Sketch-based Learning: A Case Study with Undergraduate Students of Quaid-i-Azam University

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A Thesis Submitted in Partial Fulfillment for the

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CERTIFICATE

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Miss. Ayesha Majeed

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF THE MASTER OF SCIENCE (M.S.)
IN
INFORMATION SCIENCE & TECHNOLOGY

We accept this thesis as conforming to the required standards

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Dated: April 06, 2017

Department of Computer Sciences
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Dedicated to

My Parents

DECLARATION

I hereby declare that this thesis is the presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly with due reference to the literature and acknowledgment of collaborative research and discussion.

This work was done under the guidance of Dr. Muhammad Shuaib Karim, Department of Computer Sciences, Quaid-i-Azam University, Islamabad (Pakistan).

Date: 13, Feb, 2017

Ayesha Majeed

ABSTRACT

Smartphone is one of the most popular technologies that are being used for communication at present. Its importance is more revealed when it is used for learning in educational setup. Portable technology affects teaching, increasing efficiency at classroom tasks and also opening up different modes of interaction for the students and teachers. Multiple applications are available that run on smartphone to educate the students but there is a shortage of sketching applications for education. Sketching is an encouraging solution for the creation of ideas. It facilitates problem solving in an efficient manner and it allows users to express their ideas clearly, even for inexperienced users. Our target for this research is to use sketching on smartphone in the classroom for class activities. In this thesis, we cover literature survey related with the use of sketching and smartphone in different disciplines. Our hypothesis is that the active usage of smart phone via sketch-based Apps can improve learning experience for the students. We provide sketch-based application prototype that can be used in classroom as activities creator and manager.

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Chapter 1

Introduction

1.1 Introduction

Technology has great impact on our lives especially in today's "Digital world". It affects size, efficiency, speed, accuracy of devices as well as on applications. It may change the way of living and working style of people. It plays a very important role in our daily lives. It has profound effects on our society.

Human aspect of developing technology is growing more and more and now it demands to facilitate all segments of society. It provides people greater opportunity to improve their skills and attitudes that help them to modify their behavior accordingly.

The evolution of computer has changed over time, and now a computer turned into a single hand held device that easily fits into palm and user can feel ease to work with these types of devices. If we talk about size we can analyze that computer becomes a single handheld device with much higher dispersion than traditional computers.

As the technology evolved, user's perspective and demands are changed with respect to the use of computing devices. User wants to use the devices without limitations of being sticking to a place. Uses of computing devices are very common not only in industries but also in educational institutions. Education is considered the most important way of human capital formation, which is prerequisite for nourishing the development of nations. The combination of education and technology has been considered main key elements to human progress. Education feeds technology, which in turn forms the basis for education, (Mercy, 2004).

Smart phones with sufficient computing technology are available at low cost and mobile phone has become an identity of human; it will enable the idea of education that you can hold education in your hand. Many institutes use handheld devices such as tablets; pocket PCs and smart phones to educate the students. Also, students feel ease to use these type of devices for learning purpose. Now the users with laptops, tablets, smart phones and the other hand held devices using Wi-Fi anywhere without limitation, within the coverage area where its signals are accessible. Wireless Local Area Networks are used in various fields of life, in homes, industries as well as in education. Wi-Fi helps the users to join and share information in a network without the hassle of wires and connectors. By using Wi-Fi users can communicate and interact with others to promote learning experience.

1.2 Mobile usage and adoption of Apps development all over the world

Portable technology use is increasing in every field of life a compare to desktop technology. (Meeker, 2014) conducted a survey, their results are shown in figure 1.1.

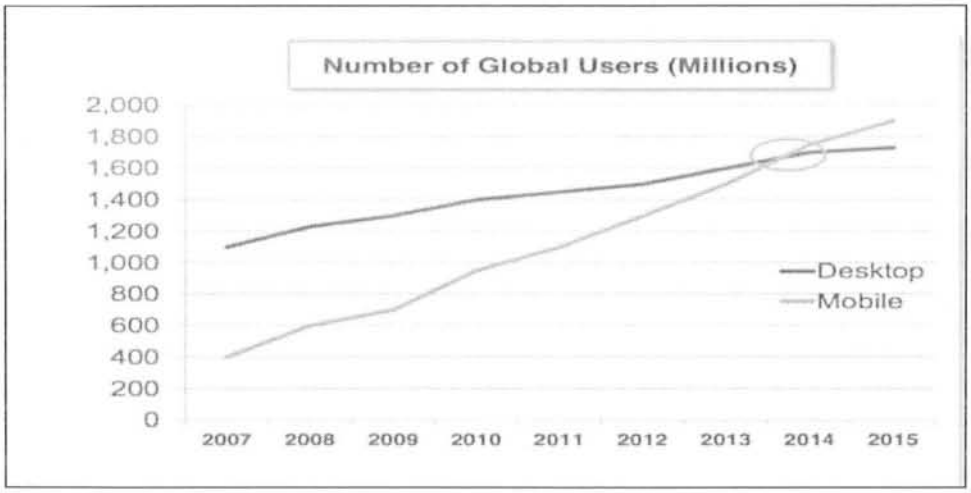

Figure 1.1: Number of global users of mobile phones

As technology becoming more popular size of devices are becoming small and it turns into a palm device, which can easily fit into hand and can be moved anywhere easily without any hassle.

As (Chaffey, 2016), analyze the use of computing devices, according to his survey, smartphone use is increasing day by day with respect to other devices. He represents it in the form of chart; figure 1.2 is the representation of his survey results.

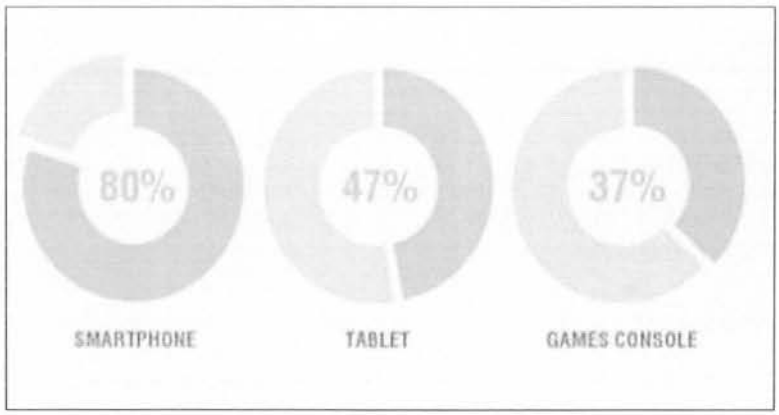

Figure 1.2: Most popular devices used to search

Figure 1.2 shows that 80% users are using smartphones in different domains such as weather forecasting, banking, and entertainment etc., 47% are using tablet for discussed domains and 37% of users are using games console.

He said that multiple technologies are available for different purpose but if multi-platform are available according to users choice, audience are more frequently shifting to other attractive platform to search the contents and according to platform their content types are also changed with respect to change in devices. He said that users are using mobile for multipurpose and the ratio of mobile use is increasing among other devices. Figure 2.3 shows the results.

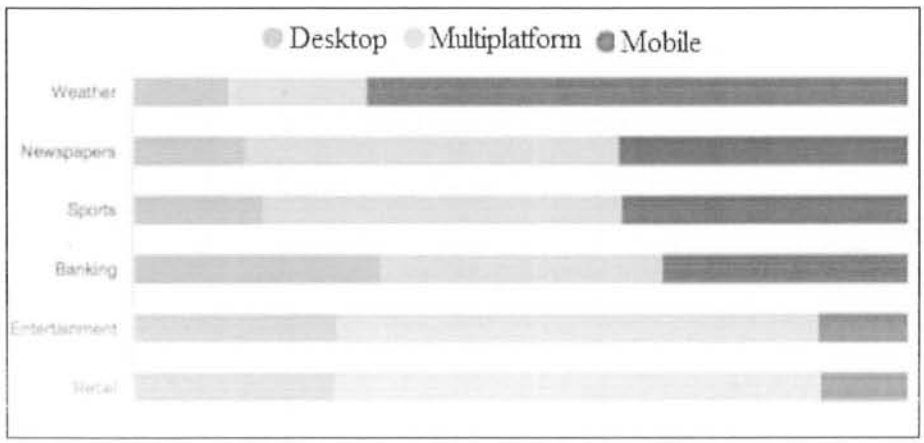

Figure 1.3: Multiple devices are used to search

He said in his article that use of smart phone and mobile is tremendously increasing but most of the mobile users are using mobile Apps instead of browser they fell ease to use the Apps.

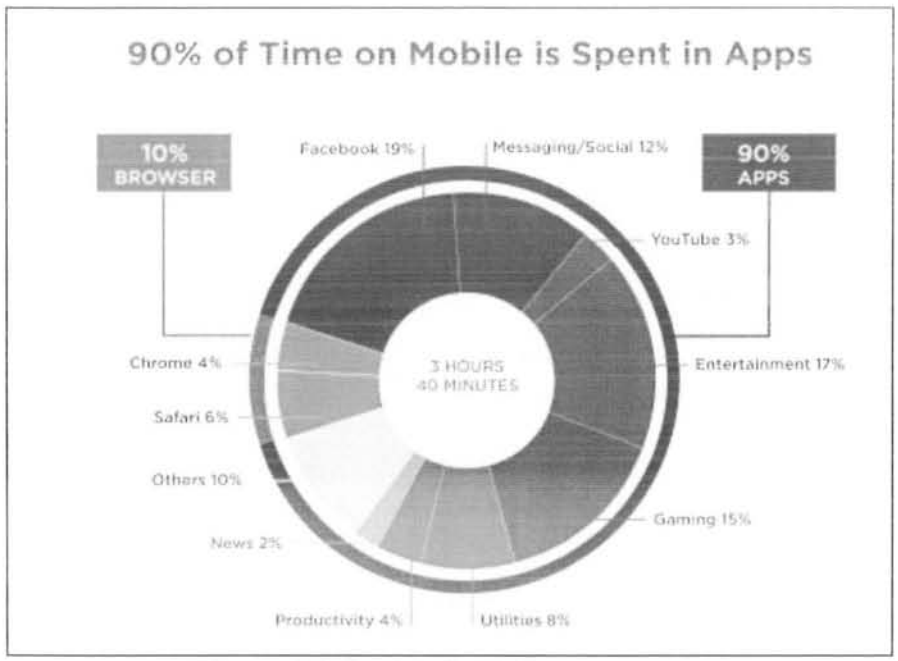

Figure 1.4: Ratio of Mobile Apps usage

According to (Chaffey, 2016), companies decided whether to develop mobile apps for multiple purposes. So there must be educational mobile apps that can be used in classrooms for learning. He further analyze the use of mobile phones he finalize his results by saying that there is 58% increment in the use of mobile phones over the year (2014-2015) for the use of personalization, news and magazines, music, media and entertainment.

1.3 Hand held technology use in developing countries

The technology is more affordable, easy to use and provide facilities to users to learn something by using it. Mobile phone technology is well-known, easy to use technology, and familiar to learners and instructors. The use of mobile phones in education in Asia has increased in the last few years. (Whattananarong, 2005) states that "the term 'm-learning' has gained serious currency in describing wireless-enabled learning strategies and processes across the entire gamut of instructional delivery".

Today's users are familiar with technology and know how to use it for different purposes. And with proper instructions, technology promises educational opportunities with an increased flexibility for different users e.g. instructors and students in educational institute, satisfying the users anytime and anywhere. (Thornton and Houser, 2004) concluded that 71% of students liked receiving lessons on their mobile phones than on the PC; 93% found mobile phones to be valuable for teaching; and 89% wanted to continue using their mobile for educational purposes. (Ramos et.al, 2006) observed that educational uses of mobile phones are increasing dramatically in the Philippines. They state that "with dropping prices and increasing functionality, it is virtually certain that not too far into the future, all students will have a cell-phone,"

The educational use of mobile phones is also gaining momentum in Africa. (Visser and West, 2005) wrote that in South Africa less than 11% of the population owns a landline telephone whereas 90% of the country's population has access to telephones due to the widespread use of cellular telephones.

People in developing nations, including Pakistan, are quickly catching up on their adoption of technology, especially smartphone use. According to PTA (Pakistan Telecommunication Authority) smartphone use is more than other handheld devices.

Table 1.1: Handheld devices use in Pakistan

Device	Usage of devices
Smartphone	50%
Tablet	10%

The usage of technology has rapidly grown in educational field. Technology has revolutionized different applications for education purposes. Presentation mechanisms used in developing countries' classrooms have changed a lot. Mobile phone itself is used as an empowering technology similar to pen and paper. Mobile technology becomes more common and useful part of education in classrooms. It can promote more interactive, student-centered learning. Students as well as instructors are using smart phones, tablets, laptop etc. during the lectures. So students have the opportunity, using their devices, to interact with their instructor. By using it we can improve interactivity in classroom by using collaborative platform.

1.4 Smartphone use in class room

Smartphones caused tremendous change in the world. Different types of users are using smart phones for different purposes. It is not just used for communication, entertainment; it can be used in multiple ways from an educational perspective such as to view the lecture, download the notes etc. but sometimes it can be considered as disturbing the class. Teachers tend to discourage their students from using smartphones in classrooms. There are many reasons for discouraging the use of smartphones in classrooms, i.e. random ring tones going on during class lectures, messaging on phones during lecture may disturb students as well as teacher, internet access during exams and test and students can use it for cheating.

At present internet capabilities with excellent and incredible versatility of smartphones exist, educators are trying to minimize the drawbacks and misuse of smart phones. Smartphones provide opportunities to students as well as teachers to create ideas effectively. It includes notes taking, reading, management of notes, recording and taking videos of lectures, taking snapshots of lecture, internet browsing and searching, and use of multiple educational apps for learning.

Smartphones can be considered as a teaching as well as a learning tool to enhance learning. It provides new mechanism to teach the students with the help of smartphones and allows the students to work with their devices and share it with their teachers thus working collaboratively to promote education. As a result its negative use in classroom can be minimized.

Teachers give tasks to their students in classroom and students can perform tasks on their phone and after completion respond back to the teachers. In order for students to use smartphones in classroom, it is important to set the limits before using phones. In this way teachers can gain real-time response from their students about lecture and can measure the effectiveness of their teaching.

It can help students to become engaged and show interest during lectures. We can use smartphone as a reading as well as a writing tool. It may increase students' performance levels.

For many years, users can interact with smartphone by clicking and dragging. User interfaces have followed the WIMP (Window, Icon, Menu, and Pointer) paradigm. Though functional, it is very complex for novice users because they feel ease to work with pen and paper, and they need expertise and effort to uses these types of interfaces. A recent trend is toward more accessible and natural interfaces, which leads to sketch based interfaces. It allows sketches, free hand drawings to be used in education to teach the students. Real pencil and paper is very rich medium for communication in every filed but in education without pen and pencil it is impossible to teach the students, and sketch provides the natural mechanism of pen and pencil to deliver ideas on canvas.

1.5 Sketching, Smartphone and Classroom

Sketching is a free hand drawing. It is a natural human practice. It is human nature that they can easily understand a free hand sketch, (Zhe et.al, 2014). As multi-touch facilities are growing now a days, sketching has become more popular means of interaction, (Kang et.al, 2015). According to (Davis et. al, 2001), sketching is widely used in early stages of design. Sketching facilitates drawing, free hand sketches that are often drawn by students and academics in several scientific disciplines, (Cheema et al., 2012).

Sketching is often used by students and teachers in several scientific disciplines. Sketch-based technique on smartphone helps students and teachers to work in natural manner. Sketch based applications can be used on handheld devices (smart phone) to visualize abstract concepts, easier ways to create presentation/lessons, activities, draw shapes freely and facilitate communication with their instructors as well as with other students. Sketch on smartphones have been made to transfer these aspects to the digital domain. It provides the pen orientation, and screen can be considered as canvas used for drawing using fingertips. It also provides active feedback to the users through screen and fingertip. Canvas (screen) provides the texture of paper and by drawing on screen by fingertip; users feel their pencil scraping across the surface.

"Everyone can draw" may not be strictly an accurate statement, but that seems to be a universal capacity for visual commination. Sketching is a natural way to communicate ideas quickly: with few pencil strokes, complex shapes can be evoked for viewers. In fact sketching is the joining

node of several diverse domains, including computer vision, human computer interaction (HCI), (Olsen et al. 2009). A sketch-based interface allows users to create layout with minimal instructions. It can save time, and minimize the cost. A few strokes are sufficient to sketch main features of a theme. This is why everyone still prefer using pen and paper to invent and communicate, and explains the theme using sketch-based applications. (Andrew et al. 2007) highlights the key characteristics of a sketch-based input device is that it allows freehand drawing that looks natural and can be used by novice as well as experts. It exploits user's ability to draw and provide natural interaction. Freehand drawing is one of the most flexible and efficient way of expressing creative ideas. Humans can draw the sketches to show their imagination, which are more specific and vivid as compared with the text.

Sketching is often a great way to communicate ideas with the implicit knowledge with the constructive stages. According to (Marquardt, 2013), paper-pencil sketches are a valuable tool, participants learn essential sketching strategies, apply these in practice during various hands-on exercises, and learn the various ways of using sketches as a tool when designing novel interactive system.

Sketch-based application has numerous advantages. It provides the facility to create the visual images with simple pencil tool of provided canvas. It includes ease of correction and modification than natural pen and paper based methodology. Sketching using smartphones combines both hand drawn representation with the technology to create environment with rapidly conceptualizing and editing. Sketching uses simple non-photorealistic adaption and interface that is based on simplified line drawings on provided canvas, (Zelznik et al. 1996).

1.5 .1 Sketching Elements

Sketching is easy and natural process; it is preferred as a process of designing an idea. It provides quick and easy way to express the idea. The requirements for sketching that medium must be simple. Sketches are informal, abstract conceptualizations of reality using icons and sketching elements. Multiple mediums for sketching are: a stick on sand, paper and pencil, whiteboard and pencil, smart phone screen and fingertip, smartphone with stylus. To sketch the idea user uses different elements according to his idea to present in effectively. Some use pencil to draw and represent their idea, others use brush to give stroke to their imagination.

Sketching elements are quite small: rectangles and oval of different dimensions, straight and curved lines. Glyphs or visual symbols are also used as sketching elements. Each element is context dependent with each discipline, (Beryl et.al, 2002).

Many elements have been available for sketching an idea. According to (Imam, 2016), sketching elements are pen and ink, graphite, pencil, charcoal. Pen and ink is essential sketching element. Pen and pencil shows the natural look to sketch the idea and looks like natural paper based methodology.

1.5.2 Sketching Functions

According to (Van der Lugt, 2002), sketching and activity is a fundamental activity and relevant functions of sketching according to his, i.e.

- It is a cyclic process in the individual thinking process.
- Motivates the users to re-interpret each other's ideas and welcome other to interpret his/her idea.
- It improving the access to prior ideas.

Sketching is a cyclic process in which individual sketches his/her idea and present them for discussion, (Schon, 1992). It facilitate archiving and retrieval of information.

1.5.3 Sketching Techniques

According to (Imam, 2016), there are three types of sketching techniques such as linear, tonal and textural sketch. Choosing the appropriate technique depends on how sketch's perceived, and how the image looks like. Sketch that uses minimum amount of lines, tones and textures give pleasant and attractive looks and users can perceive the designers idea efficiently and effectively. Sketching may influence learning experience. Academics use sketching in each discipline to represent their imagination, either in the form of texture or in the form of image sketching.

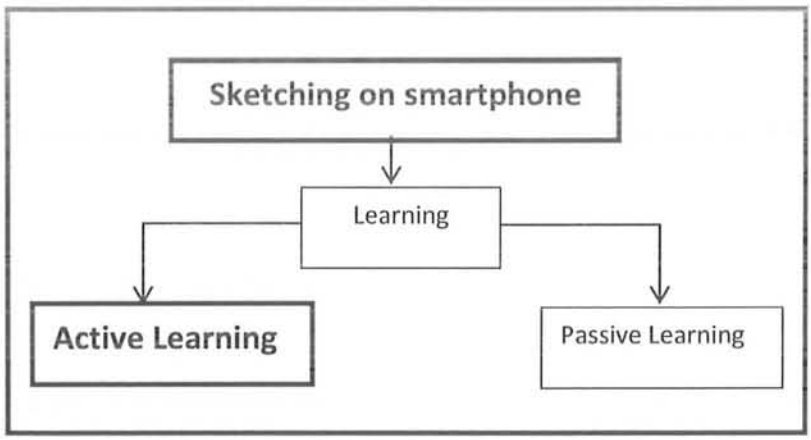

Figure 1.5: Sketching influence on Learning

1.6 Smartphones, sketching effects on classroom for learning

Smartphones are popular. Students feel ease to work with their devices and enjoy engaging with the technology. It allows wireless access to the internet; have become standard technologies in education. It has the potential to expand the effectiveness of educational tools used on smartphone.

According to (Strang, 2014), 77 % students bring their smartphone to class, 23 % find smartphones distract from learning and 56 % students enjoy using their smartphones as a learning tool in classroom.

Smartphone is increasingly smaller, affordable and portable device for use as teaching and learning tools in the classroom. It can be used anywhere and anytime to access classroom activities. Teachers can create activities for students by using it; the students answer them by means of smartphone. Activities assigned to the students can be interactively completed using smartphone.

The use of smartphone is generally, easy for students and turns out to be interesting in the classroom. Smartphone use also help the teachers in real-time assessment of the students' learning, motivation of the students and increased opportunities for active learning. For the teachers, the integration of the new technologies in the classroom can appear initially as an extra work, but the instructional advantages they have eventually a saving of time and an increase of efficiency in their profession.

Smartphones make environment collaborative and interactive to enhance learning experiences. It can save time that is utilized in printing and also save money of pen and paper. It is very flexible; students can use them anytime, anywhere, at any pace. It can empower students who are challenged visually or hearing impaired.

About the power of mobile phone it is said that "they are also particularly useful computers that fit in your pocket, are always with you, and are always on", (Prensky, 2004). Use of smartphone into the classroom is a great way to promote and enhance learning styles. It gives students the chance to interact with their classmates and with teachers by encouraging collaboration. Smartphone helps the teachers to prepare students for the real world environment.

Mobile technology affects teaching, not only increasing efficiency at classroom tasks but also opening up qualitatively different modes of interaction for the classroom, (Ratto, 2003). Different mechanisms are used in classroom to teach the students as well as for the assessment of students' knowledge. Some of them are using presentation method, some using lecture method, and some are using different tools to deliver lectures. One of them is a freehand sketching to be used in class room to make classroom more interactive and collaborative. Freehand sketching is a natural and crucial part of everyday human interaction. It combines the flexibility of paper and pencil with the processing power of a computer, that feels as natural as paper. One of the most basic steps in accomplishing it converting the original digitized pen strokes in a sketch into the intended geometric objects, (Tevfik et.all, 2006). Sketching plays important role in learning experience because it gives natural mechanism to write and draw ideas and also used to complete activities and can promote participation of students in classroom and classroom environment becomes interactive and collaborative.

1.7 Active learning

Active learning is engaging, attentive, and experimental process, where students are engaged in activities such as writing, drawing, and discussion of delivered contents. Through it students and

teachers can explore a set of learning experiences that can be more effective and interesting in the field of education to promote learning. It makes the student more active participant in the learning process. It involves self-examination of worksheets, physical activity or group participation. It happens when students are given time to work with the topic by interacting, enjoying in an activity, drawing and making maps. Students are no longer mere receivers of information but they work and understand to generate knowledge. The role of teacher shifts to being a facilitator in active learning. Active learning is "anything that involves students in doing things and thinking about the things they are doing", (Bonwell et.al, 1991). It can act as "anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes", (Felder et.al, 2009). We can represent active learning diagrammatically as follows:

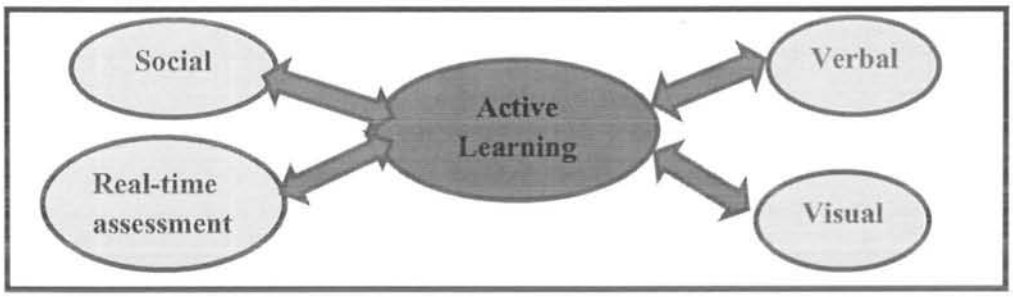

Figure 1.6: Active Learning Components

Active learning is learning approach where all students are actively learn by building knowledge and understanding of class contents provided by teacher. It means that learners take increasing responsibility for their learning, and teachers are enablers and activators of learning, rather than lecturers of contents. According to the (Examinations, 2017), organization active learning can be used as:

- **Student-centered, or learner-centered learning**

Students play an active role in their learning, with the teacher as an activator of learning, rather than an instructor.

- **Enquiry-based, problem-based or discovery learning**

Learners learn by addressing scientific questions, analyzing evidence, connecting such evidence, to pre-existing theoretical knowledge, drawing conclusions, and reflecting upon their findings.

- **Experiential learning**

This broadly describes someone learning from direct experience.

There is sample evidence of positive impact of active learning on student learning, attitudes, critical thinking, and retention. The traditional lecture-style classrooms are not suitable for group

interaction or activities. Having an appropriate classroom with proper technology to support active learning is essential, (Hossein et.al, 2011).

1.8 Motivation

Learning materials are available in digital form and instructors provide material in soft form to students so it's time to use technology in classrooms activities in developing countries like Pakistan. Students-instructor interaction is vital to student learning. However, soliciting student feedback in large lecture classes (with about 50 students or more) is challenging, and as a result, lectures tend to lack interaction, some students are hesitating to ask questions about lecture, some are disturbing the class by using their devices. Despite this problem, as educational institutions serve more students and face ever tighter resource constraints. The large scenario is likely to persist, especially at the undergraduate level, creating a need for innovative approaches to large class challenges.

Students are using their devices (smart phone) during the lecture and it may be the important aspect for instructor as well as for students that they are not concentrating on the lecture. Users (instructor/students) are using smart phone for many purposes. Some are using for notes taking, some are using for reading purpose etc. In order to avoid its misuse in classroom we may use the smart phone just like pen and paper in classroom activities. In classroom, students and instructor can use smart phone just like pen and paper to perform classroom activities. We can use smart phone in the classroom for learning purpose to enhance learning.

These types of environments enable the students to control the tempo of their learning and provide the opportunity to the instructor to evaluate the submitted activities at run time. It is less time consuming process as compared to the manual classroom activities. Instructor can monitor the work of students at a glance. There is also a possibility to provide rich feedback on student's work and evaluate at the spot. Assessment at the spot may help the instructor to judge the understanding of the students learning and can help the students to improve their understanding about lecture.

1.9 Problem Definition

Technology development and innovation can promote the use of technology. In educational institutes, technologies are used for learning, calculations, data management etc. Students use computing devices for their own purposes such as for reading and managing notes and lectures.

In educational environment smart phone is used only to read or view reading materials but not to perform formal classroom activities. There is need to explore the use of smartphone in classroom. We would like to explore whether smart phone using sketch-based Apps. can successfully be used for performing class room activities.

1.10 Proposed Solution

There is no shortage of strategies and techniques available to teachers and students to use in their classroom to perform activities using smart phones. By using technology, teachers provide the valuable feedback. They need to adjust their teaching with technology so that learning moves forward. Digital tools available in smart phones make assessment and activities easy and effective for education.

Students/instructors are equipped with different devices during lecture. By using these devices students and instructor can work collaboratively.

So aim behind is to provide a digital mechanism to use sketch-based applications. Users (Teachers/students) will interact with their homework's, quizzes and class room activities.

Goal

The aim of the Sketch based application strategy is to promote positive usage of smartphone in the classroom.

Hypothesis

Sketch based applications using smart phones for class room activities enhance learning.

1.11 Outline of Thesis

Chapter 2: Background and Related research work: describes the related terminology and research work in the field of learning, sketching on smart phone in classrooms for class activities.

Chapter 3: Proposed work and Implementation: describes the proposed work along with the change causality model, and implemented prototype is discussed.

Chapter 4: Experimental Setup: describes the research methodology and evaluation method of our prototype.

Chapter 5: Results and Discussion: we discuss evaluation of our proposed work and analyze results with different covariance.

Chapter 6: Conclusion and future work: we conclude our work with some future directions in the field of sketching on smartphone.

1.12 Summary

In this chapter we presented introduction of the technology and handheld devices. We described the uses of smart devices in the context of classrooms. There are multiple mobile applications that are being used for educational purposes but we described sketching, its elements and techniques of sketching that can be used on smart devices for learning. In this chapter we also explained active learning. At last we described the sketching, smartphone effects on classroom for leaning. At the end of this chapter, we mentioned the outline of thesis.

Chapter 2

Related Work

2.1 Introduction

This chapter describes the related work to our study, with respect to the smartphone uses in the context of academics. Researchers have performed a lot of work in which they used different technologies, techniques, and sketching tools in different ways to enhance learning and in some cases comparison has been made in different ways that how to enhance the learning using sketching on smartphone.

2.2 The impact of technology in education

Technology and education together plays important role in the development of any country. Hence it is not wrong to say that, to be a part of developed country there must be technology based education system.

Technology has great impact on society and individuals. There are tremendous uses of technology regardless of discipline, (Mercy, 2004). The rapid emergence of technologies brings the devices smaller and smaller and it turns into Personal Digital Assistant (PDA) and smartphones. With the help of smartphones, education fits in your hand and also provides new ways to access education and enhance learning.

2.3 Smartphones effects on classroom for learning

Smartphones are popular. Students feel ease to work with their devices and enjoy engaging with the technology. Smartphone is increasingly smaller, affordable and portable device for use as teaching and learning tools in the classrooms. Smartphone allows wireless access to the internet; have become standard technologies in education. According to (Examinations, 2017), 56% students are using smartphone for learning.

Mobile technology affects teaching, not only increasing efficiency at classroom tasks but also opening up qualitatively different modes of interaction for the classroom, (Ratto, 2003).

Different methodologies are used in classroom to teach the students as well as evaluation of students' knowledge such as lecture method, activity based learning etc. Different tools are also available for teaching process to enhance learning. Many researchers work on it to enhance learning with the help of sketching on smartphone.

The presentation system, Classroom Presenter (Anderson, 2004), supports student wireless submission of digital ink answers in class activities. (Koile et.al, 2006) conducted a survey to measure the use of smartphone in classroom. They created a hypothesis that is composed of four parameters that are: (1) increasing student focus and attentiveness in class, (2) providing immediate feedback to both students and instructor about student misunderstandings, (3) enabling the instructor to adjust course material in real-time based upon student answers to in-class exercises, (4) increasing student satisfaction.

Participation in classroom settings decreases with class size and diversity, thus creating passive modes of learning, due to feelings of shyness, peer pressure, and the like. Computing technology can help by creating a "safe haven" for student participation. Mobile computing has the potential to bring new modes of participation into the classroom, (Ratto et.al, 2003).

According to (Anderson et.al, 2004), the most common teaching method is presenting slides using a projector. Teachers frequently teach using slides displayed with a computer and a projector. A presentation system combines the advantages of computer-based systems with the handwriting capability. Running on a Tablet PC, a pen-based mobile computer, Presenter allows the instructor to handwrite over computer-projected slides. The slides and ink are then broadcast to other machines for students' use or to display.

Presenter is a slide-based presentation system. In its basic deployment, the instructor runs Presenter on a Tablet PC. The Tablet PC has special hardware and software support to make toner as natural as possible. Another copy of the application runs on a second machine which drives the data projector. The two machines communicate via a network connection to synchronize slide and ink data. The instructor view includes pen and navigation controls, while the projector view shows only the slide.

In instructor view pen and other controls are available for writing on slides and the size of slide has been reduced to provide the instructor with extra annotation area (see figure 2.1).

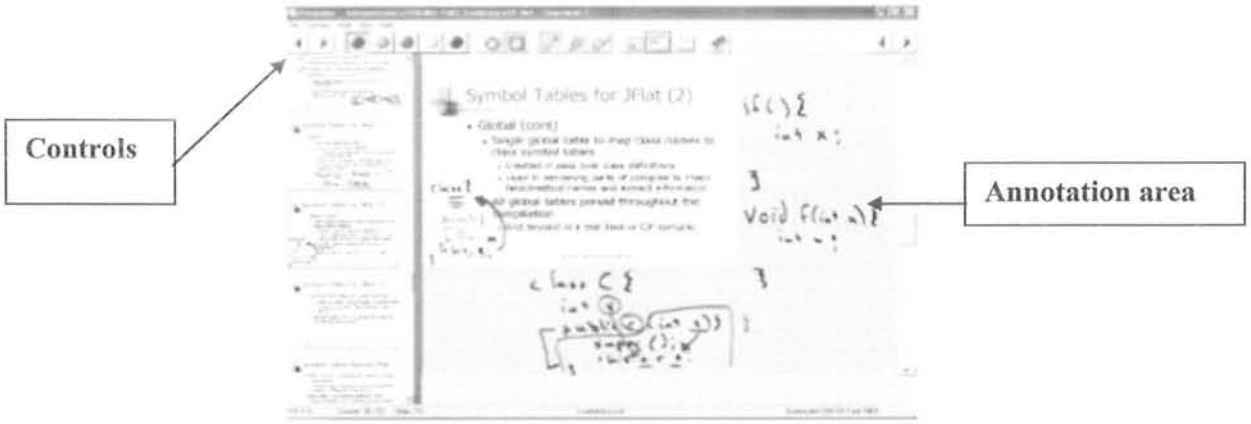

Figure 2.1: Instructor view with navigation controls

In projector views audience views the slides and slide is larger than instructor view.

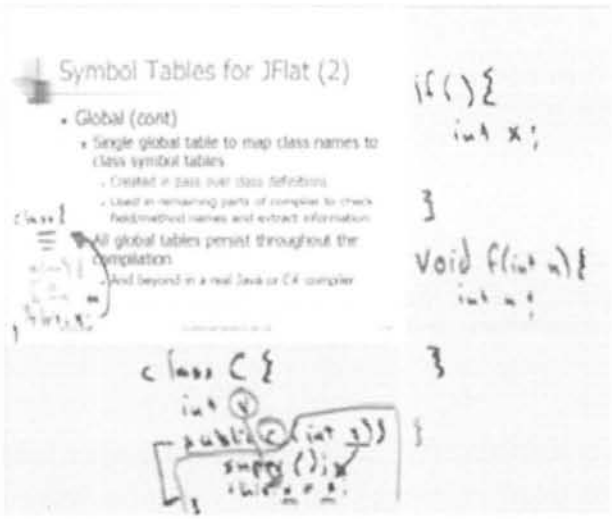

Figure 2.2: Projector view showing only the slide to the students

Tablet PCs enable integration of ink with slides, allowing annotation with natural handwriting. The high quality ink of the Tablet PC completely changes the writing experience from earlier pen computers -based on different technologies.

This has many advantages, e.g., ability to present prepared materials and ease of switching the display to a development environment during mid- presentation.

One major limitation of computer-based systems is lack of support for high-quality handwriting over slides, as with overhead projectors and other manual presentation systems. Classroom Presenter, a Tablet PC-based presentation system has been used in computer science courses and results are satisfactory.

The basic idea behind ActiveClass (Ratto et.al, 2003), is simple: using personal, mobile wireless computing devices, students can anonymously ask questions, answer polls, and give the professor feedback on the class. Every student and the professor see these lists of questions, poll results, etc. Furthermore, students can vote on previously asked questions. This raises their ranking in the display, encouraging the professor to give those questions precedence. This paper focuses on the use of personal wireless devices and ActiveClass's student question-asking feature, providing several insights into mobile technology for encouraging classroom participation.

According to (Buckalew, 1994), the chalkboard/whiteboard has been the common means of communication. Teachers use chalk as well as voice to deliver the lecture. Teachers use pen and paper to create quizzes and assignments for students. Students respond back on paper to complete the assigned task. Recently overhead projector is used to deliver the lecture. Different types of software are used to deliver the lecture on projector. These media provide one-way communication: from the lecturer to the students. Lecturer's Assistant, is the tool that provide such features to enables graphic communication from the students to the lecturer and other students. This capability allows students to easily ask questions or present ideas without disturbing the class environment. The Lecturer's Assistant also provides the preparation, presentation and editing facilities. The system is designed to be portable and inexpensive that is easily used in classroom.

The Lecturer's Assistant consists of a single computer and the input and output subsystems. The input subsystem consists of a set of graphics tablets; the output subsystem consists of an LCD projection panel which is placed on an overhead projector for viewing by the class, and the computer's monitor which shows the lecturer the system's status.

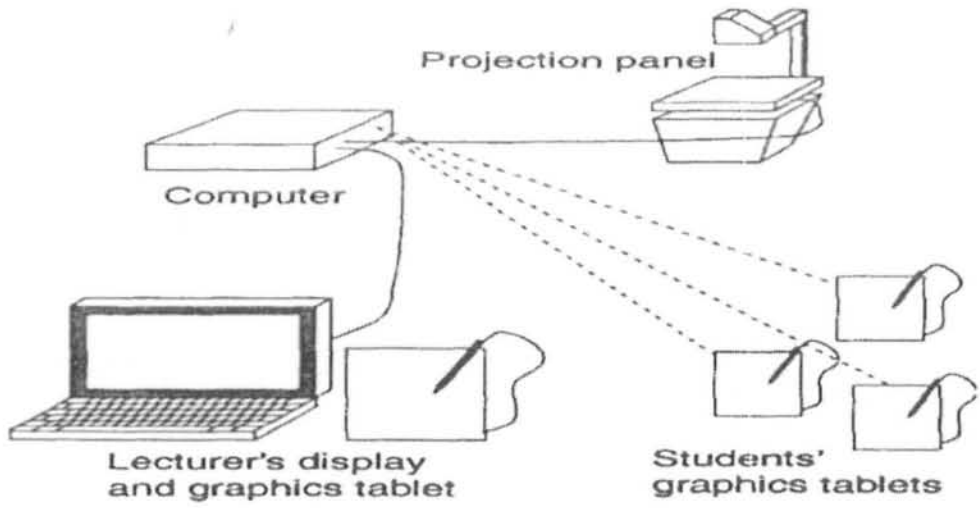

Figure 2.3: Lecture Assistant

Digital media plays a crucial role in the contemporary culture and society. Everyday life has become digital, online, and devices like desktop computer are changing to mobile media devices. So far smartphones can be used in all contexts, for example home, work or at educational institute. The affordance of writing on paper and writing on keyboard are re-shaped after the advent of multi-touch ICT use in the educational context. It seems that paper-based methodology (paper, pencil) being replaced by touch screen and stylus. The widespread presence of digital technologies (smartphone) is modifying the way of sharing and creation of knowledge. Digital technology is also effecting the development of social and educational competences, (Farinosi et.al, 2016). (Schmieder et.al, 2009) stated that expressing impressions by sketching is a natural and familiar process. According to (Balta et.al, 2015), technology in education is widely used for effective learning throughout the world.

Incorporating smartphones with other devices in the classroom helps to enhance individual as well as group discussion among students and learning becomes more interactive, (Duncan et al., 2012). Kolb (2011), claims that smartphone are very useful, students as well as teachers are using them every time and everywhere without any limitations of area. Using smartphone as learning tool in classroom is helpful and practical for the teacher because they can observe the students' learning in an efficient manner, (Manuguerra et.al, 2011).

In today's digital world stylus and fingertip touch mechanism is used to express ideas rather than a keyboard or mouse. Hand-drawn diagrams are frequently used as visualization model.

(Adler et.al, 2007) goal is to make the computer a collaborative partner of human being to design and solve problems. He stated that sketching helps to make the technology collaborative in every discipline. Educators have debated the importance and influence of handwriting on digital technology for learning.

Sketch-based applications are rapidly ahead popularity in modeling because of native pen and paper metaphor. Even inexperienced users with little knowledge of computer graphics can use sketching rapidly, (Zend, 2014).

(Gross et.al, 1996) said that sketch-based tools are encouraging solution for the creation of ideas on mind. Sketching facilitates problem solving and it allows users to deliberate the design of problems, (Wong, 1992). With sketch-based interface, even inexperienced users can create contents quickly, (Yang et. al, 2010, Olsen et. al, 2011). With the multi-touch devices and styluses, sketching has become a more popular means of human computer interaction, (Kang et.al, 2015). (Davis, et.al, 2007) stated that sketching is widely used in stages of design.

(William et.al, 2006) found that sketching helps the users to sketches their ideas to provide rich medium for discovery and communication of design ideas. They believe that sketching has the potential to complement usability testing in general, in order to generate reflective as well as reactive user feedback. According to (Marquard, 2013), sketching is a powerful tool to represent designer ideas and imaginations in interactive environment. Sketches are lightweight and easy to create and it can be considered as integral part of interaction design. Sketching often depicts shapes, color and texture to represent ideas, (Northam et. al, 2010).

(Zhang et.al, 2016) stated that sketching has widespread efficacy in many applications. It is impossible to get the photo or exact shape of anything or person, a sketch-based application helps to quickly identify the suspect. Sketching helps to render the problem in education and also in entertainment. According to (Nicolas et.al, 2016), sketching is used in large scale data analysis.

The best way to understand the problem is to have a visual image about it such as photographs and sketches. Sketching raises new methods to make the document much easier and understandable for the recipient. Freehand sketching is one the methods to discover ideas, plays main role to understand the designers thinking. Sketching is considered as an important tool to analyze the ideas. The sketching needs of today have changed due to the availability of handheld devices that strongly support the freehand sketches and with the help of fingertip and stylus on screen one can easily sketch the problem just like pen and paper. Freehand sketching helps the designer to gain understanding, insight and inspiration to express their observations, thoughts and feelings. Therefore, it is considered as an essential tool for representing the ideas, (Imam et. al, 2016).

Sketching provide rapid freehand sketching to visually explore ideas. Sketches can be used in mechanical, scientific, mathematical and software artifacts. Sketches are often used for idea generation, in order that what we think we have to sketch. Sketching is more effective in ideation and in creativity, (Zhao et.al, 2015). Sketching is appropriate method to illustrate problem solving; users can produce, evaluate and modify ideas quickly, (Geol, 1995). The requirements for sketching are simple and there are computer interfaces that facilitate sketching.

Users use a range of medium for sketching: paper and pencil, whiteboards and smartphone with fingertip or with stylus. These medium provides a direct, rapid and effortless approach to express ideas visually, (Goldschmidt, 1999). Sketching is considered to be a powerful tool to express ideas and doing design, (Ugo, 2014). According to (Buxton, 2006), sketching is quick, inexpensive, disposable, plentiful, that they have a clear vocabulary, minimal detail and suggest alternatives as well as explore solutions rather than confirm them. (Israel et.al, 2009) stated that sketching reflects the imagination of human being in well-defined manner.

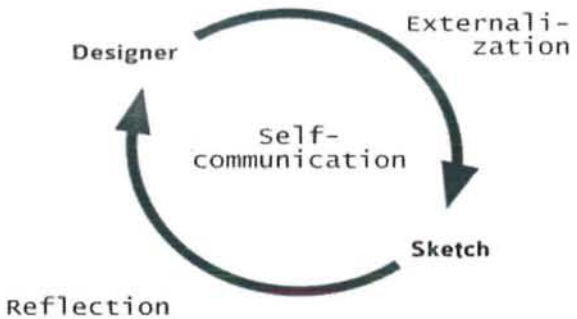

Figure 2.4: Sketching

(Suwa et. al, 1996) stated that sketches are usually the visual product of mental model that designers create to externalize their concept of the product. It also helps the designer to develop their ideas and discover new links and approaches.
Sketches are essential in product planning, conceptual phase and also in design phase, (Ponn et al., 2004). Multiple sketching tools are available that provide sketches facility. (Landay, 2002) stated that sketching tool combines benefits of paper-based sketching with merits of tools. In a paper sketch users just sit and sketch, but in sketching tool designer can drag and drop.

2.4 Sketching tools

(Landay et.al, 2002) proposed a sketching tool SILK (Sketching Interfaces Like Krazy), an informal sketching tool. SILK provide the facility to the designer to sketch. Designer can quickly sketch using an electronic pad and stylus. Designers can sketches an interface using a set of components. SILK is designed for use with stylus, tablet and LCD; designers can also use a mouse to draw. SILK is an interactive user-interface design tool that supports sketching, giving opportunities to the designers to change sketches.

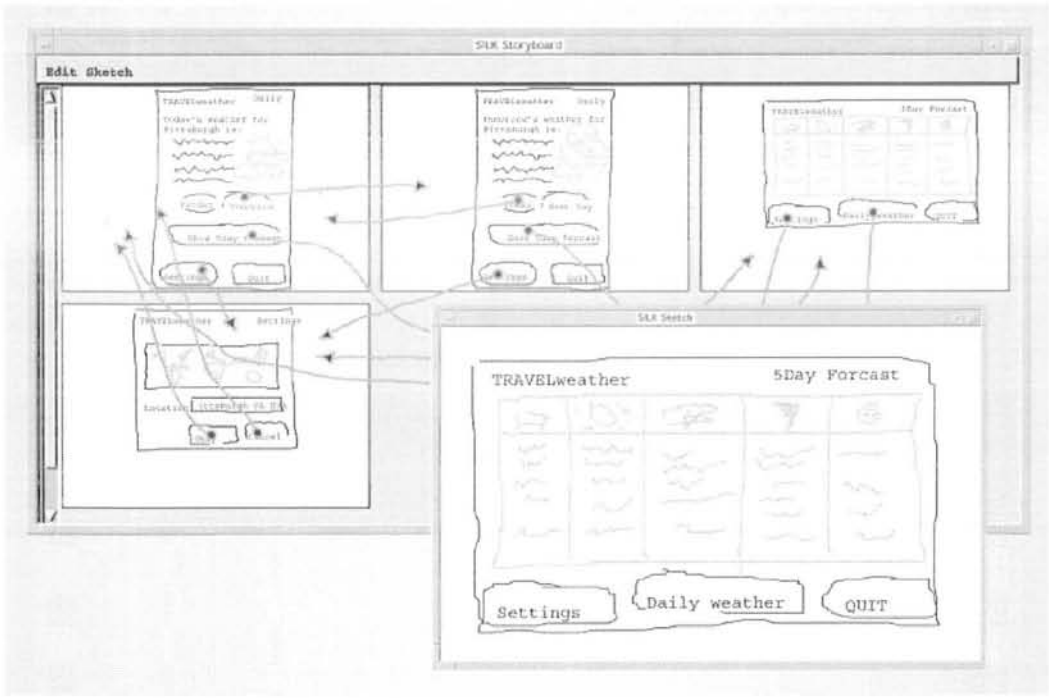

Figure 2.5: SILK story board interface

(Cheema, 2012) designed is a sketching tool QuickDraw, that is used to improve drawing experiences for geometric diagrams. QuickDraw, a prototype sketch-based drawing tool, that facilitates drawing of geometric shapes drawn by students and academics in different disciplines.

A user sketches a diagram using stylus on tablet using QuickDraw. QuickDraw recognizes the components of the sketch and infer the relationships between them.

Sketch2Cartoon system, (Wang et.al, 2011) provides the facility to sketch the novel sketch-based clipart image. It enables users to sketch major curves of character and then compose a cartoon character. LD-Sketch, (Huang et.al, 2015) a novel distributed sketching design that aims to achieve real-time detection of traffic anomalies.

Sketching enables people to externalize and communicate ideas (Forbus et.al, 2010), they designed a sketching tool CogSketch to prove their statement. It is a tool that combines the classical and sketch based techniques and user can draw maps, structure of complex system and other related diagrams easily.

(Chung et.al, 2005) implemented the sketch tool InkKit, provides an intuitive, generic and extensible sketch space. It provides basic functionalities of CAD with user friendly interface. It allows editing options such as undo, redo, save and load.

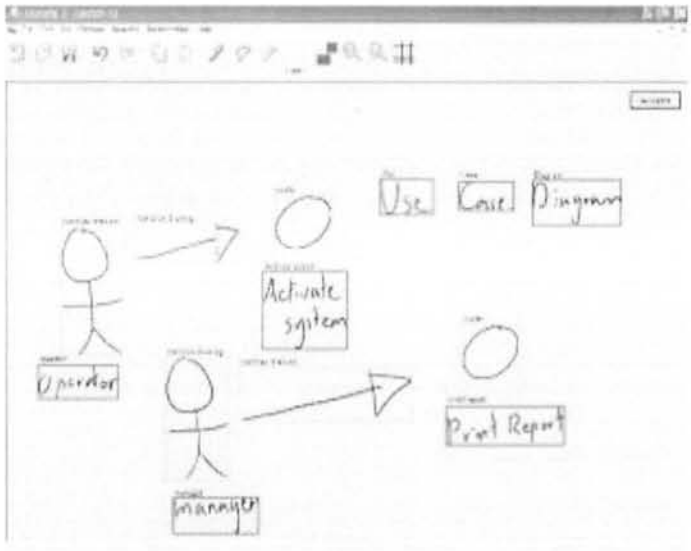

Figure 2.6: InkKit Interface

SumLow is a designing tool (Chen, 2008), designers use it when they want to work out in collaborative manner. It is used to draw and discuss design ideas, architectural solutions and to help organize the designs and activities.

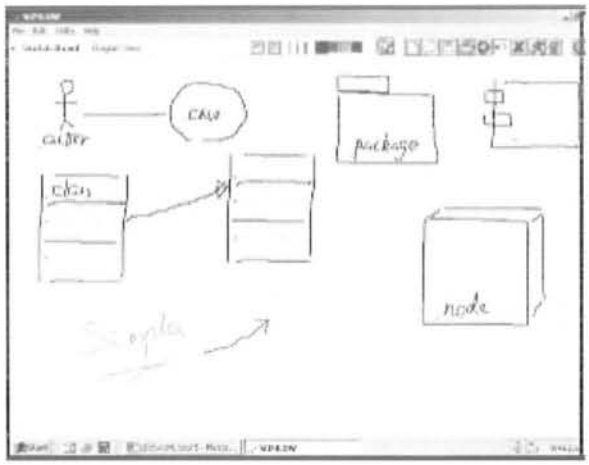

Figure 2.7:SUMLOW Interface

(Plimmer, 2005) designed a tool that provides the facility of sketching and then transforms the sketches into visual basic form. This includes formulation and beautification of computer drawn diagrams.

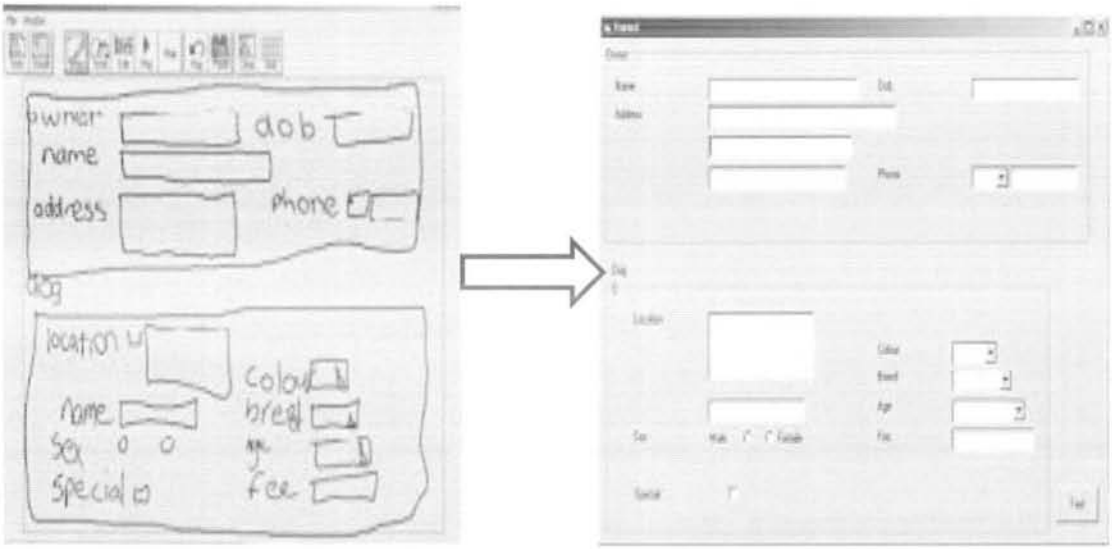

Figure 2.8: Free Form Sketch to Visual Basic Form

DENIM(Newman et.al, 2003) allows designer to quickly sketch webpages, create links, and interact with them. This tool also provides different ways of viewing web site, from site map to storyboard to individual pages. Zooming facility is also provided by DENIM.

(Awedh et. al, 2014) stated that Socrative supports learning process. It improves the students learning performance. Socrative is a smart student response system that empowers teachers by

engaging their classrooms with a series of educational exercises and games. This interactive app is super simple and takes only seconds to login. Socrative runs on tablets, smartphones, and laptops. Teachers login through their device and select an activity which controls the flow of questions and games. Students simply login with their device and interact in real time with the content. Student responses are visually represented for multiple choices, true/false and short answer questions.

To the best of our knowledge, there is a need to use sketch-based applications in classroom to enhance learning experience. As there are many researchers who emphasized that sketching is useful for conveying ideas by using technologies and also focus on its use in classroom for learning experiences.

2.5 Summary

This chapter provides the details of sketching on smart phones. We also discussed the impact of technology to education, and smartphone effects on classroom for learning. We also explored the different sketching techniques on smartphone for educational system. At last we discussed the structure and use of the sketching applications and tools available on smartphone for learning.

Chapter 3

Proposed Solution and Implementation

3.1 Introduction

In this chapter, we will describe the objectives and features, methods and procedure that are followed to target the research problem, architectural design of our research prototype, explanation of the architectural design, and at last explain the implemented prototype of sketch-based classroom activities tool.

3.2 Objectives and Features

We found that smartphone has been used in classroom for many purposes. Majority of students as well as teachers use them for viewing reading materials. We also describe in related work chapter that there is a need to use sketch-based applications in classroom to enhance learning. Technology equipped classroom helps to develop, test, implement, and introduce current and emerging technologies and tools. It inspires the use of pedagogy together with supporting technology e.g. smart phone, in both classroom and in distance education. This will broaden the pedagogical ability of teachers and students by using smart phone. It will create the spaces where teachers and students can exchange experiences, knowledge and practices by using technology.
To evaluate our hypothesis we implement the research prototype. Our prototype provides canvas component to draw a design artifact, freehand drawing mechanism to its users. Freehand drawing as well as different metaphors to touch and swipes are available to sketch the idea and pen/stylus based interaction is provided. Users can edit/modify the existing image any time and can save the updated image. Teachers can instantly assess and evaluate the activities solved by their students in the class.
Tools are acting as important in everyone's life either a students or a teacher. Now a days, students as well as teachers are equipped with smartphone in classroom and they are using it for different purposes. Some are using it as notes manager, some are using it for reading purposes and others are using for communication. We elaborate it diagrammatically.

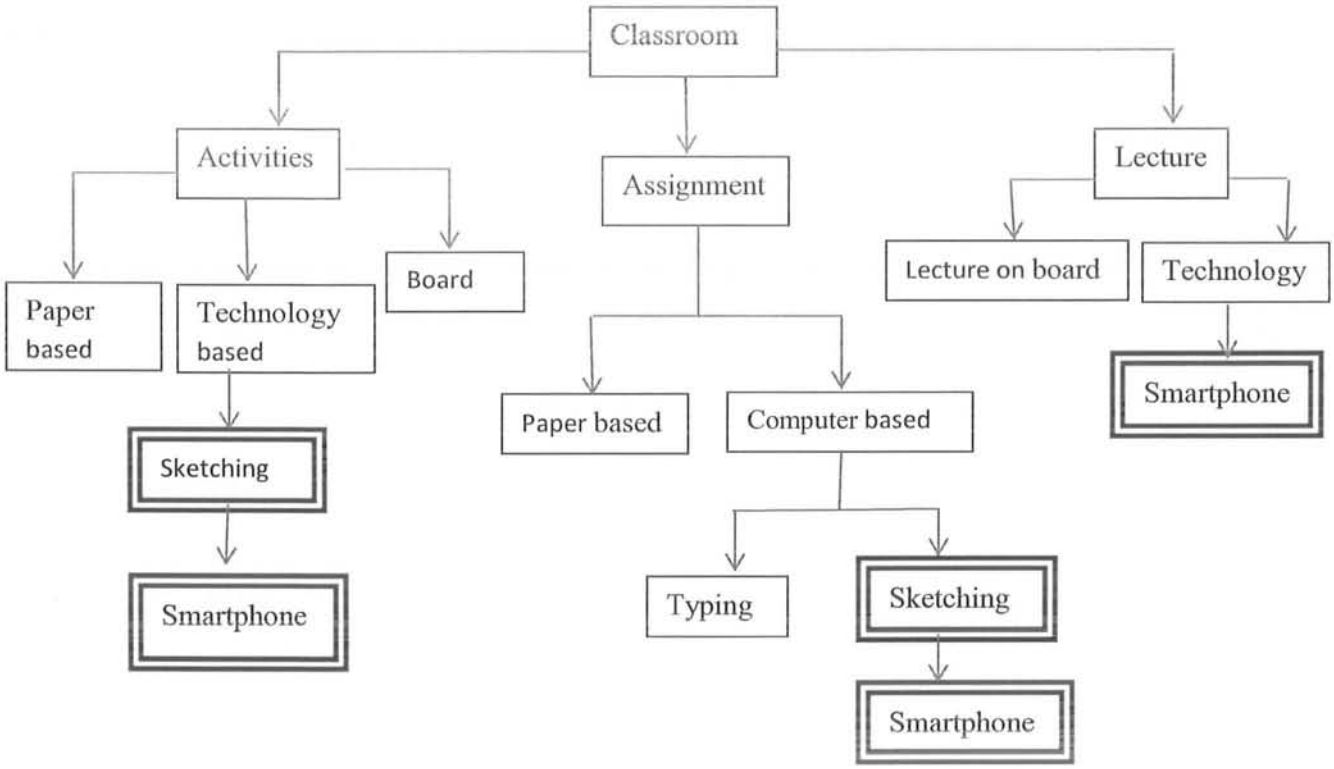

Figure 3.1: Sketching, Smartphone in Classroom

In classroom participants use smart phone just like pen and paper to perform classroom activities.

3.3 Proposed Method

The integration of technologies in the classroom has become an emerging trend, and it opens new possibilities for the teaching and learning process. Technologies are becoming popular among teachers due to its effects on students' learning and also on teaching methodology (Awedh et.al, 2014). In our study, sketch-based classroom activities tool is deployed on participants' smartphone. We describe proposed method as follows:

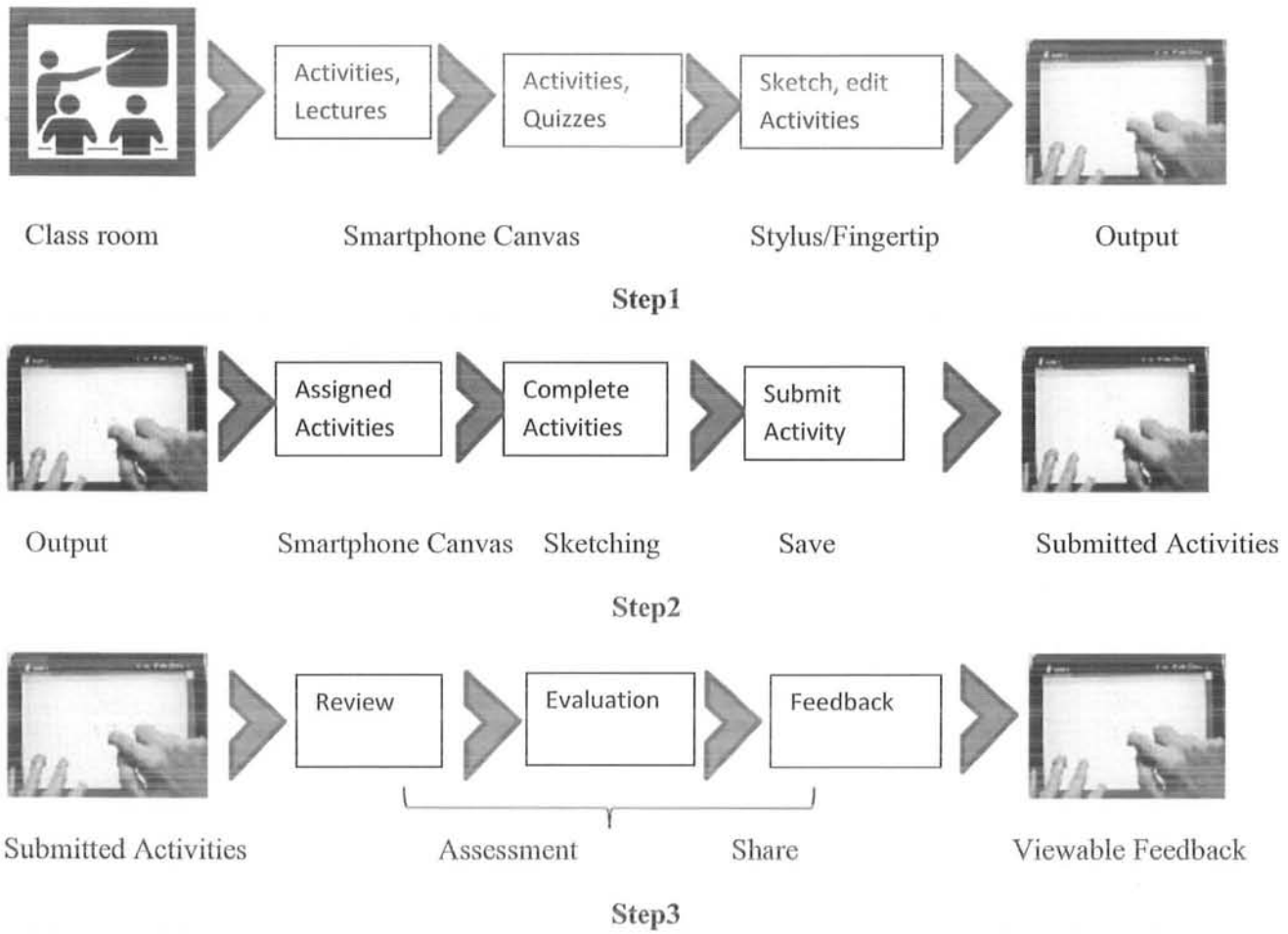

Figure 3.2: Flow of information with sketch-based prototype on smartphone

Main steps of our proposed solution

We provided three main steps to complete the procedure (see figure 3.2). Two of them are performed by the teacher, i.e. creation and evaluation of activities, and students perform completion step to complete the assigned activities.

Step 1

In first step, teacher can sketch the activity on provided canvas for students in the classroom and also create activities before class and can edit any time. After creation of activities teacher share these with the class.

Step 2

Students complete the assigned activities with fingertip or with stylus on provided canvas. Students have to submit the assigned activities within time. After time it will automatically save on teachers' device. Students can view the provided feedback about their activities anytime.

Step 3

Evaluation is performed by teacher in step 3 to check the knowledge of students; either they need the revision of lecture or move to next lecture. Teacher provide feedback in the form of marks and comments, teacher also highlights the student's mistakes and also correct it with suitable metaphor. After assessment of students work, teacher share the submitted activities with the class that help the students to check the possible solutions of an activity.

3.4 Causality Model of sketch-based application in classroom

In classroom there are two roles of users. User is either a student or a teacher. Both of them have different responsibilities to work collaboratively and enhance learning. Causality model shows different dimensions of research prototype and also demonstrates how these dimensions linked casually to achieve a change in learning. Each dimension is interlinked with other dimension and some dimensions are used by both (teacher, students) users, while some are used by individual user.

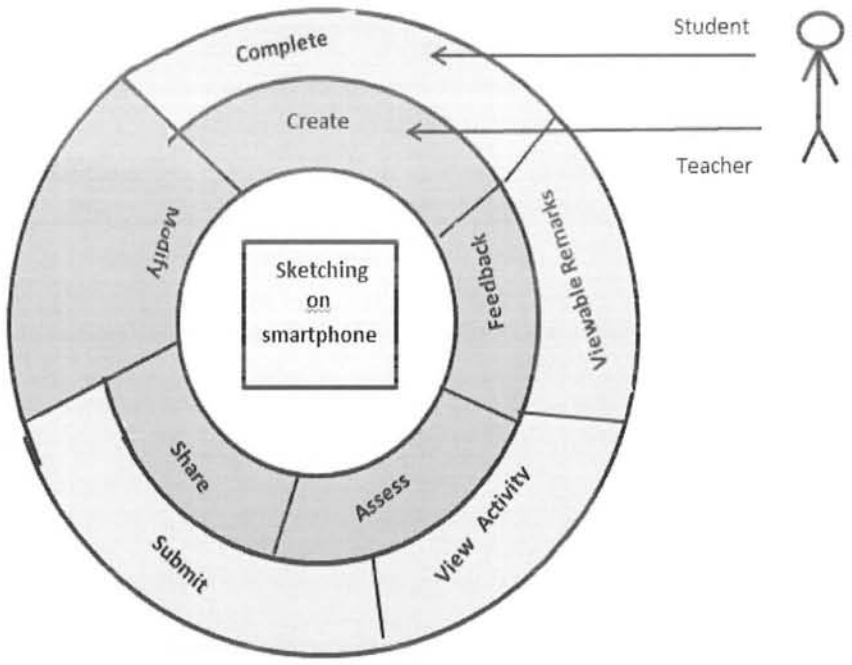

Figure 3.3: Causality Model of sketch-based application in classroom

Causality model shows the relationship of interlinked dimensions. In which teacher can create activity for students as quiz or assignment that is to be done by students in specific time. Teacher can create activity on its own personal smartphone where implemented prototype is deployed. After creation it can be saved on smartphone, later modification can be performed by teacher. After finalizing the activity, share with the class. Students will complete the assigned activity and submit the activity on teacher's device. Teacher can view the submitted activities and evaluate and share the evaluation with the class.

3.5 Architectural design

Architectural design of our prototype is represented in figure 3.4. It is collectively used to provide sketching mechanism on smartphone to sketch and draw class activities in collaboratively and in interactive environment to enhance learning.

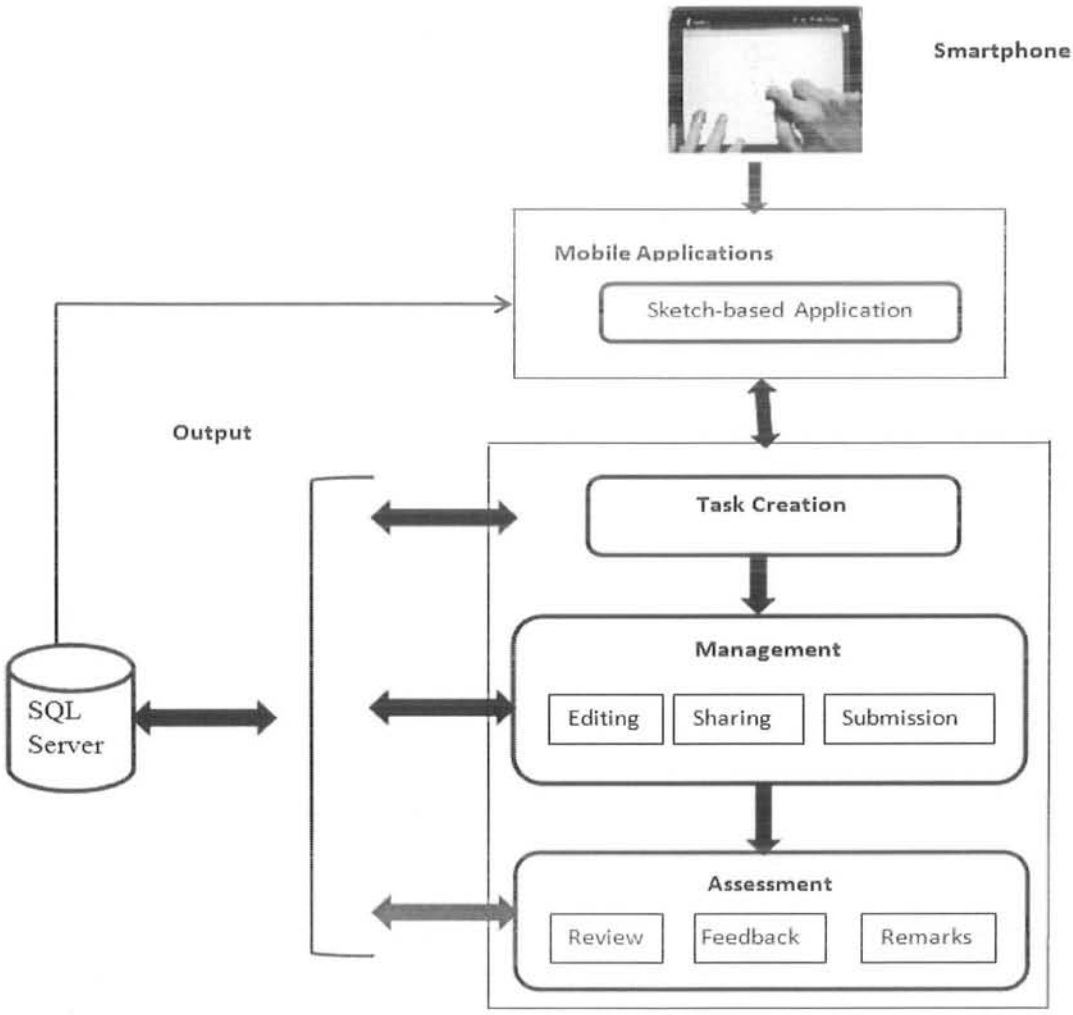

Figure 3.4 Architecture design of Sketch-based classroom activities tool

Architecture incudes three major parts task creation, management and assessments after each part information stored into database and shown on smartphone canvas. All are described below:

3.5.1 Smartphone

Users (students, teachers) are using smartphone for communication, but in classroom it can be used as educational tutorial. In our defined research problem, smartphone is used for sketching activities by using sketch-based application. After creation, modification, sharing and assessment output can be shown on smartphone screen.

3.5.2 Sketch-based Application

Sketch-based application provides the facility of sketching by using fingertip or stylus. It provides freehand drawing as well as by using different tools.

3.5.3 Task Creation

Activities can be created by teacher, using sketch-based application. Teacher can create freehand drawing. Drag and drop mechanism is also provided to users.

- **New activity**

  New activity can be created on canvas by multi-touch or drag and drop facility. After creation of new activity, teacher can save the created activity and can be modified anytime.

- **Existing Activity**

  Existing activity means, already created activity and teacher wants to modify this activity. Teacher can modify the already created activity. If teacher creates an activity but that time he/she discontinue the creation process. Our research prototype provides the facility to edit the existing activity. After creation of new as well as existing activities, activities will be saved for management and assessment.

3.5.4 Management

In management phase activities can be managed by system. New as well as submitted activities are managed in our research prototype.

- **Editing**

  Once activity is created, user can edit the created activity. Modification can be done by teacher any time and students can edit the activity before submission of activity.

- **Sharing**

  After creation and editing of activities teacher can share the activities with the class to complete the assigned activities. Students also share the activities with the teacher. Teacher also shares the feedback and remarks about activities with the class. Shared activities saved in database to keep record of all assigned activities.

- **Submission**

  Completed activities can be submitted on the teacher's device, to review the activity and give feedback to enhance learning. Submitted activities can be saved in database for assessment.

3.5.5 Assessment

After creation and managing of activities final step is assessment of activities to promote learning and evaluate the students' knowledge. Assessment of activities can be done any time after class timings. It may be a run time evaluation to check the knowledge of students about previous or present activities. It may help to repeat the lecture or move to the next lecture. This method may help the students to work collaboratively and there is chance to improve learning.

- **Review**

  Submitted activities can be reviewed by teacher to give proper correction and feedback to the class. Review is important part of assessment, teacher take a review of class response and then takes a step to improve learning.

- **Feedback**

  Reviewed activities needs feedback either it is positive or negative. Feedback includes correction and highlight of mistakes of students' submitted activities. Teacher corrects the mistakes of students by fingertip or by stylus.

- **Remarks**

  After checking, giving proper feedback and the correction of mistakes it's time to give marks of submitted activities to the students. Teacher adds marks of students and then shares the corrected activities, marks and comments about activities with the students as well as with the class.

3.6 Research prototype

To test the hypothesis we proposed the prototype of a sketch-based classroom activities tool. This will help to achieve the goal. Figure 3.6 shows the interface of sketch-based class room activities tool.

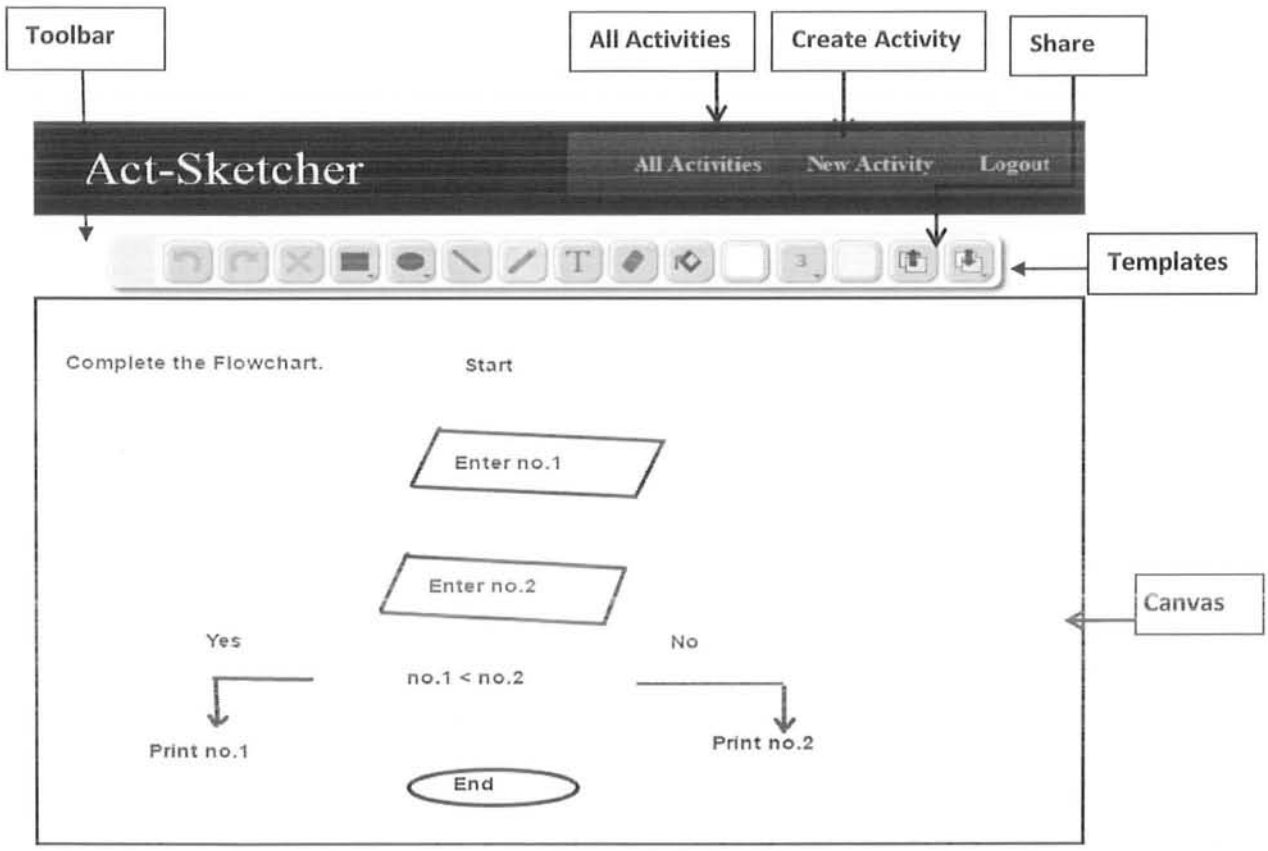

Figure 3.5: User interface of sketch-based classroom activities tool

User interface

The user can easily work with the sketch-based class room activities tool by using its different interfaces. There are several interfaces and tabs to fulfill the user's requirements, these are:

Canvas is an interface where users can sketch his/her ideas by using tools from toolbar or by fingertip and also with the help of stylus. Different tools are available in toolbar to draw different shapes (circle, rectangle), and lines. Text and shape formatting is also done by using different tools. Undo, redo icons are also provided by toolbar. When user wants to create new activity, clicks on *new activity tab*. It wills shows the canvas where users can sketch his/her idea. Users can create activities by using templates and can edit the templates according to

his/her demands. After creating an activity click on icon (save). By clicking on it activity will be shared with the class. And notification is shown to the students. After click on save (share), activity will be saved and group into all activities. All submitted and shared activities are shown. Teacher click on all activities to check the status of activities either it is marked or pending. *All activities tab* contain all activities that are marked, pending, completed and unmarked. To mark the activities user will click on all activities tab than all activities will be shown to the user and can perform any task that is to mark the activity, take an overview of all submitted activities, and check the pending activities.

Figure 3.6 shows that after clicking the *All activities tab,* all submitted activities are shown to the concerned teacher with the status of activities either it is completed or pending. It also give information to the students about remarks that are pending or given by the teacher about submitted activities.

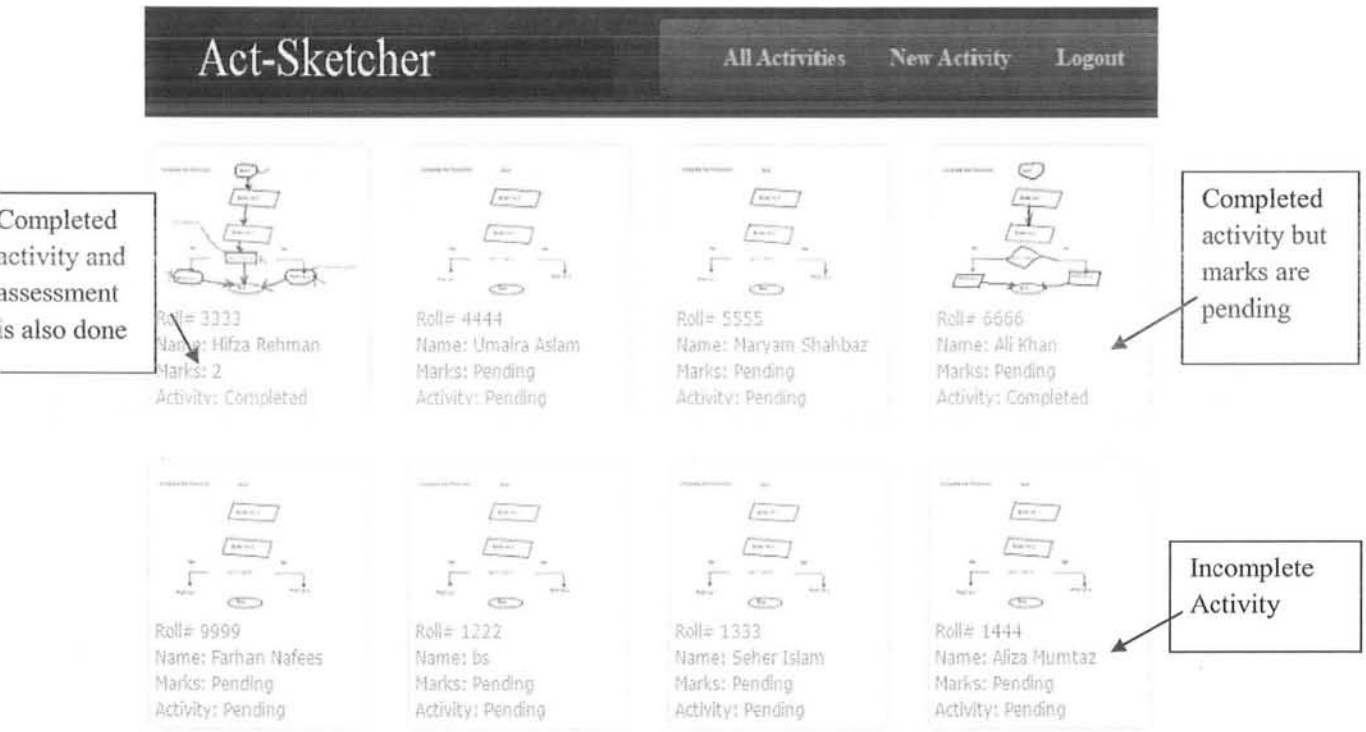

Figure 3.6: User Interface of All Activities Tab

After assessment of activity, feedback is shared with student in the form of marks and correction of mistakes.

3. 7 Summary

In this chapter we described the objectives and features of proposed work, methods to solve the research problem, by introducing causality model, architectural design of our prototype application including the user interfaces.

Chapter 4

Experimental Setup

4.1 Introduction

In this chapter we will describe the experimental design adopted to measure the learning experience while using sketching on smartphone in classrooms. In order to validate the research prototype we would perform pre, post study. We will present randomly selected participants with their tasks and analyze their results. At last we will present the participants with the post task questionnaire and analyze their interaction, investigating and finding behaviors during the task performance.

4.2 Evaluation Objectives

We evaluate our research prototype to meet the goal of our study. For this purpose we have selected the hypothesis based approach method because it's generally applicable to test the system with real users within a real environment. We evaluate our prototype with respect to the evaluation factors. These factors are gathered by conducting interviews to evaluate the underline prototype. Proposed method consists of three main components actor, system, and activities (contents) which are related to each other. For evaluation we used research prototype in classroom to measure the usability, usefulness and performance (learnability) of underline prototype as well as measure the performance of students while using smartphone. Evaluation factors are connected with each other. Relationship is shown in figure 4.1.

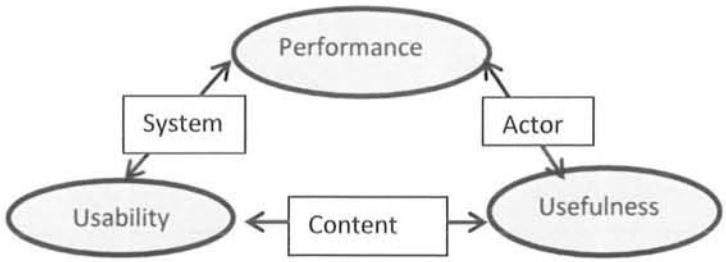

Figure 4.1: Interaction of Evaluation parameters

The actor (see figure 4.1) is a student and a teacher. These actors are the source of change in classroom environment and plays central part to improve learning. This factor validates causality model that represents actors are more responsible for changing the classroom environment permitting the use of technology in classroom.
The activity is considered as content and it is another evaluation factor which consists of created activities, pending activities, submitted activities, marked activities and unmarked activities. These components are interlinked, activity has been created, shared with the class; students submit the activity, teacher view the submitted activity and at last give remarks to the students. The prototype is evaluated on the basis of defined components that, activity is created and completed within the time, efficiently shared with the whole class and assessment of activities can be performed in real time.
System is a prototype that is implemented to meet the research question. System can be used by the actor to perform the assigned tasks on provided contents and it can be shown. With respect to these factors we also measure that it is good use of technology in classroom and influence to learning experience.

Evaluation measures are used to explore usability, usefulness and performance of the sketch-based class room activities tool. Depending on prototype these measures are selected for the testing of research prototype. For our prototype we use efficiency, ease of use and learning experiences of class. Performance is measured by measuring the accuracy and response time of sketch-based class room activities tool to determine the performance of the system, learnability of the students, and all over teaching process performance.

4.3 Research Design

We have selected experimental setup as research design in which we conduct experiments with our selected participants. We have selected the Pre-test, Post-test experimental design to meet the goal of our research problem. We observe the classroom environment that is using paper based methodology to conduct activities, quizzes, assignments and also use pen and papers for evaluation. We observe in our study that there are some classes that use technology but only for giving presentation.

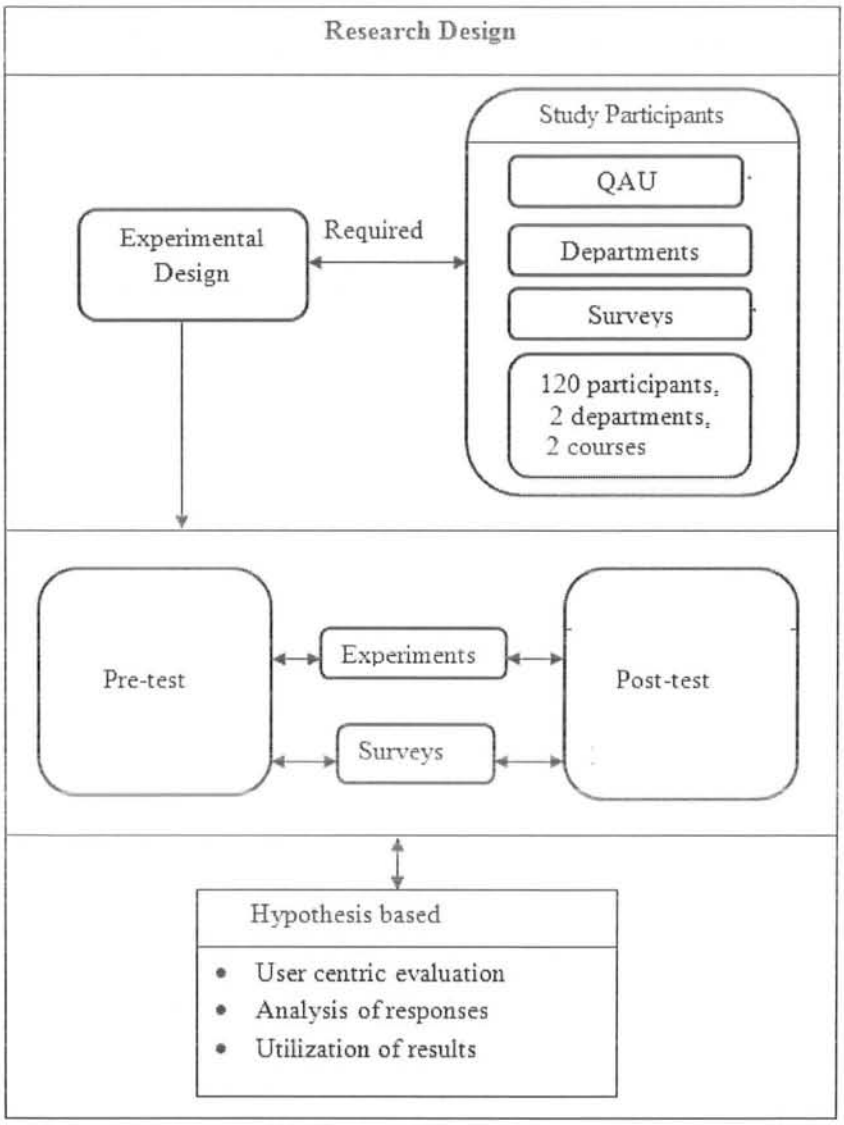

Figure 4.2: Research Design

4.4 Study Participants

To evaluate the research prototype we need samples to perform the experiments. Selected theoretical population in our study is students and teachers of Quaid-i-Azam University, Islamabad. We analyzed that there is a big ratio that are attached with academics either in the form of teacher or learner are using smartphone for different purposes and they more often spent their time in learning and seeking information. We have filter out the target population from our theoretical population set.

Our target population is a set of students and teachers to validate the research problem. They are well aware of how to use smart devices and they are well motivated to use technology in

classroom for learning purpose. After analysis and calculation of theoretical and target population we have come to know that it is a big sample to validate our prototype and it is not possible to consider the overall population as participants. After filtration of target population we have actual population, consists of undergraduate students of Quaid-i-Azam University, Islamabad. Table 4.1 shows the population size.

Table 4.1: Faculty and Departments

Faculty	Number of Departments
Natural Science	08
Social Science	10
Pharmaceutical Sciences	01

In order to extract the actual population we analyze the undergraduate departments those are using smart devices in classroom for any use. We conduct interviews from students and their concerned faculty. It includes the demographic information about the participants, basic knowledge of using computers, about latest technology, basic experience of use of smart devices, purpose of smart devices use in classroom, and about learning experience on smartphone. We performed validation by analyzing participants responses related to the smart devices use in learning aspects.

The sample size we get from validation questions. We have selected two departments that is computer science and information technology and there offered courses related to computing and programming are selected as sample size to evaluate that sketching on smartphone use for learning. Table 4.2 shows the number of students against each department and group.

Table 4.2: Sample size for our study

Departments	Number of students	Above Average	Average	Below Average
Computer Science	58	09	34	15
Information Technology	62	15	30	17
Total	120	24	64	32

We have collected the demographic information of participants to check that either male are more feasible to use smartphone for education than female or vice versa. We collect this information while conducting interviews and by filling questionnaires.

Table 4.3: Demographic information of participants

Departments	Male	Female	Total
Computer Science	43	15	58
Information Technology	50	12	62
Total	93	27	120

The selection of this research design is due to nature of our research which is experimental in nature, and after performing the experiments, results will show that our hypothesis is correct or not.

4.5 Pre-Test

In our pre-test we go to the classes and visit different classes to analyze the teaching method, working with pen and paper, making activities on paper for students, use of technology in classroom, different aspects of technology in classroom, and evaluation of students work in real time and also at later time .

Conducted interviews contains questions, related to technology use in classrooms, technology impact on classroom environment, how to make class room interactive and collaborative by using technology, is it useful to use smart devices in classroom, sketching helps to represent ideas and sketching on smartphone helps in classroom to perform class activities.

After pre-test we have come to know that we can use smartphone in classroom for education.

4.6 Post-Test

In post-test, tasks are defined for participants to perform and also designed questionnaires to evaluate the underline prototype. Questionnaires are about the learning experiences of participants and their task performance. The distribution of questions in this section to perform the tasks are: How it was complex to create, complete, marked the activities, how often you faced the problems to perform the task, collaboration and interaction among class, usability, learning performance, and at last in order to check the knowledge gap is fulfilled we would ask the question related to the satisfaction about the proposed method (Appendix A, Appendix B).

4.7 Evaluation Method

We used user centric evaluation method which is hypothesis based evaluation. The hypothesis is formulated in advance and tests are conducted to prove and disapprove the hypothesis. We have provided the prototype to the participants to validate the proposed solution. Our hypothesis is "Sketch based applications using smart phones for class room activities enhance learning".

For evaluation we develop a set of tasks and ask evaluators to carry them out. Provide evaluators with the goal of the system, and allow them to develop their own tasks. We conduct the evaluation using *Individual evaluation method.* Each evaluator reviews the sketch-based class room activities tool functionality according to provided tasks individually and reports problem related to it and then perform assigned tasks. After performing the tasks by the participants we have to conduct a survey and for this purpose we design questionnaires.

Surveys

We use survey based technique to evaluate our prototype with its real users. Two types of questionnaires are designed one for students to fill after the completion of the assigned activity and other for teacher to create activity for students, assess the environment of classroom while using smart device for activity completion, and to evaluate the students' knowledge. After completion of the experiment assigned to the participants, the participants are asked to give their judgment to fill the provided questionnaire. The survey contained questions about students and teacher's impression of proposed methodology and the advantages of using this technology. There were five point likert scale item were used that is ranged from 1 (strongly disagree) to 5 (strongly agree) (Blasco et al., 2012) another likert scale ranged from 1 (always) to 5 (never). Questionnaires consist of 32 questions, 14 for student and 18 for teacher to judge the learnability, usability, usefulness, performance of proposed methodology.

Table 4.4: Categorization of questions in questionnaires

Questionnaire related to	Question Number	Question related to
Student	1,7,8,14	Usability
	4,9,13	Usefulness
	2,3,5,6,10,11,12	Learnability
Teacher	1,3,6,7-9,15,18	Usability
	10,12,13	Usefulness
	2,,4,5,11,14,16,17	Learnability

Table 4.4 shows the description of questionnaires that are asked from participants after the completion of the assigned tasks (See Appendix A, B).

4.8 Summary

In this chapter we described the experimental design, and the evaluation objectives. Undergraduate students of Quiad-i-Azam University and their concerned teachers are selected as sample frame. We described the research design, pre and post-test. At last we described how we conducted the survey.

Chapter 5

Results and Discussion

5.1 Introduction

In this chapter we will describe results of our evaluation procedure. Evaluation process has the following objectives: Finding effect of proposed idea on its potential users, finding the potential problems faced by users, and accessing the functionality and usefulness of the research prototype. Users performed activities using our prototype (A sketch-based classroom activities manager). We analyzed and focused on the outcome of the pre-test and post-test survey.

5.2 Survey Process

Our analysis process gets started with the pilot study we have performed. After pilot study we observe that every student and teacher have smartphone, internet and other related technology. They feel comfortable to use touch devices than the paper based mechanism. We conducted interviews as a pilot study to get information about participants' understanding about how they use smartphone in classroom and what its advantages in academics are? These interviews highlight the some points in traditional teaching process that may effects on classroom environment. It also helps us in selecting our sampling frame. After conducting the pilot study we select two departments and 120 participants, their concerned teachers from the academics field.

5.3 Pre-Test

A pre-test is designed to measure user's current status of smartphone use in teaching process. Analyze the traditional teaching process that is using paper-based mechanism. After initial study, participants are divided into two groups randomly: Teacher and Students. We visit different classes and conduct interviews, asked questions about advantages and disadvantages of pen and paper as well as of smartphone based teaching process. Some questions related to smartphone use in classroom, is classroom environment becomes interactive and collaborative? Some

highlighted issues are given below those are identified in our pre-test related to pen and paper based teaching mechanism:

- **Time Consuming**
- **Cost Issues**
- **Editing Issues**
- **Record Maintenance problems**
- **Overview of students performance**

Figure 5.1 shows the detail responses provided by users.

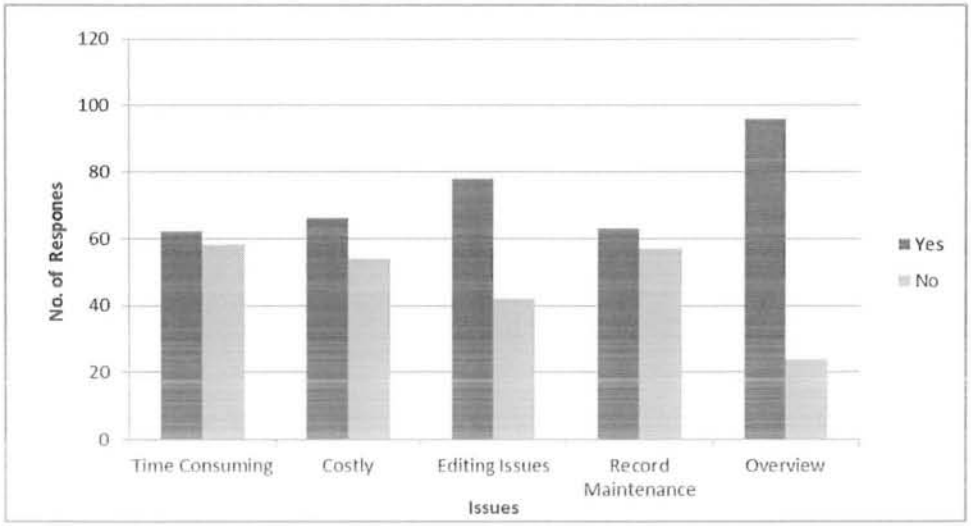

Figure 5.1: User Responses for Initial Study.

In pre-test participants responded against each factor. We asked about the factors of traditional teaching (pen and paper based). Factors are time consuming, costly, editable, maintenance and run time overview of students work in classroom for the assessment. Participants give their responses in Yes or No, which can be shown in figure 5.1. Details of each factor described below.

- ## Time Consuming

  Technology is used for presentation method and also for student's assessment in classrooms. In traditional method of teaching, technology is also involved at the time of making of quiz, creation of assignment and class tasks by the teacher but at the end they take print and give it to the students as a hard copy of tasks, this method is time consuming because time required for making and then taking its print. It is also depends on electric devices such as printer, scanner etc. if required devices and electricity is not available at run time it cause wastage of time and delay in classroom activities. Figure 5.1 shows the

responses provided by users about times consumption in traditional teaching method. According to the pre-test 52% of the selected participants responded yes it is time consuming and 48% said that it is not time consuming.

- **Costly**

Assessment is a process to check the students' knowledge, making of quizzes and assignments are the part of this process and it is costly because printing is involved. Teacher take print of class activities, quizzes for the students according to class strength. There is direct relationship between strength of the class and printing cost. If number of students increases printing cost is also increases. Teacher may use pen for delivering the lecture, but if smart devices are used for classroom activities then it may decrease the cost of printing and also of other related items. In pre-test, results are analyzed and it is shows in figure 5.1. Where 55% participants response in the favor that printing is costly and 45% participants responses are in against, that it is not costly.

- **Editing Issues**

Editing is a major issue in traditional teaching process, where editing is difficult in paper based mechanism. Once mistakes occur in this process it is difficult to correct the mistake without cutting or erasing. Once users can create their work using technology and take its print it is complex to modify it after printing. By cutting or erasing the wrong item it is possible to correct it or by taking another print of same work after correction, but with that copy modification is difficult. Editing with the same copy by taking another print is time consuming and costly. In our study we ask from our participants about modification in printed or paper based copy, on the average their responses shows that modification is a big issue in paper-based. Participants' responses showed in the figure 5.1. In pre-test majority of the participant's responses shows that editing is difficult in paper based but it is easy by using smart devices. 63% respond that editing is an issue in paper based and 37% respond that it is not an issue. After pre-test we conclude that editing is an issue in paper-based mechanism which can be somehow resolve by using technology in classrooms.

- **Record Maintenance Problem**

In paper-based mechanism record maintenance is a problem; users maintain the record of quizzes, assignments solutions, student's record in the form of marks, comments and record in hard form (submitted copies) and then convert into digital form by typing. Figure 5.1 shows the responses of the participants.

- **Run time Overview of student's performance**

In paper-based, run time overview of students' work in classroom is difficult; teachers can take quiz or create activities for students in the classroom but cannot judge students'

performance and cannot give proper feedback immediately. Run time evaluation is complex in paper-based mechanism; teacher can check the submitted copies and then give proper feedback to the class. It is difficult to take and check activities of each student one by one in the classroom and judge the concepts of students about previous lecture, that there is a need to repeat the lecture or some points to the students or not. We asked participants about run time assessment of students' knowledge is possible and can provide immediate feedback to the students in the classroom, their responses represents in the figure 5.1.

The pre-test provides us assurance about that there are some issues, we hypothesized. Seeing these possible issues, we proposed a mechanism for its solution and may use of technology (smart devices) in positive way, and to check that learning experience may increase or decrease by using sketch-based applications on smart phone for creation, modification, completion and for the assessment of activities in the classroom.

In initial study we analyzed the factor of paper-based mechanism, after it we analyzed the use of technology in academics. Our analysis shows that there is big ratio of users that are related to academics are using technology for different purpose. Mostly users are using technology in classrooms, in labs and also in their offices. In our pre-test we analyzed that in educational field different technologies are used for learning aspect and every users related to academics have smart devices so we can say that smart devices can be used for learning purpose. We analyzed the use of smart devices as well as other technology use in educational purpose. Figure 5.2 shows the percentage of users that are using technology for different purpose.

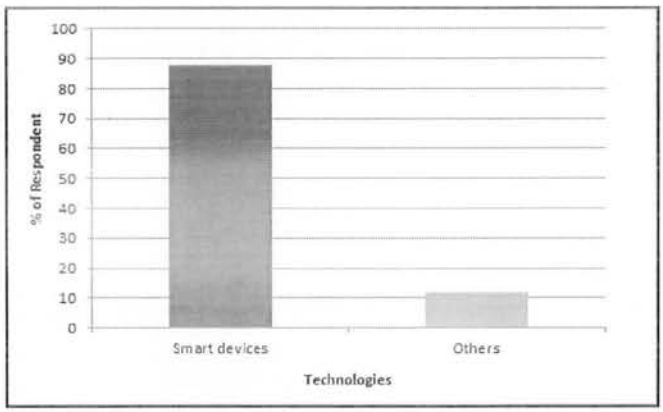

Figure 5.2: Percentage of users to use technology

After the study we conclude that majorities of the participants are using smart devices for different purposes, some are using as notes taking tool, some are for reading the books, and some are using for their own personal use. We can say that smart phones are using for different purposes and it can also be used for sketching. We can use smart devices in classroom to sketch our ideas, creation of activities, quizzes and assignments.

Figure 5.2 shows the percentage of participants those are using smart devices as well as other technology, where 88% users are using smart devices and 12% users are using other devices.
After pre-test we analyze that use of smart devices is becoming more popular now a days so we can say that it may enhance learning experience. At the end of our pre-test we sure that smart devices also have many uses in field of education and can be used for sketching.
According to our pre-test we formulate our hypothesis "Sketch based applications using smart phones for class room activities influence to enhance learning" and to evaluate the hypothesis we make a system prototype discussed in chapter 3. For the evaluation of underline prototype and to test the proposed hypothesis we conduct some class activities (See Appendix C) within two weeks and assigned the tasks to the participants to complete the given activities by using the underline prototype that was deploy on participant's smart phones.
Evaluation criteria are used that was discussed in chapter 4 to analyze the results of proposed hypothesis on the basis of assigned activities by using smart devices.
The pre-test validate that we can use sketching on the smart device for the learning purpose; both teachers and students can work collaboratively in an interactive environment and influence on learning experience.

5.4 Post-Test

In the post-test our purpose is to use our research prototype in the class environment during the lectures and then evaluates our defined parameters discussed in chapter 4. For this, sketch based application prototype is given to the participants. They can perform their task using prototype.

Tasks

There are some tasks created by the teachers related to their lectures to assess students' performance. Teachers deliver the lecture to the students and at the end of lecture or during the lectures they create activity by using their own device at run time and share with the students, and students can complete these activities. We are taken all this process as a research task for our hypothesis evaluation. Activities are created by the teachers for the students (See Appendix C) to assess the students' knowledge about delivered lectures. After the completion of the tasks we fill the questionnaires (See Appendix A, B) from the participants related to our research prototype to validate the proposed idea. Two types of participants are involved in our study teachers and students respectively. To evaluate the task we designed surveys including questionnaires. These are for teachers as well as for students including research prototype related questions to measure the usability, usefulness and performance of proposed idea, and check that sketching on smart deices influence to the learning and also about the interaction and collaborations in classroom environment. Evaluation results according to the categories of the participants are discussed in detail separately. Figure 5.3 shows the evaluation results according to teacher's survey.

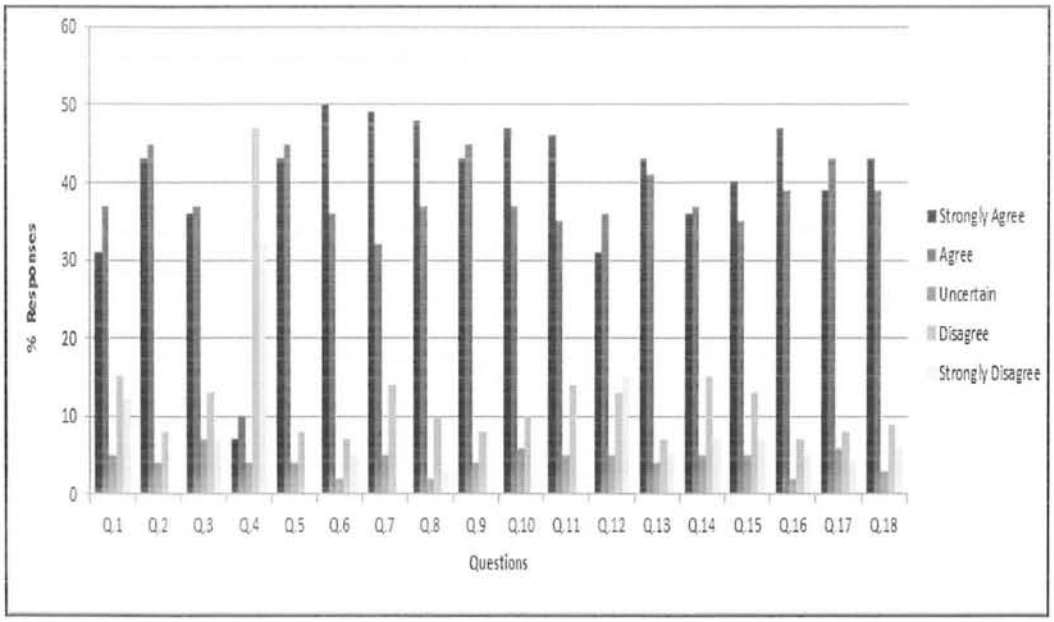

Figure 5.3: Teachers responses for proposed idea

Underline prototype is given to the participated teachers to create activities for the students to assess the students' knowledge. Teachers create the activity and share with the students and evaluate the use of smart devices in classroom for learning and assess the student's way of working on smart devices to learn. They evaluate the submitted activities of students and give remarks about each submitted activity. According to the evaluation results discussed in chart, 64% participants are said that they are satisfied with the use of smart devices in classroom for learning, teaching and for collaborative classroom environment. 55% participants said that they can create activities in an efficient way, 60% said that modification can be done easily by using sketch based application on smart devices. 72% participants said that assessment of submitted activities are easy and can be marked effectively. 67 % participants said that marked activities and remarks can easily share with the students. 63% participants said that learning objectives met satisfactory with sketch based application by using smart devices.

To more analyze the results we used statistical measures, to measure the average value, mid value and variations about responses of participants. We used Mean, Median and Standard Deviation (St.Dev) to represent the results (responses) of participants after performing the assigned tasks. Figure 5.4 shows statistical measures with respect to the respondent answers.

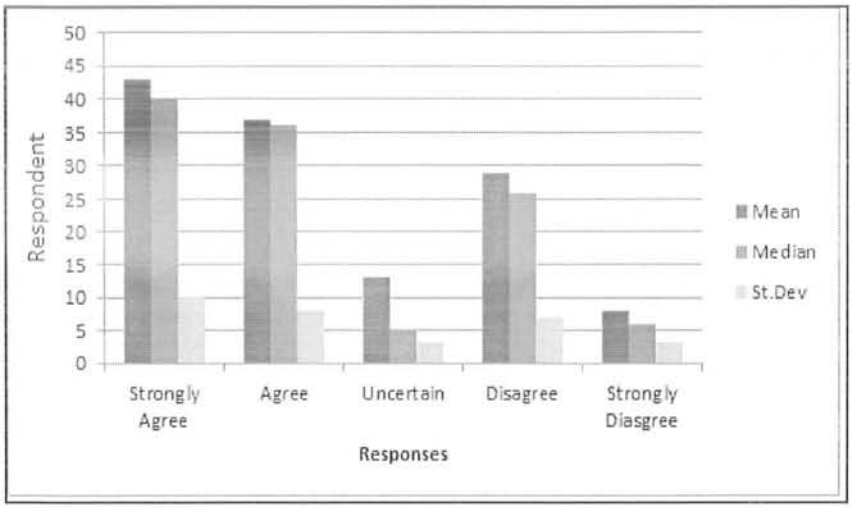

Figure 5.4: Overall satisfaction of proposed idea according to teacher

Results according to statistical measures show that most of the participants are agreed with the proposed idea. There are only fewer variations among participant's responses.

After post-task we conduct the survey with the students to measures the performance of underline prototype and their responses shows that smartphone use inspiration to the learning. Figure 5.5 shows the results of student's responses with respect of surveys questionnaires results.

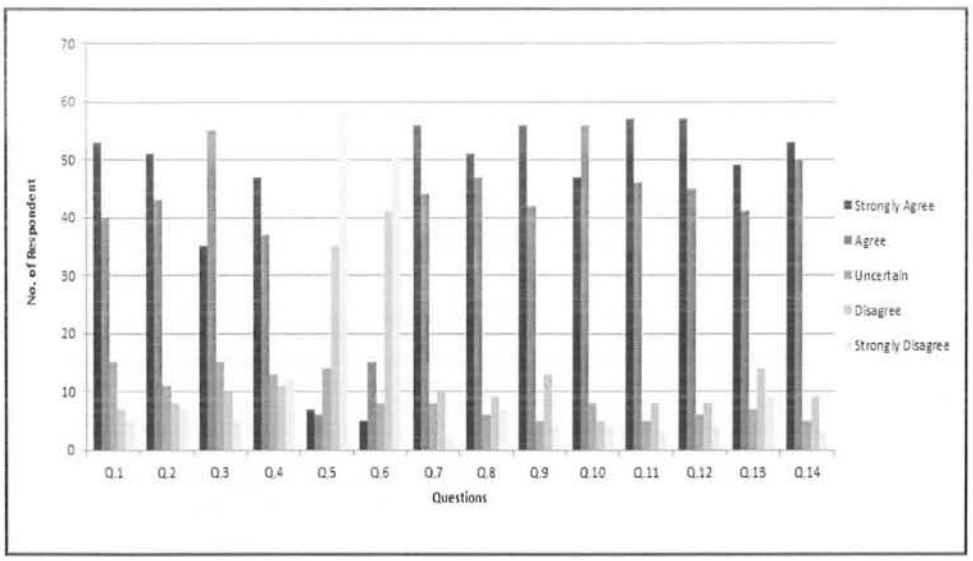

Figure 5.5: Students responses for proposed idea

After completing the task we calculated the results according to the student's response about research idea, 75% student's shows their responses in the favor of proposed idea. Questions in our designed questionnaire are about the completion of assigned activity within the given time

and 63% said that they can easily complete the activity within the time by using sketch-based application. We also asked about easiness of smart devices use, 60% said that they feel ease while using it in classroom for learning. We asked about the learning material that they needs to learn a lot of things before using this application, 65% said that there is no need to learn something before using it. We asked about marked activities and their comments given by the teacher are view able at any time, 70% students said that it is viewable at any time. Other questions are related to the use of smart devices in classroom for classroom activities, 71% said that it is a good use of smart devices for classroom environment. We further analyze our results by using different statistical measures.

Figure 5.6 shows that average of the students is agree with the proposed idea. According to statistical measures, students' responses show that smartphone can be used for learning in classroom.

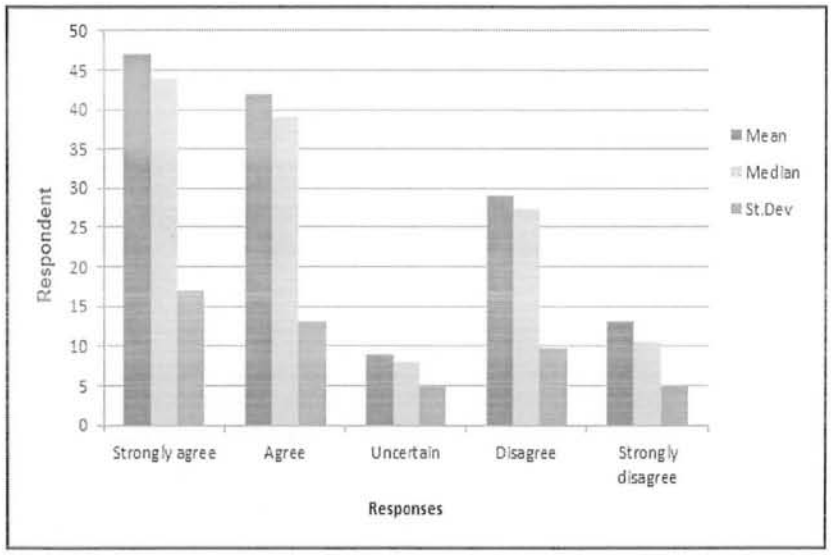

Figure 5.6: Overall satisfaction of proposed idea according to teacher

After completing the task we calculated the results according to evaluation parameters. We gather the results according to three evaluation parameters that are based upon.

- **Usability**
- **Usefulness**
- **Learnability**

This section provides the detailed analysis of post-test based on above mentioned evaluation measures. Division of questions on the basis of different evaluation measures discussed in chapter 4. We asked questions about usability, usefulness and learnability. In the next section we describe these results in detail. In the designed survey eight questions are related to usability, three questions are related to usefulness and seven questions are related to learnability.

Figure 5.7 provides the overview of participant's (teacher) results in the form of statistical measures results of our research prototype.

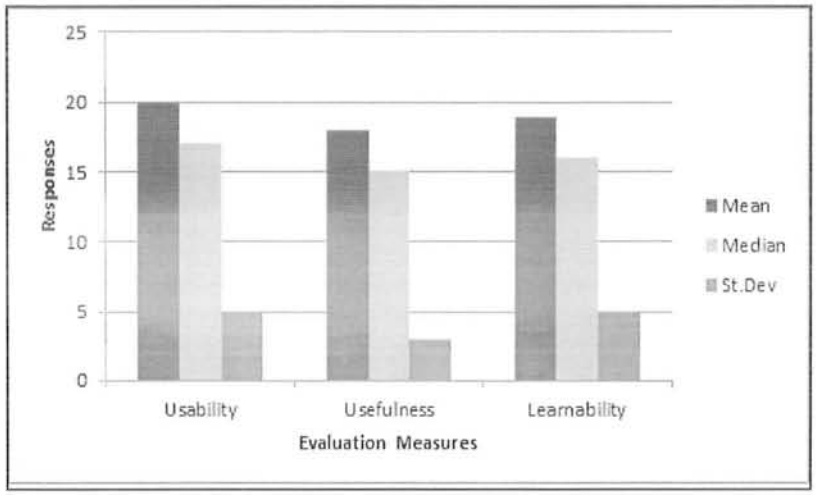

Figure 5.7: Evaluation measures results of teacher's responses

We asked questions about evaluation measures discussed in chapter 4 from students. In the designed survey four questions are related to usability, three questions are related to usefulness and seven questions are related to learnability discussed in chapter 4. Figure 5.8 provides the overview of participant's (student) results in the form of statistical measures results of our research prototype.

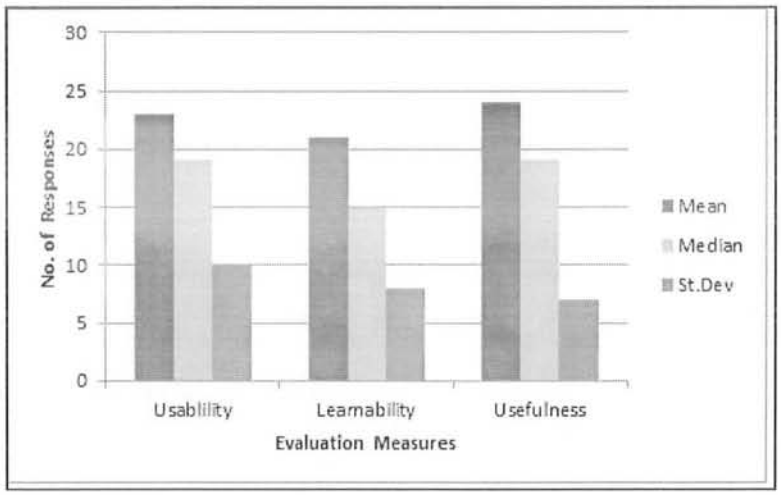

Figure 5.8: Evaluation measures results of student's responses

Figure 5.8 and 5.9 shows that on the average participants said that sketching on smart phone is useable, useful and also influence to the learning. It is also helps to create collaborative and interactive environment. In the next sections we describe these results in detail. Discussed results

show that sketching on smartphone can be used in classroom for the creation of class activities and also used for the assessment of students work in the classroom.

We further analyze the results with respect to the department and participants' demographic information that we have selected as random sample.

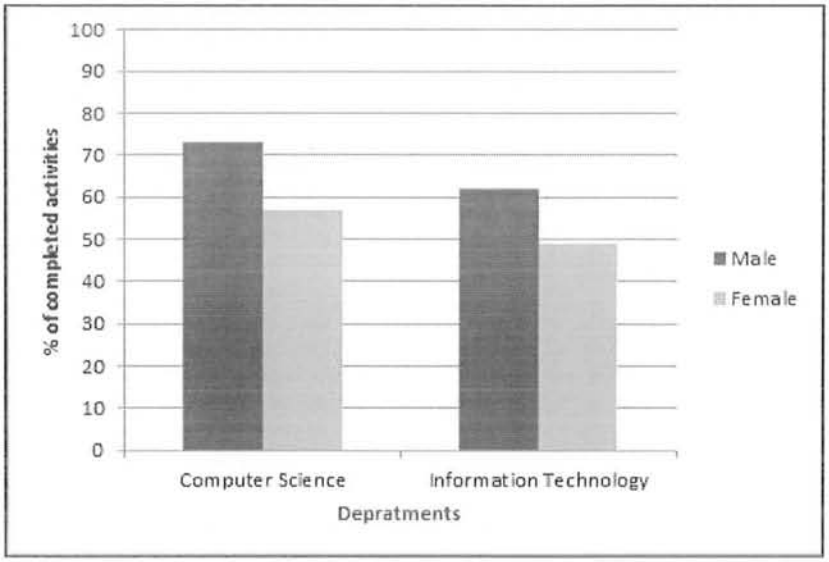

Figure 5.9: Demographical and departmental results against each course

Figure 5.9 shows that use of sketching on smartphone by the participants selected from the computer science departments is significantly high than to the information technology department. Results show that 72% male students have completed the activities in computer science department and 68% female students have completed the assigned activities within the given time. 61% male in the information technology and 59 % female have completed the activities.

We further describe the results with respect to the departments. Figure 5.10 shows that on the average we can say use of our research prototype is high in computer science department.

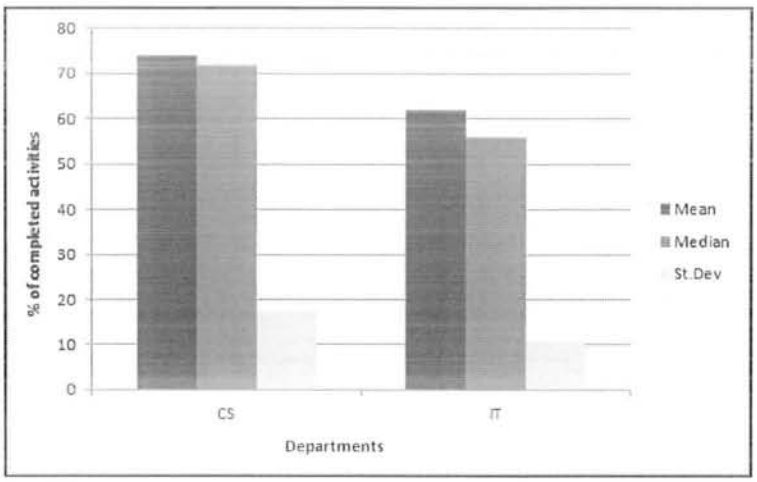

Figure 5.10: Statistical measures of departmental results

Supplementary we have analyzed the results with respect to the selected courses for evaluation. We have selected the introductory courses of programing and computing as sample. We evaluate the results of courses of different departments. Figure 5.11 shows the results of courses, where assigned activities of computing course give better results as compare to programing course.

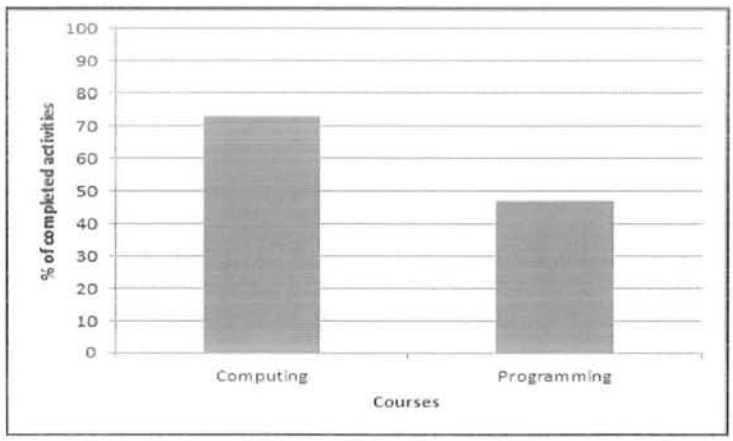

Figure 5.11: Percentage of completed activities in each course

Figure 5.11 shows that 73% of activities are completed in computing course and 53% in programming course. The reason of high results in computing course is that there are fewer activities required in programing and more activities are involved in computing course and sketching is more involved in this course as compared to the programming. So we can say that we can use sketching in different courses where concepts can be represented in the form of flow or block diagrams. Concepts are represented in the form of flow can be easily understandable by the students. At the end, with respect to the courses we conclude that sketching on smartphone

can be used in different courses but it gives better results in those courses which can be described diagrammatically.

We further analyzed the result with respect to student's categories where students are categorized according to their grades that are average students, above average and below average. We categorized the student's base on their previous results. Students having grades more than 70% can be set into above average group, those are having grades less than 70% and greater than 50% consider as average students and blow 50% consider as below average students.

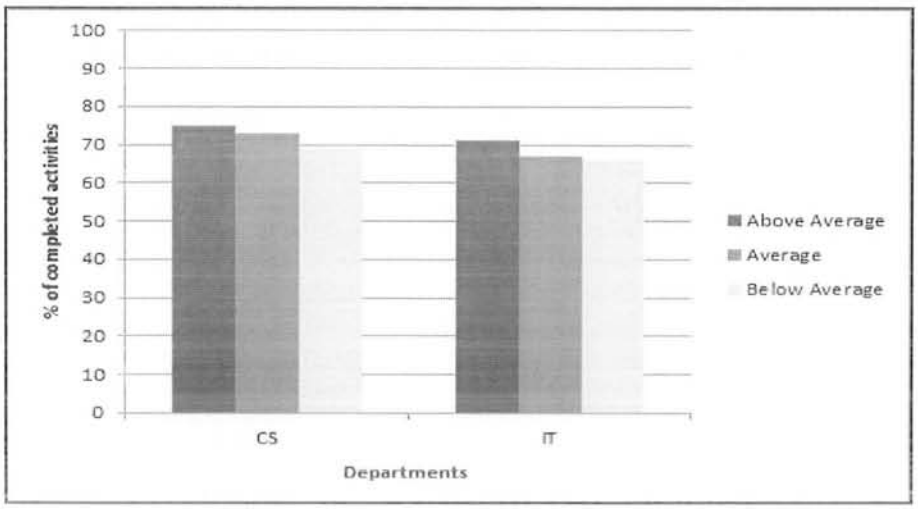

Figure 5.12: Group of students that have completed the activities

After analyzing the results according to departments, demographic information, courses and according to student's grades categorizes we conclude that results are satisfactory and sketching on smart phone can be used in classrooms and classroom environment becomes collaborative and interactive. Analyzing the results with covariance we analyze the results according to the evaluation measures results are discussed below in detail.

- **Usability**

To measure the usability in terms of ease of use we asked a total of 8 questions from the participants. In this section we provide the results of our post-test survey.

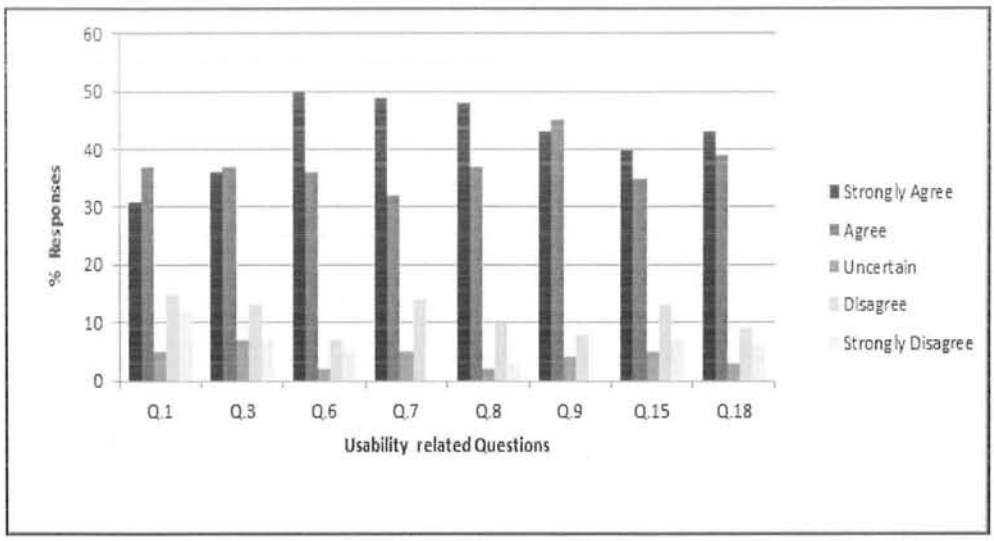

Figure 5.13: Teacher's responses for usability

Figure 5.13 provides the overview about the responses of teachers after performing post task. We asked eight questions about usability. We asked about easiness, efficiency and satisfaction of underline prototype. Most of the teachers responded by selecting "strongly agree" and "agree". 70% participants are satisfied with the proposed idea. We also asked about modification of activities, 69% participants agree with the provided editing mechanism. We asked about how evaluation is easy, 75% respond in positive way.

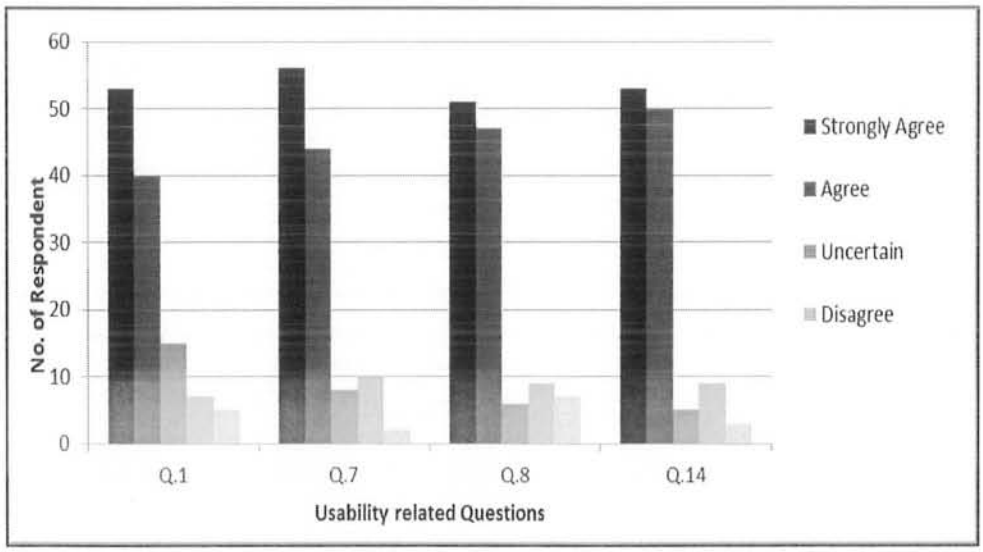

Figure 5.14: Students' responses for usability

Figure 5.14 shows the responses of students after using our research prototype. Four questions are asked from the students in the post test were related to ease of use, comfort level and about efficiency. We asked about completeness of activity, 80% participants say that it is easy to complete the task within the given time while 15% responded that do not complete their task. Further we asked about marked activities are viewable to students, 88% says that they can easily view the marked activities any time without any problem, while 10% respond that they feel difficulty and 12% respond that they have no answer about viewable activities. We asked questions related to the comfort level and satisfaction of our research prototype, 83% respond that they are agree with the satisfaction and with the comfort level, while 10% shows dissatisfaction about our research prototype.

- **Usefulness**

Usefulness on the basis of user is that how much sketch based classroom activities manager will enhance the performance of users. We asked some questions to measure the usefulness of the research prototype after post task, results are given below.

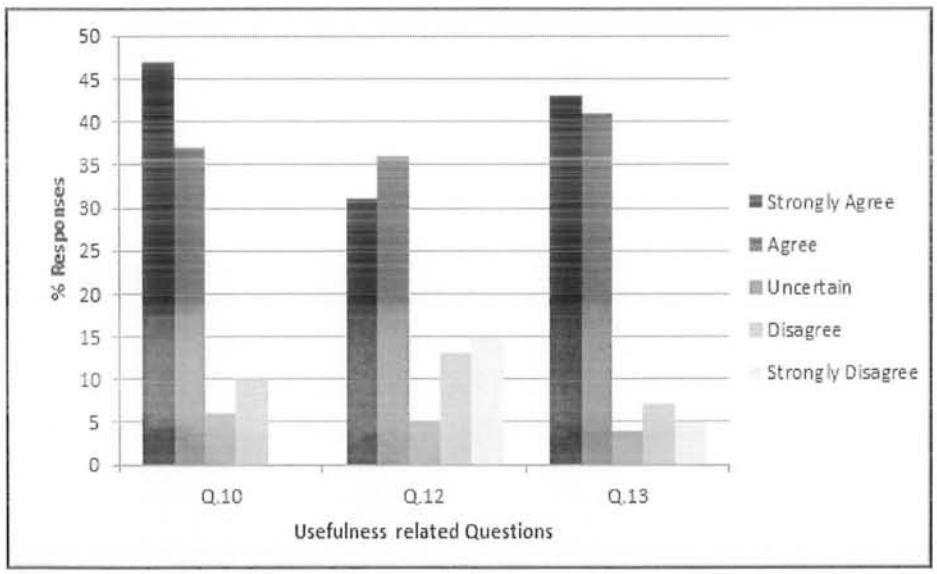

Figure 5.15: Teachers' responses for usefulness

We asked a total of 3 questions from the participants (teachers). One of the questions is related to the sharing of activities with students in classroom and share after the evaluation of activities, 53% response that they are agree with this factor and it is less time consuming method to share the activities with students. Other questions is related to the use of technology (smart devices) and sketch-based application on smart devices, and also to evaluate the effects of learning in classroom environment, 73% participants said that it is good use of technology in the classroom and can promote learning in the context of classroom.

According to the figure 5.16, results of usefulness taken from students, improved after performing the post task. The questionnaire filled by students contains three questions related to usefulness. Overview of usefulness results is shown below.

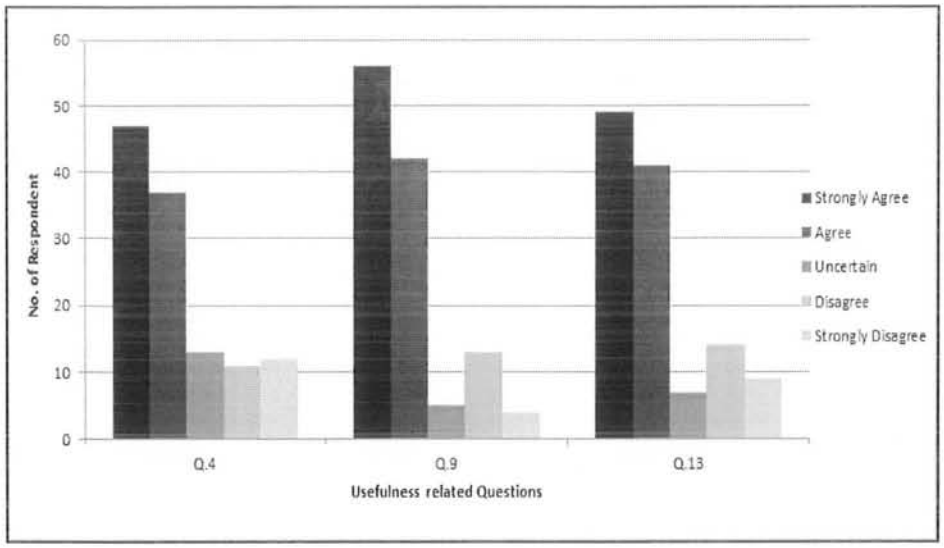

Figure 5.16: Students' responses for usefulness

We asked questions in our questionnaire about removal of errors, simplicity of sketch-based application on smart devices, and about use of technology in classroom are effective, 78% students respond that they are agree with the usefulness of the research prototype. 12% students that they are disagree with the use of smart device in the classroom. 10% participants do not show their interest in the use of smart device in the classroom for learning. A big percentage shows that use of smart devices in the classroom is not too much costly, less time consuming, and editing is also possible that is difficult in the paper-based mechanism.

- **Learnability**

We asked questions in our surveys to measure the learnability on the basis of teachers and students. There is an overview of teacher's responses about learnability by using research prototype.

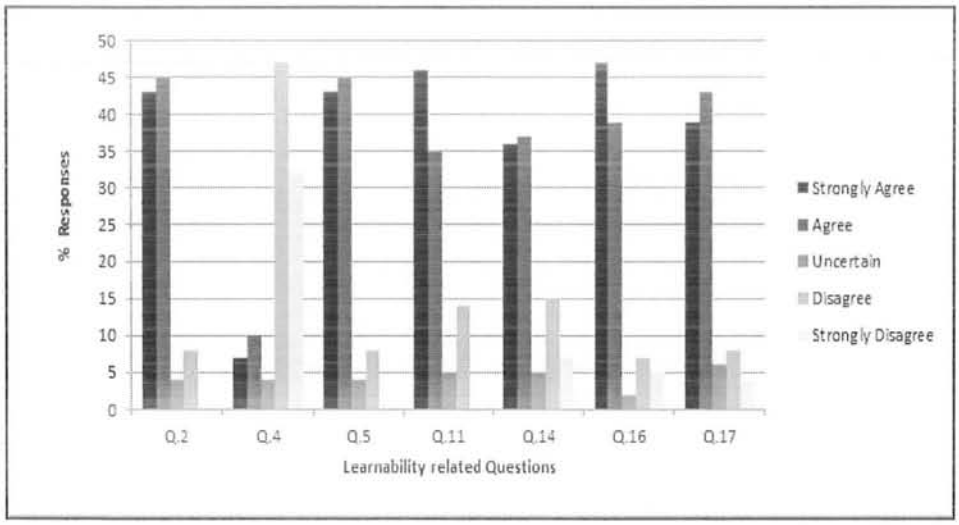

Figure 5.17: Teachers' responses for learnability

Total of 7 questions were asked to measure the learnability. Questions were asked related to classroom environment and bout learning methodology, results of learning increase or decrease, teachers responded that positive use of smart devices for academics increase the learning of students and classroom environment becomes collaborative and interactive by using sketch-based application.

They said that proposed research idea increase the learnability of the students, and all over teaching process performance. Their response shows that run time overview of students tasks are possible and can assess the students' knowledge immediately, their response also shows that record maintenance of students marks is not a big issue teacher can mark the submitted activities and can mark and assign numbers at run time as well as later.

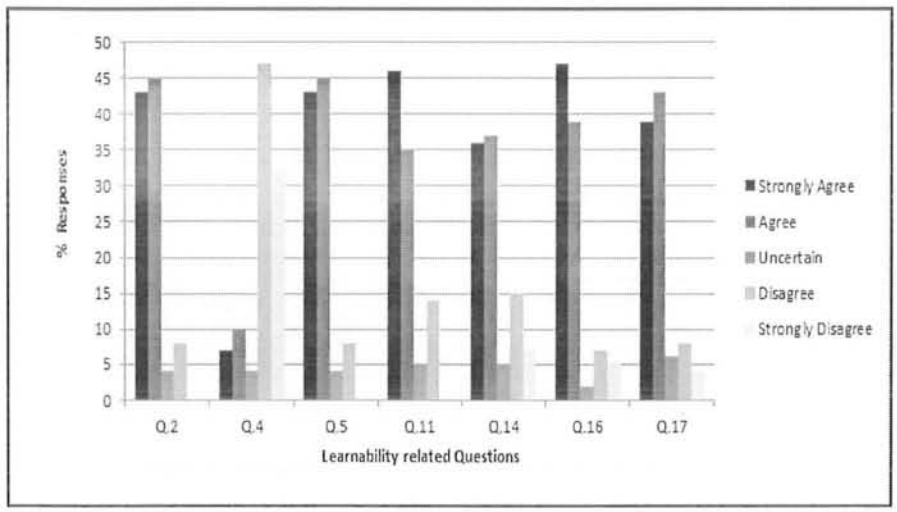

Figure 5.18: Students' responses for learnability

Figure 5.18 shows the result of students about learnability, performance of students and about all over teaching process, increase or decrease by using sketch-based application on smart devices. Seven questions were asked from students to measure the performance of teaching and learning process. Allover results shows that 77% students are agree with the performance of research prototype and proposed method increase the performance and learnability of students. After the discussion of results of pre and post-test we analyze the result of all evaluation measures and covariance by using statistical measures. At the end we measure our all results according to statistical to identify the overall performance of research problem.

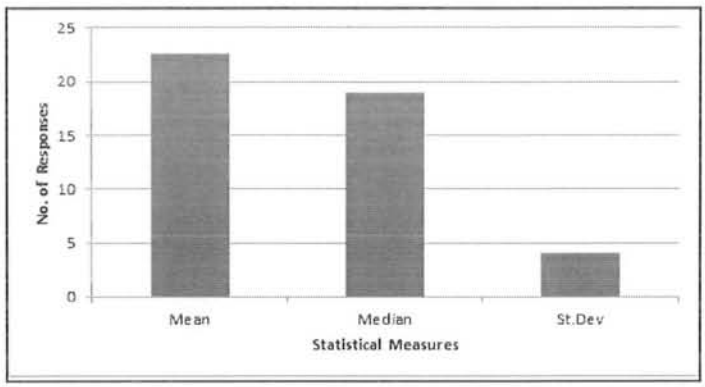

Figure 5.19: Smartphone effects on classroom environment

Results indicate that our research prototype significantly improves the learning experience by using of sketching on smart devices. Figure 5.19 shows that the usability and usefulness of our research prototype is considerably high as compared to the traditional paper-based method and it can increase learning experience. We conclude that we can use sketching on smartphone in classroom for creation, competition, and editing of activities. We can share activities and tasks with the class in collaborative and interactive environment.

5.5 Comparison with respect to issues

At the end after evaluating the results we further analyzed results with respect to highlighted issues in our pre-test. We compare the working of paper-based methodology with sketch-based application where we find that it is less costly, less editing issues, run time over view is possible after using our research prototype .Figure 5.20 shows the clear comparison of it.

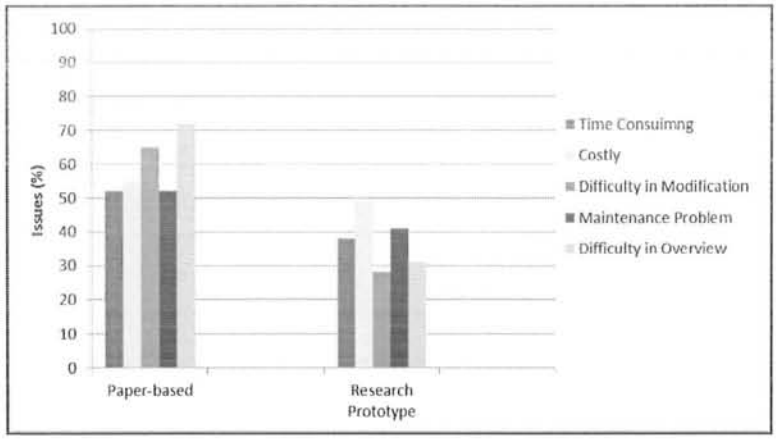

Figure 5.20: Pre-Post comparison with respect to issues

All the results and above discussion show that sketch-based application on smartphone is helpful for learning in classroom. The results of our experimental study clearly show that our prototype motivates the user to use their smart devices for the purpose of class activities and it improves learning.

5.6 Summary

In this chapter we analyzed the results of our research problem by using evaluation measure. We have initial study to discuss the traditional teaching process and discussed some factors of teaching process that were estimated by the population. After pre-test we gave some tasks to the participant to be performed on our provided prototype. At last we have done post-test in which participants performed post-task and filled the questionnaires. Participant's responses are calculated as results in terms of usability, usefulness and learning. We applied statistical measures to show the responses of participants.

Chapter 6

Conclusion and future work

6.1 Introduction

In this chapter we will describe the conclusion and future directions that we can use sketching on smartphone in different domains.

6.2 Conclusion

The aim of our research was to use sketching on smart devices in class rooms to improve learning. We observed from the literature review that there are many smartphone-based tools which are used in classrooms. These tools provide the facility to create lecture, make and take quizzes in the classroom. There are also others domains where sketching on smartphone are used to solve their problems. In our local environment smartphone is only used for entertainment, communication but not for classroom activities. We tried to find out the use of smartphone in local environment and then tried to motivate the users to use it for learning purposes. Sketching on smartphone can help the teachers as well as students to sketch their idea in the classroom and enhance learning. We built prototype of sketch-based application that is used to perform sketching on smartphone. ~~It provides the canvas to sketch their ideas. It helps the teacher to sketch their activities on the canvas by using stylus or fingertip in an effieient way just like pen and paper.~~ By using this application teacher can create activities in the classroom. This application provides the facility of editing and sharing, that teacher can modify the already created activities and share the created activities with the class. Students can use this application to complete the assigned activities and then share with the teacher. Submitted activities can be evaluated by the teacher.

This application motivates the users to use smart phone in positive way and the results show that their learning is improved. Results also showed that there is sufficient success in the use of sketching on smartphone. There is also improvement in terms of usability, usefulness, and performance (learning). These results clearly indicate that our proposed solution provide enough

help to enhance learning by using sketching on smart phone. At this stage we can say that our hypothesis is proved and our approach provides a novel solution with sketching on the smartphone for teaching purposes, that makes the classroom environment interactive and collaborative.

6.2 Future work

The work we have done in the field of sketching on smart phone provides a solution which can be used in the classroom for creating and conducting test and quizzes. Once smartphone use enhance the learning it can be used in multiple ways such as for delivering lectures, conducting exams etc.

Still there is a lot of work to be done to overcome the pending issues such as:

- Automatic sketching of well-known shapes.
- Automatic evaluation of submitted activities.
- It can be used in any other disciplines e.g. engineering where designer design the sketches of their products, in medical filed to draw the structure of concerned stuffs.

6.3 Summary

In this chapter we conclude that our research study meets our proposed hypothesis, methods of our study and evaluation. We can also discuss the future work that can be prolonged in different domains.

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Appendix A

Questionnaire

Accessible teachers to evaluate the Sketch-based Learning

Objective:

The following questionnaire is designed to obtain the overall measure of the teaching and learning experience by using research prototype on smartphones. Smart phone can be used in classroom activities just like pen and paper to complete the assigned activities. Your response can help to explore teaching and learning issues. This survey is to be filled after using our prototype that is deployed on your smartphone.

I thank you for your assistance and cooperation in advance.

Name:	_____	**Age:**	_____
Gender:	_____	**Department:**	_____
Department/Qualification:	_____		

❖ **Select only one option from the provided ones against each question.**

1. Were you able to create activity anytime?

   □ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

2. I can complete class activities effectively by using this application than paper based methodology.

   □ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

3. I believe that I can create class activities more quickly by using this application.

   □ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

4. I needed to learn a lot of things before I could get going with this application.

   □ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

5. This application has all the functions and capabilities that classroom activities needed.

   □ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

6. Was it easy for you to remove errors during the creation of activity?

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

7. Modification of activities can be performed later.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

8. I can effectively mark/comment any activity.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

9. Marked activities are viewable at any time.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

10. I can easily share submitted/marked activities with all the class.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

11. Do you feel classroom environment becomes more interactive during activities?

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

12. It is good use of technology for classroom activities.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

13. It was simple to use sketch based application in class rooms.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

14. How often available information is relevant to create activity using smartphone?

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

15. At first attempt it is easy to learn to use this application.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

16. Were the learning objectives met satisfactory with this application?

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

17. Were the teachers able to observe the change in learning curve of students?

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

18. Overall, I am satisfied with the use of smartphone in classroom for classroom activities.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

Appendix B

Questionnaire

Accessible students to evaluate the Sketch-based Learning

Objective:

The following questionnaire is designed to obtain the overall measure of the teaching and learning experience by using research prototype on smartphones. Smart phone can be used in classroom activities just like pen and paper to complete the assigned activities. Your response can help to explore teaching and learning issues. This survey is to be filled after using our prototype that is deployed on your smartphone.

I thank you for your assistance and cooperation in advance.

Name:	_____	**Age:**	_____
Department:	_____	**Semester:**	_____
Gender:	_____		

❖ **Select only one option from the provided ones against each question.**

1. Were you able to complete your activity within the given time?

   □ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

2. I can complete class activities effectively by using this application than paper based methodology.

   □ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

3. This application has all the functions and capabilities that classroom activities needed.

   □ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

4. Was it easy for you to remove errors during the completion of activity?

   □ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

5. How often you needed help from teacher/instructor while completing the activity.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

6. I needed to learn a lot of things before I could get going with this application.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

7. Marked activities are viewable at any time.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

8. I feel comfortable to complete task by using this application.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

9. It was simple to use sketch based application in class rooms.

□ Strongly agree □ Agree □ uncertain □ Disagree □ Strongly disagree

10. At first attempt it is easy to learn to use this application.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

11. Provided information to complete the activity is understandable.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

12. Do you feel classroom environment becomes more interactive during activities?

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

13. It is good use of technology for classroom activities.

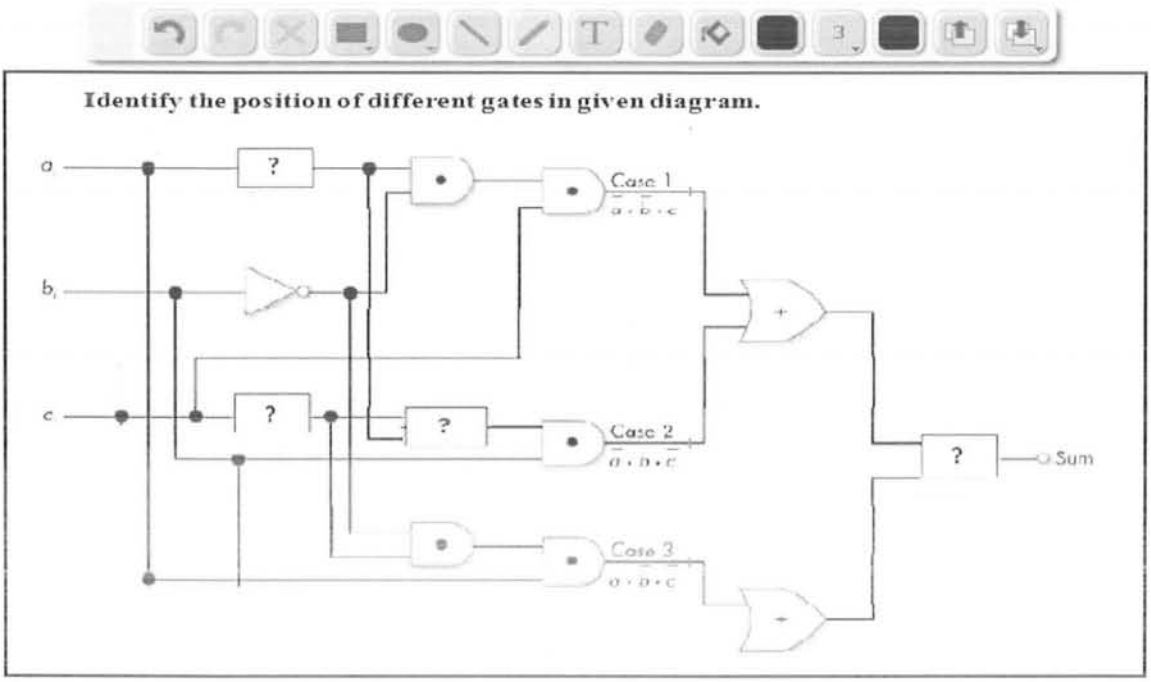
□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

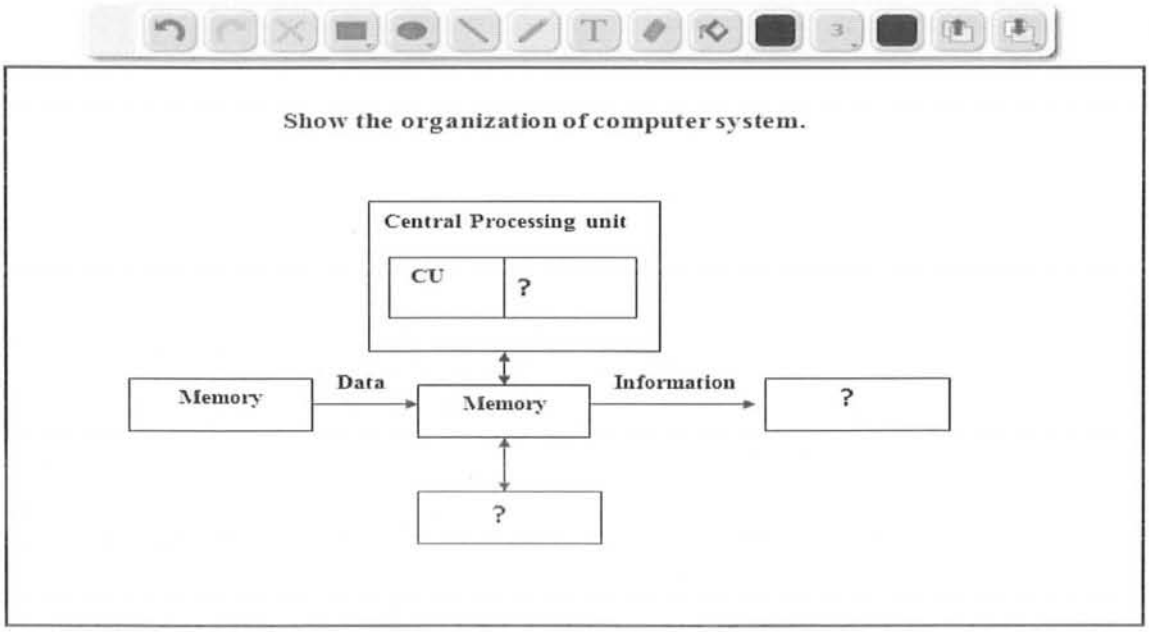
14. Overall, I am satisfied with the use of smartphone in classroom for classroom activities.

□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly disagree

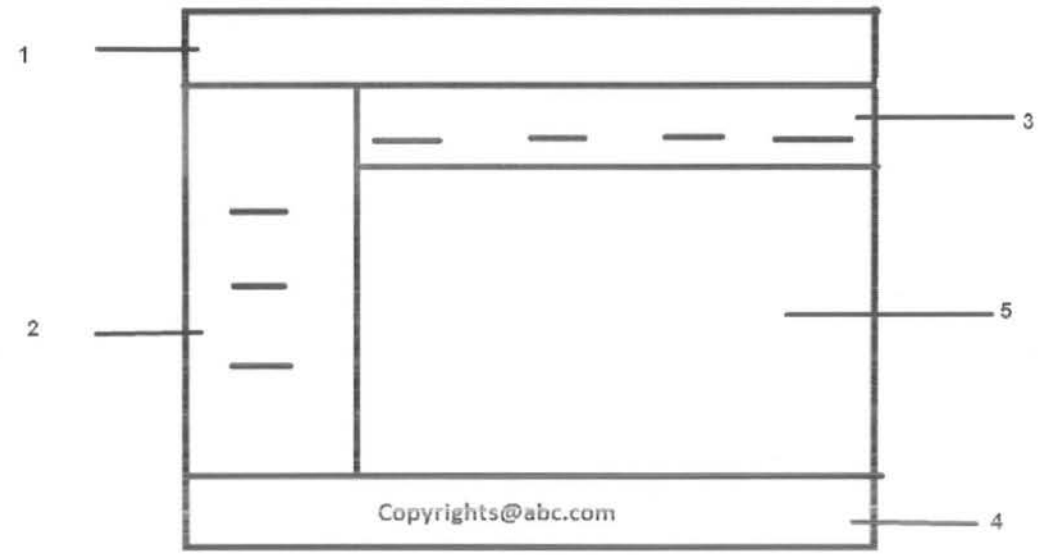
Appendix C

Activities

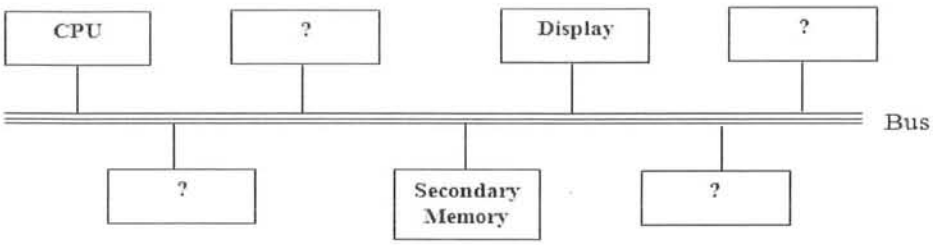




Write down the name of highlighted area.

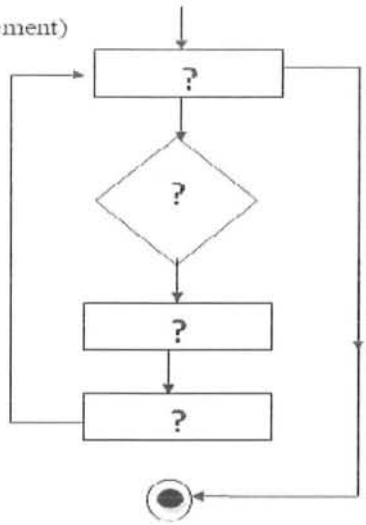


Complete the given structure.



Diagrammatically shows the working of for loop.

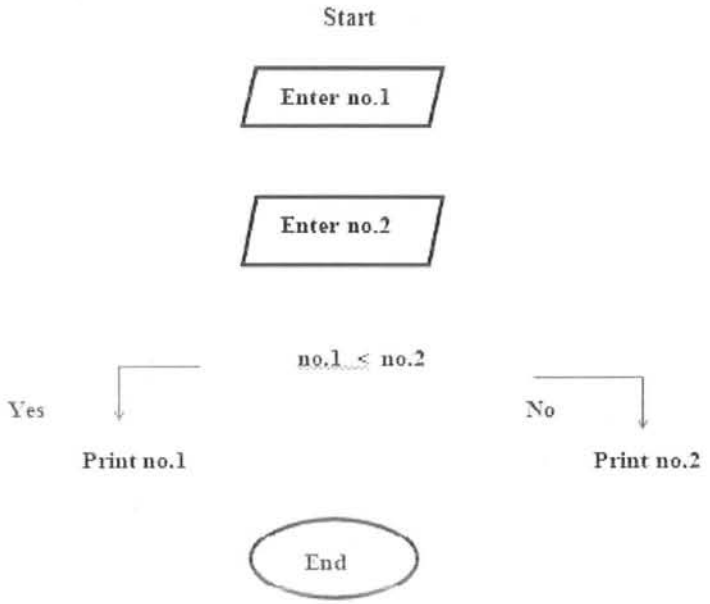
```
for (int; condition; increment/decrement)
{
        Statements;
}
```



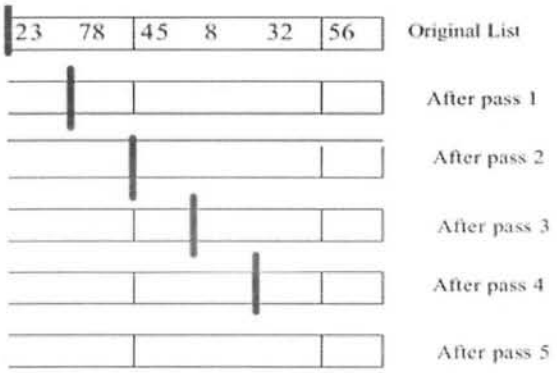
Transform the given algorithm into Flow chart.

1. Start
2. Read radius
3. Circumference = 2*3.14*r
4. Print Circumference
5. Stop

Complete it with suitable shapes.



Represent the working of selection sort.



Appendix D

Graphs

Teachers Responses

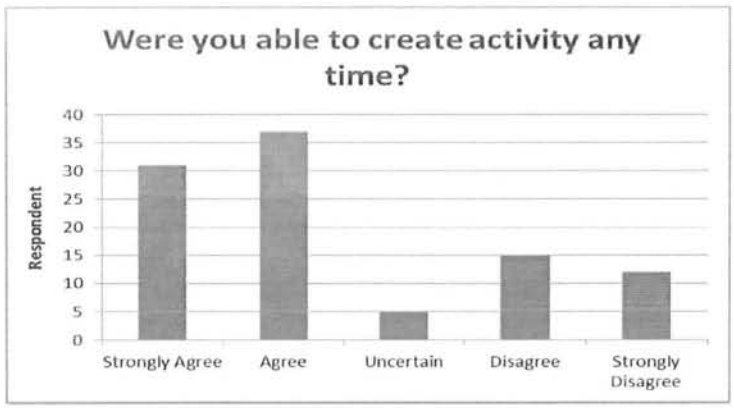


Figure (a): Creatiton of activities within the given time.

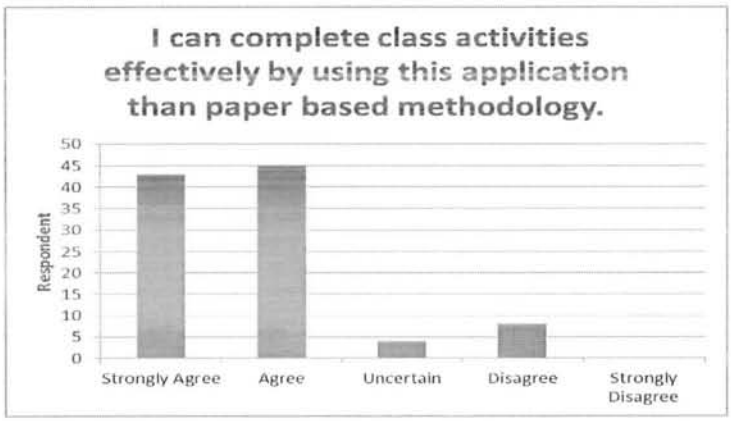


Figure (b): Compare sketch-based with paper-based.

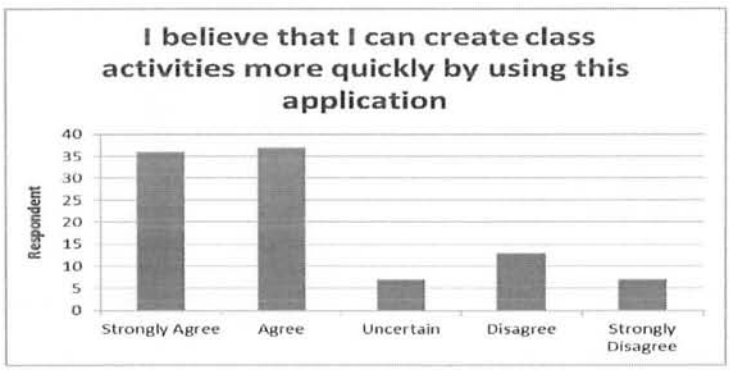


Figure (c): Quickly create activities by using sketch-based application.

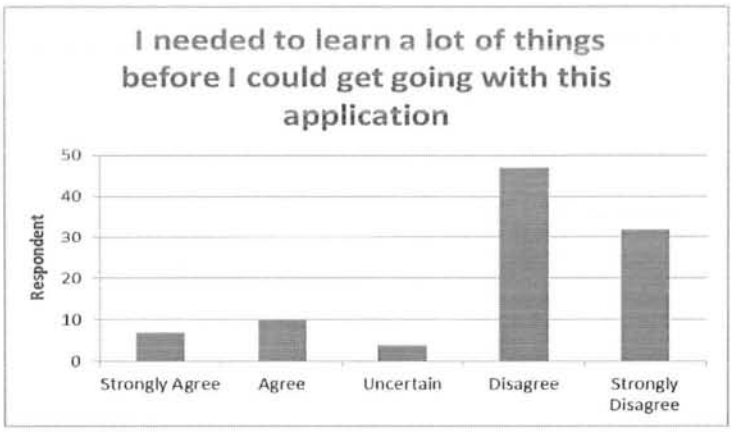


Figure (d): Prior knowledge is compulsory before using sketch-based application.

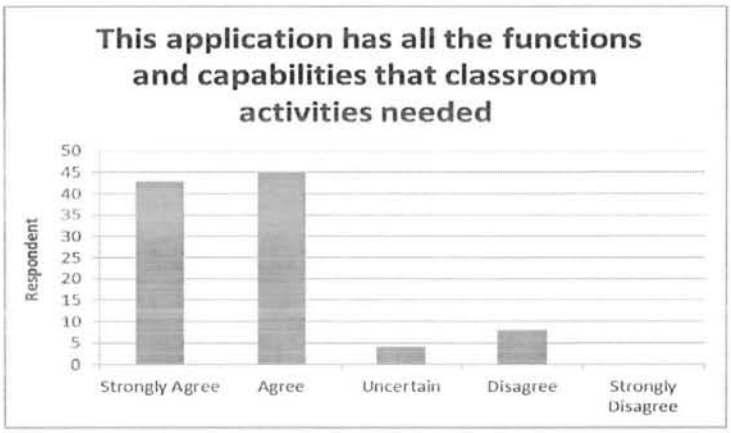


Figure (e): Required functionalities provided by prototype.

Figure (f): Easiness of error detection and correction.

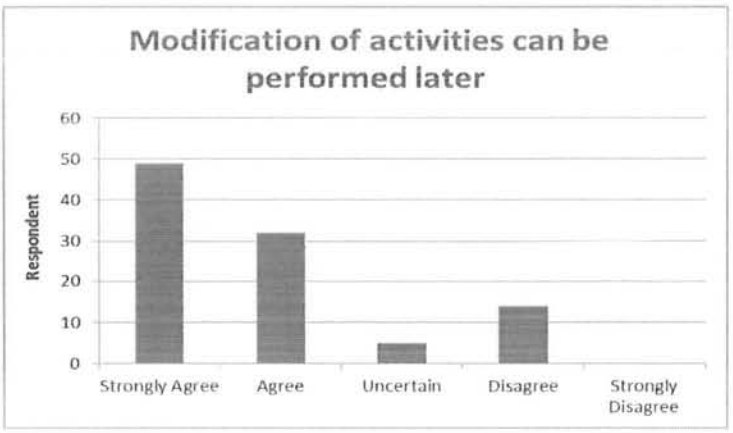


Figure (g): Creatiton of activities within given time.

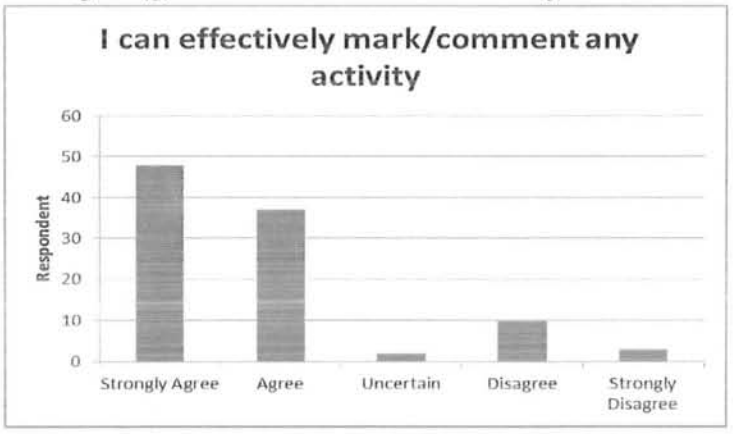


Figure (h): Effectivness of marking and commenting about activity.

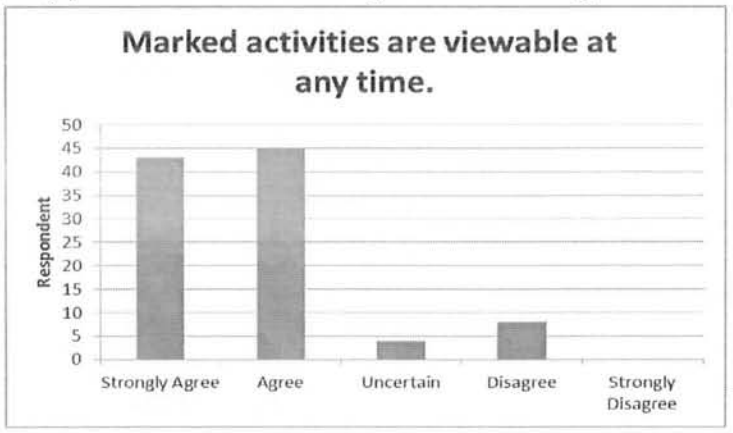


Figure (i): Marked activities are viewable.

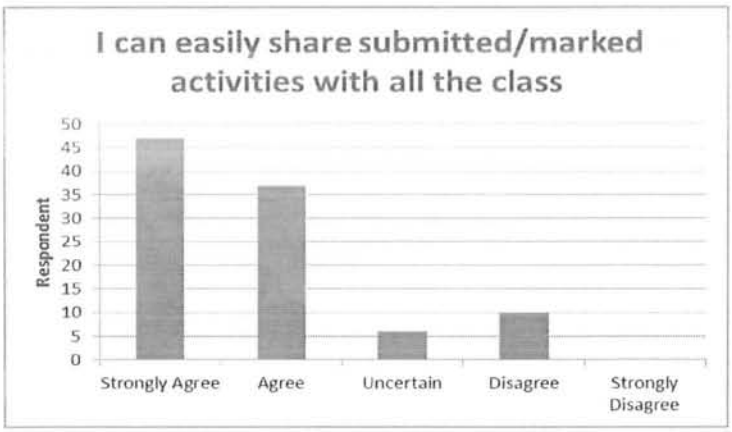


Figure (j): Share activities with the class.

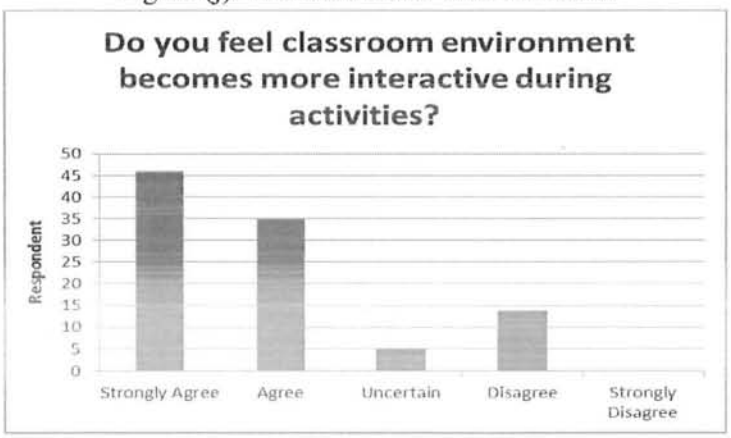


Figure (k): Interactive and collaborative classroom environment.

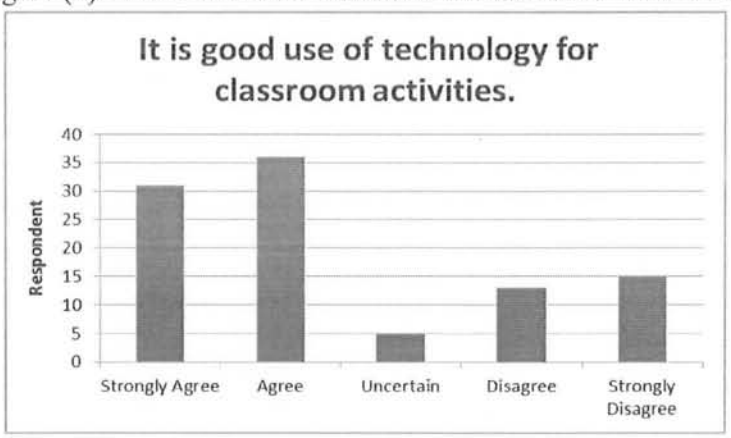


Figure (l): Use of technology in classroom.

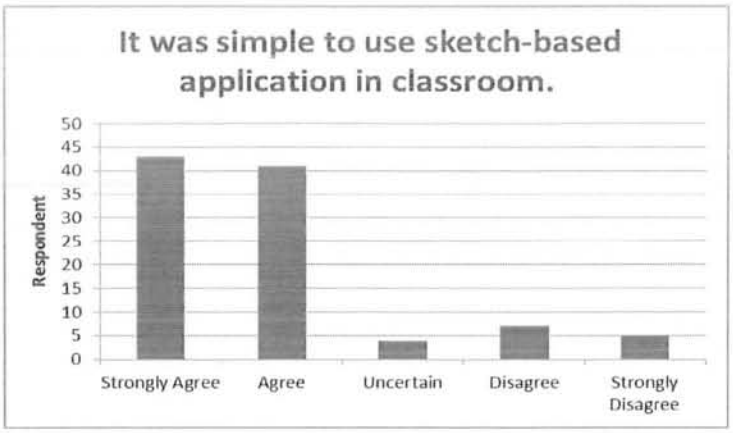


Figure (m): Simplicity of sketch-based application in classroom.

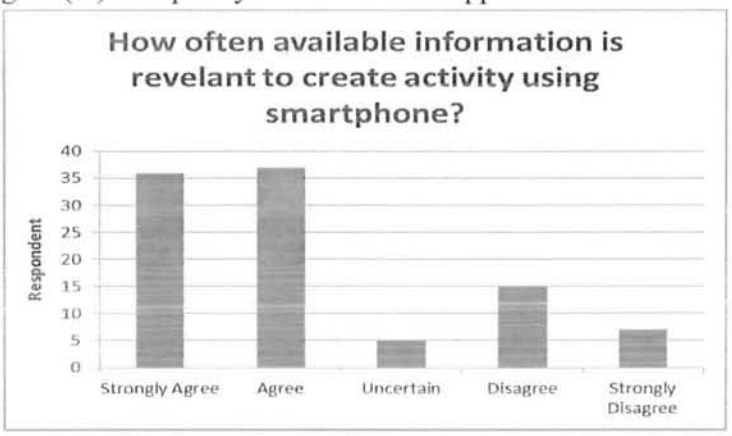


Figure (n): Relevant information about activity creation.

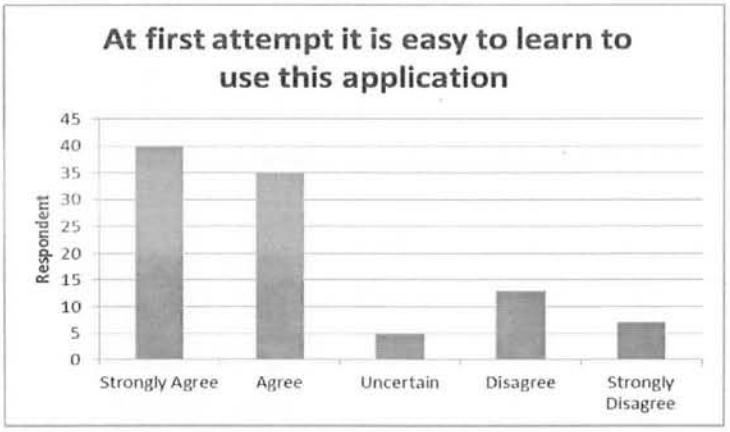


Figure (o): Easy to use sketch-based application.

Figure (p): Satisfaction of learning objectives.

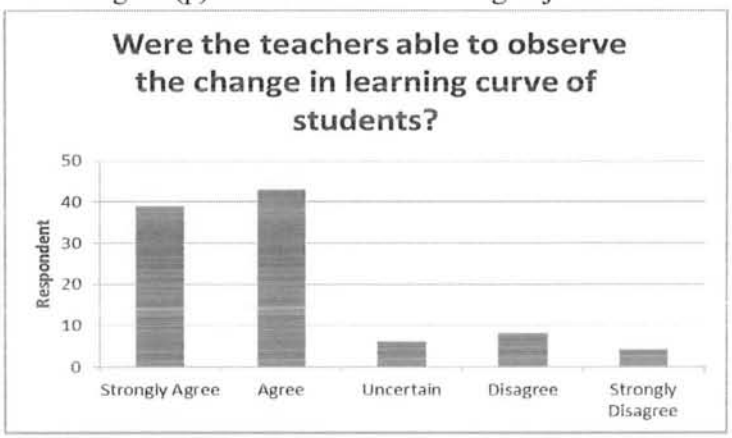


Figure (q): Change in learning curve.

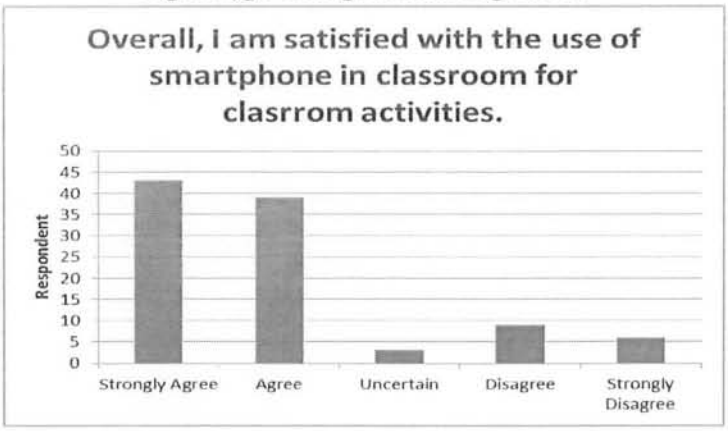


Figure (l): Satisfaction with the use of technology in classroom.

Graphs

Students Responses

Figure (a): Creatiton of activities within the given time.

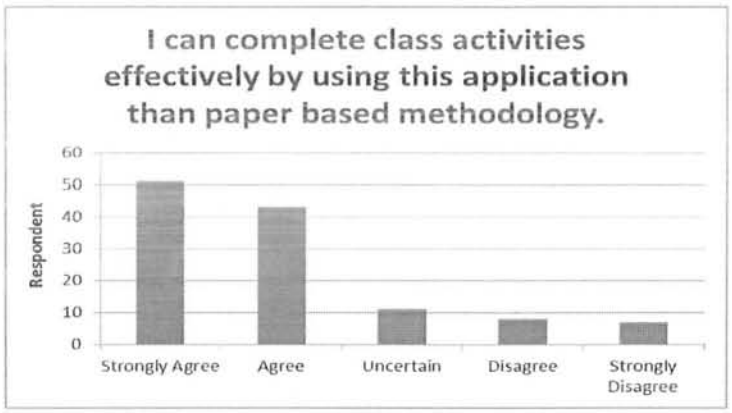


Figure (b): Compare sketch-based with paper-based.

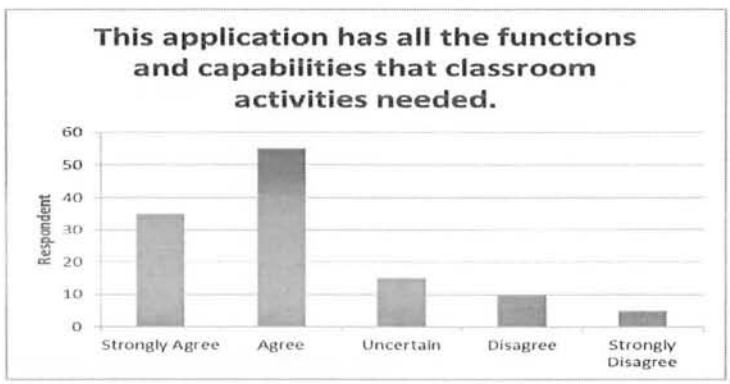


Figure (c): Required functionalities provided by prototype.

Figure (d): Easiness of error detection and correction.

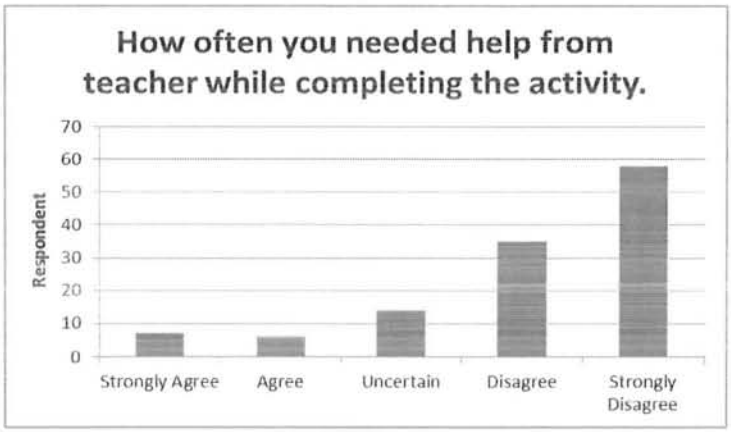


Figure (e): Need help from teacher.

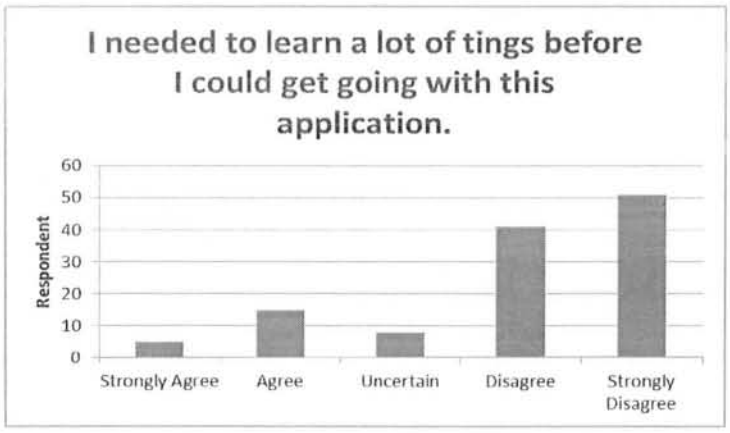


Figure (f): Prior knowledge is compulsory before using sketch-based application.

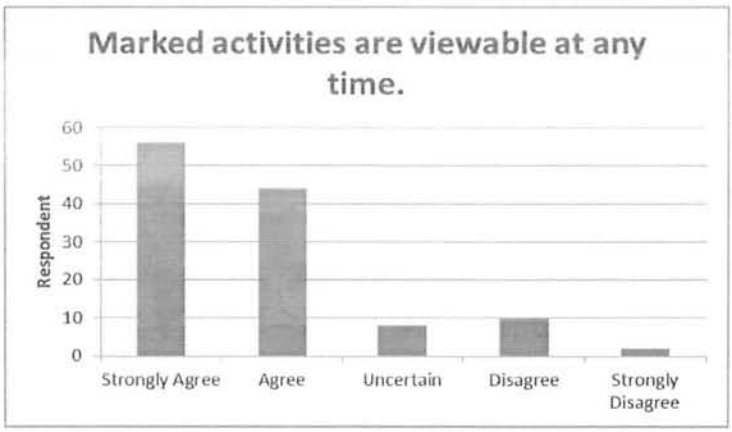


Figure (g): Marked activities are viewble.

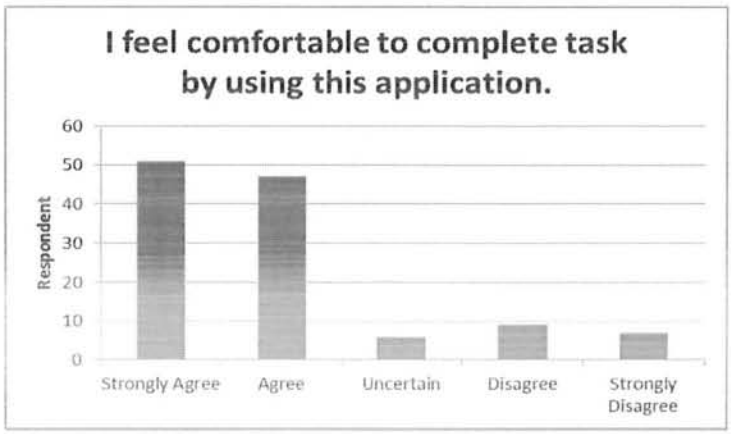


Figure (h): Comfort level to complete the activities.

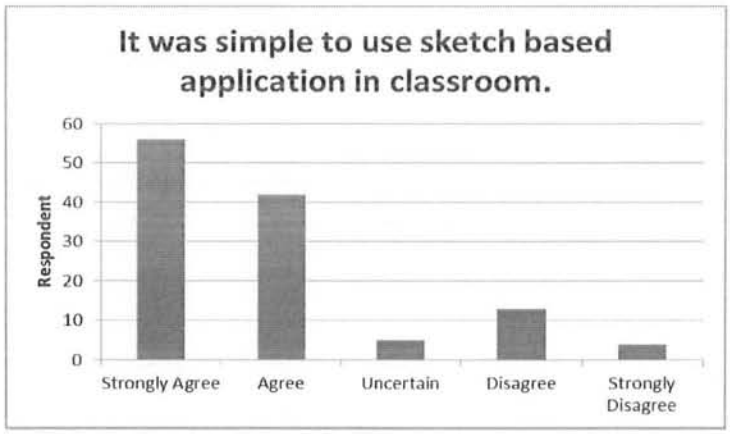


Figure (i): Simplicity of sketch-based application.

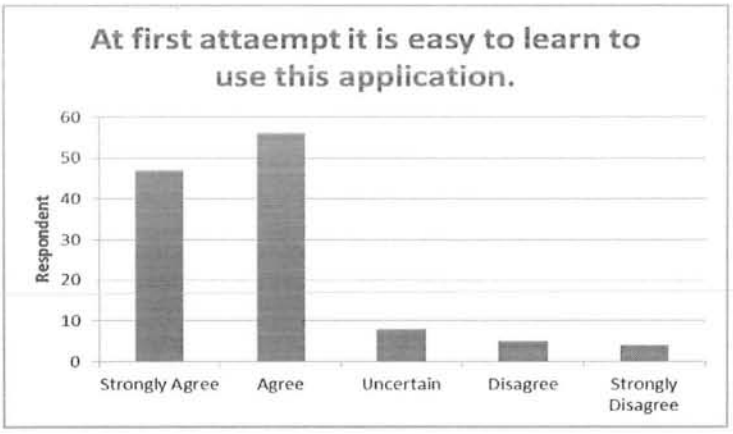


Figure (j): Sketching is easy to use in classroom.

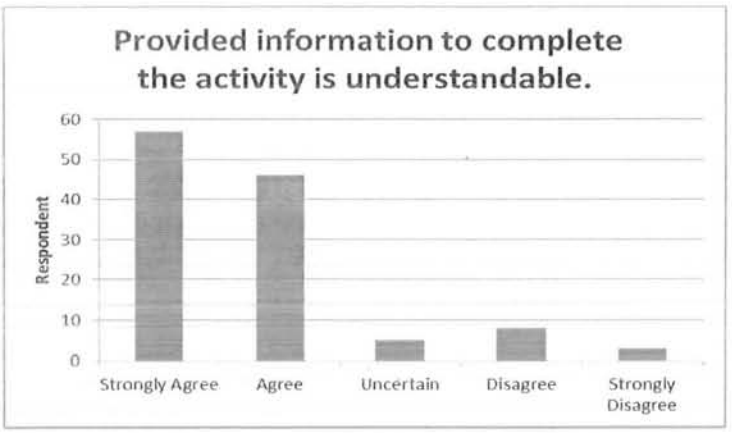


Figure (k): Understanding of provided information.

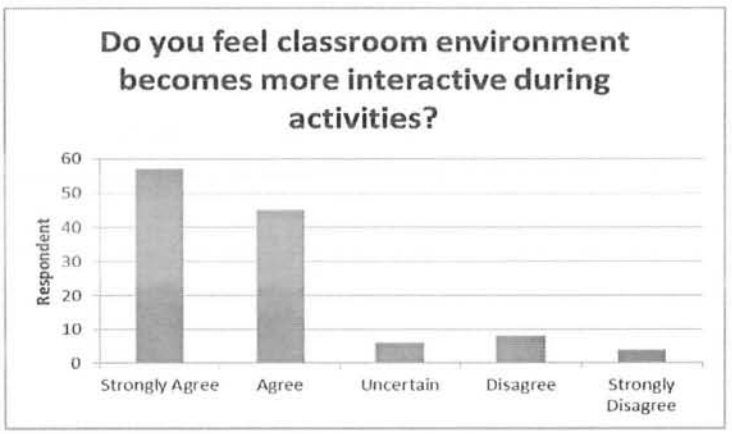


Figure (l): Interactive and collborative classroom environment.

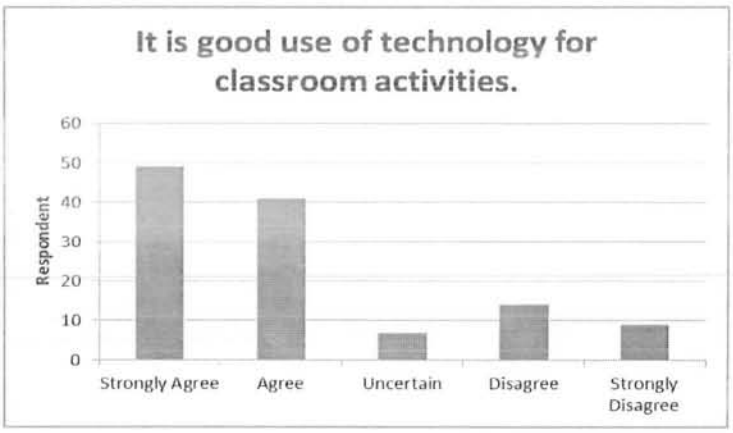


Figure (m): Use of technology in classroom.

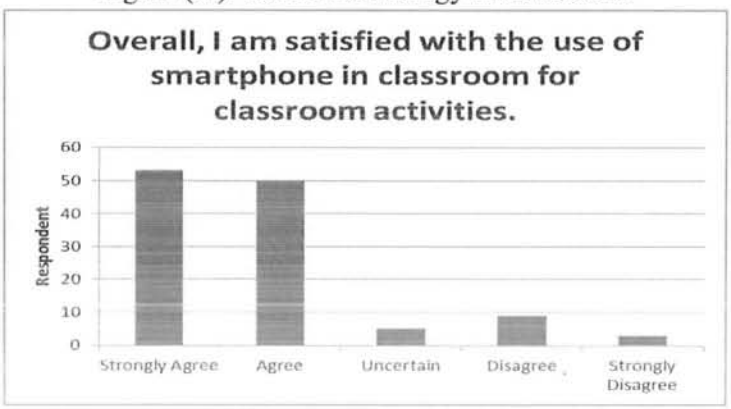


Figure (n): Satisfaction with the use of technology in classroom.

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