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Effectiveness of Low Cost FOSSEE Laptops in a CS101 Course

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Abstract. This paper presents a case study of 278 first year students enrolled in a CS101 course of the department of Computer Science at the Indian Institute of Technology Bombay. The sufficiency of a low cost (Rs.7,500 or $110) laptop for this course is assessed. From the feedback questionnaires, the students' perception on the likability of this device is assessed. It is found that the students like this device. Users of this device used it as much others who had access to more expensive computers, and also performed as well as others in the course. This device is useful for several other applications also, and hence is a candidate for mass deployment in developing countries, such as India.

Keywords: Low cost laptop, FOSSEE laptop, Student Perceptions, Usability, Spoken Tutorial

1 Introduction

For developing countries like India to become developed, excellence in education is the first requirement. The brick and mortar approach to improve the education level is too expensive and time consuming. ICT based educational methods offer an attractive alternative.

Fortunately, a large number of educational resources are available on the Internet, for example OCW and Khan Academy, to mention a few. The Indian Government has also created high quality educational content, such as NPTEL, Virtual Labs, and courses created through recording of live classes in IIT Bombay (Moudgalya et al., 2009). Such initiatives have resulted in massive training (Moudgalya, 2014), while simultaneously being effective (Eranki and Moudgalya, 2016).

Although a large amount of extremely useful content is available on the web, they are not accessible to most students in developing countries, as they do not have an access device, such as a tablet or a laptop. To address this issue, our group piloted the low cost access device at a price of about $35, with funding from the Indian Government (Moudgalya et al., 2013; Patil and Patnaik, 2013; Phalkey and Chattapadhyay, 2015).

A tablet is only a consumption device and generally cannot be used to create content. As a matter of fact, 97% of the businesses use either a laptop or a desktop, but not a tablet (Sriram, 2015). To address these issues, our group came up with a laptop, referred to as the FOSSEE laptop, at an affordable price of about $110. It has the following specifications: Dual core 1 GHz ARM v7 processor, 1GB RAM, 8GB NAND flash, 10" screen, Complete Keyboard, 2 USB, 1 mini HDMI, a 32GB SD card slot, an ethernet port and audio I/O ports. It runs on a stripped down version of Ubuntu. A review of this work, along with a list of about 150 open source software packages ported on to this laptop, the process we adopted to procure this device, and also the media articles on this effort are summarised by Moudgalya (2015).

In a preliminary study we conducted at IIT Bombay, wherein 50 students of a computer science course (CS101) used them, we found these low end laptops to be adequate for the course. Emboldened by this

result, we conducted a more rigorous study of the efficacy of the FOSSEE laptop, to the CS101 students once again, the results of which are presented in this paper. This course, which our students do in their first year, requires quite a lot of programming. Most of these assignments required a combination of the GCC compiler and SimpleCPP (Ranade, 2016).

2 Research Methodology

We carried out this study in the Autumn semester of 2015. Participants of the study were 578 first year undergraduate students, enrolled in a CS101 course. Among them, 90 students had opted to borrow the FOSSEE laptop for one semester. We refer to them as the FOSSEE laptop students. The annual parental income of these students was less than Rs. 2 lakh ($3,000). More than 50% of their parents did not even complete 10th grade. Only 30% of the fathers had a bachelor's degree. Mothers had studied even less. Studies show that students with poor socio-economic status and low parental education background have negative psychological outcomes that affect academic achievement (Rosenberg and Oxman, 1990).

The remaining 488 students either used their own laptops or the central computing facilities. We will refer to them as the non-FOSSEE students. We conducted the following three studies: 1. FOSSEE (n=90) students completed the laptop usability and student perception questionnaires at the beginning and at the end of the semester. 2. All the 90 FOSSEE students and 188 Non-FOSSEE students responded to the feedback questionnaires. 3. The FOSSEE laptop hardware use questionnaire was answered by 15 FOSSEE students only. Through this study we would like to address the following research questions:

RQ1 Research Question 1. Do the FOSSEE students like the FOSSEE laptop? This is an important requirement for the success of this project, because, if they do not like it, they would regret the decision of not having bought a computer of their own. A comparison of their perception of the device before using it with that post-use will also help answer this question.

RQ2 Research Question 2. Is the performance of the FOSSEE students adequate? What is meant by adequate? If a large number of FOSSEE students fail in the course, we could say that the performance is not adequate. We want the pass percentage of FOSSEE students to be comparable to that of non-FOSSEE students. This is the absolute minimum we would want in this study. If the answer to this question is negative, the results of this study will be inconclusive: we cannot then determine whether the laptop will be useful to other college students.

RQ3 Research Question 3. Are the FOSSEE students able to perform as well as Non-FOSSEE students? By this, we mean the following: (a) We want the FOSSEE students to use their laptops for as much time as the other students. (b) We want the FOSSEE students to write as much code as the other students. (c) We want the average marks scored by the FOSSEE and non-FOSSEE students to be comparable.

3 Answering Research Questions

RQ1: Do the FOSSEE students like the FOSSEE laptop? We begin with Q5 in Table 1, why do you want to use the FOSSEE laptop. Quite a few of them say that the hostel computers are not available (Sno. 1 and 2). This number decreased from pre-use to post-use, possibly because they found out during the course of the semester how to use other resources. Working in privacy was important to start with (Sno. 3). It increased from 70% to 85%. We conclude that they like having a computer of their own.

Wasting time in going to the computer lab (Sno. 4) was not important at the beginning (only 53%). It became important (97%) later on, possibly owing to extreme work pressure. The number of students who did not want to spend their money on computers increased from 63% to 90% (Sno. 5). At the end of the semester, 92% want to try (use) this laptop (Sno. 6), as opposed to 62% at the beginning. This also shows that they liked the FOSSEE laptop.

Table 1. FOSSEE Laptop Usability Analysis (N=90)

Q5.Why do you want to use the FOSSEE laptop?			
Sno.	Response	Pre	Post
1	Hostel computers are not adequate	98%	72%
2	Hostel computers are not available	94%	61%
3	To work in privacy	70%	85%
4	Do not want to waste time going to a computer lab	53%	97%
5	Do not want to spend money in buying a computer	63%	90%
6	Want to try this laptop	62%	92%

Q6.What are the most important features of FOSSEE laptop you would require?			
Sn.	Response	Pre	Post
1	Lightweight	93%	74%
2	High resolution screen	94%	89%
3	Stylish and sleek design	44%	29%
4	Running windows OS	93%	88%
5	Should be sufficient for CS101 course	95.5%	95%
6	Cost less	85%	93%
7	Good RAM and processing speed	88%	98%
8	Support multiple ports such as USB, HDMI	6%	70%
9	Good collection of software	70%	60%

Q5.Why do you want to use the FOSSEE laptop?			
Sn.	Response	Pre	Post
1	Watch course videos	91%	62%
2	Watch movies	7%	29%
3	Complete assignments	95.5%	89%
4	Complete course projects	88%	91%
5	Play games	3%	10%
6	Make presentations	76%	74%
7	Develop software	40%	60%
8	Other activities, like browsing, writing emails and e-commerce	20%	44%

Table 2. Reasons for disliking the device (top) and liking it (bottom). In percentage. N=15

Sno.	Reasons to like the device	%
4	Laptop is difficult to use because it has a small RAM and still like it	66
7	I like the device because of its low weight	87
8	I like the device because the battery lasts a long time	67
9	I like the look and the feel and the finish	27
10	I enjoy using it and would like to retain it	93
12	I like it because it comes with many useful software	73
13	I like it because I can install many open source software	67
14	I like it because I do not have to worry about virus	67
16	I could easily surf the Internet using it	43
20	It helped complete all my assignments	67
23	I like it, as it improves my productivity	80
24	In summary, the laptop was easy to use and would recommend	87
25	Time taken to complete my activities was shorter than before	57
26	Instant access to a computer helped me test my ideas quickly	60
27	I was able to complete all my tasks well using the device	93
A	Mean	67.3
B	StdDev	18.72
SNo.	Reasons to dislike the device	%
1	Laptop is difficult to use because of an unfriendly keyboard	50
2	Laptop is difficult to use because of a small screen	20
3	Laptop is difficult to use, as it has a small internal storage	53
5	I hate it, as it gets heated up in a short time	30
6	It is difficult to use because of an unfriendly mouse	46
11	I hate it because it does not run on Windows OS	40
15	It is difficult to use because of poor resolution	20
17	I dislike it, because if hangs often or throws up errors or both	33
18	It is difficult to use without the help of an expert	0
19	It is more stressful to use this device, compared to the other	40
21	I hate it because there is no one to help me use this effectively	7
22	I hate it because I find it difficult to connect to the Internet	20
A	Mean	28.5
B	StdDev	17.54

Next, we take up Q6 of Table 1, what are the most important features of the laptop you would require. It is interesting that they did not consider stylish and sleek design to be important (Sno. 3). Possibly, they did not understand the importance of external ports (Sno. 8) when they joined IIT. This number increased from 6% to 70%. As the FOSSEE laptops have many external ports, we can conclude that they liked the FOSSEE laptop on this count also.

Most people want Windows OS (Sno. 4). At the same time only 40% hate this laptop because of this reason (see Sno. 11 in Table 2). In any case, most students want to use this laptop for their coursework, for which, it is good enough. This shows that the students do not consider it as the greatest shortcoming.

They do not consider the collection of software important (Sno. 9), possibly because (a) they could install new software, being a Linux system or (b) they did not need more software - for them, use for CS101 is a lot more important (Sno. 5).

Next, we take up Q7 of Table 1, why do you want to use the FOSSEE laptop. For the FOSSEE students, completing course projects (Sno. 3) and assignments (Sno. 4) are the most important, both being 90%. Because of this reason, they want to use the FOSSEE laptop. The number of people who want to use this device for developing new software (Sno. 7) and for other activities, such as browsing, etc. (Sno. 8) increased after using the device. This shows that this device turned out to be better than what they expected at the beginning.

We now discuss the answers given in the likes and dislikes Table (Table 2). We have divided the answers in this fashion for easy analysis. We would like to point out that these questions were mixed in the actual questionnaire. The original serial number of every question is included in this Table. We begin with the likes. From Table 2, we notice that the FOSSEE students liked the laptop in general, with the average being 67.3%. It is interesting that I enjoy using the device and would like to retain it (Sno. 10) and I was able to complete all my tasks well using the device (Sno. 27) got the highest score of 93%. *In summary, the laptop was easy to use and would recommend (Sno. 24)* was the next highest at 87%. *I like the device, as it improves my productivity (Sno. 23*), was the next highest, at 80%. The FOSSEE students did not like the look and feel of the device (Sno. 9).

Next, we discuss the answers given in the dislikes Table 2. We notice that the FOSSEE students do not hate this device, as the mean is 28.5%. They have the least reason to dislike this device, as they have low scores: difficult to use without the help of an expert (Sno. 18 and 21), heating (Sno. 5), small screen (Sno. 2), poor resolution (Sno. 15), connecting to the Internet (Sno. 22). In the students opinion, these factors do not create any problems. They disliked the device most, because of the following reasons: unfriendly keyboard (Sno. 1), small internal storage (Sno. 3), unfriendly mouse (Sno. 6), and Windows OS (Sno. 11). These are pointers for improvement in the next version of this device.

Overall, most FOSSEE students have good things to say about the device: 1. This device is worth its price (60%). 2. I recommend it to school students (63%) and to college students (80%). 3. I recommend it to anyone who need a computer, but cannot afford high prices, such as Rs. 15,000 or more (63%). 4. This may be useful also to those who have a computer - for use during travel, as a second computer, etc. (67%). 5. This laptop is better than many other expensive computers i have seen or used before (71%). Only 29% feel that this is an expensive device and only 20% feel that this device cannot be used for serious work. We conclude that the FOSSEE students liked the laptop overwhelmingly.

RQ2: Is the performance of the FOSSEE students adequate? As mentioned earlier, here we look at the number of FOSSEE students who failed in this CS101 course and compare it with the non-FOSSEE student data. The answer to this question lies in Table 5, wherein, the overall marks scored by the FOSSEE and the non-FOSSEE students are listed. The pass percentage for this course is fixed at 30%: only those who scored less than 30% failed in this course. One has to remember that in a course such as CS101, where a lot of programming needs to be done, and projects have to be carried out, the pass percentage is arrived at after considering several factors. From Table 5, one can see that 14% of the FOSSEE students scored below 30%, while 13% of the non-FOSSEE students scored below the same level. Thus, the number of FOSSEE students who failed in this course is comparable to that of the non-FOSSEE students.

Interestingly, most of the FOSSEE students who failed in the course (12 out of 14) are close to passing. This is reflected in the average mark of the failing students: it is 17.31 for non-FOSSEE and 22.86 for FOSSEE. Thus, with a little bit of effort, a majority of the FOSSEE students can be helped to go past the pass mark. We can

conclude that the performance of the FOSSEE students is definitely adequate, when compared with the non-FOSSEE students.

Table 3. Hours of coding and number of program lines written. N = 188+90 = 278.

	nF	FOSSEE	
		Pre	Post
How many hours of coding you have done until now? (%)			
0-10	8	38	26
10-50	37	22	23
50-300	34	36	21
> 300	21	4	30
How many lines you have coded until now? (%)			
< 10	8	26	5
11-100	20	36	7
101-1000	49	36	31
> 1000	23	2	57

nF: non-FOSSEE (post); Pre: FOSSEE (before IIT)
Post: FOSSEE (post)

Table 4. Performance of non-FOSSEE (188) and FOSSEE (90) Students. N=90 for FOSSEE students for all, except in TheoryQuiz, in which, N=89.

Sno.	Activity	G*	Mean	StdDev	t	p 0.05
1	Quiz1(20)	1	17.97	4.25	1.73	0.09
		2	16.85	5.28		
2	Midsem(10)	1	7.8	5.60	1.657	0.10
		2	6.7	5.8		
3	TheoryQuiz	1	8.1	2.16	2.710	0.007**
	(10) (N=89)	2	7.37	2.16		
4	TheoryMidsem	1	20.50	7.31	2.68	0.008**
	(30)	2	17.67	8.65		
5	LabQuiz2	1	25.94	12.12	2.46	0.01**
	(30)	2	21.71	13.98		
6	TheoryQuiz2	1	9.22	5.45	1.76	0.008
	(10)	2	7.93	5.85		
7	LabEndSem	1	23.75	10.01	0.76	0.45
	(30)	2	20.17	12.20		
8	Endsem(30)	1	23.75	10.01	2.41	0.017**
		2	20.17	12.20		
9	Project(20)	1	16.41	4.61	2.00	0.05**
		2	15.16	5.26		

G* 1: Non-FOSSEE; 2: FOSSEE

Table 5. Frequency distribution of marks. N = 188+90 = 278.

Marks	G-1	G-2
0-10	4	1
10-20	2	1
20-30	7	12
30-40	10	10
40-50	8	12
50-60	11	11
60-70	14	17
70-80	13	14
80-90	16	12
90-100	15	9
Mean	62.1	58.45
Stdev	52.2	41.48

G-1: non-FOSSEE
G-2: FOSSEE

RQ3: Are the FOSSEE students able to perform as well as Non FOSSEE students? From Table 3, we find that the average number of hours a student used the computer is the following: FOSSEE student - 25.70, non-FOSSEE student - 20.92. These data are not statistically significant. We can nevertheless conclude that the FOSSEE students worked on the computer at least as much as the non-FOSSEE students. From Table 3, we find the average number of lines of code a student wrote is the following: FOSSEE student - 150.5, non-FOSSEE student - 70.42. These data are not statistically significant. We can nevertheless conclude that the FOSSEE students wrote at least as much code as the non-FOSSEE students. In Table 4, we have listed the performance of all the students assessment areawise. The non-FOSSEE students performed better than the FOSSEE students in the following: Theory Quiz, Theory Midsem, Endsem and Project. It is interesting that out of these, three have to do with the theory. The difference between the two is about 10%. In all other schemes, there is no significant difference. In Table 5, we have listed the overall score of all students at the end of the semester. We see the mean mark of the FOSSEE students as 58.45 and that of the non-FOSSEE students as 62.1, with a much higher standard deviation of 52.2. The difference of less than 10% in the mean is statistically insignificant.

A Teaching Assistant of CS101 says, *..students with FOSSEE laptop completed all assignments on time and showed more interest in concepts while the non-FOSSEE group had more absenteeism...* This agrees with our earlier observation: average marks of the failing FOSSEE group is much better than that of non-FOSSEE. We conclude that the FOSSEE students performed as well as the non-FOSSEE students.

4 Conclusions and future work

The FOSSEE laptop has been proved effective for student performance in a rigorous IIT Bombay course-work. Students liked the laptops and wanted to continue to use it. We also validated the usefulness of this device in a non-IIT environment: Sasi (2015) has reported the effective use of this device by data entering health volunteers, most of whom have not studied beyond 10th grade.

Educational institutions and governments should consider making available such laptops in their curriculum and eGovernance applications for those who do not own such devices. If good enough for IIT Bombay and health volunteers, then such a device will surely be useful in many other fields as well.

This study has pointed out some improvements that will enhance the value of the FOSSEE laptop. We have now overcome these shortcomings (Patnaik, 2016), in a much better laptop, at a slightly higher cost of Rs. 10,000 ($ 150): Quad core intel atom (1.33GHz x 4) processor with a hardware graphic accelerator, 11.6" screen, 2GB RAM, 32GB NAND flash, a micro SD card slot, a professional keyboard, and a 10,000 mAH battery. The preliminary results with this new low cost, and a complete Linux, device are promising.

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