical education (Scalese, Obeso, & Issenberg, 2008). Also in the IT sector some research was conducted, Bassellier, Horner Re-

ich, and Benbasat (2001) provide an theoretical approach on the competency assessment of business managers in the IT sector.

Also surveys have been conducted to evaluate competencies in different sectors. One sector would be the educational sector where different methods on identifying competencies for teachers and educational stuff where used (Thach & Murphy K.L., 1995; Plake, Impara, & Fager, 1993).

In addition, the field of skills or competency training seems to be more practitioner-led than research-led as mentioned in chapter 3.2.2. so there is no additional work, which can be mentioned in this section.

All the above mentioned research only focuses on the assessment of different competencies and not on how different competencies have been or can be developed by others, so there is no evidence on how such competencies have been learned or could be trained to help others gain them, which is the goal of this thesis.

Except for the research of Kimmelmann (2013) and the work of Glott and Gosh (2005), on which this theses is based on, no academic research on the topic of assessing and learning competencies in the field of FLOSS development, could be found.

This lack of research in the specific field of FLOSS confirms the need of studies in this field and therefore the approach of this thesis in this special field.

3.4 Research Question

3.4.1 Question

Open source human capital is increasingly important to firms, in particular the knowledge, influence and connections of individuals who hold key positions in economically important open source projects. The original research question was:
Is open source competency gained largely through self-study, or do more formal teaching methods such as courses, conferences and mentoring play a role? To what extent have open source contributors gained competency through formal teaching methods?

But as the scope of this question was too broad for the scope of this thesis and is not fully addressed by the hypothesis, so the question was scaled down to:
Do FLOSS developers differ from software developers without engagement in FLOSS according to learning the different competencies through formal or informal methods in the past?

3.4.2 Hypothesis

To answer the previous questions, we first have to take a look at the way FLOSS developers think about the different methods of learning based on the literature.

According to Glott and Ghosh (2005), FLOSS developers report that participating in workshops and formal training courses is seen as least useful. Workshops were only rated with 17 percent and formal training courses only reached 12 percent of the participants. So people who engage in free and open source software development report low levels of learning through formal methods. In addition to that, fixing bugs is considered as the most useful way, as two thirds of the survey participants found it very useful (Glott & Ghosh, 2005). So those participants obviously report a high level of informal learning. Furthermore FLOSS development constitutes a model for the creation of self-learning and self-organizing communities where the core knowledge is acquired through learning by doing (Glott, Meiszner, & Sowe, 2007). This leads to the assertion, that people who engage in FLOSS development are more

likely to use informal methods of learning, like learning-by-doing, than formal methods of learning. Findings in other areas of volunteer contributions suggest that people who are likely to be key contributors already possess the attributes which make them top contributors prior to contributing (Panciera, Halfaker, & Terveen, 2009). FLOSS developers might therefore be different from other software developers. To sum up, FLOSS developers prefer methods of study which are not favored by the general population, and FLOSS is biased toward these methods of learning, also there has to be a difference between FLOSS developers and the general population in learning.

For people who are not engaged on FLOSS it is the opposite. As the work of Grundmann (2011) shows, self-study and learning in a web-based environment are seen as the least effective learning for all classes of competencies for the general population (Grundmann, 2011). So the tendency here is towards formal learning methods.

Also the FLOSS community members are not convinced that all skills learned or improved in FLOSS are also better be learned in the community (Glott & Ghosh, 2005). Competencies of FLOSS developers include technical competencies (e.g. programming, quick induction into new projects, implementation of new features without disturbing others), social competencies (e.g. giving constructive feedback, self-organization and presentation skills) and personal competencies, like openness to new things and approaches, time-management and curiosity (Kimmelmann, 2013). Those Competencies and the skills from Glott and Ghosh (2005) can be mapped to the categories Social, Reasoning, Motivation, Knowledge and Mental Style, and also to the categories highly trainable, moderately trainable and less trainable, from Grundmann (2011) (see Appendix B).

Competencies like the documentation of work are categorized in the class Knowledge and are highly trainable. E-mail competency, capacity for teamwork, active communication and presentation are here categorized in the class Social and are therefore moderately trainable, as well as the class Language which contains the competency English skills. Also Reasoning belongs to this group and includes e.g. programming, architecture competency and dealing with technical problems. Motivation competencies like motivation in participating in community life, to improve software or the internalization of the social give and take philosophy of the community, are less trainable. As well as Mental Style like the ability to learn, persistence, time-management, curiosity and the ability to take criticism (Grundmann, 2011). So FLOSS competencies can also be developed and trained by other methods. Therefore, I expect that software developers who are not active in FLOSS will have acquired these, or some of these competencies, if they possess them, through more formal methods than FLOSS developers, because the general population prefers these training methods.

So this leads me to the following Hypothesis:

Software developers who are not active in FLOSS will report higher levels of learning through formal methods of instruction compared to FLOSS developers for FLOSS competencies they possess.

3.5 Research Approach

3.5.1 Competency Model

For the survey I decided to take the skills by Glott and Ghosh (2005), as they were surveyed before and therefore it is reasonable to repeat them in this survey. Using the competencies of Kimmelmann (2013) would have created different problems, as they are named very generic. If we wanted to ask about a specific competency, it would be necessary to clarify the intrinsic meaning so every single competency would have to be described. That is, because e.g. an e-mail competency might have different characteristics to every participant as they are based on the context in which they are used. That would have been a massive amount of reading to the participants and increased the length of the survey which would lead to a decreased tendency of finishing.

The other problem is the way the competency would have to be described. For example the E-Mail competency would look like this: “E-Mail competency contains the ability to follow discussions on mailing lists, describing bugs per email properly so others are able to understand and to write constructive and polite answers.” So one single description would provide three cases, for which the participant has to decide if he is actually good at or not, but he has just one slider to rate them altogether. This would have been confusing to the participants and is in conflict with the rule that every question should only provide one statement that it asks for (see chapter 3.5.2.2.) and therefore the questions contain the skills of Glott and Ghosh (2005) as they directly define the basic activities in the competency.

The skills used in this survey are a combination of the skills Glott and Ghosh (2005) discovered in their survey of FLOSS participants and skills based on the original interviews of the research of Kimmelmann (2013), to fill in the gaps where no skills from Glott and Ghosht matched, to keep integrity. The skills from Glott and Ghosh (2005) are improved in the FLOSS community and therefore necessary for activities there. Based on the categorization of Grundmann (2011) those skills were categorized as shown in and the skills shaded in green were chosen as items for this survey (see Appendix B). First, the skills were selected based on their trainability. The skills in the categories Motivation and Mental Style are less trainable and therefore less interesting to this research approach, as it is intended to find out if future software developers can be supported in training the competencies necessary for FLOSS. The other skills were chosen in a way that every remaining category is represented at least once and in order to assure an easy understanding to the participant. Also only those skills from Glott and Ghosh (2005) were chosen that match to the competencies of Kimmelmann (2013), because those are indispensable for an successful career as FLOSS developer.

3.5.2 Survey Design

In the following chapters I will explain the construction of the survey and the intentions behind the structure. Therefore I explain the different steps relevant for this thesis.

3.5.2.1 Methodology

For this survey an online questionnaire based on the self-report of the participants was chosen, where the selected population, the community of the JDownloader 2 Beta, got access via a link distributed in a client-interface of the JDownloader 2 Beta software.

This method has many advantages as Diekmann (2011) summarizes. Online-surveys are fast in operation and first analyzes are possible right after the start of the survey. They are inexpensive as, e.g. no costs for printing or distributing occur. Especially in our case, as limesurvey is open source survey software and free to run. Also there are multiple possibilities in presenting different graphics and question types. Furthermore it is possible to vary the sequence

of questions, implement jumps to skip questions not relevant to the participant and control access.

3.5.2.2 Selection of Items

To answer the research question it is necessary to find out to what extent people learned with each method of learning, so the decision was to formulate the items as questions instead of statements as we here have the possibility to use answers to grade the intensity (Bortz & Döring, 2006).

Also it is necessary to stick to standards, when it comes to formulating the items correctly. The items should not be worded suggestive, whether it is positive or not. This can influence the participant in either way. Additionally, the items should be written in clear and distinct words and contain only one statement per question. Furthermore they should be formulated in a way that the interpretation of the answer is distinct. In addition, the phrasing should be clear to all participants and generic, there should be no technical terms if possible (Bortz & Döring, 2006). One aspect that was highly relevant for the design of the survey is to make sure that the context of a question does not influence the way the participant answers (Bortz & Döring, 2006), as the participants of this survey come from different areas, not only FLOSS and to explain that the competencies are based on FLOSS developers might have influence their response.

3.5.2.3 Format of Answers

The general questions on software development and FLOSS participation, as well as the demographic questions and the questions on the survey are a compound of different options to answer. There are bound answer formats like multiple choice questions, deciding questions, and also open formats like short text fields. The open formats are basically used for the questions asking for a year, or in an “other” option in the third skill-question to include the possibility of a different answer than expected.

To correctly measure the skills, the survey uses graphical rating scales in a slider design. As there should not be any accumulations, the numbers the limesurvey software shows usually above the slider while moving, were hidden with a script. Also the maximum value of the slider was set to 10000 instead of 100 as it is almost impossible to move the slider intentionally directly on a concrete value, like 50 or in this case 5000. A numeric continuous variable with a ratio scale was chosen, as more mathematical methods, like calculating the difference or the ratio between groups, are possible, which can not be used on ordinal variables. Additionally a unipolar verbal description of the scale was used. The slider in the first skill-question was marked with the minimum “I am not skilled at all” and the maximum “I am very skilled”, the second question type had the markers “not at all” as minimum and “all” as maximum. In this way the slider design avoids the problem of the middle value in a Likert-scale with five stages and therefore the problem to decide if the participant did not have a concrete opinion (indifference) or if it is really the middle value, because both sides are equal (ambivalence) (Bortz & Döring, 2006).

3.5.2.4 Test Falsification

In addition to the possible problems mentioned above, there exist additional problems that occur in questionnaires which are based on self-evaluation of the participant. Bühner (2006) summarizes them into social desirability, motivation, sequence effects and response bias. Those problems exist in two manifestations. On the one hand the simulation, where the participants fake better responses, on the other hand dissimulation, where the responses are faked to achieve lower values. These problems are described as follows.

Social desirability means that the participant tries to emphasize positive values to hide the negative ones, which often occurs in situations where they want to represent themselves in a better light, like testing performance or knowledge, which would affect their reputation. Bühner (2006) provides different approaches to test the amount of social desirability, but as this questionnaire is not conducted in a situation of selection, there is no need to test on this problem.

The second problem is the motivation of the participant, as it can decrease in the response process. This problem occurs in tests which are very long and complex in answering. To avoid this behavior the original survey was split into seven shorter surveys, which is explained in chapter (see chapter 3.5.2.3.), to reduce the original length of 30 minutes to 15 minutes. Also the questions are formulated as simple as possible to avoid overwhelming the participants.

Sequence effects relate to the position of the different items, which can affect the way of response. In the case of this survey the categorization of the different skills might have an effect on that. Bühner (2006) suggests that the sequence of items in questionnaires should be randomized in general, what was taken into account at the creation of this survey.

Last issue of the self-evaluation is the response bias, which means the tendency of the participants to choose yes or no. To measure this tendency a variation of arrangements exists, but the interpretation is critical and it would be necessary to check on a high amount of validity scales, which would exceed the scope of this thesis.

One issue according to conducting the survey is the problem of controlled access. This problem could not be addressed in our case, as there was no information on the participants, or mail-addresses available. So it was not possible to control the access via tokens or passwords, therefore the possibility that the survey might be answered by a participant more than once had to be accepted.

3.5.2.5 Sample Selection

As mentioned earlier a survey via online-questionnaires can reach a high number of people. The JDownloader 2 Beta community was chosen as it is one of the most popular download tools and JDownloader in general has a big community with about 200 000 users. So a high number of responses were expected. As JDownloader is an open source software, it was reasonable to suggest that a lot of the users are also engaged in FLOSS, as FLOSS developers usually run the software they want to improve. As JDownloader is not a specific tool only FLOSS members can use, there was also the suggestion that people who are not engaged with FLOSS can be reached. The total number of responses in the seven surveys altogether was 5878 completed surveys.

3.5.2.6 Description of the Survey

The following chapter provides a short overview of the seven surveys. A full example of the survey structure can be found in Appendix E.

The basic structure is:

1.Questions on software development

2.Questions on participation in FLOSS

3.Skill questions

4.Demographic questions

5.Questions on Survey and JDownloader

I will not explain the seven surveys in particular as most of the sections are alike, which are the “General Questions”, Demographic Questions and the Questions on the Survey and JDownloader.

The surveys 1 to 6 contain 101 Items with 42 questions in 12 groups. Survey 7 has 89 items with 39 questions in 11 groups. The 17 skills are distributed in the surveys. Every survey contains 5 of the skills and one block of control questions, except for Survey 7, which only contains 4 skills plus control-block. Every skill exists twice, for example “to document code” in Survey 1 and 2, so every skill has the same chance to get answered and all Surveys have nearly the same length. The splitting of the skills can be seen in Table 12, where skills are numbered in brackets. The number of the questions belonging to each skill can be seen in the first column, the skills 1b, 4b, 7b, 10b, 13b, 17b and 6b , shaded in gray, are the control questions.

Question #	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Survey 7
11-13	to evaluate the work of others (1)	to document code (5)	to understand high level structures of software systems (7b)	to communicate without offending others (10)	to coordinate own work with the work of others (15)	to evaluate the work of others (1)	to clearly articulate an argument (6)
14-16	to work on own software module alone (2)	to comprehend technical discussions in English (4b)	to follow discussions on mailing lists (9)	basic/introductory programming skills (12)	to change criticized behavior (16)	intercultural cooperation (17b)	to coordinate own work with the work of others (15)
17-19	to communicate with many different target groups (3)	to clearly articulate an argument (6)	to communicate without offending others (10)	to acquaint yourself with code from others (13)	to acquaint yourself with code from others (13)	to change criticized behavior (16)	basic/introductory programming skills(12)
20-22	to understand English, especially technical discussion (4)	to understand different software architectures (7)	to show respect for the work of others (8)	to write code in a way that it can be re-used (11)	to understand and work with people from different cultures (17)	to work on own software module alone (2)	to express your reasoning so others can easily understand (6b)
23-25	to document code (5)	to show respect for the work of others (8)	to understand different software architectures (7)	to have discussions without upsetting other people (10b)	to make yourself familiar with code from someone else (13b)	to communicate with many different target groups (3)	to follow discussions on mailing lists (9)
26-28	to assess other people's work (1b)	to understand English, especially technical discussion (4)	to write code in a way that it can be re-used (11)	to maintain contact with a community (14)	to maintain contact with a community (14)	to understand and work with people from different cultures (17)	

Table 12: Distribution of Skills

The questionnaire itself was distributed to the participants per link in the JDownloader interface.

By clicking on that link some information of the kind of research is provided, that it is conducted by the Friedrich-Alexander University Erlangen-Nürnberg and that there are no financial motivations behind this research (Appendix D).

After starting the survey the first page again provided some information on the research, but in more detail. The description contains information on the intention behind the questionnaire that the goal is to understand which skills they possess, how they acquired them and how they would improve them in the future. It also provides the time, 10-15 minutes, the participation will take, information on possibilities to be notified after the publishing the results and on anonymity.

The first part includes questions on the general activity in software development, if people work in software development and if yes since when. This is necessary as the questions are how FLOSS developers learn, so there has to be the opportunity to identify the software developers first.

Section 2 then identifies the people who engaged in FLOSS, as the first question asks for participation in FLOSS, if the answer is yes some more questions on the year in which they started, the way they participated appear.

The third part, with questions on the skills, is the biggest section of the survey (see Figure 8).

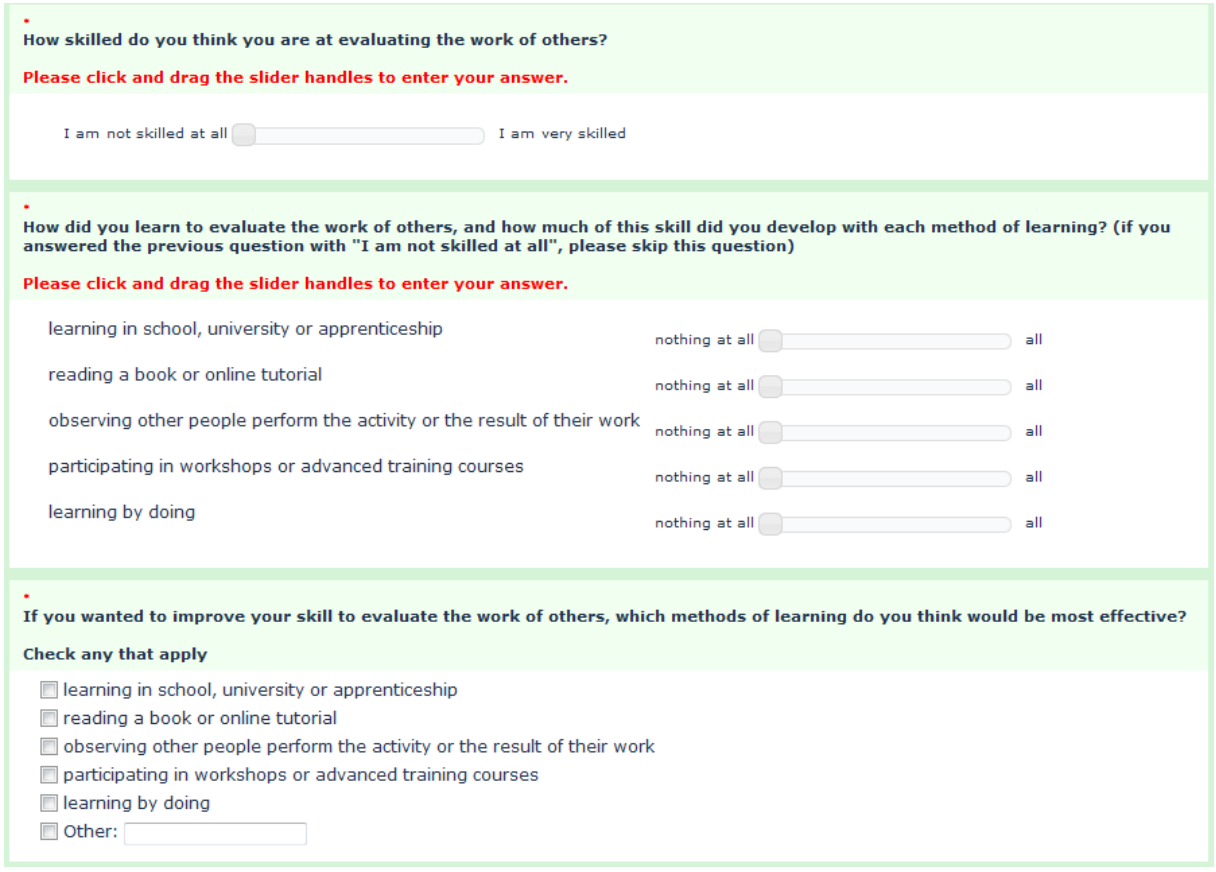

Figure 8: Example of Skill Questions

For every skill there are three questions. The first asks about how skilled the participants are, the second question asks about how the participants learned their skill, if they possess it, and it provides answers where they can rate the different methods of learning with a slider scale. The third question then asks how the participant would actually improve the current skill level, even if they do not possess this skill. Here the same answers are provided as in the second question, but this time with the option of multiple choice and an “other” category, where they can insert alternatives. Every skill-block, containing these three questions, was shown on

an own page. Except for the copies, the skills were randomly distributed, e.g. not all social skills in one survey, to the different surveys, within them also randomly provided to avoid possible sequence effects (see chapter 3.5.2.2.).

The next section provides the demographic questions. The first page is an info box which explains the intention of asking these questions to the reader. This is necessary as most people do not like answering this questions and less than ever if they do not know why those questions are asked. It informs that the questions help to analyze the results of this survey and that the information is just used to identify groups and will not be analyzed for every single person, so they do not have the feeling of being exposed. Otherwise this fact would increase the likelihood to give incorrect or dubious answers. This is also the reason why the demographic questions are the only part of the questionnaire where all answers are voluntary, so nobody is forced to give an answer who actually does not want to. In addition to that, this section was placed at the end intentionally, to avoid declining the participant's motivation right from the beginning. The demographic questions are about gender, year of birth, current country, employment status and job and income.

At the end, some questions on the survey and the JDownloader community follow. First the participants are able to decide if they want to be contacted for further surveys and if they want to be notified when the results are published. As in general people do not like to distribute their email addresses an alternative was added. They were also informed that the results will be announced directly by JDownloader and also on the website of the OSR group.

3.5.2.7 Assessment in detail

In the following chapter I provide the process of assessment in the different steps that have been taken to conduct the survey.

The first step was to test the preliminary version of the survey on a group of people who belong to the desired group of software developers and who also have experience in engaging in FLOSS. They were asked to evaluate the survey on clarity of the introduction, instructions, items and response category, and also on the length. Some people mentioned problems in understanding the different items, which led to a reformulation of those items. Also the length of the survey was considered too long, so the survey was split to the final seven surveys.

The final surveys were distributed with a link in the JDownloader client-interface. As seven different surveys were executed, the related links were randomly assigned to the participants. Also the participants had the option to choose a German version of the survey, if they prefer. In this way every user of the JDownloader community was able to enter one of them. The users were not forced to enter, the participation was voluntary.

The survey was completely anonymous, as no information was required beforehand to access and also no information on the participant has been saved during the process of answering, except the participant wanted to, e.g. providing the email address for notification or further participation in surveys of the OSR group.

The final surveys were distributed on 12.12. 2013 to the JDownloader community and was open until 15.01.2014.

3.6 Used Data Sources

In addition to the data gathered in this survey, the raw data from the "The FLOSS2013 Free/Libre/Open Source Survey" by Arjona-Reina, Robles, and Dueñas (2014) was used to compare the demographics of the FLOSS developers in this survey with another population of FLOSS developers, to check on the representation.

3.7 Research Results

3.7.1 Methods of Statistical Analysis

3.7.1.1 Descriptive Analysis

As seven surveys were conducted, the descriptive analysis for the relevant items had to be done for each one separately first and then the results were added together in a second step. Especially in the case of the skill questions, each skill had to be analyzed in two of the surveys separately and the results were then added together and the new mean value was calculated with the formula of *weighted mean*.

3.7.1.2 Test for Normal Distribution

The test for normal distribution is a precondition for running most statistical tests and specifically for the further methods of testing used in this thesis. To test this requirement the Kolmogorov-Smirnov-Test with the niveau of significance of Lillefors was used, which calculates a value of probability for normal distribution. This value makes it possible to decide if the hypothesis, that the values of the items are normally distributed, is correct or not. The higher this value, the higher is the probability of normal distribution (Brosius, 1998). If the value of significance is lower than $p = 0.20$ the items are not normally distributed (Pospeschill, 2012).

3.7.1.3 Test for Homogeneity of Variance

Many statistical procedures which test and compare different case groups expect that the variance within each of the groups is equal, especially tests for significance. To examine if these requirement is fulfilled for the items necessary to test the hypothesis the test for homogeneity of variance by Levene is used which tests the null hypothesis that the variances in all groups are homogeneous. If the value of significance is higher than $p = 0.20$ the homogeneity of variance can be assumed (Pospeschill, 2012).

3.7.1.4 Mann-Whitney-U-Test

To test the hypothesis that software developers who are not active in FLOSS report higher levels of formal learning than FLOSS developers the Mann-Whitney-U-Test is used which tests the null hypothesis that both groups belong to the same population against an alternative hypothesis. This test is the non-parametrical equivalent of the t-test and does not require assumptions regarding the normal distribution (Bamberger, 2012). As the items necessary for testing the hypothesis were not normal distributed, this method was chosen.

In this case the following hypotheses are tested:

H0: The participants who have not worked in software development report the same level of formal learning as the Non-FLOSS developers

H1: The participants who have not worked in software development report a different level of formal learning as the Non-FLOSS developers

H0: Non-FLOSS developers report the same level of formal learning as FLOSS developers

H1: Non-FLOSS developers report a different level of learning formal learning as FLOSS developers

The same hypotheses were tested for informal learning.

The values of both groups are summarized and then sorted in ascending order. Each value is assigned to a rank and subsequently the sum of the ranks of each group is calculated separately. After that the value of significance is calculated (Brosius, 1998). Is the value of significance $p < 0.05$ the null hypothesis will be rejected, otherwise it will be adopted (Bortz & Döring, 2006).

To conduct the U-Test and to calculate the total amount of formal and informal learning, the answer options of the "How did you learn to...?" questions where grouped into a "formal" and "informal" variable according to the literature (see chapter 3.1.3).

This can be seen in Table 13:

formal	informal
learning in school, university or apprenticeship	reading a book or online tutorial
participating in workshops or advanced training courses	observing other people perform the activity or the result of their work
	learning by doing

Table 13: Grouping of Answer Options

3.7.1.5 The Spearman-Correlation

To examine if the participants followed the survey correctly the control questions were compared. The items of those questions were also not distributed normally so the coefficient of correlation by Spearman was used as this test does not require a normal distribution. The Spearman-Correlation is the direct counterpart of the Pearson-Correlation (Pospeschill, 2012) which is usually used for this kind of analysis. The values of correlation are defined as follows:

Values of the coefficients of correlation	Interpretation
$0 < r <= 0.2$	Very low correlation
$0.2 < r <= 0.5$	Low correlation
$0.5 < r <= 0.7$	Mid-level correlation
$0.7 < r <= 0.9$	High correlation
$0.9 < r <= 1$	Very high correlation

Table 14: Values of correlation of Bühl, 2008 (p.269)

3.7.2 Data Analysis

The raw data was exported directly as SPSS files from limesurvey and analyzed via SPSS 22.0 for Windows. Before starting the analysis the data had to be normalized. Some variables had to be transliterated into numeric as SPSS cannot handle strings to resolve conditions. The answers of the "How skilled do you think you are at…?" questions were normalized to a maximum value of 100 instead of 10000. The answers of "How did you learn to …, and how much of this skill did you develop with each method of learning?" were set to a dependency of 100% as this was intended before, but the limesurvey software does not provide this function in a practical manner.

This is the term used to normalize the data for every participant:

$$A_{new} = \frac{A_n}{\sum_{i=1}^{n} Ai} * 100$$

Subsequently every country had to be normalized and got a code to identify it, as this question was an open question, because there was no evidence of the origin of the participants. Last, all data sets got deleted, which did not answer a minimum of one of the "How skilled do you think you are at…?" questions, the amount of how many data sets were deleted can be seen in Table 15.

Remaining Data sets after Deleting			
	Raw Sets	Deleted	Remaining
Survey 1	815	42	773
Survey 2	889	48	841
Survey 3	913	61	852
Survey 4	906	28	878
Survey 5	753	26	727
Survey 6	734	30	704
Survey 7	868	36	832
Total	5878	271	5607

Table 15: Remaining Data Sets after Deleting

The control questions were analyzed to check on normal distribution. As none of them showed this characteristic, the Spearman Correlation was used, because the case of normal distribution is not required. Every survey has one control question related to one skill question, those questions were paired and the coefficient of correlation was calculated. All pairs showed a coefficient between $0.5 < r < 0.8$ which represents a mid- to high-level correlation (Bühl, 2008). As it was not possible to set the slider in the control question exactly to the same value as in the related skill question, some deviations had to be expected. So in this case a mid- or high-level correlation is enough to conclude that the participants followed the survey correctly. Therefore no further data sets were deleted. After that 5607 data sets remained which are 95.39% of the total.

3.7.3 Results

In the following chapter the results of the statistical analysis are provided. First the results of the demographics are shown and compared to existing demographic statistics of FLOSS developers, then the results of the descriptive analysis and the values of the U-Test of the skills questions are described.

To provide the different results and to compare the groups of participants, each group is named separately. The "non-developers" are all participants who have never worked in software development or FLOSS development, "Non-FLOSS developers" are the software developers without engagement in FLOSS and "FLOSS developers" are the software developers who have experience in FLOSS development.

3.7.3.1 Demographic Questions

The following chapter presents the results which are necessary to answer the research question and to examine the constructed hypothesis. The first part describes the characteristics of the chosen sample, the second part provides an overview of the results of the statistical data analysis described in the previous chapter.

Participation in FLOSS

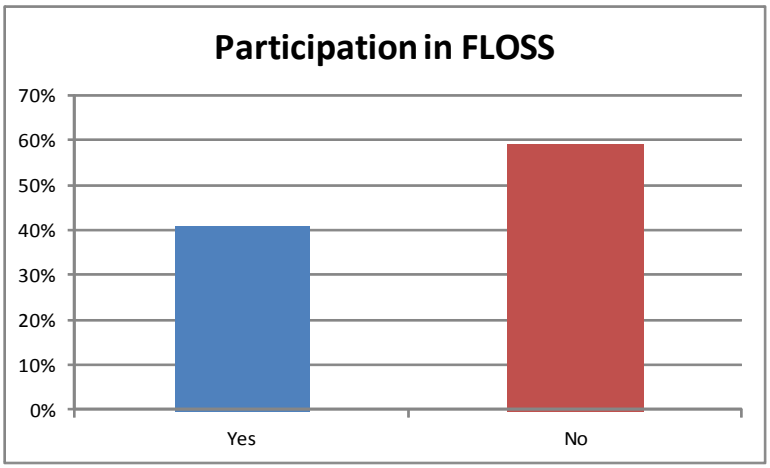

Figure 9: Participation in FLOSS

Figure 9 shows the total amount of all seven surveys of FLOSS developers (Yes) and software developers without engagement in FLOSS (No). 41% reported to participate in FLOSS 59% do not (N = 3091).

Gender

1262 participants in the group of FLOSS developers and 1829 Non-FLOSS developers answered this question. In the category of FLOSS developers a very high amount of male developers exists 97.64% of FLOSS developers and 96.97 % of Non-FLOSS developers, 1.55% (FLOSS) and (2,23% Non-FLOSS) are female, the remaining participants chose the option "other".

In the FLOSS2013 survey 86.83% of the FLOSS participants reported to be male, 11.64% are female and 1.53% chose "other" (N = 1632) (Arjona-Reina et al., 2014). In the survey of Glott and Ghosh (2005) only 1.7% were female, so about 98% of the participants were male. So this indicates that our survey is representative in case of the gender of the FLOSS participants.

Year of Birth

The average year of birth in our survey is 1981 for the the FLOSS developers and 1979 for Non-FLOSS developers. So our FLOSS developers are on average 33 years and the Non-FLOSS developers 34 years old ($N_{FLOSS} = 1236$, $N_{non\text{-}FLOSS} = 1772$).

As the average year of birth was calculated with the mean values of the birth years of all seven surveys, seven different values for the standard deviation were calculated. The values vary between 11-15 for the FLOSS developers and between 11-14 for the Non-FLOSS developers.

Country

In general our participants reported to come from countries all over the world. But almost half of the FLOSS developers (49%) and 40% of the Non-FLOSS developers live in Germany, which might be due to the fact that JDownloader is a German Open Source software. About 5% of FLOSS developers and 9% of Non-FLOSS developers come from Italy, and 4% FLOSS and 5% Non-FLOSS developers from Spain. The remaining countries are only represented with less than about 4% ($N_{FLOSS} = 1251$, $N_{non\text{-}FLOSS} = 1829$).

In the FLOSS2013 Survey the distribution is quite different. Most participants come from the United States of America with 28%, only 8% from Germany, 7% from Spain and about 6% from the United Kingdom (N = 1629). So a representation in case of the countries can not be assumed.

Employment Status

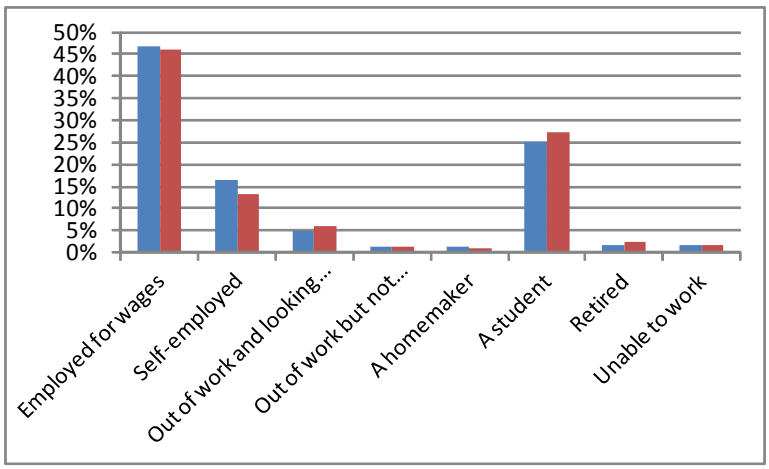

Figure 10: Employment Status; FLOSS (blue), Non-FLOSS (red)

The employment status of the participants in this survey is depicted in Figure 10. Almost a half of the FLOSS (47%) and Non-FLOSS developers (46%) are employed for wages. Second highest are the students with 25% in FLOSS and 27% in Non-FLOSS and then the group of self-employed with 16% of FLOSS developers and 13% of the Non-FLOSS developers ($N_{FLOSS} = 1207$, $N_{non\text{-}FLOSS} = 1728$).

In the FLOSS2013 survey 69% of the FLOSS participants reported to be employed, 20% to be self-employed and 6% to do not paid work as a student (Arjona-Reina et al., 2014).

So this comparison indicates that our survey is representative for the employed and self-employed FLOSS developers.

3.7.3.2 Skill Questions

The next section shows how the participants reported their methods of learning, based on the questions “How did you learn to [skill], and how much of this skill did you develop with each method of learning?” and “If you wanted to improve your skill to [skill], which methods do you think would be most effective?”.

The diagrams of the “How did you learn to...?” questions provide the mean percentage for the amount of learning in the different categories, where as the diagrams of the “If you wanted to improve...” questions show the percentage of the multiple choice answers of the different categories.

The results of the skills are categorized into Knowledge, Language, Social and Reasoning and one skill of every category was chosen, as the general tendency of learning through the different method is the same in each category. Except for Knowledge and Language which only include one skill. The diagrams and the descriptive percentages of the remaining skills are listed in Appendix C.

3.7.3.3 Knowledge

To document code

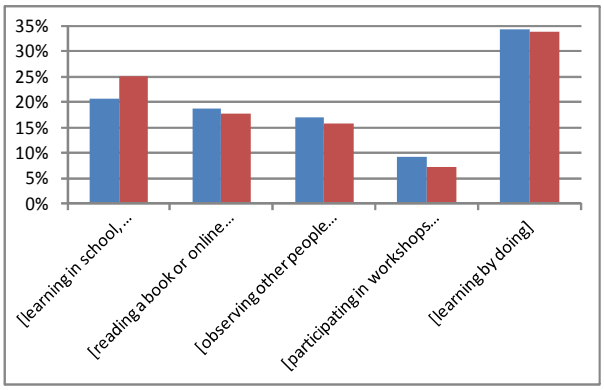

Figure 11: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

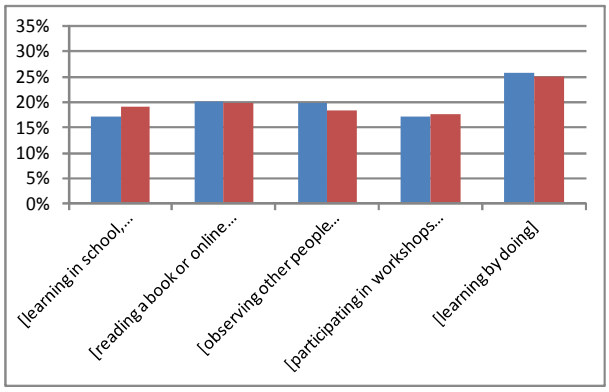

Figure 12: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

The distribution of the different answer options for learning this skill are shown in Figure 11, the belonging percentages in Table 17. For improving this skill the distribution is shown in Figure 12 and the percentages in Table 16.

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	313	20,73%
	[reading a book or	313	18,82%
	[observing other pe	313	16,99%
	[participating in wo	313	9,13%
	[learning by doing]	313	34,33%
	Valid N	313	
No	[learning in school,	484	25,16%
	[reading a book or	484	17,75%
	[observing other pe	484	15,89%
	[participating in wo	484	7,20%
	[learning by doing]	484	33,99%
	Valid N	484	

Table 17: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	144	17,20%
	[reading a book o	168	20,07%
	[observing other p	166	19,83%
	[participating in w	144	17,20%
	[learning by doing	215	25,69%
Total		837	100,00%
No	[learning in school	255	19,22%
	[reading a book o	263	19,82%
	[observing other p	245	18,46%
	[participating in w	233	17,56%
	[learning by doing	331	24,94%
Total		1327	100,00%

Table 16: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

The Mann-Whitney-U-Test results in not-significant values ($p = 0{,}346$ in survey 1, $p = 0{,}319$ in survey 2) for formal and informal learning between FLOSS and non-FLOSS developers. For the comparison of non-developers to non-FLOSS developers the U-test could not be executed as both values were not variance-homogenous.

3.7.3.4 Language

To understand English, especially in technical discussion

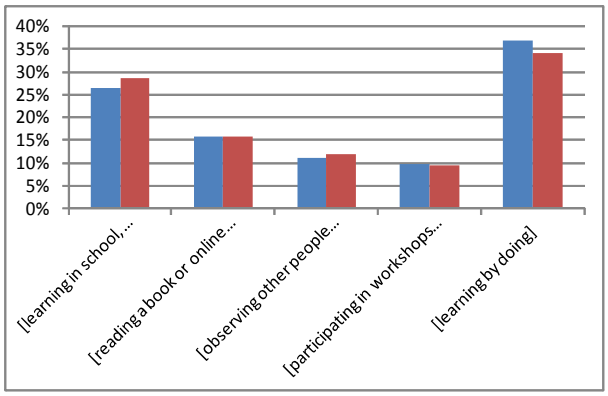

Figure 13: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red))

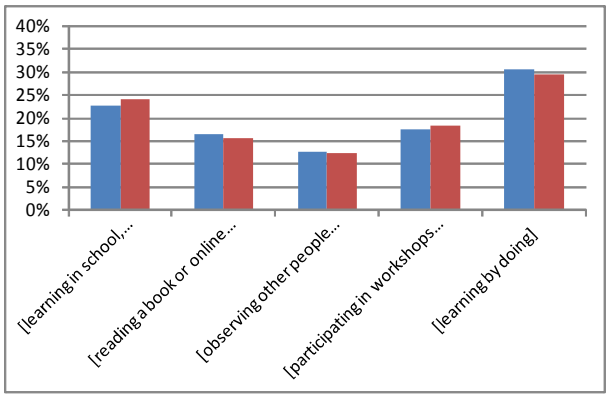

Figure 14: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Figure 13 shows the distribution of learning this skill, the beloging percentages are provided in Table 18. The multiple choice answers for improving this skill are shown in Figure 14, the percentages in Table 19.

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	329	26,43%
	[reading a book or	329	15,84%
	[observing other pe	329	11,26%
	[participating in wo	329	9,66%
	[learning by doing]	329	36,82%
	Valid N	329	
No	[learning in school,	527	28,64%
	[reading a book or	527	15,88%
	[observing other pe	527	11,87%
	[participating in wo	527	9,53%
	[learning by doing]	527	34,07%
	Valid N	527	

Table 18: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	193	22,81%
	[reading a book o	139	16,43%
	[observing other p	108	12,77%
	[participating in w	148	17,49%
	[learning by doing	258	30,50%
Total		846	100,00%
No	[learning in school	314	24,12%
	[reading a book o	203	15,59%
	[observing other p	161	12,37%
	[participating in w	241	18,51%
	[learning by doing	383	29,42%
Total		1302	100,00%

Table 19: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

The Mann-Whitney-U-Test could only be executed for survey 1 where it resulted in a non-significant value ($p = 0{,}190$) for formal and informal learning between FLOSS and non-FLOSS developers. For the non-developers and the non-FLOSS developers both values were not-significant ($p = 0{,}290$ in survey 1, $p = 0{,}506$ in survey 2).

3.7.3.5 Social

In this category “learning in school, university or apprenticeship”, “observing other people perform the activity or the result of their work” and “learning by doing” play the biggest role according to learning this skill in the past. For improving this skill “observing other people...”, “participating in workshops or advanced training courses” and again”learning by doing” are seen as most effective. The following skill was chosen to represent the general tendency in the group of social skills.

To communicate with many different target groups

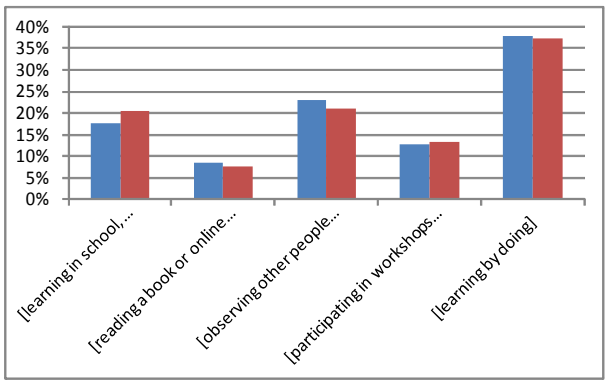

Figure 15: Mean percentage of amount of learning in “How did you learn to ...?”FLOSS developers (blue), Non-FLOSS developers(red)

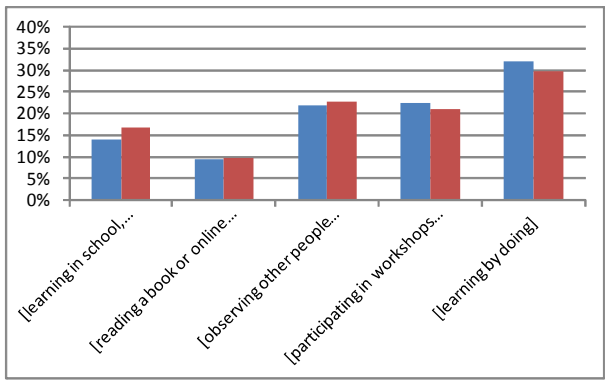

Figure 16: Percentage of multiple choice answers of “If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Figure 15 shows the distribution of the answers for learning this skill, the percentages are provided in Table 20. For improving this skill in the future, the distribution can be seen in Figure 16, the related percentages are shown in Table 21.

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	271	17,72%
	[reading a book or	271	8,52%
	[observing other pe	271	22,93%
	[participating in wo	271	12,87%
	[learning by doing]	271	37,97%
	Valid N	271	
No	[learning in school,	413	20,59%
	[reading a book or	413	7,53%
	[observing other pe	413	21,16%
	[participating in wo	413	13,46%
	[learning by doing]	413	37,27%
	Valid N	413	

Table 20: Mean percentage of amount of learning in “How did you learn to ...?”FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	91	14,02%
	[reading a book o	62	9,55%
	[observing other p	142	21,88%
	[participating in w	146	22,50%
	[learning by doing	208	32,05%
Total		649	100,00%
No	[learning in school	175	16,78%
	[reading a book o	103	9,88%
	[observing other p	236	22,63%
	[participating in w	219	21,00%
	[learning by doing	310	29,72%
Total		1043	100,00%

Table 21: Percentage of multiple choice answers of “If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

The results of the Mann-Whitney-U-Test for this category can be seen in Table 23 and Table 22.

	formal & informal	
Skill #	Value 1	Value 2
3	0,556	0,219
9	0,134	0,829
15	0,586	0,464
8	0,256	-
1	0,764	-
6	0,257	-
17	0,001*	-
10	0,782	-
16	0,838	0,029*
14	-	-

Table 23: U-Test non-developers and non-FLOSS developers

	formal & informal	
Skill #	Value 1	Value 2
3	0,147	0,157
9	-	-
15	0,981	0,940
8	0,700	-
1	0,435	0,000*
6	0,632	0,747
17	0,420	0,986
10	0,304	-
16	0,831	0,146
14	-	0,264

Table 22: U-Test FLOSS developers and non-FLOSS developers

3.7.3.6 Reasoning

This category contains the different technical skills. The participants reported that “learning in school...”, reading a book...” and “learning by doing” have the highest impact for learning the skills in the past, in this category. For improving the same methods are reported as most effective.

To work on your own software module alone

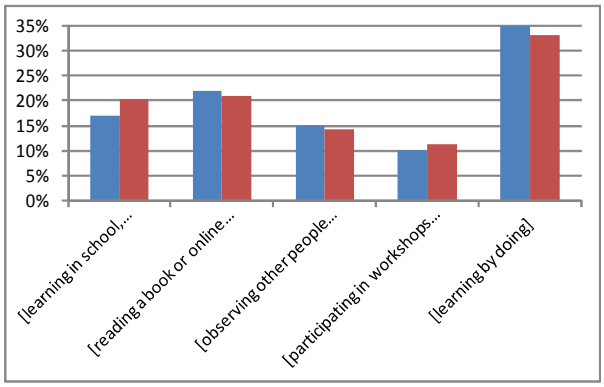

Figure 17: Mean percentage of amount of learning in “How did you learn to ...?”FLOSS developers (blue), Non-FLOSS developers(red)

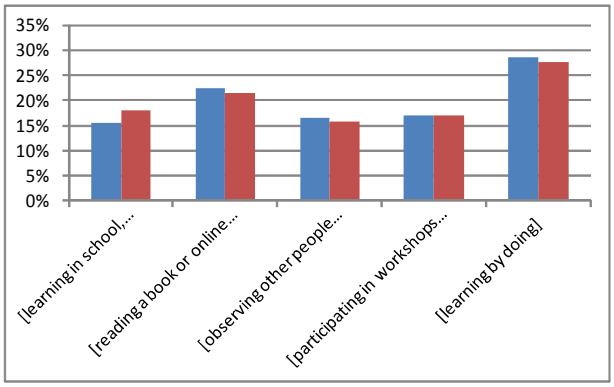

Figure 18: Percentage of multiple choice answers of “If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

For learning this skill the distribution can be seen in Figure 17, the percentages in Table 24. The allocation for improving this skill in the future is shown in Figure 18, the corresponding percentages are provided in Table 25.

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	285	16,94%
	[reading a book or	285	22,10%
	[observing other pe	285	15,11%
	[participating in wo	285	10,07%
	[learning by doing]	285	35,78%
	Valid N	285	
No	[learning in school,	428	20,26%
	[reading a book or	428	20,95%
	[observing other pe	428	14,31%
	[participating in wo	428	11,32%
	[learning by doing]	428	33,16%
	Valid N	428	

Table 24: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	132	15,53%
	[reading a book o	190	22,35%
	[observing other p	140	16,47%
	[participating in w	144	16,94%
	[learning by doing	244	28,71%
Total		850	100,00%
No	[learning in school	229	18,13%
	[reading a book o	272	21,54%
	[observing other p	198	15,68%
	[participating in w	214	16,94%
	[learning by doing	350	27,71%
Total		1263	100,00%

Table 25: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

The results of the Mann-Whitney-U-Test in this category can be seen in Table 27 and Table 26.

	formal & informal	
Skill #	Value 1	Value 2
12	-	-
11	-	0,972
7	-	-
13	-	0,051
2	-	-

Table 27: U-Test non-developers and non-FLOSS developers

	formal & informal	
Skill #	Value 1	Value 2
12	0,000*	0,220
11	0,048*	0,008*
7	0,983	0,048*
13	-	-
2	0,115	0,000*

Table 26: U-Test FLOSS developers and non-FLOSS developers

3.8 Results Discussion

The following chapter summarizes the important results of this analysis, which are then interpreted according to the hypothesis and the research question.

The values of the Mann-Whitney-U-Test report that there is no significant difference according to learning through more formal methods between FLOSS and non-FLOSS developers in the categories of Knowledge and Social skills. This can be additionally confirmed with the percentages of the descriptive analysis of the "How did you learn to...?" question, where formal learning in general is reported low and the difference between FLOSS and non-FLOSS developers is only about 5%. For the comparison of non-developers and non-FLOSS developers 7 of 20 values could not be calculated due to variance-inhomogeneity. The remaining values show a tendency to not-significant values. As the descriptive values only show a small difference of about 4% between the groups within the surveys, it can be said that there is also no difference in learning formal or informal between the software developers and the participants who have never worked in software development.

In the category of Language there was only one value calculated, which reported that learning is also equal in this section between FLOSS and non-FLOSS developers, as the related item of the corresponding survey did not provide the requirements for the U-Test. So no statement can be made according to the value of significance, but here also the descriptive percentages

of formal learning for FLOSS and Non-FLOSS developers show only a difference of about 2%, so it stands to reason that both groups do learn equally. The values in this skill group for non-developers and non-FLOSS developers were both not significant, so here is also no difference in learning.

For the skill group of Reasoning between FLOSS and non-FLOSS developers, the values of the U-Test were often contrary for each skill, one was significant and the related value of the second survey was not, therefore they would neutralize each other. The reason for this might be the random distribution of the participants to the different surveys, as the items of the surveys with the significant values in this category also show a tendency to significant values in general. So the decision of learning equal or not can only be made with the descriptive values. The difference of both groups of about 5% is slightly higher than in the other categories, but according to the high value of participants answering these questions, still low enough to conclude that FLOSS and non-FLOSS developers do not learn significantly different from each other. Only two values could be calculated for the non-developers and non-FLOSS developers, but according to the descriptive values there is only a difference of about 5% within the surveys, so both groups also learn equally. So there is no difference between non-developers and non-FLOSS developers, as well as between FLOSS developers and Non-FLOSS developers, when it comes to learning through formal or informal methods.

As this is the fact for all four categories of skills, the hypothesis that software developers who are not active in FLOSS will report higher levels of learning through formal methods of instruction compared to FLOSS developers for FLOSS competencies they possess, can be refused and it can be said that FLOSS developers and non-FLOSS developers report equal levels of learning through formal and informal methods. This result as well as the result between the software developers without engagement in FLOSS and the participants who never worked in software development, stands in conflict with the findings of the literature in chapter 3.4.2.. An explanation of this on the one hand could be that the literature reviewed was focused on the characteristics of FLOSS developers and less on software developers in general. On the other hand there could be reasons like generational differences or that the sample might be biased. Also the people could have misrepresented how they learn, deliberately or unintended.

The research question if FLOSS developers differ from software developers without engagement in FLOSS according to learning through formal or informal methods in the past, can therefore be answered with no. There is no difference between both groups.

3.9 Conclusions

In this thesis the characteristics of Non-developers, Non-FLOSS developers and FLOSS developers according to formal and informal learning of their competencies were investigated. As we found out through the literature that competencies are not innate and are mostly all trainable and that various methods of training exist, the different methods of learning these competencies by FLOSS developers and Non-FLOSS developers were investigated and the result was that the most important method was “learning by doing” for both groups. Also formal methods were only used to 40% in total and learning through informal methods plays the biggest role. Also we found out, that there is no significant difference between Non-developers, Non-FLOSS developers and FLOSS developers according to learning through formal methods. In Addition, the results not only showed no difference in formal learning, there also does not exist a difference in informal learning. So the hypothesis developed in the beginning could be refused and the question could be answered.

This thesis provides a first fundamental analysis on how FLOSS developers and software developers without engagement in FLOSS have gained their competencies in the past and on

how they would improve them in the future. Both groups learned their skills mostly through informal methods and would choose almost the same methods for advancing them.

As software developers learn equal to the FLOSS developers it should therefore be possible to find a concept of training to develop the same competencies by Non-FLOSS developers. “Learning by doing” had the highest impact for both groups, so Non-FLOSS developers seem to have the same ability of self-learning as the FLOSS developers. So there is reason to believe that it would be possible to transfer the concept of learning in FLOSS communities, project-based-, case-based-learning and project-based-learning, to formal environments to train software developers in such skills successfully outside of FLOSS communities, which might be a interesting substantial scope for research in the future.

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5 Appendices

Appendix A The Stallman-Ghosh-Glott mail exchange on the FLOSS survey (excerpt)

Richard Stallman, head of the Free Software Foundation, Rishab Aiyer Ghosh, FLOSS lead author, and Ruediger Glott, sociologist and FLOSS-team member, have exchanged following mails on the Free Software - Open Source questions. We recommend their reading, because they may clarify the goals, motivations and way of work of the FLOSS survey.

We would like to thank Richard Stallman for his time, interest and suggestions (and, of course, for giving permission to make this public).

From: **Richard Stallman** <rms(AT)gnu.org>
To: **Rishab Aiyer Ghosh** <rishab.ghosh(AT)infonomics.nl>, **Gregorio Robles** <grex(AT)scouts-es.org>
Subject: Two communities, or two movements?
Date: 26 Aug 2002 15:51:52 -0600
[text in red are original quotes from the FLOSS final report]

I just saw the FLOSS study, and here are some comments.

Although members of both communities collaborate intensively on practical projects, they claim that, on the level of the underlying ideas and philosophies, both communities have to be considered as entirely separate movements. [5]

That is somewhat misleading, because it seems to imply that the idea of two separate communities comes from us. On the contrary, we always say that these are two movements within one community. The evidence you've found, showing that people with different political views work together, confirms something that is apparent within our community.

Could you possibly correct this so as not to suggest we believe there are two separate communities?

According to this ongoing discussion, one would expect a sharp polarization of the whole community of developers of non-proprietary software into two very different parties,

This unlikely expectation may have come from the idea of "two communities", since that implies two separate groups with little interaction. However, the understanding that there are two movements in one community leads to completely different expectations. It is very rare for any political disagreement to polarize society entirely into two firm camps with no neutrals; the usual situation is to find a range of views, including both intermediate views and "don't care". Finding that here is normal, not surprising.

Members of the open source software community define "Open Source Software" as software that allows everybody to have a look at its source code

Actually this is not true: the definition of open source software includes criteria for the rights that users must have. (See www.opensource.org.) What you've stated is a common misunderstanding of the term "open source". Could you please add a note to indicate that this is a mis-

understanding? Although I don't support the open source movement, I think it is unfortunate to spread misinformation about their criteria.

The first type consists of those developers who assign themselves to the Free Software community and who see fundamental differences between the two communities (18%).

Did your question suggest use of the term "communities" to for Free Software and Open Source? If so, people who identify specifically with one movement or the other, but do not think there are two communities, would have faced a quandary about how to answer. None of the answers provided fits that picture. They could have given this answer, saying there are two different communities, or they could have said there is just one community and no difference between Free Software and Open Source. Either one would be misleading.

Nevertheless, it is evident that the world of Open Source/Free Software is not strictly separated from capitalistic principles, and that a lot of money can be earned by the development or application of OS/FS, like it is illustrated by the example of LINUX.

Do you really mean Linux, the kernel, or are you thinking of the GNU/Linux operating system? It is hard to tell, since many people call the latter "Linux". I suspect you mean the whole GNU/Linux system, since people make more money from that than from Linux, the kernel, on its own.

If so, would you please call it "GNU/Linux", and give its principal developers a share of the credit? For more explanation, see http://www.gnu.org/gnu/linux-and-gnu.html.

Source: http://flossproject.org/floss1/stallman.html, last accessed March 11, 2014.

Appendix B Mapping of Competencies

	Grundmann (2011)	Kimmelmann (2013) (competencies)	Gosh&Glott (2005) (skills)	Interviews from Kimmelmann (2013)
Highly Trainable	**Knowledge**	- documentation of work	- to document code	- to document work so others can properly understand
			- to understand the differences between copyrights, patents and licenses	
			- to understand licenses	
			- to understand copyright issues	
			- to understand patent law issues	
			- to improve my understanding of liability issues	
			- to get an overview of developments in software technology	
			- to get an overview of the skills you need in the software professions	
Moderately trainable	**Language**	- English skills	- to better understand English, especially technical discussion	
	Social	- E-mail competency		- to follow discussions on mailing lists
				- to describe bugs properly
				- to write constructive and polite answers
		- capacity for teamwork	- to interact with other people	- to share own knowledge
			- to coordinate own work with the work of others	- to take help from others in a proper degree
		- not being arrogant against others		- to be modest
				- to show respect to work of others
		- target- group-		- to communicate

	Grundmann (2011)	Kimmelmann (2013) (competencies)	Gosh&Glott (2005) (skills)	Interviews from Kimmelmann (2013)
		specific communication skills		with many different target groups
		- giving constructive feedback	- to evaluate the work of others	- to response non-judgmental and constructive
				- to offer help or guidance
				- to response objective
		- compliance with social rules		- to respect social rules (no discrimination,sexism)
		- active communication skills	- to clearly articulate an argument	
			- to express personal opinions	
		- intercultural competency	- to understand and work with people from different cultures	- to respect the different cultural conventions
		- dealing with different styles of communication		- to adjust own style of communication to others
				- to communicate without offending others
		- gaining recognition and earning reputation		- to be active in a project
				- to increase the quality of own work
				- to put continuous effort into a project
		- implementation of feedback		- to accept feedback
				- to change the criticized behavior
		- presentation skills		- to give a qualitative presentation
				- to represent the company or project in a presentation
		- ability to establish and maintain contact with the community	- to keep a community going	- to maintain contact with a community
				- to be active in a

	Grundmann (2011)	Kimmelmann (2013) (competencies)	Gosh&Glott (2005) (skills)	Interviews from Kimmelmann (2013)
				community
			- to clearly define and achieve targets	
			- to settle conflicts within a group	
			- to motivate people	
			- to lead a project or a group of people	
	Reasoning	- programming	- basic/introductory programming skills	
			- to become familiar with different programming languages	
			- to re-use code written by others	
			- to look for and fix bugs	
			- to run and maintain complex software systems	
			- to write code in a way that it can be re-used	
		- architecture competency	- to design modular code	-to understand different software architectures
				- to understand code dependencies
		- quick induction into new projects		- to acquaint yourself with code from others
		- dealing with technical problems		
		- high number of qualitative patches		- to follow programming guidelines
		- implementation without disturbing others		- to only work on own software module alone
				- to implement requirements without disturbing users
		- identification of possible		- to keep up to date with new projects

	Grundmann (2011)	Kimmelmann (2013) (competencies)	Gosh&Glott (2005) (skills)	Interviews from Kimmelmann (2013)
		successful projects		- to follow the development of projects
			- to create new algorithms	
Less trainable	**Motivation**	- motivation to improve software		
		- motivation through acknowledgment		
		- want to be in on the whole		
		- intrinsic motivation to work in OS		
		- motivation for participation in the community life		
		- internalization of social give and take philosophy of the community		
	Mental Style	- altruistic character		
		- ability to take criticism	- to accept and to respond to criticism from others	
		- “be tough”		
		- be unafraid of publicity		
		- ability to learn		
		- openness to new things and approaches		
		- persistence		
		- time-management	- to plan work and stick to a work schedule	
		- ability to adapt to changing situations		
		- demand high quality of your work		
		- curiosity		

Appendix C Introduction to Survey

JDownloader has partnered with the **Open Source Research Group at Friedrich-Alexander University Erlangen-Nürnberg** to conduct a series of surveys. The research is intended to improve the JDownloader experience and/or promote academic research into applied software development. There is no financial motivation behind this collaboration, but the whole JDownloader Project will profit from the survey results.
Please consider taking a moment to support this research.

Appendix D Descriptive Diagrams of Skills

Knowledge

To document code

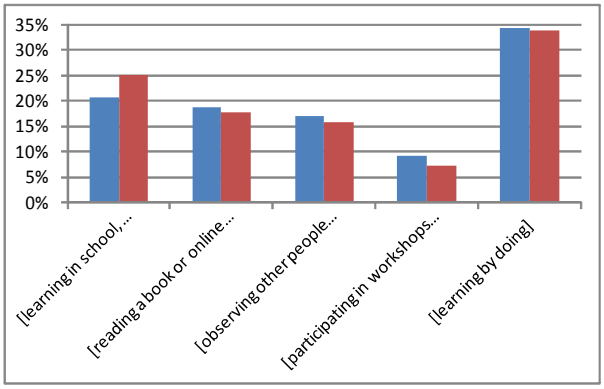

Figure 19: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

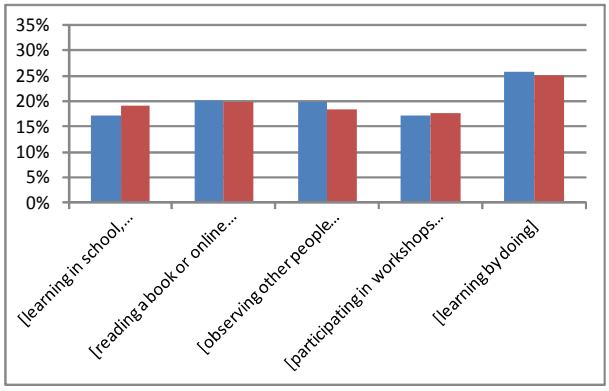

Figure 20: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	313	20,73%
	[reading a book or	313	18,82%
	[observing other pe	313	16,99%
	[participating in wo	313	9,13%
	[learning by doing]	313	34,33%
	Valid N	313	
No	[learning in school,	484	25,16%
	[reading a book or	484	17,75%
	[observing other pe	484	15,89%
	[participating in wo	484	7,20%
	[learning by doing]	484	33,99%
	Valid N	484	

Table 29: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	144	17,20%
	[reading a book o	168	20,07%
	[observing other p	166	19,83%
	[participating in w	144	17,20%
	[learning by doing	215	25,69%
Total		837	100,00%
No	[learning in school	255	19,22%
	[reading a book o	263	19,82%
	[observing other p	245	18,46%
	[participating in w	233	17,56%
	[learning by doing	331	24,94%
Total		1327	100,00%

Table 28: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

Language

To understand English, especially in technical discussion

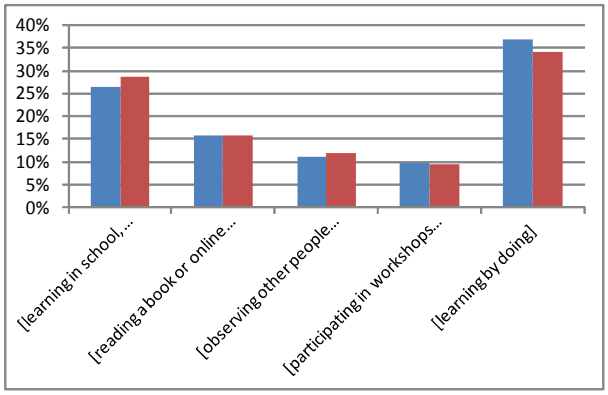

Figure 21: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

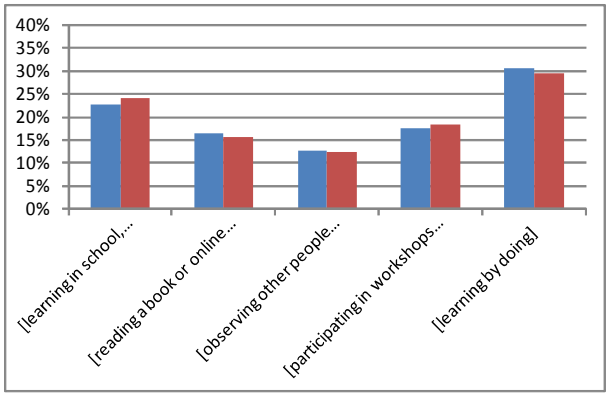

Figure 22: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	329	26,43%
	[reading a book or	329	15,84%
	[observing other pe	329	11,26%
	[participating in wo	329	9,66%
	[learning by doing]	329	36,82%
	Valid N	329	
No	[learning in school,	527	28,64%
	[reading a book or	527	15,88%
	[observing other pe	527	11,87%
	[participating in wo	527	9,53%
	[learning by doing]	527	34,07%
	Valid N	527	

Table 30: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	193	22,81%
	[reading a book o	139	16,43%
	[observing other p	108	12,77%
	[participating in w	148	17,49%
	[learning by doing	258	30,50%
Total		846	100,00%
No	[learning in school	314	24,12%
	[reading a book o	203	15,59%
	[observing other p	161	12,37%
	[participating in w	241	18,51%
	[learning by doing	383	29,42%
Total		1302	100,00%

Table 31: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

Social

To communicate with many different target groups

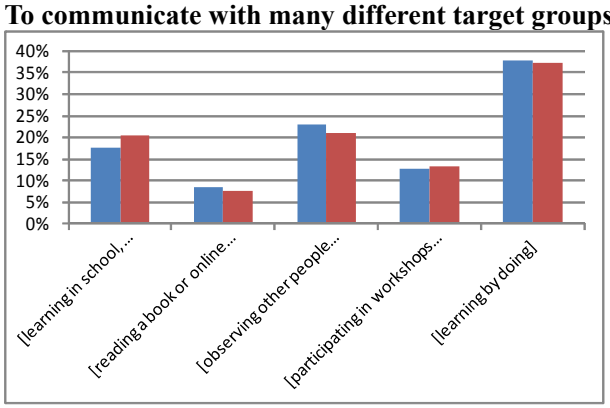

Figure 23: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

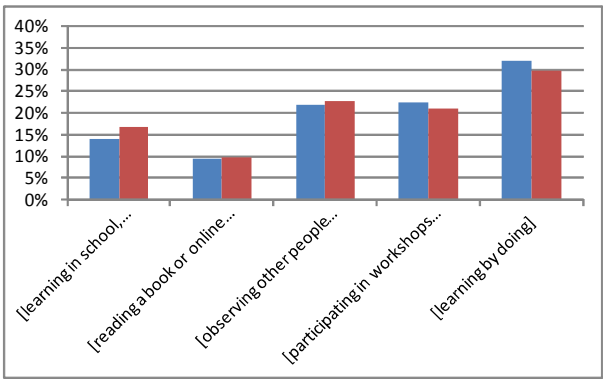

Figure 24: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	271	17,72%
	[reading a book or	271	8,52%
	[observing other pe	271	22,93%
	[participating in wo	271	12,87%
	[learning by doing]	271	37,97%
	Valid N	271	
No	[learning in school,	413	20,59%
	[reading a book or	413	7,53%
	[observing other pe	413	21,16%
	[participating in wo	413	13,46%
	[learning by doing]	413	37,27%
	Valid N	413	

Table 32: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	91	14,02%
	[reading a book o	62	9,55%
	[observing other p	142	21,88%
	[participating in w	146	22,50%
	[learning by doing	208	32,05%
Total		649	100,00%
No	[learning in school	175	16,78%
	[reading a book o	103	9,88%
	[observing other p	236	22,63%
	[participating in w	219	21,00%
	[learning by doing	310	29,72%
Total		1043	100,00%

Table 33: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To evaluate the work of others

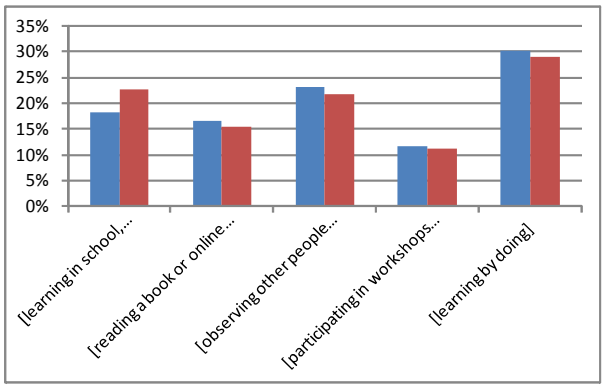

Figure 25: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

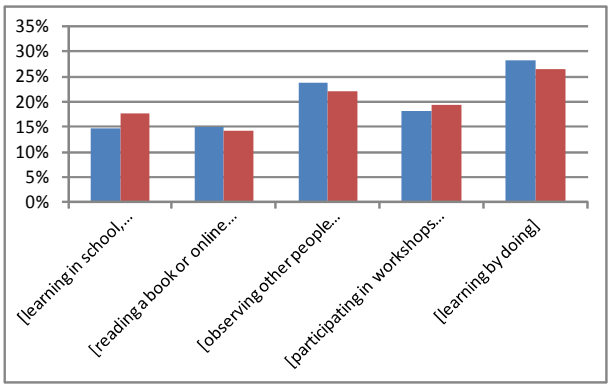

Figure 26: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	309	18,32%
	[reading a book or	309	16,68%
	[observing other pe	309	23,05%
	[participating in wo	309	11,69%
	[learning by doing]	309	30,26%
	Valid N	309	
No	[learning in school,	457	22,65%
	[reading a book or	457	15,44%
	[observing other pe	457	21,73%
	[participating in wo	457	11,26%
	[learning by doing]	457	28,92%
	Valid N	457	

Table 34: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	120	14,63%
	[reading a book o	123	15,00%
	[observing other p	196	23,90%
	[participating in w	149	18,17%
	[learning by doing	232	28,29%
Total		820	100,00%
No	[learning in school	205	17,70%
	[reading a book o	164	14,16%
	[observing other p	256	22,11%
	[participating in w	225	19,43%
	[learning by doing	308	26,60%
Total		1158	100,00%

Table 35: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To clearly articulate an argument

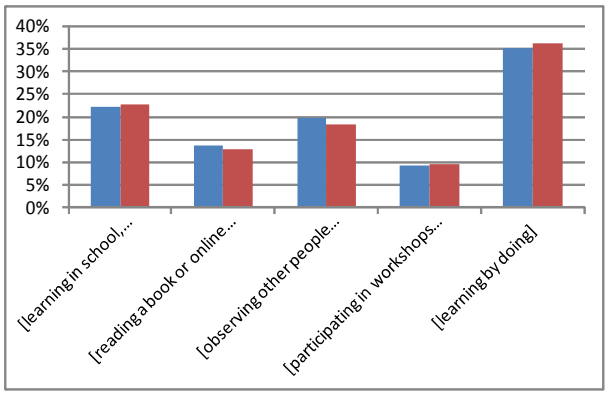

Figure 27: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

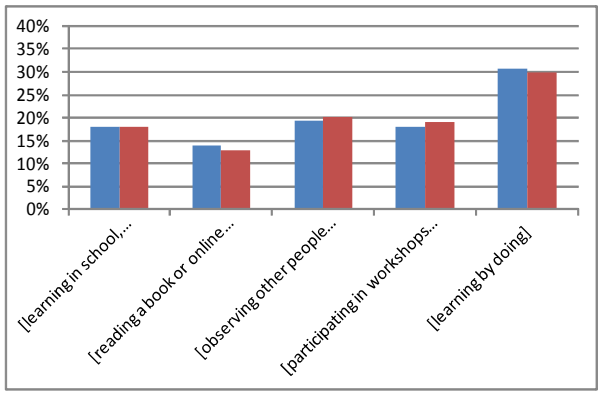

Figure 28: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	369	22,34%
	[reading a book or	369	13,64%
	[observing other pe	369	19,68%
	[participating in wo	369	9,28%
	[learning by doing]	369	35,07%
	Valid N	369	
No	[learning in school,	498	22,79%
	[reading a book or	498	12,93%
	[observing other pe	498	18,40%
	[participating in wo	498	9,60%
	[learning by doing]	498	36,28%
	Valid N	498	

Table 36: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	159	17,87%
	[reading a book o	124	13,93%
	[observing other p	173	19,44%
	[participating in w	160	17,98%
	[learning by doing	274	30,79%
Total		890	100,00%
No	[learning in school	216	17,97%
	[reading a book o	154	12,81%
	[observing other p	242	20,13%
	[participating in w	230	19,13%
	[learning by doing	360	29,95%
Total		1202	100,00%

Table 37: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To show respect for the work of others

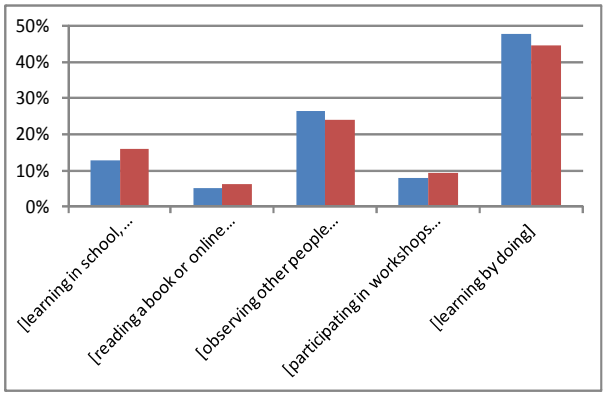

Figure 29: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

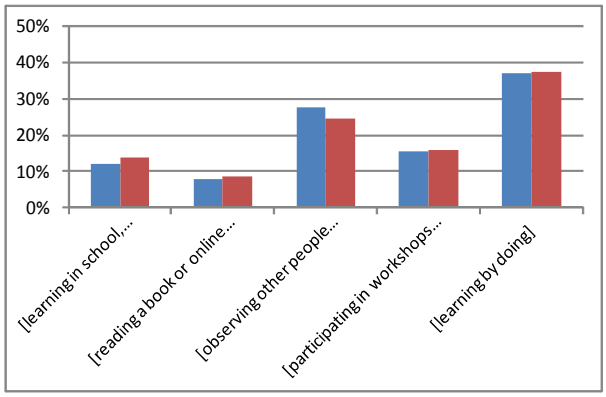

Figure 30: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	347	12,89%
	[reading a book or	347	5,24%
	[observing other pe	347	26,35%
	[participating in wo	347	7,77%
	[learning by doing]	347	47,75%
	Valid N	347	
No	[learning in school,	523	16,00%
	[reading a book or	523	6,07%
	[observing other pe	523	24,07%
	[participating in wo	523	9,40%
	[learning by doing]	523	44,46%
	Valid N	523	

Table 38: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	83	11,89%
	[reading a book o	55	7,88%
	[observing other p	194	27,79%
	[participating in w	107	15,33%
	[learning by doing	259	37,11%
Total		698	100,00%
No	[learning in school	137	13,69%
	[reading a book o	87	8,69%
	[observing other p	245	24,48%
	[participating in w	158	15,78%
	[learning by doing	374	37,36%
Total		1001	100,00%

Table 39: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To follow discussions on mailing lists

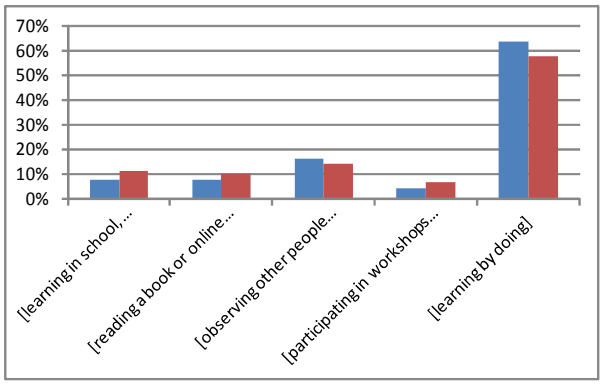

Figure 31: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

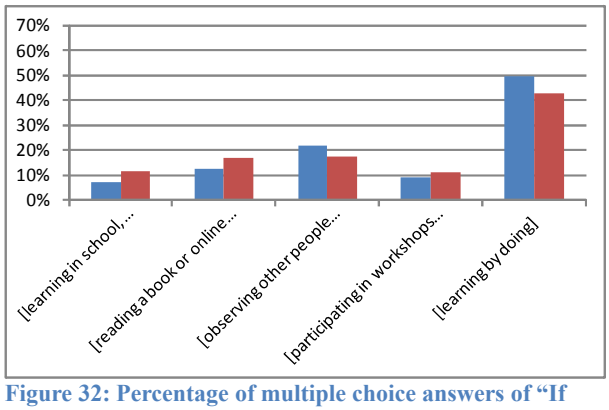

Figure 32: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	326	7,95%
	[reading a book or	326	7,81%
	[observing other pe	326	16,33%
	[participating in wo	326	4,37%
	[learning by doing]	326	63,53%
	Valid N	326	
No	[learning in school,	371	11,27%
	[reading a book or	371	10,10%
	[observing other pe	371	14,18%
	[participating in wo	371	6,79%
	[learning by doing]	371	57,67%
	Valid N	371	

Table 40: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	46	6,97%
	[reading a book o	84	12,73%
	[observing other p	144	21,82%
	[participating in w	59	8,94%
	[learning by doing	327	49,55%
Total		660	100,00%
No	[learning in school	96	11,58%
	[reading a book o	140	16,89%
	[observing other p	144	17,37%
	[participating in w	92	11,10%
	[learning by doing	357	43,06%
Total		829	100,00%

Table 41: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To communicate without offending others

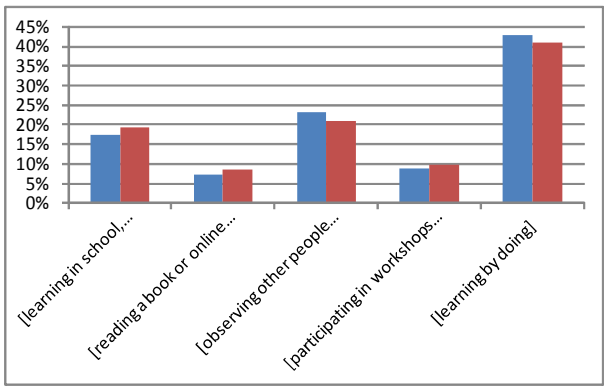

Figure 33: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

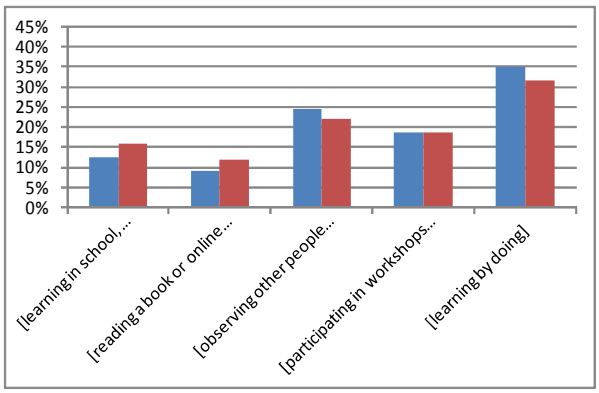

Figure 34: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	375	17,55%
	[reading a book or	375	7,32%
	[observing other pe	375	23,31%
	[participating in wo	375	8,88%
	[learning by doing]	375	42,93%
	Valid N	375	
No	[learning in school,	516	19,26%
	[reading a book or	516	8,62%
	[observing other pe	516	21,06%
	[participating in wo	516	9,94%
	[learning by doing]	516	41,12%
	Valid N	516	

Table 42: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	103	12,52%
	[reading a book o	76	9,23%
	[observing other p	202	24,54%
	[participating in w	154	18,71%
	[learning by doing	288	34,99%
Total		823	100,00%
No	[learning in school	176	16,00%
	[reading a book o	130	11,82%
	[observing other p	241	21,91%
	[participating in w	205	18,64%
	[learning by doing	348	31,64%
Total		1100	100,00%

Table 43: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To maintain contact with a community

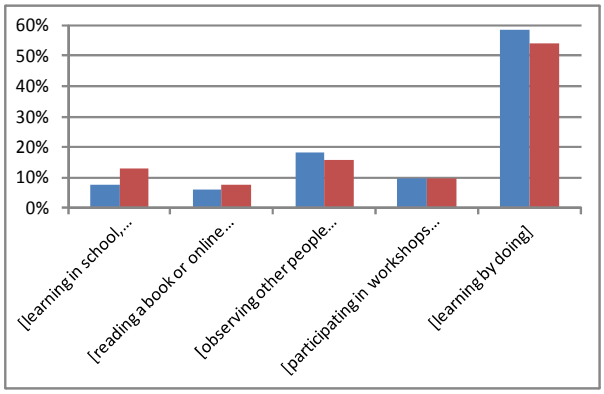

Figure 35: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red))

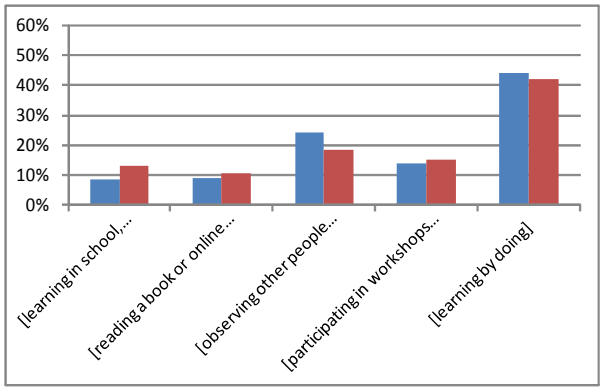

Figure 36: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	306	7,68%
	[reading a book or	306	6,14%
	[observing other pe	306	18,05%
	[participating in wo	306	9,55%
	[learning by doing]	306	58,58%
	Valid N	306	
No	[learning in school,	403	12,98%
	[reading a book or	403	7,75%
	[observing other pe	403	15,59%
	[participating in wo	403	9,60%
	[learning by doing]	403	54,08%
	Valid N	403	

Table 44: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	57	8,61%
	[reading a book o	60	9,06%
	[observing other p	161	24,32%
	[participating in w	92	13,90%
	[learning by doing	292	44,11%
Total		662	100,00%
No	[learning in school	118	13,27%
	[reading a book o	96	10,80%
	[observing other p	165	18,56%
	[participating in w	135	15,19%
	[learning by doing	375	42,18%
Total		889	100,00%

Table 45: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To coordinate own work with the work of others

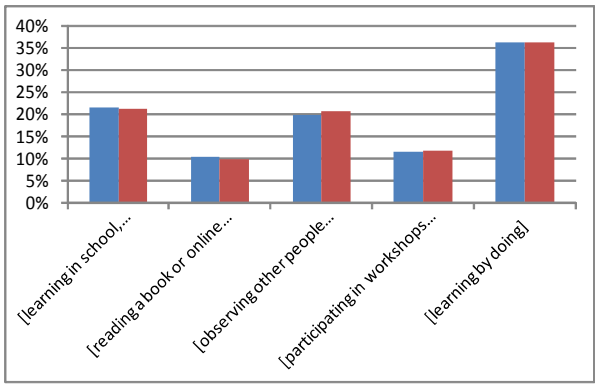

Figure 37: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

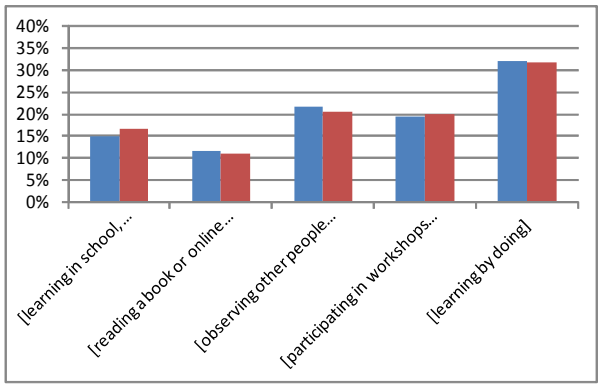

Figure 38: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	369	21,58%
	[reading a book or	369	10,52%
	[observing other pe	369	19,87%
	[participating in wo	369	11,65%
	[learning by doing]	369	36,37%
	Valid N	369	
No	[learning in school,	472	21,25%
	[reading a book or	472	10,00%
	[observing other pe	472	20,73%
	[participating in wo	472	11,90%
	[learning by doing]	472	36,12%
	Valid N	472	

Table 46: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	132	15,12%
	[reading a book o	101	11,57%
	[observing other p	190	21,76%
	[participating in w	170	19,47%
	[learning by doing	280	32,07%
Total		873	100,00%
No	[learning in school	177	16,62%
	[reading a book o	118	11,08%
	[observing other p	220	20,66%
	[participating in w	212	19,91%
	[learning by doing	338	31,74%
Total		1065	100,00%

Table 47: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To change criticized behavior

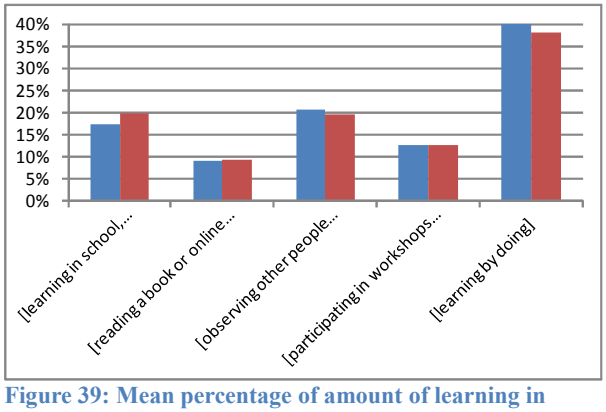

Figure 39: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

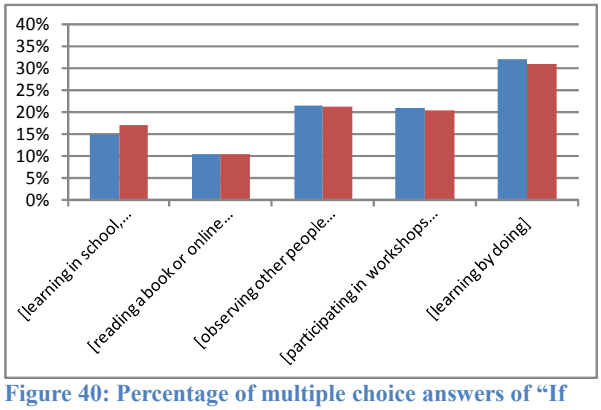

Figure 40: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	297	17,26%
	[reading a book or	297	9,13%
	[observing other pe	297	20,85%
	[participating in wo	297	12,67%
	[learning by doing]	297	40,09%
	Valid N	297	
No	[learning in school,	415	19,94%
	[reading a book or	415	9,44%
	[observing other pe	415	19,74%
	[participating in wo	415	12,79%
	[learning by doing]	415	38,09%
	Valid N	415	

Table 48: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	99	14,75%
	[reading a book o	71	10,58%
	[observing other p	145	21,61%
	[participating in w	140	20,86%
	[learning by doing	216	32,19%
Total		671	100,00%
No	[learning in school	153	17,04%
	[reading a book o	93	10,36%
	[observing other p	191	21,27%
	[participating in w	183	20,38%
	[learning by doing	278	30,96%
Total		898	100,00%

Table 49: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To understand and work with people from different cultures

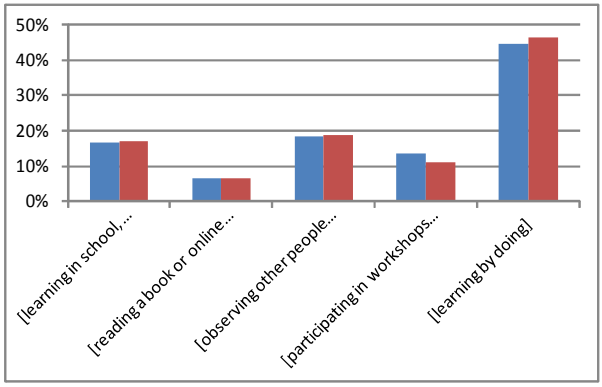

Figure 41: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

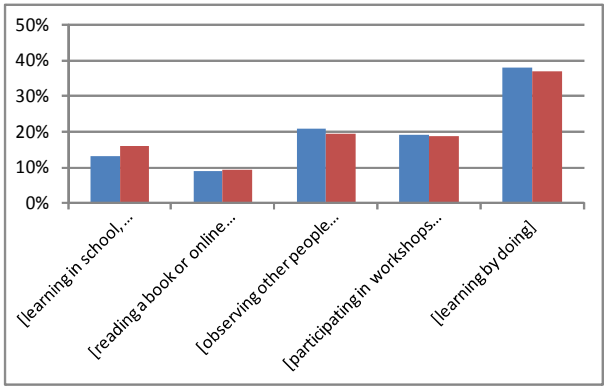

Figure 42: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	288	16,67%
	[reading a book or	288	6,59%
	[observing other pe	288	18,50%
	[participating in wo	288	13,52%
	[learning by doing]	288	44,73%
	Valid N	288	
No	[learning in school,	410	17,13%
	[reading a book or	410	6,55%
	[observing other pe	410	18,81%
	[participating in wo	410	11,08%
	[learning by doing]	410	46,43%
	Valid N	410	

Table 51: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	81	13,11%
	[reading a book o	56	9,06%
	[observing other p	129	20,87%
	[participating in w	118	19,09%
	[learning by doing	234	37,86%
Total		618	100,00%
No	[learning in school	140	15,87%
	[reading a book o	82	9,30%
	[observing other p	172	19,50%
	[participating in w	164	18,59%
	[learning by doing	324	36,73%
Total		882	100,00%

Table 50: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

Reasoning

To work on your own software module alone

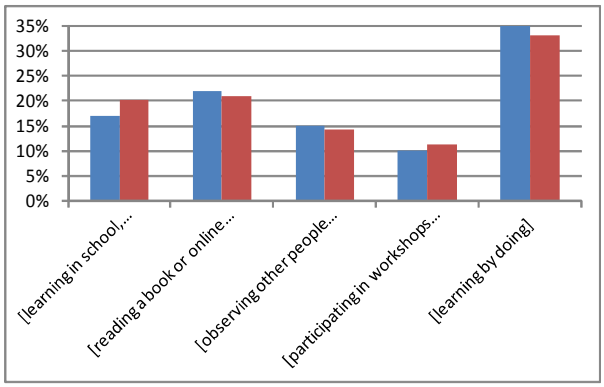

Figure 43: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

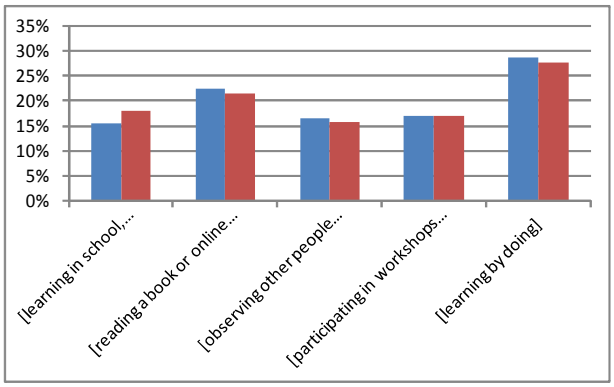

Figure 44: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	285	16,94%
	[reading a book or	285	22,10%
	[observing other pe	285	15,11%
	[participating in wo	285	10,07%
	[learning by doing]	285	35,78%
	Valid N (listwise)	285	
No	[learning in school,	428	20,26%
	[reading a book or	428	20,95%
	[observing other pe	428	14,31%
	[participating in wo	428	11,32%
	[learning by doing]	428	33,16%
	Valid N (listwise)	428	

Table 52: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	132	15,53%
	[reading a book o	190	22,35%
	[observing other p	140	16,47%
	[participating in w	144	16,94%
	[learning by doing	244	28,71%
Total		850	100,00%
No	[learning in school	229	18,13%
	[reading a book o	272	21,54%
	[observing other p	198	15,68%
	[participating in w	214	16,94%
	[learning by doing	350	27,71%
Total		1263	100,00%

Table 53: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To understand different software architectures

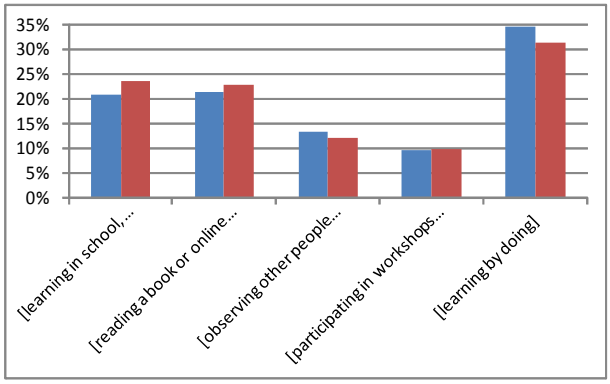

Figure 45: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

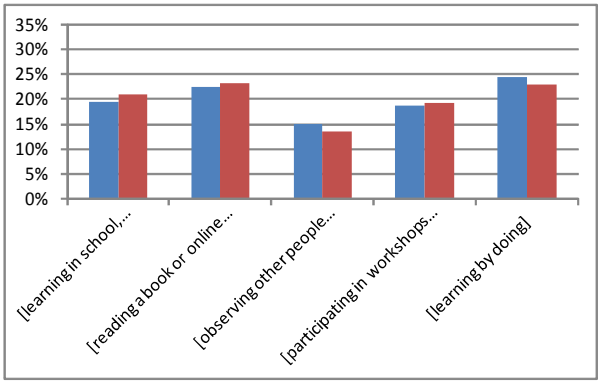

Figure 46: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	334	20,90%
	[reading a book or	334	21,40%
	[observing other pe	334	13,50%
	[participating in wo	334	9,66%
	[learning by doing]	334	34,54%
	Valid N	334	
No	[learning in school,	502	23,59%
	[reading a book or	502	22,90%
	[observing other pe	502	12,17%
	[participating in wo	502	9,94%
	[learning by doing]	502	31,39%
	Valid N	502	

Table 54: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	190	19,59%
	[reading a book o	217	22,37%
	[observing other p	145	14,95%
	[participating in w	181	18,66%
	[learning by doing	237	24,43%
Total		970	100,00%
No	[learning in school	293	20,94%
	[reading a book o	326	23,30%
	[observing other p	190	13,58%
	[participating in w	268	19,16%
	[learning by doing	322	23,02%
Total		1399	100,00%

Table 55: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To write code in a way that it can be re-used

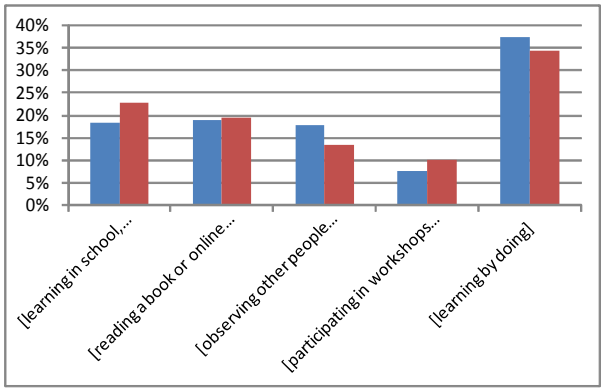

Figure 47: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

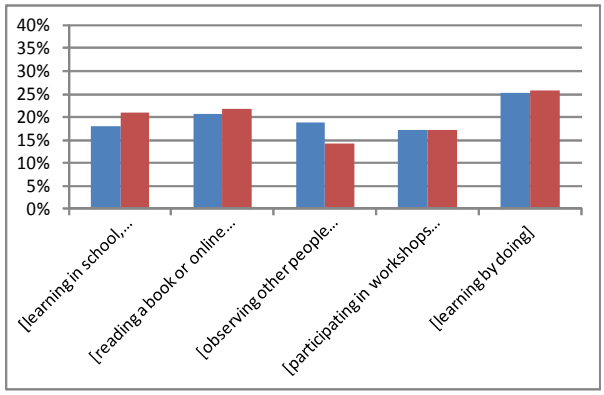

Figure 48: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	351	18,48%
	[reading a book or	351	18,88%
	[observing other pe	351	17,77%
	[participating in wo	351	7,60%
	[learning by doing]	351	37,27%
	Valid N	351	
No	[learning in school,	469	22,75%
	[reading a book or	469	19,39%
	[observing other pe	469	13,48%
	[participating in wo	469	10,03%
	[learning by doing]	469	34,36%
	Valid N	469	

Table 56: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	183	18,01%
	[reading a book o	211	20,77%
	[observing other p	192	18,90%
	[participating in w	174	17,13%
	[learning by doing	256	25,20%
Total		1016	100,00%
No	[learning in school	278	20,84%
	[reading a book o	292	21,89%
	[observing other p	191	14,32%
	[participating in w	230	17,24%
	[learning by doing	343	25,71%
Total		1334	100,00%

Table 57: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

Basic/introductory programming skills

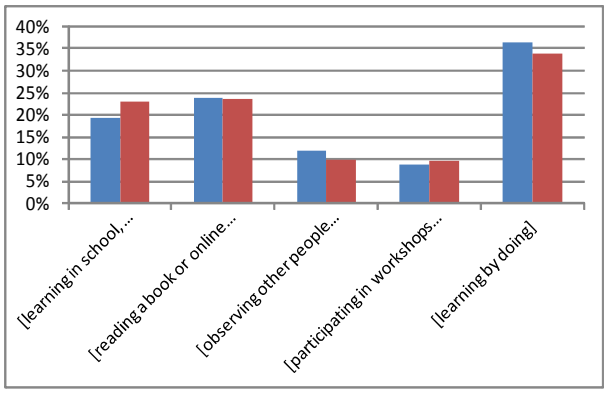

Figure 49: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

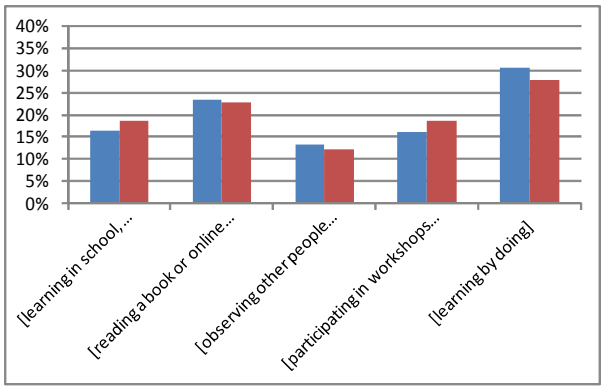

Figure 50: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	387	19,20%
	[reading a book or	387	23,82%
	[observing other pe	387	11,92%
	[participating in wo	387	8,75%
	[learning by doing]	387	36,31%
	Valid N	387	
No	[learning in school,	488	22,96%
	[reading a book or	488	23,67%
	[observing other pe	488	9,84%
	[participating in wo	488	9,56%
	[learning by doing]	488	33,97%
	Valid N	488	

Table 58: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

		Responses	
		N	Percent
Yes	[learning in school	180	16,51%
	[reading a book o	256	23,49%
	[observing other p	144	13,21%
	[participating in w	175	16,06%
	[learning by doing	335	30,73%
Total		1090	100,00%
No	[learning in school	248	18,56%
	[reading a book o	303	22,68%
	[observing other p	164	12,28%
	[participating in w	248	18,56%
	[learning by doing	373	27,92%
Total		1336	100,00%

Table 59: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

To acquaint yourself with code from others

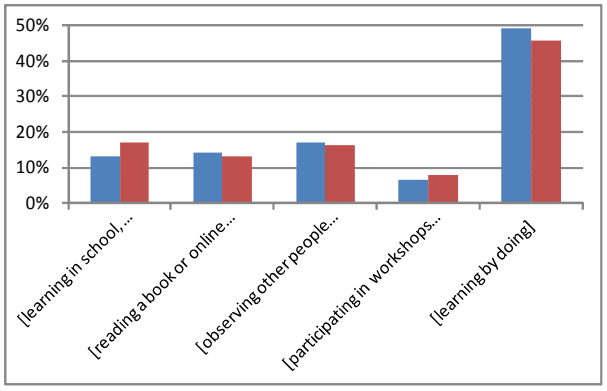

Figure 51: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (blue), Non-FLOSS developers(red)

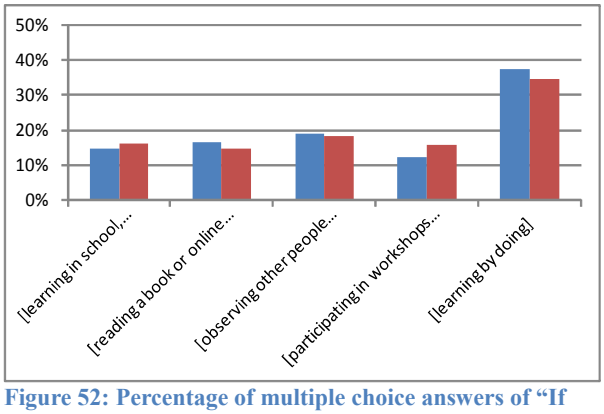

Figure 52: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (blue), Non-FLOSS developers(red)

Descriptive Statistics			
		N	Mean
Yes	[learning in school,	329	13,21%
	[reading a book or	329	14,15%
	[observing other pe	329	17,02%
	[participating in wo	329	6,43%
	[learning by doing]	329	49,19%
	Valid N	329	
No	[learning in school,	462	17,09%
	[reading a book or	462	13,33%
	[observing other pe	462	16,35%
	[participating in wo	462	7,77%
	[learning by doing]	462	45,45%
	Valid N	462	

Table 60: Mean percentage of amount of learning in "How did you learn to ...?"FLOSS developers (Yes), Non-FLOSS developers(No)

			Responses	
			N	Percent
Yes		[learning in school	115	14,88%
		[reading a book o	128	16,56%
		[observing other p	147	19,02%
		[participating in w	95	12,29%
		[learning by doing	288	37,26%
	Total		773	100,00%
No		[learning in school	168	16,15%
		[reading a book o	155	14,90%
		[observing other p	191	18,37%
		[participating in w	165	15,87%
		[learning by doing	361	34,71%
	Total		1040	100,00%

Table 61: Percentage of multiple choice answers of "If you wanted to improve your skill ...? FLOSS developers (Yes), Non-FLOSS developers(No)

Appendix E Example of Survey (printable version)

FLOSS Skill Survey (example)

JDownloader has partnered with the Open Source Research Group at Friedrich-Alexander University Erlangen-Nürnberg to conduct a series of surveys. In this survey we are trying to understand what skills you possess which are required for information technology work, how you acquired them, and how you would improve these skills. The survey is intended both for people working in information technologies and those in other fields.

Welcome to our Free/Libre/Open Source Software Skill Survey!

We estimate that it will take about 10-15 minutes of your time to complete the questionnaire. We appreciate your participation.

You will have the opportunity to subscribe to be notified of results of the survey, and JDownloader will also publish a link to the completed study when it is available.

If you provide your email address (optional), it will not be connected with your survey answers during analysis and will be deleted from the data set once it has been stored in our contact list.

There are 42 questions in this survey

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[]Have you worked in software development (including QA, testing, and documentation)? *

Please choose **only one** of the following:

- ○ I work or worked in software development as part of my job.
- ○ I work or worked in software development as a hobby only.
- ○ I have never worked in software development.

[]In which year did you start to work in the software industry? *

Only answer this question if the following conditions are met:
Answer was 'I work or worked in software development as part of my job.' at question '1 [G1Q0001]' (Have you worked in software development (including QA, testing, and documentation)?)

In dieses Feld dürfen nur Zahlen eingegeben werden.
Jede Antwort muss zwischen 1900 und 2013 sein

Please write your answer here:

[]If you have considered participating in a Free/Libre/Open Source Software project, what has prevented you from doing so?

Only answer this question if the following conditions are met:
Answer was 'I have never worked in software development.' at question '1 [G1Q0001]' (Have you worked in software development (including QA, testing, and documentation)?)

Please write your answer here:

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[]Have you ever participated in a Free/Libre/Open Source Software project? (including observation and non-programming activities) *

Only answer this question if the following conditions are met:
Answer was 'I work or worked in software development as part of my job.' or 'I work or worked in software development as a hobby only.' at question '1 [G1Q0001]' (Have you worked in software development (including QA, testing, and documentation)?)

Please choose **only one** of the following:

- ○ Yes
- ○ No

[]In which year did you start to participate in Free/Libre/Open Source Software development? *

Only answer this question if the following conditions are met:
Answer was 'Yes' at question '4 [G2Q0001]' (Have you ever participated in a Free/Libre/Open Source Software project? (including observation and non-programming activities))

In dieses Feld dürfen nur Zahlen eingegeben werden.
Jede Antwort muss zwischen 1900 und 2013 sein

Please write your answer here:

[ ]

[]How did/do you participate in Free/Libre/Open Source Software Development? *

Only answer this question if the following conditions are met:
Answer was 'Yes' at question '4 [G2Q0001]' (Have you ever participated in a Free/Libre/Open Source Software project? (including observation and non-programming activities))

Please choose **all** that apply:

- ☐ I have observed but did not actively participate
- ☐ I have written email or forum contributions
- ☐ I have contributed to documentation, translation, web-design etc.
- ☐ I have submitted bug reports
- ☐ I have submitted code contributions
- ☐ I have been a project founder or in another leading role

[]To what extent is Free/Libre/Open Source Software Development part of your job? *

Only answer this question if the following conditions are met:
Answer was 'Yes' at question '4 [G2Q0001]' (Have you ever participated in a Free/Libre/Open Source Software project? (including observation and non-programming activities))

Please write your answer(s) here:

| 0%| 100%

[]How much time did you spend on participation in Free/Libre/Open Source Software Development, the last month? (hours/week) *

Only answer this question if the following conditions are met:
Answer was 'Yes' at question '4 [G2Q0001]' (Have you ever participated in a Free/Libre/Open Source Software project? (including observation and non-programming activities))

Please choose **only one** of the following:

- ○ less than 2
- ○ 2 - 5
- ○ 6 - 10
- ○ 11 - 20
- ○ 21 - 40
- ○ more than 40

[]If you have considered participating in a Free/Libre/Open Source Software project, what has prevented you from doing so?

Only answer this question if the following conditions are met:
Answer was 'No' at question '4 [G2Q0001]' (Have you ever participated in a Free/Libre/Open Source Software project? (including observation and non-programming activities))

Please write your answer here:

[]If you previously participated in one (or more) Free/Libre/Open Source project(s) but are no longer involved, why did you leave?

Only answer this question if the following conditions are met:
Answer was 'Yes' at question '4 [G2Q0001]' (Have you ever participated in a Free/Libre/Open Source Software project? (including observation and non-programming activities))

Please write your answer here:

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[]

How skilled do you think you are at evaluating the work of others?

*

Please write your answer(s) here:

| I am not skilled at all | I am very skilled

[]

How did you learn to evaluate the work of others, and how much of this skill did you develop with each method of learning? (if you answered the previous question with "I am not skilled at all", please skip this question)

*

Please write your answer(s) here:

learning in school, university or apprenticeship | nothing at all | all

reading a book or online tutorial | nothing at all | all

observing other people perform the activity or the result of their work | nothing at all | all

participating in workshops or advanced training courses | nothing at all | all

learning by doing | nothing at all | all

[]

If you wanted to improve your skill to evaluate the work of others, which methods of learning do you think would be most effective? *

Please choose **all** that apply:

- ☐ learning in school, university or apprenticeship
- ☐ reading a book or online tutorial
- ☐ observing other people perform the activity or the result of their work
- ☐ participating in workshops or advanced training courses
- ☐ learning by doing
- ☐ Other:

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[]

How skilled do you think you are at working on your own software module alone?

*

Please write your answer(s) here:

| I am not skilled at all | I am very skilled

[]

How did you learn to work on your own software module alone, and how much of this skill did you develop with each method of learning? (if you answered the previous question with "I am not skilled at all", please skip this question)

*

Please write your answer(s) here:

learning in school, university or apprenticeship | nothing at all | all	
reading a book or online tutorial | nothing at all | all	
observing other people perform the activity or the result of their work | nothing at all | all	
participating in workshops or advanced training courses | nothing at all | all	
learning by doing | nothing at all | all	

[]

If you wanted to improve your skill to work on your own software module alone, which methods of learning do you think would be most effective? *

Please choose **all** that apply:

- ☐ learning in school, university or apprenticeship
- ☐ reading a book or online tutorial
- ☐ observing other people perform the activity or the result of their work
- ☐ participating in workshops or advanced training courses
- ☐ learning by doing
- ☐ Other:

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[]

How skilled do you think you are at communicating with many different target groups?

*

Please write your answer(s) here:

| I am not skilled at all | I am very skilled

[]

How did you learn to communicate with many different target groups, and how much of this skill did you develop with each method of learning? (if you answered the previous question with "I am not skilled at all", please skip this question)

*

Please write your answer(s) here:

learning in school, university or apprenticeship | nothing at all | all

reading a book or online tutorial | nothing at all | all

observing other people perform the activity or the result of their work | nothing at all | all

participating in workshops or advanced training courses | nothing at all | all

learning by doing | nothing at all | all

[]

If you wanted to improve your skill to communicate with many different target groups, which methods of learning do you think would be most effective? *

Please choose **all** that apply:

- ☐ learning in school, university or apprenticeship
- ☐ reading a book or online tutorial
- ☐ observing other people perform the activity or the result of their work
- ☐ participating in workshops or advanced training courses
- ☐ learning by doing
- ☐ Other:

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[]

How skilled do you think you are at understanding English, especially technical discussion?

*

Please write your answer(s) here:

| I am not skilled at all | I am very skilled

[]

How did you learn to understand English, especially in technical discussion, and how much of this skill did you develop with each method of learning? (if you answered the previous question with "I am not skilled at all", please skip this question)

*

Please write your answer(s) here:

learning in school, university or apprenticeship | nothing at all | all

reading a book or online tutorial | nothing at all | all

observing other people perform the activity or the result of their work | nothing at all | all

participating in workshops or advanced training courses | nothing at all | all

learning by doing | nothing at all | all

[]

If you wanted to improve your skill to understand English, especially in technical discussion, which methods of learning do you think would be most effective? *

Please choose **all** that apply:

- ☐ learning in school, university or apprenticeship
- ☐ reading a book or online tutorial
- ☐ observing other people perform the activity or the result of their work
- ☐ participating in workshops or advanced training courses
- ☐ learning by doing
- ☐ Other:

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[]

How skilled do you think you are at documenting code?

*

Please write your answer(s) here:

| I am not skilled at all | I am very skilled

[]

How did you learn to document code, and how much of this skill did you develop with each method of learning? (if you answered the previous question with "I am not skilled at all", please skip this question)

*

Please write your answer(s) here:

learning in school, university or apprenticeship | nothing at all | all

reading a book or online tutorial | nothing at all | all

observing other people perform the activity or the result of their work | nothing at all | all

participating in workshops or advanced training courses | nothing at all | all

learning by doing | nothing at all | all

[]

If you wanted to improve your skill to document code, which methods of learning do you think would be most effective? *

Please choose **all** that apply:

- ☐ learning in school, university or apprenticeship
- ☐ reading a book or online tutorial
- ☐ observing other people perform the activity or the result of their work
- ☐ participating in workshops or advanced training courses
- ☐ learning by doing
- ☐ Other:

[]

How skilled do you think you you are at assessing other people's work?

*

Please write your answer(s) here:

| I am not skilled at all | I am very skilled

[]

How did you learn to assess other people's work, and how much of this skill did you develop with each method of learning? (if you answered the previous question with "I am not skilled at all", please skip this question)

*

Please write your answer(s) here:

learning in school, university or apprenticeship | nothing at all | all

reading a book or online tutorial | nothing at all | all

observing other people perform the activity or the result of their work | nothing at all | all

participating in workshops or advanced training courses | nothing at all | all

learning by doing | nothing at all | all

[]

If you wanted to improve your skill to assess other people's work, which methods of learning do you think would be most effective? *

Please choose **all** that apply:

- ☐ learning in school, university or apprenticeship
- ☐ reading a book or online tutorial
- ☐ observing other people perform the activity or the result of their work
- ☐ participating in workshops or advanced training courses
- ☐ learning by doing
- ☐ Other:

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[]Next are the demographic questions.

The following questions help to analyze and evaluate the results of this survey. It is important that we can evaluate the previous questions by characteristics that describe social groups. For this, we need information about yourself, so that we can identify an apropriate group and also to evaluate if the participants are representative for our topic. We do not analyze you personally, but as part of a group to which we can assign you, for example, according to your age, your gender etc.

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[]What is your gender?

Please choose **only one** of the following:

- ○ Male
- ○ Female
- ○ Other

[]What is your year of birth?

In dieses Feld dürfen nur Zahlen eingegeben werden.
Jede Antwort muss zwischen 1900 und 2013 sein

Please write your answer here:

[]In which country do you live?

Please write your answer here:

[]Are you currently...?

Please choose **only one** of the following:

- ○ Employed for wages
- ○ Self-employed
- ○ Out of work and looking for work
- ○ Out of work but not currently looking for work
- ○ A homemaker
- ○ A student
- ○ Retired
- ○ Unable to work

[]What is your job? (e. g. graphic designer, software developer, salesman etc.)

Only answer this question if the following conditions are met:
Answer was 'Employed for wages' *or* 'Self-employed' at question '33 [G10Q0004]' (Are you currently...?)

Please write your answer here:

[]What is your total household income (per year)?

Please choose **only one** of the following:

- ○ Less than $10,000
- ○ $10,000 to $19,999
- ○ $20,000 to $29,999
- ○ $30,000 to $39,999
- ○ $40,000 to $49,999
- ○ $50,000 to $59,999
- ○ $60,000 to $69,999
- ○ $70,000 to $79,999
- ○ $80,000 to $89,999
- ○ $90,000 to $99,999
- ○ $100,000 to $149,999
- ○ $150,000 or more

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[]Can we contact you for further surveys? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

[]

Would you like to be notified when the results from the survey are published?

(Alternatively, the results will be announced by JDownloader or on the OSR group website http://osr.cs.fau.de in February 2014) *

Please choose **only one** of the following:

- ○ Yes
- ○ No

[]Please leave your E-Mail address: *

Only answer this question if the following conditions are met:
Answer was 'Yes' at question '36 [G11Q0001]' (Can we contact you for further surveys?)

Please write your answer here:

[]

Please leave your E-Mail address:

*

Only answer this question if the following conditions are met:
Answer was 'No' at question '36 [G11Q0001]' (Can we contact you for further surveys?) *and* Answer was 'Yes' at question '37 [G11Q0002]' (Would you like to be notified when the results from the survey are published? (Alternatively, the results will be announced by JDownloader or on the OSR group website http://osr.cs.fau.de in February 2014))

Please write your answer here:

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[]How frequently should JDownloader present OSR group research surveys? *

Please choose **only one** of the following:

- ○ Never
- ○ Monthly
- ○ A few times a year
- ○ Annually

[]How would having a chance at a prize drawing influence your participation? *

Please choose **only one** of the following:

- ○ I would be more inclined to participate in surveys
- ○ I would be less inclined to participate in surveys
- ○ It would not affect my participation

[]Comments on the survey:

Please write your answer here: