UNIVERSITY OF DELHI

INNOVATION PROJECTS 2015-16

FINAL REPORT

1. PROJECT CODE: MH-305

2. PROJECT TITLE: Mobile! MyLab Anytime, Anywhere

3. NAME OF COLLEGE/INSTITUTION: Miranda House

4. PRINCIPAL INVESTIGATORS

S No	**Name**	**Dept**	**Email**	**Phone**
1	Dr Pratibha Jolly (Principal)	Physics	pratibha.jolly@mirandahouse.ac.in	9811600386
2	Dr. Mallika Verma	Physics	mallika.verma@mirandahouse.ac.in	9811143326
3	Dr. Bani Roy	Chemistry	bani.roy@mirandahouse.ac.in	9810966041
4	Dr. Janaki Subramanyan	Botany	janaki.subramanyan@mirandahouse.ac.in	9868210169
5	Dr. Seema Aggarwal	Computer Science	seema.aggarwal@mirandahouse.ac.in	9810284682

5. MENTOR
   Mr. Vikas Sahni, School of Computing, National College of Ireland, and Technical Consultant, Expert from Products to Projects; Net to Mainframe Assembler.

6. STUDENTS INVOLVED IN THE PROJECT

S No	**Name**	**Department**	**Email Id**	**Phone No.**
1	Isha Gupta	Computer Sc	contact.isha15@gmail.com	9971756138
2	Saloni Bansal	Computer Sc	saloni.bansal@mirandahouse.ac.in	8470832778
3	Priya Bundela	Computer Sc	bundelapriya322@gmail.com	9717140742
4	Manika Nagpal	Physics	manikanagpal1@gmail.com	9911688099
5	Megha Pant	Physics	meghapant.96@gmail.com	8860151788
6	Nitya Gupta	Physics	nitya11nitya@gmail.com	9650245015
7	Nancy Suri	Chemistry	swtnano12@gmail.com	8860214285
8	Phroyia Pfuze	Chemistry	pfuzephroyia@gmail.com	8470960172
9	Nisha Sella	Botany	nishasella1@gmail.com	
10	Deepali Manchanda	Botany	deepalimanchanda140@gmail.com	

Final Report
MH-305
Miranda House

1. Project Title: Mobile! MyLab Anytime, Anywhere

2. Project Code: MH-305

3. Abstract

This project recognizes the enormous potential of the 'smart' mobile phone and the advantages that can come out of using this 'popular' device in formal education. There are two major reasons for promoting the use of a mobile phone as a laboratory tool: one, it is by now an almost universal possession of students in the formal education sector under consideration and two, even a relatively inexpensive phone is packed with sufficient features to be classified as a powerful teaching instrument. A third reason is that a vast range of applications, or 'apps', exist in the public domain that can be easily adapted to create powerful teaching-learning techniques. However, the quality of the learning experience most of these applications offer remains largely untested and undocumented. This project aimed at introducing, testing and documenting some innovative applications of the smartphone in the Science laboratory.

4. Introduction

The advancements in the technological world are being made at very high speed. The numbers of smartphone users in every country are increasing day by day. For India, it is expected that by the end of 2016, it will exceed 200 million smartphone users, topping the US as the world's second-largest smartphone market. The smartphone offers wonderful features mostly because of the sensors like GPS, accelerometer, magnetometer, etc. present in it. By clubbing several of these in an innovative way, a smartphone can be used as a great tool in educating students at school as well as undergraduate level. In this direction, an effort has been made to design science experiments of high school and undergraduate level using the smart features of a smartphone. An android application 'MobileMyLab' has also been designed to support the same that includes easy collection of data from the built-in sensors of the phone, adjusting the frequency and duration of data collection, and other exciting features.

5. Research problem/objectives

The objective of *Mobile! MyLab* is to generate the joy of learning science by creating hands-on minds-on laboratories with simple equipment. As science is empirical in nature, an important step in the process of creating an *Active Learning Environment* that promotes enquiry-based learning is to develop low-cost, easily accessible and robust instruments or experimental set ups and carefully crafted resource material.

The aims of the project were to:

- Create new learning experiences making use of a popular technology.
- Explore the potential of the Mobile or the so-called 'Smart Phone' as a laboratory instrument to carry out a comprehensive set of innovative experiments in basic science, spanning Physics, Chemistry, Biology and multidisciplinary contexts.

- Develop a product titled *Mobile! MyLab* that will include hardware, software and appropriate text material for students at high school and undergraduate level.

6. Methodology

The work was carried out collaboratively by student-teacher teams in consultation with experts from the industry.

In the first phase, the undergraduate student teams developed some laboratory applications replacing various traditional measuring instruments with the smart phone for performing curriculum-based experiments. In this phase, the focus was on adopting the new technology within the existing laboratory practice. To gain rapid familiarization, the students used the following:

- In-built device sensors to use smart phone as a measuring tool in real-time.
- In-built software features to observe, measure, record, represent, analyze and display.
- 'Apps' available in public domain for generic and specific measurement and data-processing tasks.

In the second phase, the student teams

- Underwent training to design and develop applications for both generic and dedicated real-time measurements, data processing and display
- Developed an Android based 'app' as per the methodology outlined below.

Methodology for Android Application (app) Development

- *Planning phase*
  - The basic requirements of the application were specified which would help to achieve the following objectives: generating learning *beyond the walls*; using the in-built features of the smart phone (sensors, camera, etc.); generating analysis of the experiments (graphs); being user friendly and self- explanatory.
  - Functional requirements of the app were discussed which included the features that determine the quality of the application. All the modules of the application were listed.
  - Further requirements included
    - Identifying users of the application and recording user information.
    - Developing experiments that can be performed using the application.
    - Recording and analysis of data.
    - Export options for the data.
- *Design phase*
  - Design choices were developed and the selected choice was implemented in the execution phase.
  - The design template of the database was created which included deciding how to tabulate the data with proper constraints in real time.
  - A phone (Samsung Galaxy S6) with maximum sensors available was identified and purchased for the purpose of testing and experimentation.
- *Execution phase*
  - This phase included the actual coding and building of the application.
  - To develop the MobileMyLab application, *Eclipse ADT* was used. *Eclipse* is the most widely used Java Integrated Development Environment (IDE).

- The two ends of the application (frontend and backend) were designed separately according to the modules discussed.
- The frontend includes the Graphical User Interface (GUI) of the application. Initially, screens were developed to give the application a structure. Screens included were :
  - Login screen
  - Registration screen
  - Sensor List screen
  - Experiment details screen
  - Experiment screen
  - Export via gmail
- Backend includes the server side code of the application. A cloud server was purchased on *digitalocean.com* for the application. All the user information that was captured in the application was recorded on the server side in the decided format.
  - Opencsv(jar) was used to implement the export feature.
  - Achartengine(jar) was used to implement the graph feature.

- *Follow up phase*
  - The app developed was shared within the team for experimentation and feedback and changes were made as per the feedback.
  - Analysis was done to check how well the specified requirements were mapped in the application.

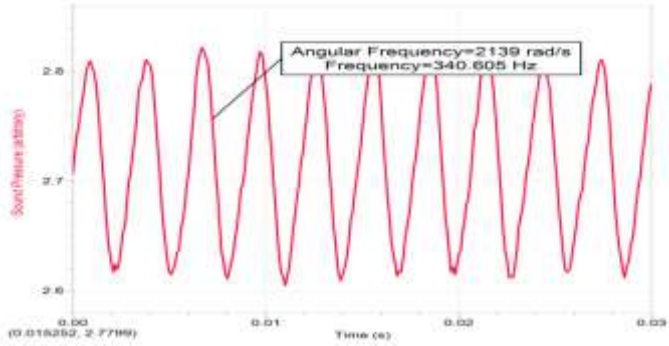
7. Results and Discussion

Apart from using the stopwatch, room temperature sensor and calculator of the smartphone in typical Chemistry experiments such as determination of coefficient of viscosity, the camera was used to record rapid changes during the progress of a reaction and magnified images of crystal structure. Physics experiments were performed using the accelerometer, gyroscope, magnetometer, microphone, timer and camera. Results were compared with the same measurements using conventional computer interfaced sensors. Biology experiments used the camera and the timer.

Physics Experiments

Smartphone applications were used to perform simple physics experiments. The same experiments were performed by conventional methods or by using computer interfaced sensors and the results were compared. The results obtained through Smartphone sensor-collected data matched well with the results through conventional techniques.

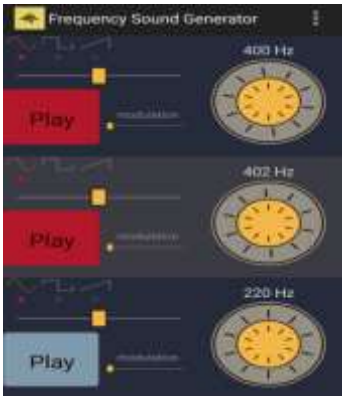
To study the oscillations of a tuning fork and the phenomenon of beats:
Real time audio data was collected using Smartphone microphone and also using a computer interfaced microphone and software. Fitting the Sound pressure- time graph to the sinusoidal curve fit the value of amplitude, frequency, time period and phase of the oscillation could be determined. In the smart phone “Spectrum Analyze” App was used for analysis. It provides Fast Fourier Waveform Analysis and the peak frequency is frequency of tuning fork .The table below gives values obtained for frequency with both methods



Vibrating tuning fork placed in front of smart phone and Sound Pressure vs time graph

Demonstration of Beats:

When the two tuning forks are sounding simultaneously, by striking the forks equally hard and hold them the same distance from the sound sensor beats are observed.



Changing the beat frequency (by varying the frequency difference between the superimposed frequencies) reflects the change in the waveform. The data acquisition and pictorial representation feature helped to visualize and study the beat phenomena qualitatively. These waveforms can be used for doing further analysis. Aoustic beats are observed with Smartphone playing two different frequencies simultaneously using *Frequency Sound Generator* app placed near microphone sensor. The *iAnalyzer lite* App provides graphical analysis of the waveform. Beat frequency are determined graphically. A screen shot of Beat frequency of 2, 4, 1 and 5 Hz is shown below

Wave interference and Beat frequency of 2, 4, 1and 5 Hz

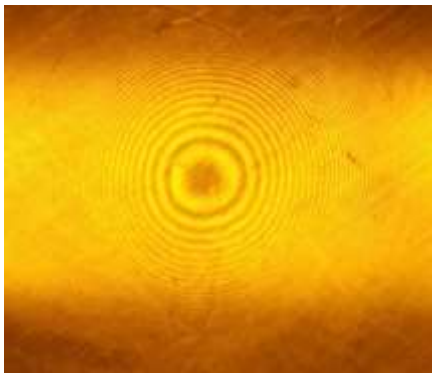
Verification of Malus' Law

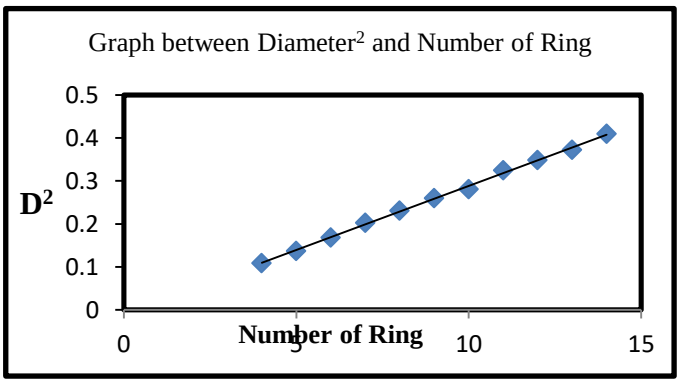
Light sensor of smartphone is used to verify Malus' Law. The set-up shows optical bench with two polaroids and two smartphones, one as a light source and the other a light intensity reader. The data obtained showed an excellent match with Theory.

Newton's Rings:

In this experiment

- Smartphone camera was used to click the interference pattern shown below created by a reflection of light (sodium light) from the surface of a thin air film formed between the plane glass and the plano-convex lens whose thickness varies while moving from the center towards the end surface.
- The picture is analyzed using *ImageJ* software.
- A plot of the square of the diameter of the n^{th} bright fringe versus the number of the ring was observed to be a straight line. The slope of the plot was then used to find the radius of curvature of the plano-convex lens. Thus the Radius of curvature of the convex lens was determined by calibrating the distance.
- Values obtained using the above method are compared with that from the conventional method and found to match

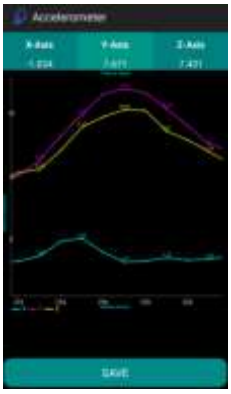




Determination of Spring Constant

The spring mass oscillations were recorded and analyzed using the smartphone's accelerometer The plot of acceleration versus time was found to be sinusoidal which shows that the motion of the spring mass system is simple harmonic. The *VidAnalysis* App and the *MobileMyLab* App were used for recording data and analysis. The spring constant calculation matches within experimental error.

MobileMyLab App screenshot images is shown below



Chemistry Experiments

Jumping Sodium: A piece of sodium is put in a test tube containing water and gasoline. The sodium jumps through the entire length of the upper layer that is gasoline and the whole amount of the water turns pink as the solution turns alkaline

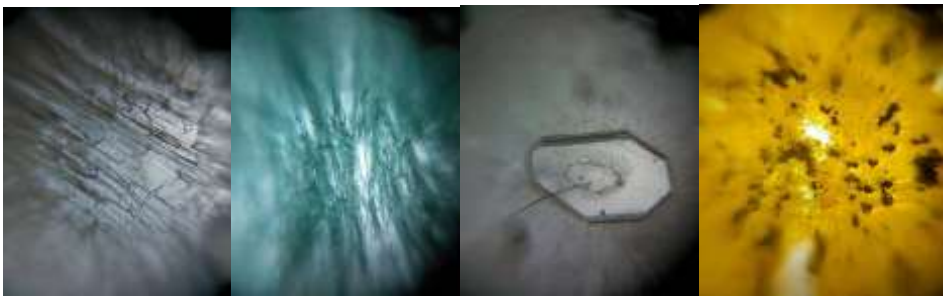
Jumping Sodium

Magnetic Fluid

Magnetic Fluid: A fluid consisting of a mixture of LaserJet toner and vegetable oil generated spikes around it when brought near a Neodymium magnet.

Iodine Clock Reaction: A solution of hydrogen peroxide is mixed with one containing potassium iodide, starch and sodium thiosulphate. The clear liquids turn into a jet-black iodine-starch complex.

Crystal Structure at Microscopic Level: Crystals of different salts were grown and photographed with the smartphone through the Foldscope microscope.



Smartphone Projector: It was observed that a smartphone can be turned in a projector by use of a lens and a shoebox.

Verification of Beer-Lambert's law and determination of the molar concentration of copper sulphate solution using the app MobileMyLab:

The intensity of light decreases on passing through an absorbing medium such as a coloured solution, i.e. the emergent beam is less intense than the incident beam. Beer Lambert's law states that the *absorbance* of light is directly proportional to the thickness of the medium through which the light is being transmitted multiplied by the concentration of absorbing solution. Mathematically, $A = \varepsilon bc$ where A is the absorbance, ε is the molar extinction coefficient, b is the

thickness of the solution (cell length) and c is the concentration. The absorbance A is a property defined as

$A = - \log (I/I_{initial})$ ..... (i)

The ratio $I/I_{initial}$ is called *transmittance*. To prove Beer Lambert's law, a graph between absorbance and concentration is plotted. A line passing through the origin showing increasing intensity is observed with change in concentration if the law holds true. The absorbance measurements require a spectrophotometer or at least, a colorimeter.

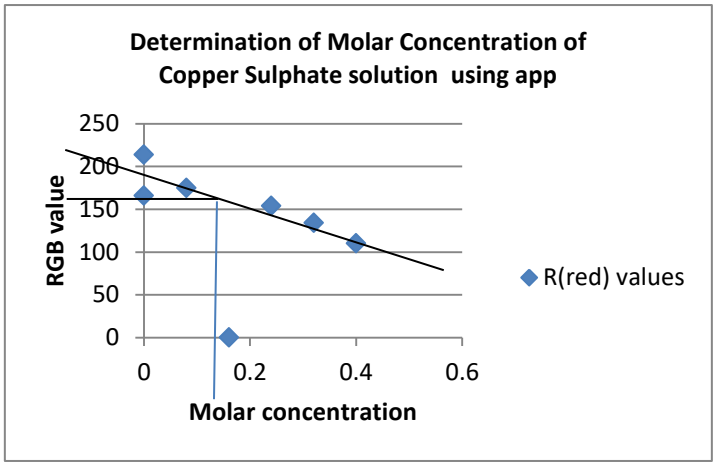
Since the mobile phone cannot measure absorbance, in this experiment, the camera of **mobilemylab** app was used to prove Beer Lambert's law by measuring the RGB value of different concentrations of copper sulphate solution.

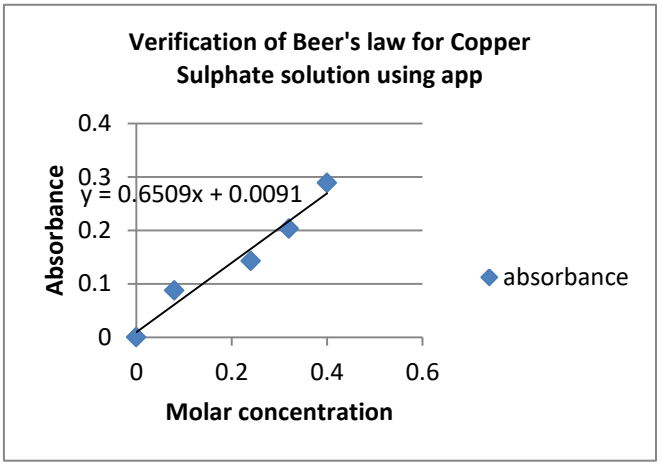
RGB (**Red, Green, Blue**) refers to a system for representing the colours to be used on a computer. Only the R (red) value is taken into consideration while plotting the graph for better result where

$A = -\log (R/R_{\mathbf{initial}})$, R being the Red value …… (ii)

Procedure

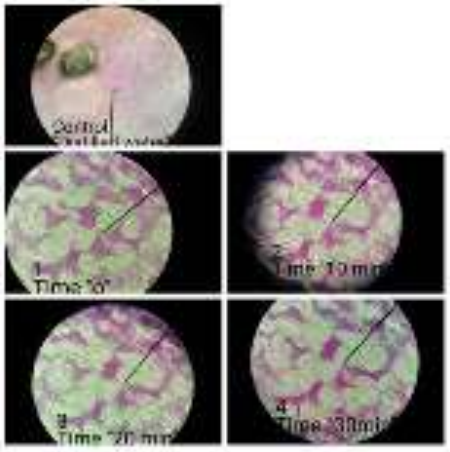
1) Using the camera through the **mobilemylab** RGB icon, the RGB value of solution in each test tube was obtained separately and saved by tapping on the SAVE option for each test tube. The final RGB values of all test tubes were viewed using CSV viewer. A graph was plotted between R (Red) value of all four solutions on y-axis and their concentrations on x-axis. The unknown molar concentration of copper sulphate solution was determined from the graph. The molar concentration of the unknown copper sulphate solution can be read directly from the graph or calculated as the slope of the straight line.
2) To prove Beer's Law, the R (red) values were converted into absorbance using the above Equation (ii) and a graph passing through the origin was plotted between absorbance and concentration. The unknown molar concentration of copper sulphate was also obtained from this graph.



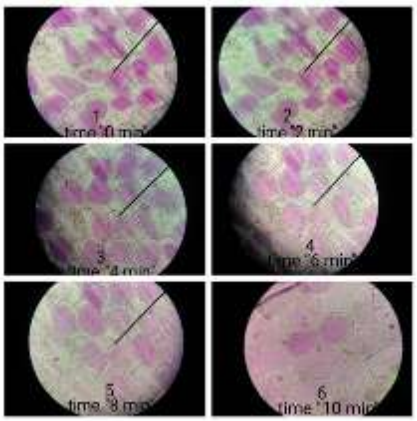


Biology Experiments

Plasmolysis in epidermal peel mounts of *Rhoeo discolor* leaf



Deplasmolysis in distilled water



The movement of the pedicel of *Papaver rhoeas* (ornamental poppy) bud when it prepares to open out: from day 1 to 5, and on the 7th day

Progressive colour changes in *Lantana* flowers following pollination: on day 1, 3, 5 and 6. Note the colour change from yellow to orange, and then to pink.

Comparison of the cell structure of epidermal peel mounts of *Rhoeo discolor* leaf under a binocular microscope (left) and the Foldscope (right)

8. Innovations shown by the project

Hands-on exploration of Science requires availability of laboratory set ups that are of appropriate quality, cost intensive, and available in requisite quantity in large classes. This is rarely the case across the world, particularly, in the developing world. This project highlights the enormous potential of the 'smart' mobile phone as a Science teaching aid. While there is already awareness about the various sensors featured on even low end smartphones and their potential as teaching aids, there has been no systematic study of such use in the interdisciplinary context. This project has made a beginning in documenting experiments with the smartphone.

The generic app *MobileMyLab* developed under the project allows the use of several smartphone sensors and freely available measuring apps in the Physics, Chemistry and Biology laboratories. Having made a beginning in this regard, the scope of this app can be expanded to include more such tools to make it more versatile.

9. Conclusion and Future direction

This project showed that Science students could derive huge benefits from using the smartphone as a lab tool. During the project, it was observed that the student researchers, being more at home with smartphone technology than the faculty mentors, were in a good position to suggest refinements in experiments. This was a tremendous confidence booster for the students and a learning experience for both teams.

Future plans include hands-on testing of the mobilemylab app through educational outreach activities in schools and colleges and further refinements in the app based on feedback from these activities. Extending the scope of the app to include Geography and Mathematics is also being considered.

10. References in APA format

Books

1. B. L. Worsnop and H. T. Flint, Advanced Practical Physics for Students, Asia Publishing House, New Delhi and Acrobat 7 Pdf 29.2 Mb.
2. D. P. Khandelwal, A Laboratory Manual of Physics for Undergraduate Classes, Vani Publication House, New Delhi
3. G. L. Squires, Practical Physics, Cambridge University Press
4. Nelson and Jon Ogborn, Practical Physics.
5. Kenneth Appel, John Gastineau, Clarence Bakken and David Vernier, Physics with Vernier, Lab books by Vernier Software and Technology
6. Larry Dukerich, Advanced Physics with Vernier, Lab books by Vernier Software and Technology
7. Pricilla Laws, Robert Teese, Maxine Wills, Patrick Cooney, Physics with Video Analysis, Vernier Software and Technology

8. J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Prentice Hall
9. Adarsh Gulati, V.C. Garg and B.D. Khosla, Senior Practical Physical Chemistry, R. Chand and Co.

Useful links

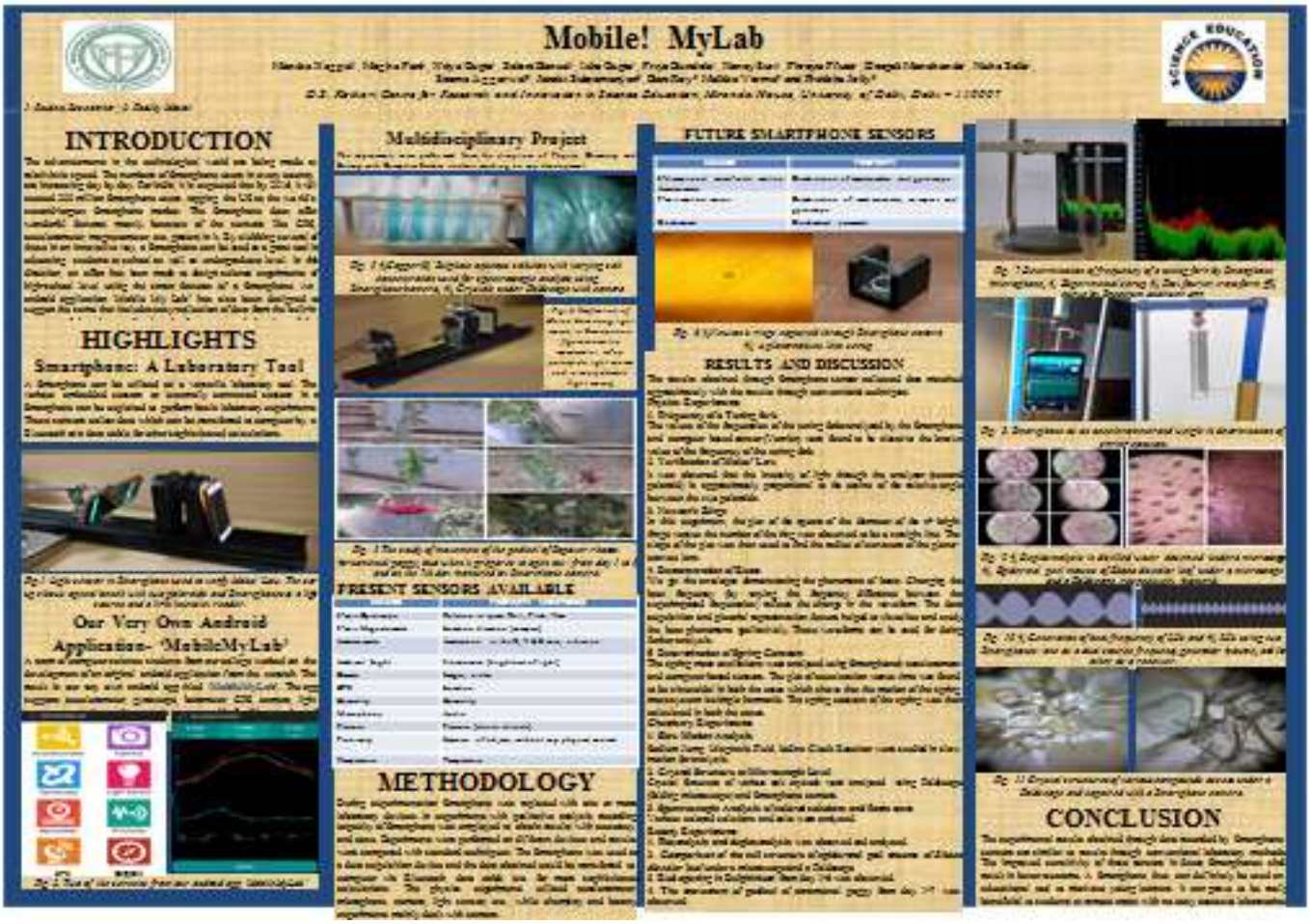
1. http://www.vieyrasoftware.net
2. https://sites.google.com/site/rebeccavieyraaef/
3. http://physicsbuzz.physicscentral.com/2015/01/your-smartphone-can-do-physics.html
4. https://opensignal.com/blog/2015/05/05/smartphones-in-the-classroom-2-teaching-physics/
5. http://www.slideshare.net/teemconference/doing-physics-experiments-and-learning-with-smartphones
6. https://itunes.apple.com/us/itunes-u/chemistry-comes-alive!-videos/id391599380?mt=10

11. Publication/s from the work

Subramanyan, J., Jolly, P., Manchanda, D. & Sella,N.2016 Health sensors and smart medical devices, Proceedings International Conference on Public Health Issue, Challenges,Opportunities,Prevention and Awareness,(Public Health:2016) ,
Editors: Roy,S., Mishra,G.C., Nanda,S., &Jain,A.
Vol II, pp 189-190, Krishi Sanskriti Publication, New Delhi,ISBN:978-93-85822-10-0

12. Conference Presentation

Poster Presented at Acharya Narendra Dev College Innovation Conclave 25 October 2016



13. Patent/s and Technology Transfer: No

14. Media Coverage: No

15. Pictures related to the project: Photographs related to experiment incorporated in text

16. Annexure/Any other information

- User Manual for MobileMyLab App developed under the project (pdf as separate attachment)

University of Delhi

Certificate of Originality

This is to certify that the research work carried out and the final report submitted by the Project Investigators and the students of Innovation Project having Project Code MH 305 and title *Mobile! MyLab Anytime, Anywhere* from Miranda House is original. Any plagiarism/academic dishonesty reported at any stage will be our responsibility.

Signatures of the all PIs

Utilization Certificate
Innovation Project 2015-16
Project Code -MH-305

Project Title : Mobile! Mylab Anytime, Anywhere

Audited Financial Statement under Innovation Project scheme

College: Miranda House

Project Investigators: Dr. Pratibha Jolly Dr. Bani Roy Dr. Mallika Verma
Dr. Janaki Subramanyan Dr. Seema Aggarwal

Grant sanctioned	(in figures) Rs. 6,50,000 (in Words) Rupees six lac fifty thousand only/-			
S.No.	Budget head	Amount sanctioned	Total Amount utilized	Amount Remaining
1.	Equipment/Consumables	3,75,000	3,75,089	(89)
2.	Travel	55,000	20,565	34,435
3.	Stipend	1,20,000	1,02,000	18,000
4.	Honorarium	25,000	12,000	13,000
5.	Stationery/Printing	20,000	20,081	(81)
6.	Contingency	55,000	31,170	23,830
7.	Others		76,000	(76,000)
Total amount utilized	**Rs. 6,36,905 (Rupee six lakh thirty six thousand nine hundred five only)**			
Amount Remaining.	**Rs. 13,095 (Rupee thirteen thousand ninety five only)**			**13,095**

Certified that out of Rs. **6,50,000/- (Rupee six lac fifty thousand only)** Sanctioned to Innovation Projects MH-305, out of which **Rs. 6,36,905 (Rupee six lakh thirty six thousand nine hundred five only)** has been utilized during the period of the project. The remaining amount of **Rs. 13,095 (Rupee thirteen thousand ninety five only)** is being returned back to the University.

Pratibha Jolly BRoy
Signature of Project Investigators

Mallika Verma Janaki
Financial Audit Clearance
and Stamp of Chartered Accountants

Dt. 04-11-2016

Pratibha Jolly
Signature of Principal

Principal
Miranda House
University of Delhi
Delhi-110007