CLOUD BASED SOFTWARE ENGINEERING LEARNING ENVIRONMENT: GUIDELINES TO HOST SOFTWARE ENGINEERING TOOLS ON THE CLOUD

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ABSTRACT

Cloud computing is one of the latest trends in IT; its values have been proven effectively in various sectors. Education is one of these sectors. In the 21st century, the students can no longer be restricted to the traditional teaching methods, an example of which is the lecturer lecturing and the student listening in the classroom. However, this claim is still true for Software Engineering majors.
This motivated the author to study the current status of Cloud computing in Education and how its values can be captured to enhance the learning environment of Software Engineering. This can happen through utilizing the value of Cloud computing to host the Software Engineering tools of the laboratory courses on the Cloud.
Data collection took place to answer the questions and to achieve the aim which is to utilize Cloud computing for better Software Engineering learning environment. To achieve this, 325 software engineering students of three universities and other overseas friends whom are software engineering students were chosen to participate in the questionnaire. Six software engineering lecturers and three IT leaders of three universities were interviewed as well. The results obtained were that SE students are facing some difficulties related to the availability of labs and tools; software engineering lecturers are also facing the same problems. The students and the lecturers were happy to see the tools made available on the Cloud to be used anytime and anywhere without any constraints. The lecturers were ready to accept the changes to enhance the learning environment. The IT leaders thought that Cloud computing would aid the software engineering students, help the university to eliminate some of issues and enhance the students' outcome, but there are no tools available yet on the Cloud for the students and lecturers in the universities that have been interviewed. Thus, guidelines to host tools on the Cloud were created. Three experts assessed the guidelines and they approved its effectiveness.

Keywords: *Cloud Computing, Software Engineering, Learning Environment, E-Technologies in Education, New Trends in Education*

1. INTRODUCTION

With the huge growth in educational content, resources and the number of students and services, a proper environment should be adopted that can accommodate such growth. One of the basic problems in developing a proper environment is to provide reliable and scalable educational applications and tools. One of the technologies that would enable such an environment is called Cloud computing and it is meant to aid in providing a highly scalable IT. Cloud computing is an infrastructure which can add value to the current learning infrastructure of an educational system.

According to technology experts, most institutions and companies will move to the Cloud by 2020, and this would help to eliminate the dependency of desktops [1]. When it is about education, in [2] they argued that the learning environment in educational institutions is very important. From this, it is very important to provide an effective learning environment for both the faculty and students. This is the focus point of this research. An example would be where [3] mentioned that to test a security

algorithm in a distributed environment; network connectivity is needed before testing the code. This will drive the student and faculty to divert from focusing on the original problem of testing the algorithm to testing connectivity and related issues. Therefore, the Cloud will aid to keep the student and faculty focused on the problem.

Cloud computing is one of the best solutions for e-learning environments, especially after the financial crisis [4]. Because of this, the educational institutions and companies should educate and encourage their students and/or staff to use the Cloud solutions. Cloud computing concept can help higher education institutions enhance their software and hardware resources management as well as improve their productivity. There is a necessity in the educational sector for an enhanced learning environment, especially with an accelerated development in Information Technology [5]. The learning environment can be enhanced by harnessing existing technologies and resources. Cloud computing is one of those technologies.

However the Cloud computing was utilized to increase the benefits of common applications for the students and lecturers. By utilizing the Cloud computing in educational institutions, the students and administration would be able to have the opportunity of accessing various application platforms and resources through the Internet. The cost of organizational expenses will be reduced by utilizing the Cloud.

Many advantages would be gained by utilizing the Cloud in a university, such as the responsibilities of IT staff will be decreased, the cost will be reduced, scalability and so on. There are also some of disadvantages which have been addressed in the presented research, such as there being constraints related to the service level agreement, security issues, and the different capabilities of cloud service providers, as each cloud service provider has certain capabilities. All of these concerns have to be considered before moving to Cloud.

there has not been much research done about how Cloud computing can be utilized to enhance the SE learning environment, nor how it can be utilized to solve the issues related to the labs.

Since the Cloud computing had been used to enhance and improve part of the learning environment which is the library, it would be possible to utilize it to enhance and solve some related issues of lab availability. Hence, this research will utilize the Cloud computing to host the Software /engineering (SE) tools and remove some of the issues that are related to labs availability. As a result, the SE students will be able to access the tools anytime anywhere without any restrictions such as the unavailability of labs.

2. PROBLEM STATEMENT

In the 21st century, students can no longer be restricted to traditional teaching methods [5]. An example of this is the lecturer lecturing and the student listening in the classroom. Would this claim be true for software engineering majors? This is a concern that has to be addressed.

Since this research is focused on software engineering majors, the main issue that this research is trying to address is related to the availability of tools and laboratories, especially as software engineering requires their intensive use. This point is elaborated by using a scenario in which a lecturer tends to use the latest version of any programming environment. The very first issue that may arise is the licensing of that application; if that is not the case then the consideration that both the students and the university labs have the proper hardware specifications to run the application. Moreover, even if they do have the proper specifications, there is still a possibility that their operating system does not support that type of application. If the operating system is able to run the application, the earlier problems may still arise whenever there is an update or if a newer version of the application is to be issued. If the previous issues do not occur, then there is still a possibility that providing the labs for the students and lecturers might be of an issue, as the administration has to carefully assign the lab with given specifications to a given class, let aside manage and maintain the lab.

There should be a proper setting that allows for any technological changes, especially as software engineering is in constant advancement. There should be an environment that allows for more students to use the lab computers, more computers available to students and lecturers at any needed time; assigning labs to courses should not become troublesome and so is maintaining it. All of that stated is if the university has the resources like in having the sufficient number of computers. So when universities start thinking about creating a learning environment for software engineering students, they should consider the number of computers, the space to put the computers in, the

network aspects, electricity considerations and of course the necessary hardware specifications. All of these are issues should be looked at and it will consume a lot of resources like money and man power. Clearly, there is a problem in creating and setting up the proper learning environment especially for software engineering students. This is what this research will come to resolve.

3. RESEARCH QUESTIONS

This research is about utilizing Cloud computing for Software Engineering learning environment. The research will answer the following questions:

- Are there issues in the current SE learning environment?
- Are lecturers and students ready to accept changes in the current environment?
- Is the university administration ready to accept changes in the current environment?
- What tools can be adopted in the Cloud?
- Is the university using any tools in the Cloud?
- How the cloud can be harnessed as a learning environment for software engineering majors?

4. METHODOLOGY

4.1 Methods
Research methodology is a way to systematically solve the research questions [6]; however it is an important part of any research, including the possible steps that would guide the research to achieve the proper answers for the research questions. The aim of the current research is to enhance the learning environment of software engineering students and to see whether Cloud computing can be harnessed to remove the limitations of labs. This research would also try to discover any existing issues in the current SE learning environment, such as whether lecturers and students are ready to accept changes in the current environment, whether the university administration is ready to accept changes in the current environment, and what tools can be adopted in the Clouds. Questionnaires and interviews have been used to answer these questions. Students usually face problems in finding the proper tools to aid in their courses,

such as in accessing labs and in sharing files amongst each other. These obstacles limit the students' performance and hence innovation. Fortunately, with the current technologies, these obstacles can be overcome. One proposition is Cloud computing and this is what this research aims to find: Can Cloud computing be a better solution for software engineering students? If it is, how can it be utilized properly? The current research attempts to find out whether the Cloud technology is an appropriate solution for software engineering education.

4.2 Tools
The quantitative and qualitative paradigms have been utilized as a suitable paradigm for the current research. The mixed paradigm allows more flexibility and to combine the advantages of both the quantitative and qualitative paradigms [7]. Hence, the decision was made to go with the mixed paradigm to have the research questions answered. That choice would end up with a more comprehensive finding and more insight into the case in hand. An investigation would take place to answer the research questions to grasp the familiarity of software engineering students with Cloud technologies as well as individuals' knowledge on Cloud computing; therefore, opinions from the two perspectives have to be tackled to answer these questions.

The questionnaire focused mainly on software engineering students in order to address the questions of their awareness of Cloud technologies, what issues and difficulties they currently face in the learning environment, whether they accept the changes, and what tools are currently being used. With a quantitative paradigm, however, the questions of the questionnaire do not fully answer the research questions; so an interview would be used as another technique to answer the research questions. Software engineering lecturers and IT leaders were the interviewees that have been chosen; the interview was very successful and widely spread in various fields? As a result it has to be verified for the validity of the information that is to be answered using qualitative paradigm.

4.3 Sample Space
The sampling decision has to be considered in the earlier stage of the research because of the factors that might limit the researcher's gathering of information from the population such as time,

accessibility and expense factors [8]. This statement was considered in this research before choosing the sample of the research. Population and Sample are the key terms that the researcher has to be familiar with; the population is all the individuals of interest to the researcher [9]. The population of the current research is SE students, SE lecturers and IT leaders. It is impossible to include all the entire population in the research due to the restrictions of time and cost [10]. Since the size of the target population is very large and it was impossible to ask all the software engineering students, SE lectures and IT leaders, taking subset of the population called a sample would be the most suitable solution for this problem. The questionnaire sampling was quite troublesome, especially as the population is very huge, to simplify matters, the sampling frame was made to cover three universities: UCTI, UTM and UM. These universities were chosen based on the achievements of each one. UCTI was chosen as it has students from different cultures, so that the different perspectives of software engineering students would be gained. UTM was chosen based on its high achievements, especially those of the staff of software engineering department have a lot of publications; this point would be reflected to the experience of students; Different ways have been conducted in the current research to obtain the sample. The first one was by using email and Facebook messages for the SE students of UCTI and some other friends who are software engineering students from different countries such as Iraq, Algeria, Lebanon, Turkey, USA and UK. A software engineering page on Facebook was used as well. The second method that has been utilized is by distributing the questions physically for the software engineering students of UM and UTM University.

The same universities were chosen to conduct the interview of the current research; the SE lecturers and IT leaders of UCTI, UM and UTM were chosen as a sample space for the interview part. The method that was followed and conducted to select the SE lecturers and IT leaders was by visiting the website of each university, then listing the SE lecturers and IT leaders for each university was made. Due the time and cost constraints, two SE lecturers and one IT leader from each university were chosen.

4.4 Response Rate
The questionnaire was open for the duration of four weeks before the analysis took place.

Starting with UCTI students that made up 60% of the completed questionnaire as 125 emails were sent; the return rate was 75 so: UCTI students made up 60% of the completed questionnaire as 125 emails were sent with a return rate of 75. Thus: Response rate of UCTI students = 75/125 = 0.6 = 60%. 30 emails were sent to friends who are software engineering majors; the return rate was 22 so: Response rate of friends = 22/30 = 0.73 = 73%. (80) Questionnaire forms were distributed amongst SE students of UM; the return rate was 48 so: Response rate of UM students = 48/80 = 0.6 = 60%. (85) Questionnaire forms were distributed amongst the SE students of UTM; the return rate was 50 so: Response rate of UTM students = 50/85 = 0.58 = 58%

5. RESEARCH RESULTS AND DISCUSSION.

5.1 Questions of the Questionnaire
Q: Do you think that current "Classroom" teaching is limiting students?

Table 1: The frequency and percentage of the students who think that current classroom teaching is limiting

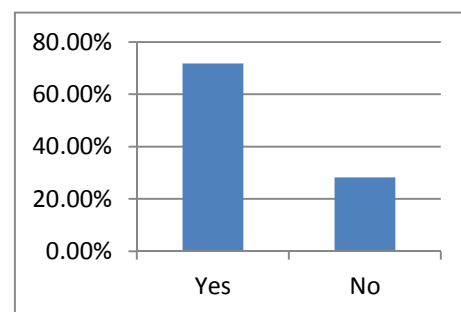| Response Item	Frequency	Percentage
Yes	140	72%
No	55	28%
Total	195	100%

Figure 1 Percentage of the students who think that current classroom teaching is limiting.

The aim of this question was to find out whether the current classroom teaching method is limiting the students. The current classroom teaching method is reflected on the students getting the schedule of subjects from the administration of the university. The schedule

has to be assigned according to the availability of resources such as classrooms, labs and lecturers. The students have to attend the class or lab accordingly. In the classroom, the students usually listen to the lecturer explaining the subject, and in the labs, the students usually apply/experience while the lecturer shows or explains. The question showed that 72% of the participants of SE students think that the current classroom teaching is limiting students, while 28% of them do not think so; from the presented numbers there is a clear indication that there is a limitation, even with 28% saying otherwise.. Thus, the limiting part would be of the students attending the classrooms or labs, because the lecturer teaching and the student listening is the norm. So, the limitation is formulated around the attendance of the labs and having to stay in them in the times set by the administration. As a result, the students sometimes have to waste a lot of time waiting for the lab or class time.

Q: Do you think software engineering courses can be taught without attending the labs?

Table 2: The frequency and percentage of the students who think that SE courses can be taught without attending the labs

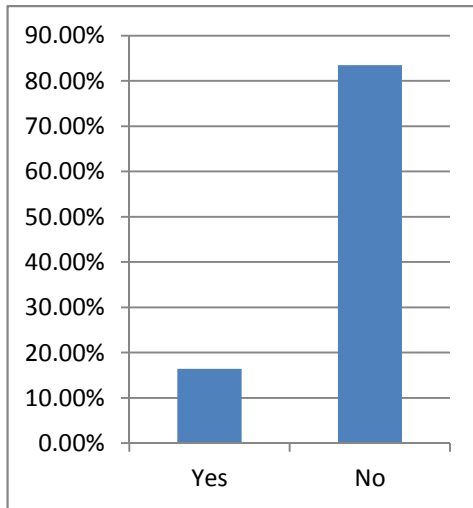| Response Item	Frequency	Percentage
Yes	32	16%
No	163	84%
Total	**195**	100%

Figure 2 Percentage of the students who think that SE courses can be taught without attending the labs

The question's aim was to get the opinion of SE students on whether they think the courses can be taught without attending the labs. Software engineering courses involve theory and practice; the practical courses usually need the laboratory. The question showed that 84% of the software engineering students who participated in the questionnaire think that the courses cannot be taught without attending the labs, while 16% of them think otherwise. Since the majority of participants see that the software engineering courses cannot be taught without attending the labs, this reflects that for the SE students, the lab is very important to them. The labs are generally represented in the tools needed by the students being available in computers.

16% saw that SE courses can be taught without the need to attend the laboratories; even though 16% is somewhat low; it has to be mentioned given the nature of the studies and the university regulations that require having laboratories. One of the reasons is for the lecturer to follow up

with the performance of the students; thus, laboratories cannot be ignored. The solution should accommodate both opinions and not neglect the universities' regulations. The previous questions showed that the current classroom teaching method is limiting the students, yet the courses cannot be taught without attending the labs and that the laboratories are still considered important to the students. So to remove the limitation of the current classroom teaching method, there are has to be a flexible solution that would allow for a more flexible environment such as the student and lecturer would not be constrained by time and location to access the laboratory with the needed tools;. The solution should also be easier for the higher administration to work with and would not be more problematic. These issues are addressed with the use of the Cloud.

Q: Do you think if software engineering laboratory courses were virtual, they will be any good? If not, why not?

Table 3: The frequency and percentage of the students who think that if laboratory courses were Virtual, they will be good

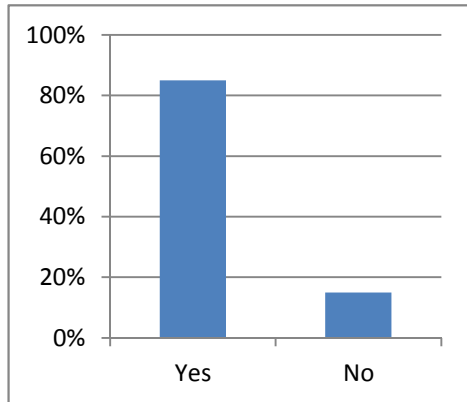| Response Item	Frequency	Percentage
Yes	165	85%
No	30	15%
Total	**195**	100%

Figure 3 Percentage of the students who think that if laboratory courses were Virtual, they will be good

This question was aimed to grasp the possibility of providing the software engineering laboratory courses virtually and how the students would perceive it. 85% of the participants thought that if software engineering laboratory courses were virtual, they will be good, while 15% of them do not think so. The findings of this question further support the previously stated statements or claims, such as the students thinking the current classroom teaching is limiting them. This question showed that most of the students think that the software engineering courses would be good if they were online. Being online means freeing the students from the location and time constraints, and it also reflects that the participants are willing to accept the change. For the students who answered "No"; they were asked to state their reasons why they think that the SE laboratory cannot be virtual. The respondents with the response "No" consisted of fourteen students, six of which did not state any reason, while four of them shared the same response of that they wanted to communicate with the lecturer. The rest of the respondents mentioned it was because they want to work more with computers, like connect to the Internet. These concerns with the use of the Cloud would all be addressed, such as to have the laboratory computers on the Cloud would enable access to them anytime and at any place even while the theoretical part of the course is taking place or even while meeting with the lecturer.

Q: Do you prefer working with your laptop or in the lab?

Table 4 The frequency and percentage of the students who prefer working using either laptop or lap

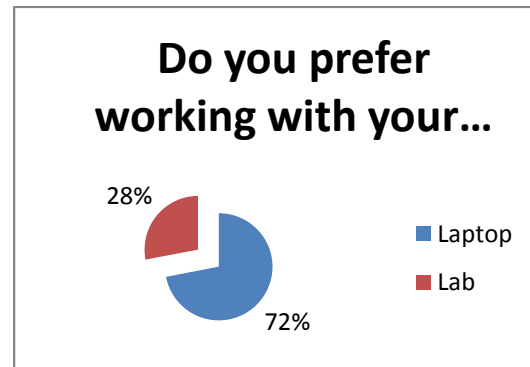| Response Item	Frequency	Percentage
Laptop	141	72%
Lab	54	28%
Total	195	100%

Figure 4 Percentage of the students who prefer working using either laptop or lap

This question was meant to find out whether SE students prefer to work with their own laptops or in computer labs. 72% of the participants prefer to work with their own laptops while 28% prefer to work in labs. It was clear from the statistics that the majority of SE students prefer to work with their own laptop. The previous question showed that the majority of SE students accepted the idea of working with a virtual lab due to the place and time constraints; however, using a laptop anytime and anywhere would give the SE students the motivation to work in the lab as they can use their own laptop as well as not have to pay attention to the time and place constraints.

Q: Do you use any application on the Cloud? If "Yes", kindly state what it is:

Table 5 The frequency and percentage of the students who use application on the Cloud.

Response Item	Frequency	Percentage
Yes	159	82%
No	36	18%
Total	195	100%

This question was meant to find out how familiar the participants are with the Cloud as well as to

know the type of applications that are mostly used by SE students that sit on the Cloud. The question showed that 82 % of the participants use applications on the Cloud while 18% of them do not do so. For the ones who answered yes, they were asked to mention the kind of application they were using; the majority of the students who answered yes mentioned that they used Google Docs as an application,; around (16) of those who answered yes added Dropbox and Skydrive. 18% is somewhat low but it might reflect the lack of awareness of the Cloud and its utilization, especially in SE majors.

Q: Have you ever used Google Docs?

Table 6 The frequency and percentage of the students who used Google Docs

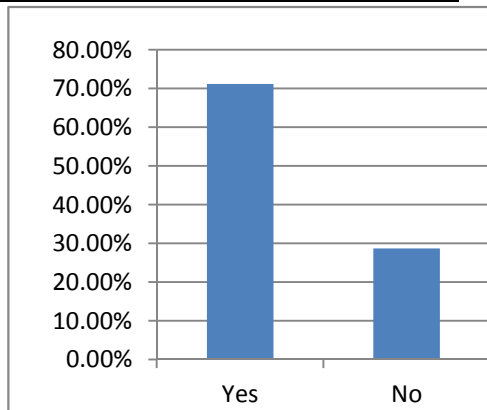| Response Item	Frequency	Percentage
Yes	139	71%
No	56	29%
Total	195	100%

Figure 6 Percentage of the Google Docs

The aim of this question was to find out if Google Docs is in use by the students, especially as there are many researches that show Google Docs as being important to academics. The question showed that 71% of the participants used Google docs while 29% of them do not do so. The next question will further clarify this question.

Q: Do you use any software for the university that sits on the Cloud (even if it not provided by the university)?

Table 7 The frequency and percentage of the students who use Cloud application

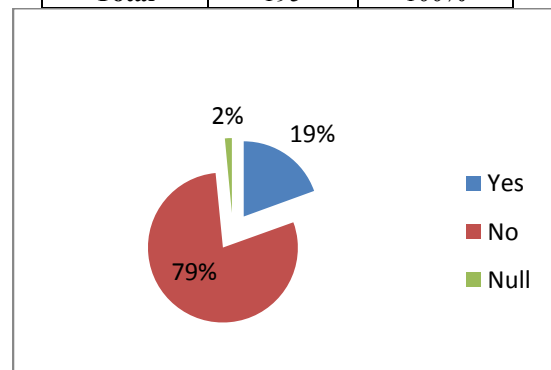| Response Item	Frequency	Percentage
Yes	38	19%
No	154	79%
Null	3	2%
Total	195	100%

Figure 7 Percentage of the students who use Cloud application

This question was meant to show whether universities are using any type of application over the Cloud and whether they are provided to the students. The question showed that 19% of the participants are using software hosted in the Cloud, while 79% of them do not use any application for the university that sits on the Cloud; 2% did not answer the question. It is clear from the statistics that a majority of software engineering students are working with the traditional process of teaching and that the universities are not accommodating much of the benefits associated with the Cloud. The participants who answered yes to the question were asked to mention the kind of software they are using to study the kind of software used for the universities. Surprisingly, even though most of the students used Google Docs, few of the % mentioned it as a tool on the Cloud used for the university; this reflects that students only used Google Docs mainly for their own personal use.

Q: Is it hard to find software for your courses? If Yes, kindly state the reason

Table 8 The frequency and percentage of the students who face difficulties in finding the tools for their courses

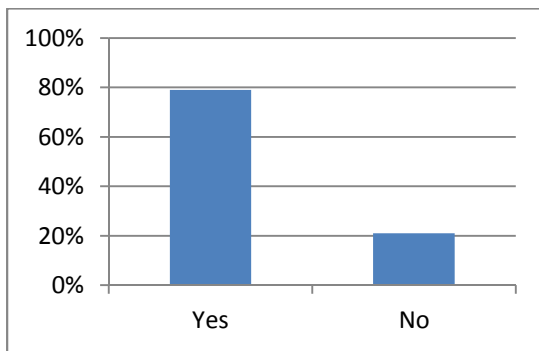| Response Item	Frequency	Percentage
Yes	154	79%
No	41	21%
Total	195	100%

Figure 8 Percentage of the students who face difficulties in finding the tools for their courses

This question aimed to find out what the difficulties of SE students are when it comes to finding the proper software for their courses. For the students who answered yes, they were asked to state the type of difficulty. The question showed that 79% of the participants found difficulties in finding the software for their courses, which reflects that it is quite problematic. For the ones who answered "yes" they stated various reasons; their reasons formulated around compatibility, availability, portability and licensing. (46) students stated that the compatibility issues made up most of the difficulties faced, (34) of them stated that the availability issues were the reason, (28) of them stated that the portability issues were the issues that they faced, and (46) of them stated that the licensing issues were the biggest difficulties they faced.   21% of the students did not find difficulties in finding software for their courses. The percentage of the participants who answered no is somewhat low compared with the ones who answered yes. It is clear from the statistics that the majority of the participants faced difficulties in finding tools for their courses; however all these concerns would be addressed in the proposed solution.

Q: Have you used any technology to save your applications, software and drivers for a long term without using any magnetic disk?

Table 9The frequency and percentage of the students who have used certain technology to save their application

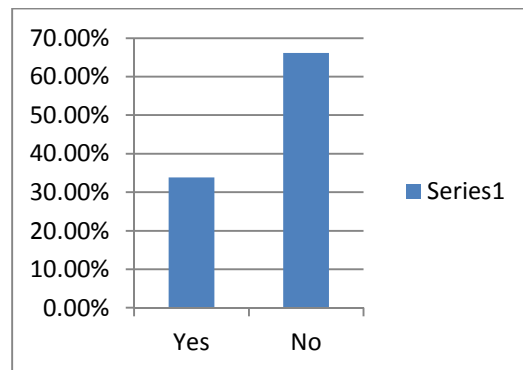| Response Item	Frequency	Percentage
Yes	66	34%
No	129	66%
Total	195	100%

Figure 9 Percentage of the students who have use certain technology to save their applications

This question was aimed is find out about the techniques that SE students apply to save their applications, software and drivers. The question showed that 34% of the participants use certain technology to save their applications, software and drivers for a long term without using any magnetic disk, while 66% of them they do not use technology to do so. For the ones who answered yes, they were asked to mention the kind of application they were using; most of them mentioned that they used Dropbox and Skydrive to save their needs and the rest of the participants did not mention the technology they used.

5.2 The Survey Analysis Findings
The survey results showed that the current teaching methods of SE students are limiting them. One of these limitations is attending the labs; the students have to attend the labs at a given time, but the current labs are limited by the number of PCs, licenses and so on. This reflects that the lecturer needs to book the lab based on its availability. As for the necessity of labs for SE students, the question showed that the majority of SE students see the SE courses as

being unable to be taught without attending the labs; this shows that availability of the labs are important for them to do practice, especially as SE courses by nature are represented by theoretical and practical so the availability of labs is very important for the practical courses. Due to some of the issues that relate to the labs' availability, the majority of SE students agree with using the labs online, especially as they would be free to use the needed tools without any constraints. As for finding the proper tools for their courses, the majority of SE students face difficulties involving compatibility, availability, portability and licensing; however they are willing to accept the changes that would help them to remove part or all of these issues. The survey also showed that the majority of SE students are currently working with the traditional process of teaching. Nonetheless, they are willing to accept the changes to use the latest technologies.

5.2 Questions of Interview

The interview of this research involves two parts; the first part of the interview was conducted with SE lecturers. Six interviewees from UCTI, UTM, and UM were interviewed. These interviews are piloted to question whether the current teaching methods should be enhanced; whether laboratory courses can be taught online as well as what necessary tools are recommended for students to use; what issues that they currently faced to dealing with these tools in terms of compatibility, availability and portability; are they accepting the changes in the learning environments. These interviews are piloted to question whether the current teaching methods should be enhanced; whether laboratory courses can be taught online; what necessary tools are recommended for students to use; what issues they currently face when dealing with these tools in terms of compatibility, availability and portability; and whether they would be willing to accept changes in their learning environment. The second part of interview was conducted with IT leaders: three interviewees have been selected. These interviews are steered towards knowing whether allocating the resources for SE students are easy, what they think of Cloud, would be possible to utilize it to aid SE students and are they accept the changes in the current environment as they decision maker These interviews are steered towards knowing whether allocating the resources for SE students are easy; their opinions of the Cloud; whether it would be possible to utilize it to aid SE students; and whether they would accept changes in their current environment if they were the decision makers.

Q: What courses do you teach?
The interview was initiated with a friendly question to aid in releasing tension and creating a friendly environment. The interviewees were asked about the courses they teach as well as their specialty; the interviewees' responses are to aid in knowing whether the different software engineering lecturers who teach the course use the same tools,and whether the lecturers who teach same module have the same issues. The responses are also meant to reflect the similarity of the courses taught by the lecturers if there is any. The interviewees' response showed they teach more than one module: five of them teach SE courses, two of them teach Database, two of them teach object oriented, one of them teaches system design, AI and CS, and one of them teaches Bioinformatics. It is clear from the responses that the same modules are given; it is logical that there is a similarity in the modules because the interview was conducted with SE lecturers from different universities. It would aid in finding out what tools are used for the similar courses, and whether they face the same issues when it comes to the availability of tools. . These questions would be clarified with the upcoming questions.

Q: Do you think that the current teaching methods should be enhanced?
This question is meant to get the opinion of SE lecturers on whether the current teaching methods should be enhanced. The interviewees answered. "Yes", the current teaching method should be enhanced". However, two of them added if the suitable techniques are available, while one of them added the teaching method should always be enhanced. This reflected that the current teaching methods need to be paid more attention on, especially as they can motivate the students to perform better. It is clear from their answers that they all agree with enhancements; there was a clear indication to that they are ready to accept the changes and any kind of enhancement in the SE teaching methods. It is logical that teaching methods need improvement to move students from the traditional teaching methods to modern teaching methods as well as to encourage the students to be in touch with new technology, especially as SE students need to be always updated with new technology.

Q: *Do you think SE courses should only be taught in the classroom?*

This question is meant to find out whether the SE courses need more than just the classroom, and; whether the laboratories can be excluded or not. The result was that SE courses are both theoretical and practical. All of them answered no for the question, but one of them added that SE students have to do more practice in the lab to get more experience. Another one of them also added that since the SE students are very hands on in regards to the programing elements, the main thing is to always do the programing in the lab. It is clear that the interviewees strongly disagree with the idea of software engineering courses not involving laboratories and hands on tools used for the modules. This reflected that the theoretical courses of SE can be taught without attending the classroom; instead, it might be taught using online technology. (Another interviewee?) added that the SE students should have access to the lab at all times to encourage them to do more practices and to get more experience.

This also reflected the importance of the labs for SE students,; in particular, the availability of the labs for SE students at all times would aid them to get more knowledge and experience. Not only that, the availability of labs is also represented by the availability of necessary tools to work with. By providing the SE students with labs and the necessary tools without constraints, more value would be added to the learning environment of SE students.

Q: Can the SE courses laboratory be taught using a virtual lab?

The previous question showed that the SE courses, by nature, are hands when it comes to programing elements and the importance of the labs for SE students. So, the availability of labs for SE students is necessary. The interviewees answered that the SE laboratory courses can be taught using a virtual lab. From the presented answers, the SE lecturers had some limitations in terms of the availability of the labs and PCs due to various reasons. One interviewee mentioned that he had to divide the students into groups just to accommodate with the number of PCs; and clearly this process would require effort in dividing the students, re-teaching the same material taught to each of the groups, consumes time and of course consumes space. One interviewee mentioned that he had to divide the students into groups just to accommodate with

the number of PCs. Clearly, this process would require effort in dividing the students. It would also be time and space consuming as the lecturer would need to teach the same material to each separate group.

 The interviewees' excitement towards the virtual lab reflects that the lecturers are hoping to see the changes in the learning environment; they see that the virtual lab will remove many of the limitations that they are currently facing.

Q: What kind of tools do you use in your module?

The interviewees were asked about the kind of tools that they recommend students to use. The interviewees answered that the tools they recommend depend on the requirements of the subject. The first question showed that even though the SE lecturers teach different subjects, it is still logical to find somewhat of a similarity in the tools used. This question showed that the case tools, SQL, Netbeans, Visual studio, and Microsoft Project are the similar tools that are often used in the lectures; this reflected that these tools are those that are required for the subject and they might be made available for the students by the university. The findings of this question will aid in choosing the tools that would be adopted in the solution in chapter 5. This question is further clarified with the upcoming question.

Q: Is it mandatory to stick to these tools?? And why?

The question further explains the previously stated question. It is meant to find out whether the tools used for the modules can be replaced with other alternatives or not and whether the lecturers are ready to choose another alternative tool. One of the interviewees thought that certain tools would be quite hard to be replaced with other tools because the tools need experience. This is a very important point to consider; when choosing the tools to sit in the Cloud, they should either be the same tools used or at least should require the same experience of the original tools if they are alternatives. The rest of the respondents thought that it was fine to go for other tools if they deliver the same purpose.

Q: Are the tools always available for you and for the students?

The question is aimed to find out whether the SE tools are always available for the lecturers and for the students, and how difficult it is to obtain them. The majority of the interviewees thought that the tools were generally easily provided as

needed, while two participants answered that it was not always available due to licensing issues. The question answers that the tools needed for the modules are generally always available but the question does not answer whether they are easy to deal with and prepared for use; for that the upcoming questions were made.

Q: Is it easy to install, especially in various platforms?

The question is aimed to find out whether the tools are easy to install in various platforms. Three interviewees answered that the tools are not easy to install on different platforms; this reflected that the tools that they recommend working with require generally specific platform, which would mean that the students will face some difficulty, especially if they are working on a different platform. Two of the interviewees answered yes, and that the tools are easy to install in different platforms; these considerations should be considered in the solution.

Q: How would you feel if the tools were available for use on the Cloud?
The question is aimed to see what the reactions of the interviewees would be if they were given the choice of seeing the tools made available on the Cloud. All of the interviewees who participated would want to see that happen.

The following questions were conducted in the second part of the interview; three IT leaders from different universities were interviewed:

Q: Is allocating resources to students often easy?
The question is meant to find out whether allocating resources for students is often easy. The interviews answered no. However, one of them added that allocating the resources needed effort. This reflected that allocating resources for students needs time, adding to more cost. It is clear that they did a lot of effort to allocate the resources for the students; nonetheless, they will still definitely agree with changes that would help them to reduce the effort in terms of time and cost.   All these considerations will be taken into account in the proposed solution to add more value for the learning environment, especially as allocating resources is part of building the proper learning environment.

Q: Do you think that using Cloud computing will reduce the use of resources?

The pervious question showed that allocating resources for the students is not an easy job. This question showed that all of the interviewees think that Cloud computing will reduce the use of resources; this reflected that applying Cloud technology would remove many limitations that they are facing such as preparing the environment in terms of staff, PCs, software and so on. Thus, the proposed solution will consider all these concerns as well as add more value for the SE learning environment.

Q: Do you think Clouds can aid SE students?
The question is meant to get the opinion on whether Cloud technology can aid SE students. All the interviewees answered yes, and one of them added "*if the right environment is given*". It is clear from the interviewees' answers that using the Cloud would aid in SE. This would provide more value for the proposed solution, especially as the Cloud will contribute to enhancing the learning environment of SE as well as to remove the limitations that SE students face in using the lab. This question answered that the Cloud can aid SE, but it did not answer whether working with it is hard; for that the next question was made.

Q: Are Clouds hard to work with?
The question is to know whether working with the Cloud is hard. The previous questions showed that the Cloud can be used to remove many limitations in the learning environment as well as to enhance the SE learning environment. The interview showed that one of the interviewees answered yes, that working with the Cloud is hard if there is no familiarity with it; Two of them answered no. For the interviewee who answered yes, it is a logical answer because any technology will be hard to work with if there is no familiarity with it. It is clear that working with Clouds is not hard.

Q: Do you have a Cloud environment?
The question is asked to know whether they have a Cloud environment in their universities. One of the interviewees answered that the environment of the Cloud exists but there is no tool host on the Cloud; two of them said that they do not have any system on the Cloud. This reflected that the ones who have a Cloud environment would find it easy to accept the solutions, while the others who do not have a Cloud environment might not have the proper knowledge to adopt the Cloud.

However, both opinions will be considered in the proposed solution.

Q: Do you have any tools on the Cloud?
The question is meant to know whether there are any tools that have been used on the Cloud. The previous question showed that one of the interviewees has a Cloud environment and two of them do not have one. It is clear from their answers that they do not have any tools on the Cloud. This would be considered in the proposed solution.

5.4 Qualitative Analysis Findings
As for the tools that the SE students utilized in their courses, the interviews showed that different tools can be used; the tools were assigned by the university according to the course requirements. This reflected the importance of the tools for SE students to use in their courses. As for the current teaching methods, it showed that the teaching methods always need constant improvement; the interviews showed that the SE lecturers agree with any enhancements, especially if it will improve the current environment for the better. As for the availability of labs for SE students, there is a clear indication that current labs are limiting for students, especially as the SE students need the lab every time to get proper knowledge and experience. One of the issues that the SE lecturers constantly face in terms of labs availability is they have to divide students into groups to accommodate the number of PCs; the SE lecturers have to book labs in the first place and then inform the students. So, setting up the proper environment such as place, PCs, staff, air-conditioning and so on is one of the obstacles that the university is currently faced with. Hence, the SE lecturers are always in agreement with any solution that might help them to remove these limitations. The interviews show that the SE lecturers are excited to see the lab online, especially is the tools are move to the lectures and students at any given time any given place. As for the kind of tools that are usually used, some of them need certain specifications to install on; the students have to settle the needed requirements to install the tools. All of the interviewees who participated in this interview are hoping to see the tools on the Cloud and they will be happy to see the tools made available for them and for the SE students anytime and anywhere without any constraints. Part of the interviews showed that the allocation of resources for the SE students is not an easy job,

taking into consideration issues such as place, staff, PCs and so on. This reflected that the decision makers would be ready to accept any solutions which can reduce their efforts. The majority of the interviewees? are convinced that utilizing the Cloud can aid SE students.

6. WILLINGNESS IN ADAPTING CLOUD-BASED TEACHING AND LEARNING

6.1 Students' Perspective
A survey was conducted among software engineering students in three different universities in Malaysia (APU, UTM and UM) to find out the current issues related to their learning environment as well as their attitude toward adopting cloud computing as a solution to their problems. A total of 325 students participated in the survey. The survey results indicate that the current teaching and learning resources utilized for SE students are quite limited in their scope. One of the limitations is the mandatory requirement of attending the lab sessions. Students need to attend the labs at a prescribed time set aside the constraints of number of PCs, licenses and so on. This reflects that the lecturer is bound to follow the availability of lab slots in order to book it for any curriculum requirement. Regarding the question of compulsion of lab usage, the survey showed that the majority of SE students believe that their courses cannot be taught effectively without experiencing the practical part of it which can only be achieved through attending the labs. Most of the students are concerned that they should be allowed and provisioned to use the lab resources at any given time for revision of course material, practice and assignment preparation. Typically majority of the SE courses consist of both theoretical and practical elements, therefore understanding of the theoretical components are naturally dependent on the comprehension of applied segments. Due to the stated issues that relate to the labs' availability, majority of SE students agreed in using the online lab resources, especially as they will be allowed to use the required tools anytime without any constraints. Regarding the question of how conveniently they are able to find suitable software tools for their courses, the survey results indicate that majority of SE students face difficulties of compatibility, availability, portability and licensing of software. However they all seem willing to accept any changes that would help them eliminate part or all of these issues. The survey also showed that

the majority of SE students are currently using the traditional processes of teaching and learning. Nonetheless, they are more than willing to accept changes in order to use the latest technologies. The survey also specify that 82% of the students are familiar with the cloud applications like Google Docs etc., therefore the paradigm shift from a traditional lab to a cloud-based state of the art lab is considered well-anticipated by students.

6.2 Lecturers' Perspective

Interviews were conducted with six software engineering lecturers and three IT heads (from the three universities stated before) to figure out whether the current teaching and learning resources should be reconsidered in light of the students' needs. Questions were also asked on whether labs can be conducted effectively online; what necessary tools are recommended for SE students to use; what are the most common issues with these tools in terms of compatibility, availability and portability; and whether they would be willing to accept changes to promote the existing learning environment. Following is a brief description of the answers provided by the selected SE lecturers during the interview sessions which shows their inclination towards adopting cloud computing based teaching and learning. There is always a need of using innovative, highly effective and technology-specific techniques in educating students therefore ideally teaching methodology needs to be constantly reviewed looking at the demands of that era. Software engineering field requires even more integration of technology keeping in view the demanding job market. These interviews with the SE lecturers specified that they are agreeable with any technological enhancements, especially if it is for the purpose of improving the teaching and learning experience. They all agreed that current labs are not enough for accommodating the increasing number of students as well as for meeting the needs of the students. Considering that the lab requirements for SE courses are relatively high, universities don't have the resources, infrastructure and sometime budgets to meet the quality expectations. Lecturers emphasized the need of software tools for various SE subjects which reflect the importance of the lab-based learning environment. Availability of labs is a major concern everywhere.

Most of the time this issue is addressed by dividing the larger classes into smaller and manageable groups, however it all adds to the restrictions of individual students' lab consultation times. Issues related to booking of labs are a common concern for most of the interviewees. Moreover ensuring the suitable environment in terms of managing place, machines, technical staff, air-conditioning etc. are few major obstacles that almost every university is facing. Hence, the SE lecturers are always in anticipation of any optimal solution that significantly reduces these limitations. These interviews indicate that the SE lecturers are eager to use the online lab facility. As they always need various specifications of tools to be installed, all interviewees were keen to use the cloud-based solution to resolve their problems.

7. GUIDELINES TO IMPLEMENT SE TOOLS ON THE CLOUD

The following are the guidelines to implement SE tools in the Cloud. The implementation of these guidelines was tested using a public cloud (Amazon).
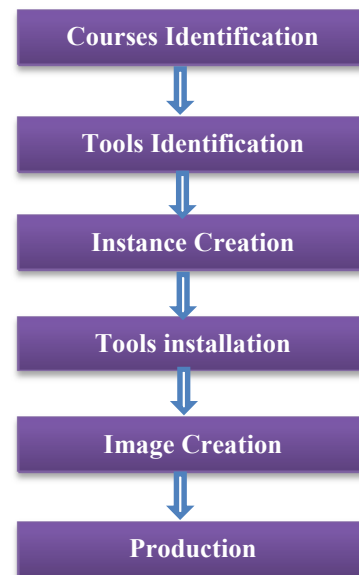

Figure 10 Guidelines to Implement SE Tools on the Cloud

7.1 Course Identification

This step involves identifying the SE courses that require usage of software tools. Since majority of SE courses are a combination of theoretical and practical approaches, all such courses will be shortlisted that are recommended to be taught in the lab. The courses should be

listed and filtered in accordance with the programme (e.g. SE in this case) requirements.

7.2 Tool Identification

This step involves identifying the appropriate tools for the courses. Since the practical-natured courses are already listed, the required tools for these courses need to be identified in this step. There could be multiple tools serving the same purpose, but the appropriate tools would be selected based on precise curriculum requirements.

7.3 Instance Creation

This step involves creating an instance with the appropriate specification that would conform to the identified tools and courses. Amazon Elastic Computer Cloud (Amazon EC2) was chosen to test run the instance creation. It enables the user to launch and manage different types of operating system instances (such as Windows Server instances and Linux/UNIX instances) in Amazon data centers. The instances can quickly be launched using the AWS Management Console [11].

7.4 Tool Installation

This step involves installing the appropriate tools that were identified in the Tool Identification step. Since the tools have already been identified, installing them on the created instance is straight forward.

7.5 Image Creation

This step involves creating an image of the installed tools in the created instance. When all identified tools are installed and resided in the instance, an image of the instance is created. This image would be taken as the reference for creation of more instances [11].

7.6 Production

This step involves providing the instances with the necessary tools for the students. This step follows from the Image Creation. The created image will suffice for SE students because they all share and use the same tools. For example, when new students enroll into the University, they would have the same instance until they graduate. Enabling the students to use the given instance with specified tools is done through implementing a Web Portal which would enable them to access their specified instance at any given time and at any given place.

Table 10 Comparisons between traditional lab and cloud based laboratory

Several factors were considered for the comparison criteria that include cost,

infrastructure needs and maintenance requirements. We also catered for factors like accessibility, scalability, compatibility, affordability and resource utilization. The cost factor was derived by comparing the total expenditure that is required to setup the necessary components of both traditional lab and CBL. It includes the costs of machines, hardware, and software. The infrastructure was taken into account by considering the structural components and facilities of both traditional lab and CBL. It includes components like servers, physical storage etc. The maintenance aspect was considered by looking at the configuration needs and updating requirements of the installed hardware and software for both traditional lab and CBL.

Criteria	Traditional Lab	Cloud Based Laboratory
Cost	High	Low
Need for Infrastructure	Yes	No
Need for Maintenance	Yes	No
Accessibility	Yes	Yes
Scalability	Limited	Unlimited
Compatibility	Yes	Yes
Resource Utilization	Not utilized well	High utilization

Time and location based constraints in both traditional lab and CBL setup were used to reflect the accessibility factor. Scalability was measured in terms of the number of enrolled students and the growing needs. Compatibility was taken into account by finding out the alteration needs and requirements of any special hardware to work with these labs. Finally the resource utilization was considered by looking at the consumption of the available resources like storage, network, and computer resources. Currently many of the educational institutions are facing problems in providing the needed IT infrastructure especially for research activities due to the financial crisis [12]. This problem can be minimized or at least can be significantly reduced by getting benefitted from cloud technology rather than by building a complex infrastructure with maintenance and configuration issues associated with it [13]. Hence the proposed solution is important to be adapted quickly in the education sector. The

learning content can be easily created and deployed in cloud-based environments [14]. Moreover, CBL is advantageous because of its ability to host the tools needed for system users. By building a cloud-based education system, we can ensure optimal utilization of computer technology and improvement in the quality of the overall teaching and learning process [15].

8. BENEFITS OF CLOUD BASED LAB

There are plenty of benefits for academic staff, students and university management in following this approach. It will enhance the level of interactivity among the students and staff. In fact the use of cloud will help to make the teaching and learning environment scalable which will help in cost cutting [16]. Students will no longer be required to install the specific applications or buy an access code for training toolkits (such as my IT lab). Administrators will save a lot of their time because updating, licensing, and configuration issues will be eliminated using the cloud. All of these elements would add to the cost reduction and ease of access and usage [17].

8.1 Benefits for Students

The most visible benefit for SE students to use cloud-based infrastructure is the availability of the needed resources at any time and at any place [18]. The portable nature of the cloud will enable students to work from multiple computers and operating systems [19]. Students will be able to access the system tools and other software regardless of time or location restrictions. As mentioned, currently students are facing availability and portability issues; however the proposed system guarantees the solution of these problems. It also promises to eliminate problems like networking issues, hardware or software restrictions, lack of resources, maintenance requirements etc. which ultimately would enable students and academicians to focus on their tasks without any distractions. Better resource utilization will promote ease of use and availability of required services which would help students to accomplish their tasks faster [20].

We expect that an improvement in overall teaching and learning experience would lead to produce better quality students having more in-depth understanding of the concepts and applied skills which are essential for SE graduates. It would enable the students to address the needs of a leading technology. Therefore, it eventually will help to improve the overall student performance and will provide them experience in dealing with such technology. In turn, it is also assistive for their job prospects because the technology shift towards cloud has already been started in industry and students comfortable in using this technology will certainly have an edge in the job market [21].

Programming is an important component of any software Engineering degree. Institutes need to have the latest programming tools and IDEs to support a better programming experience for their students. By utilizing the cloud, programing language constraints can be diminished as we no longer need the time consuming downloads, complex setup configurations, use of additional resources, etc. [21]. Therefore students will only be concerned to write and execute the code in the specified programing environment.

8.2 Benefits for Faculty

Cloud technology would provide the access portability, resource availability, flexibility and agility to the hosted applications [22], thus the lecturer would find it easier to construct multiple difficulty levels for beginner and advanced audience.
Faculty will not be bothered by the maintenance issues anymore which eventually will impact positively for the overall learning environment [21]. The faculty would expose the students to real situations that cannot be faced in locally simulated environments, thus building a deep knowledge base for the students [21]. Hence the teaching process will improve and it would be more efficient without placing additional loads on the faculty [23].

8.3 Benefits for Universities

In utilizing cloud-based education, institutions are expected to be the top beneficiaries, as they would have the opportunity to optimize their resources more manageably which will in turn benefit the number of enrollments. Student numbers will also benefit from increased resource availability, high accessibility, better job opportunities and improved quality of students [23].
A key advantage that the university management (network administration department) would get by utilizing the cloud is that they don't have to worry about software licensing issues [24] which also will help in eliminating the cost associated with it [25]. Another finding indicates that some specific hardware constraints would disappear mainly due to virtualization feature which gives

the students the ability to share the resources with multiple operating systems and virtual hardware platforms [22]. Thus, the administrators would have the choice to run large-scale applications without having to consider the resource limitations since with the use of cloud, universities will have the provision of all the required resources and practically unlimited space.

Maintenance would be minimized because the cloud would take care of the maintenance issues. The main concern that the administration has to take into account is that the service availability of cloud service provider (CSP) has to be addressed and ensured on the service-level agreement (SLA). The service availability should be a matter of concern, especially as it involves identifying the backup and disaster recovery in case of down service of CSP [26].

8.4 Limitations and Key Assumptions
Due to time and cost, the first limitation of this study is the sample space; it covers only three universities out of more than (44) that currently exist. According to study [27] listed down the number of higher education institutions in Malaysia; he found that there are (44) universities, (25) university colleges, (21) polytechnics, and (537) colleges, so the total number of institutions in Malaysia is (627). However, other universities may have different attitudes towards the adoption of Cloud computing to enhance their learning environment. Furthermore, the survey of this research targeted the SE students of three universities and friends who are software engineering students; they are located in different countries. Thus, this means that the finding of this research cannot be generalized

The learning environment is quite huge. For example, there is the classroom, laboratory and library to cover each and every part of the learning environment would be not possible due to the time limitation, for that the scope of this research is on the laboratories and how the environment can be enhanced using the Cloud as a solution.

As the learning environment is quite huge, it was difficult to cover each and every part of it due to time limitations. As a result, the scope of this research covers only laboratories, and how their environment can be enhanced using the Cloud as a solution.

CONCLUSION
The proposed solution suggests utilizing the power of cloud computing in enhancing the learning environment of SE students. The difficulties faced by SE students related to the availability of lab facilities, tools and the other mentioned issues can be solved by implementing the power of cloud computing. Thus, as per the proposed solution, it is highly recommended to use cloud computing to help improve the SE learning environment.

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