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Triggering Innovative Output through Hands-On Learning at Undergraduate Level

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Abstract: **Innovative changes in educational setups world across need to be implemented to make the education more meaningful by integrating the industry, society and academia sectors. The concept of innovation and its applications in field of education need to be clearly spelt out by realistic examples both to the learner and the facilitator. The entrepreneurial approach for solving society related problems by the students can happen only by bringing three important changes in the educational environmental setup namely innovative curriculum, innovative educational setup and innovative role as mentor to be played by the teacher. In 2011, based on recommendation of India's National Innovation Council, University of Delhi has implemented the above-mentioned change in its educational setup by starting a Cluster Innovation Centre with non-traditional two undergraduates and one postgraduate course of studies. The innovative concepts of hands-on learning assisted by an engineering kitchen, industrial workshops, teaching mathematics through resource labs, freedom to design their own degree, project based learning to solve real world problems, innovative curriculum etc. have triggered an enhanced learning experience for students that has resulted in innovative output in form of products, designs and processes. The participative role played by learners in solving immediate neighborhoods problems based on the knowledge acquired in their course of studies has made the learning process more meaningful. The present paper reports the implemented pedagogical innovations and their outcome.**

Keywords: **Innovation, innovative pedagogy, hands-on learning, project based learning.**

I. INTRODUCTION

The learning environments or educational setups are dynamic systems, which keeps evolving with time. Various research papers related to suggestive changes in classrooms & laboratories, academia-industry relationships, innovative science teaching approach, Technology usage in education and different innovative education models are reported in literature [1-9].

In search for better pedagogical techniques, lots of experimentation in real educational settings is necessary. In specific context, transforming existing university educational system is possible and necessary for realizing the dreams of twenty-first century young, energetic, thoughtful, globally aware and risk-taking generation. Innovation is the key word for this. For desired creative and socially meaningful innovative output from the young minds pedagogical innovation shall start from school level and being realistically be implemented at university level. The aim of pedagogical transformation shall be to develop clarity, in the mind of students, of the concept of innovation and its practical application of developing entrepreneurs for solving societal problems. The classroom teaching has to take as big as 180-degree turn for this transformation. The classrooms need to be really converted into activity workspace. The science laboratories need to be transformed into engineering kitchens and industrial workshops. The mathematics has to be taught in mathematical resource labs rather than on blackboards. The humanities courses shall also be taught in project based learning mode and solution of the society problems shall be searched in scientific manner. For schools and colleges the need is for perforated boundary walls, which allow to and fro movement of students so that they can work on real world problems in real settings. The last but not the least change has to be brought in evaluation and promotional system too. The sequential progress from one class to another at school level and then categorization into science, art and commerce streams and again sequential progress from first year to final year at university level is too monotonous. This has stagnated the

learning process to large extent and has promoted rote learning. Instead, at school level, from the initial stages emphasis shall be on physical activities and skill development to have healthy, educated and skilled human resource ready for taking up the challenges. At university level, an interest-based learning shall be promoted without boundaries of subjects with the freedom in hands of students to design their own degree. The best of the use of information technological advances (ITA) shall be made for realistic implementation of these pedagogical innovations in the education system. The present paper reports the innovative outcomes triggered through hands on learning at undergraduate level at Cluster Innovation Centre, University of Delhi in support of the suggested measures.

II. INNOVATION: UNDERSTANDING THE CONCEPT IN EDUCATIONAL ENVIRONMENT

Innovative pedagogy follows when concept of innovation is nurtured in educational setups. Equal likely, innovative pedagogy give rise to innovation in educational context. It is important to note that education is imparted for knowledge transfer, for individual's growth and success, for society development, for evolving processes and procedures, for character building and enabling the learner with skills etc. However, the current adopted system of imparting education both at school and college level (specifically in India) has structured itself to impart knowledge and more knowledge at a very fast rate without bothering the intake capacity of the learner. This has taken away the joy of learning as well as enjoyment associated with teaching. More elaboration of the problem is not necessary here as it is prevailing for long and is acknowledged by all concerned. To bring back the charm of learning and teaching the driving force for transformation indicates that the changes shall be in innovative ways all along in content, educational setup and pedagogy and that to preferably in that order.

To begin with, it is important to understand that the word innovation implies use of knowledge, experience and creativity to design new or transformed products, processes and applications, which provide comfortable, simplistic and better solutions to problems both at local and global level. A careful reading of this implies that our educational setup and pedagogy is needed to be purely based on concept of innovation. Till now this is partly followed in schools and colleges. The question may be why are we not doing this. It is primarily because innovation comes into existence when maximum potential from a process, system or technology has been achieved and till this point the need that derives innovative thinking doesn't stimulate.

With advent of information technology supplemented by superfast communication methods and easy access to knowledge has made it mandatory for all of us to take education practices to the next level. The students are no more solely dependent on teachers for acquiring knowledge. This indicates the role played by teachers has to under go a change. The way students dealt with the acquired knowledge has also to transform. The knowledge does not put to use fades away very quickly. However, any newly acquired knowledge put to use gives rich dividends. This indicates the need for change in current curriculum content and a new role for teachers. It necessitates a change in prevailing educational setups. Accordingly, the three prong changes required in educational environmental setups based on concept of innovation are:

- Innovative curriculum
- Innovative educational setup
- Innovative role as mentor to be played by the teacher

Taking a lead in implementing the innovative pedagogy in education, University of Delhi in 2011 established the Cluster Innovation Centre (CIC) with the objective of fostering an ecosystem of innovation and connecting research with application for the benefit of society. The Centre has been designed to seek and drive innovations from industrial clusters, village clusters, slum clusters and educational clusters and to inculcate an innovation mindset as part of the curriculum and pedagogy. The Centre strives to stream relevant ideas and programmes stemming from the above mandate into its learning and research programmes. Given below are the details of implementation and results based on outcome of the students' performances under different program at CIC.

III. DEVELOPING AND FOLLOWING AN INNOVATIVE CURRICULUM

The present curriculum of various courses and study programs in schools and colleges (in India) are knowledge based and content driven. The application base is either completely missing or is present in form of prescribed fixed set of practical. It is the need of the hour that emphasis is shifted from acquiring knowledge to applying knowledge for finding solutions to the problems surrounding us and for bringing changes in the society we are living in. For this, content in every paper taught in every subject shall have certain limited emphasis on theoretical knowledge and mainly focuses on project based learning.

The three courses taught at Cluster Innovation Centre, University of Delhi namely, (i) B. Tech. (IT and Mathematical Innovation), (ii) B. A. Honours (Humanities & social sciences) and (iii) M. Sc. (Mathematics Education) are very different from regularly offered courses. In each of these courses, there is 40% emphasis on theoretical knowledge and 60% emphasis on project based hands-on learning. Students coming straight from schools, where they followed a fixed prescribed syllabus based learning method; find the change a little disruptive. However, students quickly accommodate with new innovative philosophy as they find it easy to connect with it. It happens as it provides them flexibility to choose the problem they want to solve and that to by the method they want to adopt. To make the point clear we are reporting three examples of projects one from each course done by the students:

(i) A project titled "Popularizing mathematics among masses through radio" done by students of M.Sc. (Mathematics Education)

(ii) A project titled "Designing a software for evaluation of OMR type answer scripts using a scanner or mobile phone" done by students of B. Tech. (IT and Mathematical Innovations)

(iii) A project titled "The Problem of Sanitation and Hygiene in Azadpur Vegetable Mandi: Looking for Solutions" done by students of B.A. Honours (Humanities & Social Sciences)

In the first case, students of M.Sc. (Mathematics Education) in theory papers were taught about innovative methods of teaching mathematics at schools and were exposed to use of media and its role in education. In workshop mode students were familiarized with Radio Production and Broadcasting techniques such as, audio and voice recording; editing prerecorded content to broadcast quality standards; producing audio content and ability to carry out radio show. This was a hands-on learning experience for students. In an effort to make students more resourceful, participative and innovative, a two and half months long Community Radio Series on Popularizing Mathematics among Masses was conducted along with faculty members and field experts. It was an outreach program on making mathematics more eloquent and interesting for common people through the Community Radio Station at A. J. K. Mass Communication Research Centre (MCRC), Jamia Millia Islamia, New Delhi.

Mathematics is largely viewed as a dull and highly mechanical subject where only few can have mastery in it. All those who are not related to mathematics-allied professions don't appreciate the contribution of mathematics in their lives. This program was an attempt to present humanistic perspective of mathematics. This kind of discourse may also interest students who would like to know more about mathematics beyond their curriculum. Each weekly program of the series was focused on unconventional themes, namely:

(i) Yeh bhi Jaanna Jarori Hai (This is also necessary to know)

(ii) How to make Mathematics Child Friendly

(iii) Mathematics in Everyday Life

(iv) Women Mathematician

(v) Career in Mathematics

(vi) Discussion on relation between language and mathematics

(vii) Mathematics Journey so far

The content of each 30-40 minute live telecasted program was developed and presented by the students under the guidance of teaching faculty. The radio series motivated the students for collecting data on various aspects of life related to mathematics, enhancing their communication skills and also helped them in experiencing another technology with potential use for teaching and learning. These deliberations also helped students to articulate their ideas in a team work and to explore possible ways to connect with masses.

In the second case, students of B. Tech. (IT and Mathematical Innovations) who were taught concepts of mathematics and IT were asked to apply the concepts and come up with some applications for solving problems they face around them.

In one of the project, students designed a customized OMR sheet, conducted a mock test and developed mathematical algorithm for reading & evaluation of OMR sheets by commonly available scanner or mobile phone. The developed technique is then applied for conducting MCQ type Internal Assessment tests at Cluster Innovation Centre. Shown below in Fig-1 the sample of OMR sheet, its reading of recorded data, comparison with answers and Score Marks.

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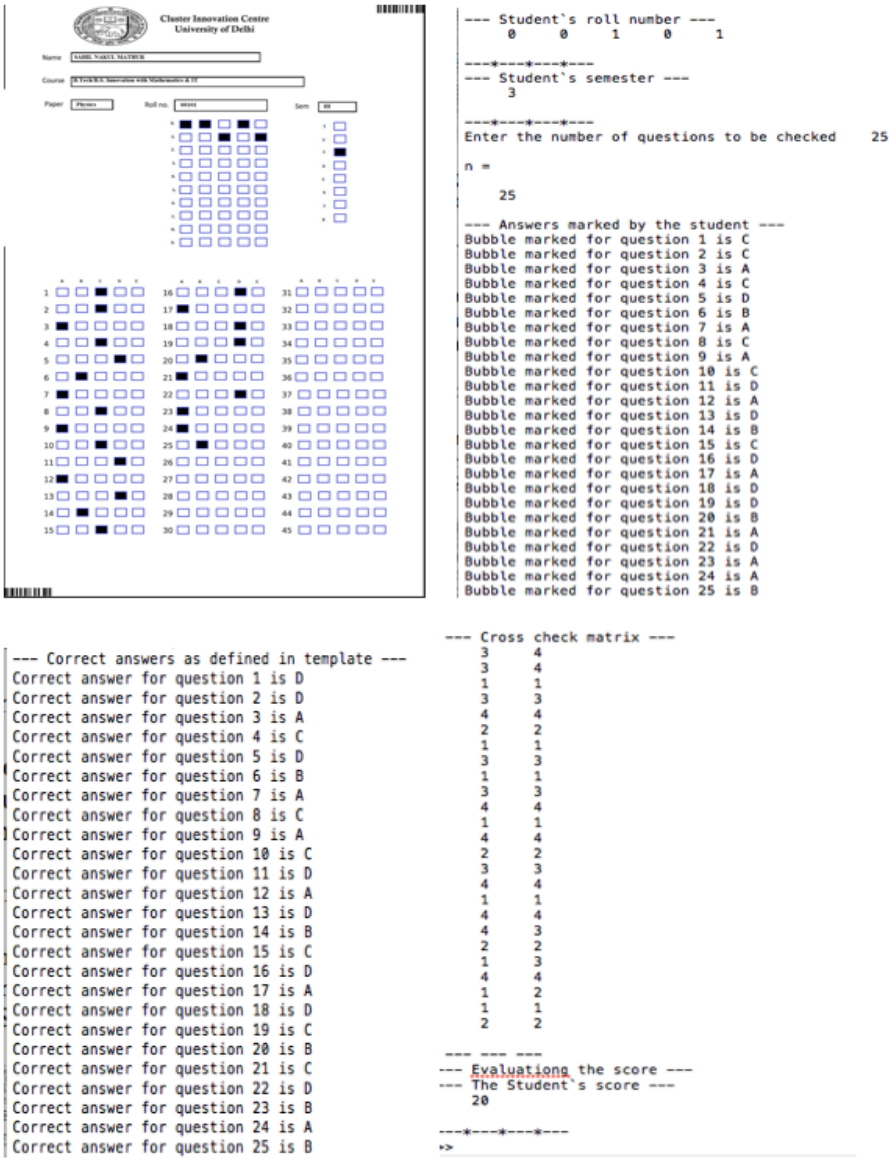

Fig 1: Sample OMR Sheet and data analysis

Here, the methodology adopted depicts that students are instantly encouraged to apply the acquired knowledge to problem solving. This keeps the students interest in studies alive as it appears meaningful to them.

In the third case, students of B.A. Honours (Humanities & Social Sciences) did a project titled "The Problem of Sanitation and Hygiene in Azadpur Vegetable Mandi: Looking for Solutions". This project aimed to understand the sanitary and hygiene conditions at the Azadpur Vegetable Market in Delhi and provide alternate solutions to improve the situation. The study focused on a survey of the hygiene and sanitation conditions in the Mandi and compares them with standard parameters. The method adopted was interviewing the labourers, porters, shop owners and others at the Mandi to collect information about the impact of the existing sanitary and hygienic conditions in the study area. This also involved an interaction with doctors of the hospitals/health centres in the surrounding areas to find out about the types of health problems faced by people residing in, and the adjoining areas of, the Mandi. Here too, students of humanities stream were trained to handle the social problems around them and to look for a viable solution. Here, it shall be noted that every class has around 40 students and every project has about 3 to 4 students.

It is very clear from the above explained project based hand-on learning methods of problem solving by the students that for sustaining education and making it more meaningful the pedagogy shall be innovation driven and provide flexibility to both the teacher and the students.

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IV. BUILDING UP AN INNOVATIVE EDUCATIONAL SETUP

The innovation-based learning necessitates a transformation in the existing educational setups. In this regard, some successfully experimented and implemented changes are explained below:

A. Classrooms shall pave way to activity workspaces:

The first transformation for output driven education has to be brought in classrooms. The classroom equipped with black or white boards and projectors actually need to be converted into activity workspaces. It shall be a place where students love to go. Everyday in classroom shall begin with freedom to students to carry out some activities, which are not predetermined. This is the time when individual brain is forced or liked to think innovatively of its own without boundaries.

Activity workspace in actual is a place for floating ideas and planning their execution. At workspaces, the role of teacher too undergoes a transformation as mentor, teachers need to overcome their own boundaries of subjects and promote interdisciplinary talks and projects. The pedagogy of imparting knowledge also needs to be transformed. It shall be imparted in such a manner that even during this process students mind is on applying it for some applications. Even hobby classes shall also be incorporated into activity workspaces. For example, at Cluster Innovation Centre, Robotic Lab and Reading Rooms self-managed by student are the most engaged activity workspaces. Most of the ideas from students belonging to different courses emerge and merge into reality at these places. Inter-disciplinarity and self-learning integrate students of different streams faster than anything else.

B. Laboratories shall pave way to Engineering Kitchen:

To execute science based innovation projects the concept of engineering kitchen is practiced at Cluster Innovation Centre. Engineering kitchen is a replacement for science laboratories. Like a kitchen, it is only equipped with loose ingredients necessary for carrying out subject specific projects. For example, for physics and electronics based projects commonly available stuff like electric wires, resistances, capacitors, multimeters, logic gates, ICs, pendulum bobs, vernier calipers, screw gauge, tool kits, nut bolts, soldering kits, Arduino products etc. are stored in it. However, based on project idea and on mentor's recommendation students are encouraged to help the institute in procuring other needed items from time to time. This brings in the flexibility even in conducting presently prescribed practicals with modifications. It is this feature of engineering kitchen that provides opportunity for the students to do innovation. For example, even converting a simple pendulum to a mechanical clock requires an independent thinking and lots of hands on work, which is based on concept that you learn when you do. This also provides lots of opportunities to the teacher for unfolding many concepts in front of the students. For example, under papers titled "Physics at work: Deconstructing Machines and Devices" students are encouraged to open and reassemble many daily use machine based devices like grinder, mixer, sewing machine, electric iron, electric heater and blower etc. and their physics is taught then and there only. This also inculcate a habit in students for using internet for searching for matter relevant to their need from education point of view.

C. Engineering Kitchen concept to be supported by design fabrication:

To actualize the innovation concept of transforming knowledge and practices into products, the engineering kitchen shall be supplemented by industrial workshops. This is the design space. Without learning to design products hands-on activities will not lead to solutions for local problems. For physical designing of models space need to be equipped with lathe machine, cutters, drill machine, etc. and for IT related product design the computer labs be equipped with high end computing machines and servers. At CIC a Design Centre has been setup for this.

D. Developing Mathematical Resource Laboratory for teaching mathematics:

Even though for each subject there can be separate pedagogy, mathematics shall always be taught innovatively and that is through mathematical resource laboratory. CIC has created one such place where students of M.Sc. (Mathematics Education) have developed innovative resources for teaching mathematical concepts. Being part of their curriculum, these students design various actual models for teaching various concepts of mathematics to the school students [10]. For the evaluation of working of these models various school students are invited to explore these models. Based on feedback from school students the course students are awarded grades. The innovative pedagogy of teaching mathematics through models was also practiced in actual classroom settings in more than 20 schools and 30 classes from class VI to X. It is observed that the concept learning enhances manifold by this pedagogy. Further, students are encouraged to design

models based on societal needs. For example, one batch of students developed resources for teaching mathematics to visually challenged people, while another group worked on designing of a basic mathematical kit to assist mathematical development among children with autism [11]. The mathematics resource room developed by students at CIC has models based on following:

- Tangram
- Pythagoras Theorem
- Vedic Mathematic square
- Magic polygon puzzle
- Magic square of Great Indian Mathematician Srinivasa Ramanujan
- Mathematical tools in Architecture
- Napier Bones multiplication techniques
- Galaxy of Mathematicians
- Fun loving crossword
- Fibonacci Numbers and Golden ratio
- Martin Garner's Mathematical puzzles
- Mathematical board games
- Banking of roads
- Origami- Pedagogical significance

Also, students have prepared videos telling about different mathematical concepts such as:

- Math Tricks and Modules
- Approaches of Probability Theory
- Quadratic Equation Ghost
- Relations and functions
- Permutation and combination
- Rational Numbers
- Fractions

These videos are evaluated for grading the students and are also uploaded on YouTube for wider public consumption as well.

E. Scientific approach for imparting knowledge of humanities subjects:

Even for teaching humanities subjects, project based learning is needed. The students shall be enabled to find solution process for the social problems in scientific manner. For this it is necessary to integrate science and social science subjects at student level. It happens only when projects are done by joint participation of students from different streams. For example, to work on a project finding solution for shelters for homeless during winters and summers, both social and technical inputs are necessary. In one such project at CIC, while humanities students helped in understanding the problem from social aspect the students from technological background provided physical feasible models for foldable houses.

Allowing intermixing of even different humanities subjects at CIC has resulted in a better skilled human resource. For example, students want to pursue journalism and that to in economics are given freedom to choose their core papers from both the streams under "design their own degree" concept. The students are allowed to study these various subject specific papers in different colleges of University of Delhi in nearby places. It helped students, as in above example, to pursue career in economic journalism.

The above suggested and practiced innovations in educational setup have resulted in enhancing the learning level of students and have equipped them well with the skills for the prospective career. In addition to this, all students mandatorily go for evaluative internships in industrial setups. This integration of academia and industry helped institution not to conduct campus placement kind of activities for providing jobs to their students. Instead, all those who performed better during the internship period at different companies were offered job then and there only. Based on their interest, those interested in higher education are allowed to do internships at various research centers of India. In fact, many students have published research papers at undergraduate level [11-14].

V. INNOVATIVE ROLE-PLAY BY TEACHER

The innovative curriculum and innovative educational setup bear fruits only when supplemented by innovative role by the teacher as mentor. Mentor is the one who guide the student at every step of its learning not only by the knowledge he or she possesses but also by making sure that all his or her needs are taken care from existing sources of knowledge and practices around us. Mentor not necessarily be the subject expert but shall have access to provide right help to the learner. At time, mentors too have to follow the traditional pedagogical methods for imparting education. However, mentor shall make it sure that learner is in good conversation with him so that ideas of the learner get unfolded in the manner in which he wants them to happen. At no point mentor shall impose his authority to modify the learner's ideas unless he is supporting the changes willingly. This mechanism is very necessary for growth of innovation in educational setup.

For example, in the institute, at the beginning of the semester, innovative ideas are invited both from students and faculty members. During a common meeting all floated ideas are written on board, explained and discussed. Follow these marathon discussions; participants voluntarily join the group they like to work with. The participating teachers adopt the role of mentor in the group. Several times the external mentors are too arranged. This arrangement also provides opportunities for faculty member to acquire fresh and updated knowledge in many recent topics.

VI. CONCLUSION

The reported paper clearly shows that innovative changes in educational set ups are necessary to make the education more meaningful to the learner. The changes implemented through non-traditional courses of studies with innovative curriculum and focus on hands-on learning under the guidance of mentor has shown that students' participation in learning has enhanced manifold by these practices. Interlinking of industry, society and academia sectors helped students to solve the real world problems i.e. the knowledge gained during acquiring process is put to immediate use. Students are more comfortable seeing the teacher in the role of a mentor. This made the bonding between the two stronger. Clear understanding of the concept of innovation through hands-on learning helped students to use their educational skills creatively for model and product designing and thus pushing them towards the entrepreneurships. Further, the interdisciplinarity of projects as innovative pedagogy helped students of one stream to understand the importance of other streams as well.

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REFERENCES

[1] Avi Hofstein and Vincent N. Lunetta, "The laboratory in science education: Foundations for the twenty-first century" Science Education, Volume 88, Issue 1, January 2004 , Pages 28–54

[2] Maura Borrego, Elliot P. Douglas and Catherine T. Amelink, "Quantitative, Qualitative, and Mixed Research Methods in Engineering Education" The Research Journal for engineering Education, Volume 98", Issue 1, January 2009, Pages 53–66

[3] Markus Perkmann and Kathryn Walsh, "University–industry relationships and open innovation: Towards a research agenda", International journal of management reviews, Volume 9, Issue 4, December 2007, Pages 259–280

[4] Elaine Seymour, "Tracking the processes of change in US undergraduate education in science, mathematics, engineering, and technology", Science Education, Volume 86, Issue 1, January 2002, Pages 79–105

[5] Karl A. Smith, Sheri D. Sheppard, David W. Johnson and Roger T. Johnson, "Pedagogies of Engagement: Classroom-Based Practices", The Research Journal for engineering Education, Volume 94, Issue 1, January 2005, Pages 87–101

[6] P. S. Aithal and Shubhrajyotsna Aithal, "An Innovative Education Model to Realize Ideal Education System", International Journal of Scientific Research and Management (IJSRM), Volume 3, Issue 3, 2015, Pages 2464-2469

[7] Sibananda Sana and ChandanAdhikary, "Modern trends in pedagogical practices for teacher educational institutions", International Education & Research Journal, Volume 3, Issue 5, May 2017, Pages 697-701

[8] Jee KyungSuh and Soonhye Park, "Exploring the relationship between pedagogical content knowledge (PCK) and sustainability of an innovative science teaching approach" Teaching and Teacher Education, Volume 64, May 2017, Pages 246-259

[9] Aibhin Bray and BrendanTangney, Technology usage in mathematics education research – A systematic review of recent trends, Computers & Education, Volume 114, November 2017, Pages 255-273

[10] Jyoti Sharma, Pankaj Tyagi, "Revival and Innovations in Mathematics Pedagogy: A Case Study", International Journal of Innovative Trends in Engineering, Volume 1, Issue 1, 2014, Pages 13-16

[11] Vashishth Himanshi, Sangeeta, Jyoti Sharma, Pankaj Tyagi, "Designing of a Basic Mathematical Kit to Assist Mathematical Skill Development Among Children with Autism" International Journal of Advanced Research in Education & Technology, Volume 3, Issue 3, 2016, Pages 153-158

[12] Pankaj Tyagi, Jyoti Sharma, Kamal , Ranjan, Vikas Tomar, Raghavendra Tripathi, "Trig-Disc: An innovative device for determination of values of trigonometric functions with single measurement", International Journal of Innovation and Scientific Research, Volume 27, Issue 1, 2016, Pages 216-224

[13] Shobha Bagai, Parul Madaan, Tarun Khajuria , "A Mathematical Model for the Effect of Earthquake on High Rise Buildings of Different Shapes" DU Journal of Undergraduate Research and Innovation, Volume 2, Issue 1, 2016, Pages 180-188

[14] Shikhar Sharma, Raghavendra Tripathi, Pankaj Tyagi, "Development of Target-Group Specific Innovative Android-Based Mathematics Educational Modules" DU Journal of Undergraduate Research and Innovation, Volume 1, Issue 1, 2015, Pages 224-232