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Learning Through Innovative Undergraduate Research: Enhancing College Impact, Professional Development and Social Outreach

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ABSTRACT

Promoting innovative ways of learning by combining it with real life challenges enhances the learning experience and helps encourage youth to find solutions to global and societal problems. Promoting Undergraduate Research (UR) is pivotal in providing an impactful college education. This paper studies impact of year-long student-faculty innovative research projects at college level for enhancing learning and developing a research culture at the undergraduate level. Increased interest to undertake research and skill enhancement were main student outcomes. Professional development of college teachers and generating social impact were other significant outcomes. Insights are shared for successful replication in predominantly taught Higher Education Institutions (HEIs) in national and international contexts. This is the first report of its kind with the involvement of faculty and students of over 60 colleges of a University at the undergraduate level; and Inquiry Based Learning based on over 300 research projects involving over 900 teachers and over 3000 students. The study is significant in promoting a research mindset early in higher education and the first such model in developing countries.

Keywords: Undergraduate Research, College Impact, Inquiry Based Learning.

INTRODUCTION

As observed by the Boyer Commission, 'Many students graduate having accumulated whatever number of courses is required, but still lacking a coherent body of knowledge or any inkling as to how one sort of information might relate to others' (1998, p. 61). The report propounded the relation between research and scholarship and in that relation brought to light the need for research programmes at the undergraduate level. Inquiry Based Learning (IBL) caters to the goals of higher education set forth by the Humboldtian education ideal and research serves as an effective mode of learning and teaching in the inquiring society (Clark, 1997). Undergraduate Research (UR) is an essential part of IBL, taking a seat in the heart of the teaching-research nexus. Undergraduate research can be understood as an attempt to engage students joining Higher Education Institutions (HEIs) in academic and creative enquiry and in the creation and dissemination of knowledge, ideas and innovations. The benefits of such engagement are plenty.

Boyer (1998) emphasised UR as a necessary practice for research universities. Kuh (2008) identified UR as a high impact activity in Higher Education that can help students gain essential learning outcomes like knowledge of human cultures, physical and natural world; intellectual, experiential and practical skills; and integrative and applied learning abilities. Empirical research strongly suggests that UR has positive transformational effects like increased academic achievement and retention (Cole and Espinoza, 2008); clarity in choice of academic major (Seymour et al., 2004); interest and preparedness in joining graduate research programmes (Seymour et al., 2004; Lopatto, 2004, 2007; Russell, Hancock & McCullough, 2007); building career ambition and other avenues of personal and professional development (Carpi et al., 2017; Hunter, Laursen & Seymour, 2007). Studies with alumni at the University of Delaware, which adopted institution-wide URP in 1980, showed that participation in URP enhances ability to develop intellectual curiosity, acquire information independently, understand scientific findings, analyze literature critically, speak effectively, act as a leader, and possess clear career goals (Bauer & Bennett, 2003, 2008).

The ability to think critically, to analyse problems and to make informed decisions when faced with complex knowledge is required of all professionals in the twenty-first century. In the knowledge economy, the passive reception of knowledge as a given, regardless of one's mastery of this skill, is of little to no use. There is a growing need for 'deep learning' that involves 'examining new facts and ideas critically, and tying them into existing cognitive structures and making numerous links between ideas' (Houghton, 2008, 11). The realisation of this led universities to see research and inquiry as important in students' development and the transition to teacher-scholar model was promoted (Brew, 2006; Kartin, 2003). The agenda for promoting UR is strenuous for institutions that don't follow the teacher-scholar model. Students in such colleges and institutions don't have access to an environment filled with well-funded faculty, postdoctoral fellows, and graduate students who have the resources and expertise for encouraging them to take up research at undergraduate level. In such institutions, the motive is not to promote a culture of UG research, but to promote a culture of research; one in which both students and teachers stand to gain. Further challenges include finance, space, administration, evaluation, and large enrolment among several others.

This paper puts forth the case of Innovation Projects at the University of Delhi as an innovative model of UR programme that is suitable for replication in HEIs. With a survey of theoretical underpinnings for designing URPs, it elucidated the structural benefits of the Innovation Projects scheme. It grapples with the context of Higher Education in Indian affiliated colleges and in US four year colleges in understanding Innovation Projects as an

effective model for enhancing college impact through interdisciplinary, collaborative projects. Results from online surveys and case studies are also presented to verify the practicality of the conceptual appeal the programme holds.

Context for a New Programme

Promoting academic research at the Undergraduate level is a challenge for any HEI, especially ones that have not transitioned to the teacher-scholar model. Faculty and students at these institutions face alienation from academic research due to heavy teaching load, dearth of research programmes, infrastructure and funding opportunities. Such concerns have been found to prevail among college faculty in the US (Baker et al., 2015; Baker et al., 2017; Johnson et al., 2015). The case is all the more true in India and other developing countries.

In India, colleges affiliated to public universities account for more than 77% of all UG enrollment (All India Survey of Higher Education [AISE], 2015). Despite being affiliated to research-intensive Universities, due to their physically scattered nature and lack of research programmes and funding opportunities, there is alienation between academic research activities in University departments and the teaching of undergraduates at the colleges. The conventional approach is to introduce research at the Masters level and to take up in-depth research in M.Phil. and Ph.D. levels. Only about 14% of all students in Higher Education enroll in these degrees (AISHE, 2015). The first degree is the final for most students, making it necessary to ensure that young men and women completing UG courses are exposed to research trends and gain deep learning abilities that in turn contribute in graduate employability, responsible citizenship, research, innovation, and development. Sharma (2013), writing the history of the University Grants Commission (UGC), the Indian national higher education funding agency, says 'They [undergraduates] should develop basic skills and knowledge necessary for employment in various professions and industries… with training for an enlightened citizenship' (p. 65). She also emphasised the symbiotic relation of research and teaching and need for group projects and problem-based learning starting right from undergraduation (p. 340-41).

Characteristics of Successful URPs

HEIs with thriving innovative ecosystems, generally share some essential and good-to-have characteristics that effectively promote UG research. From studying best practices in the US, the UK and other countries, the Council on Undergraduate Research (CUR) (2012) and the Higher Education Academy (Healey & Jenkins, 2009) identified some factors for designing, implementing and evaluating a varsity's UR initiatives. Two of the suggestions therein, pertinent to the context of the University of Delhi's affiliated colleges and other such HEIs, are discussed below.

Infrastructure

Space and infrastructure are of serious concern. Facilities and student-teacher spaces like project labs and studios are difficult to arrange within the constraints of the college. The subscription to scholarly journals, however, is being supported through the National Knowledge Network and the N-List program (INFLIBNET Centre, n.d.) and most of the colleges in India have access to journals through the college wifi facilities. OpenAthens and similar initiatives are also helpful. However, how many teaching institutions have subscription to such services and whether and for what purposes students use these services are unclear.

UG Research Office

Setting up an Undergraduate Research Office will be beneficial for monitoring and facilitating the research activities at the undergraduate level. However, setting up a central office in large and physically scattered university systems is a relatively new practice. Oxbridge departments, centres and colleges make a range of opportunities available for their students but do not have a unitary UG research office. The Oxford Career Services helps students get research internships within the university, in partner institutes, and the industry. The UROP of University of Cambridge Department of Engineering is another instance. However, neither have an independent UG Research Office, as in the case of its US counterpart Harvard's URAF.

The colleges of the City University of New York have their own noteworthy UR offices and programmes (Caplan & MacLachlan, 2014), however the centrally administered 'Research Scholars Programme' (a yearlong funded laboratory experience, research assistantship and summer symposium) and the 'C-SURP' programme (a mentored summer research with USD 4000 stipend, free accommodation, and travel expense) of the Advanced Science Research Center are suitable examples to begin with for promoting UR in university systems (CUNY, n.d.). The Innovation Desk at the Research Council has been instrumental in managing and setting uniform guidelines for smooth conduct of URPs at the University of Delhi.

URP Models

Keeping in mind the context and challenges engulfing UR initiatives in colleges, it is important to understand the theoretical foundations before attempting to design or evaluate new programmes. There are several structural models of mentored URPs. Capstone projects, dissertation and senior thesis, creating a database of faculty-mentored research opportunities, research work-study, travel grants for attending conferences, summer internships, and publishing a journal of UG Research are the most common models currently in practice (University of Houston, 2008, p. 18). The choice of model and the design of the programme, including eligibility and selection criteria, funding size, and time period among others, is influenced by the current status and future trajectory of the campus-wide initiatives for research, innovation and importantly for enhancing college impact.

Apart from these structural models, there are also theoretical classifications that conceptualize and help understand the design requirements of the programme for achieving the intended learning and research outcomes. The continua of UG Research laid out by Beckman and Hensel (2009), allow for a range of programmes with varied impact. While the focus of their work is on the definition of UG research, its implications on programme design are to be noted. Continuums 2 - 5 of Table 1 (adapted from Beckman & Hensel, 2009) have immediate implication on the goal and structure of the programme whereas the rest are

overarching.

Table 1:*Dimensions of Undergraduate Research and Inquiry (Beckman and Hensel, 2009)*

1	Student, process centred	< === >	Outcome, product centred
2	Student initiated	< === >	Faculty initiated
3	All students	< === >	Honors students
4	Curriculum-based	< === >	Co-curricular fellowships
5	Collaborative	< === >	Individual
6	Original to the student	< === >	Original to the discipline
7	Multi- or interdisciplinary	< === >	Discipline-based
8	Campus/community audience	< === >	Professional audience

Haley (2005) (further amended in Healey & Jenkins, 2009) developed the classification of research − based, oriented, led, and tutored − programmes based the nature of UR and inquiry with two axes, focusing on student participation (as audience *vs* as participant) and research (content *vs* process and problems).

The Sheffield Centre for Inquiry-based Learning in the Arts and Social Sciences proposes a four-fledged IBL model (Levy, 2009; Levy et al., 2010) which is based on the nature of the student-knowledge interaction: (a) *Authoring* − Students explore their own open questions, problems, or lines of inquiry ('how can I answer my open question?'), (b) *Producing* − Students explore open questions/problems framed by teachers or others ('how can I answer this open question?'), (c) *Pursuing* − Students explore a knowledge-base by pursuing their own questions/problems ('what is the existing answer/response to my question?'), and (d) *Identifying* − Students explore a knowledge-base actively in response to questions, problems, and scenarios framed by teachers ('what is the existing answer/response to this question?').

Multhaup et al. (2010) highlighted three models of UR projects based on the nature of student-teacher interaction: (a) the *traditional model*, in which an undergraduate joined a professor's ongoing research project; (b) the *consultant model*, in which an undergraduate conducted a largely independent project with a professor's guidance; and (c) the *joint-creation model*, in which a student and the professor launched a new project together. They identified faculty's career stage, student's prior research experience and underlying reason of undertaking the project (for the faculty member and the student) as factors affecting the model choice. The nature of student-teacher interaction (Multhaup's classification) or student-knowledge interaction (IBL model) in turn influences the structural makeup of the programme.

Overview of Innovation Projects

The University of Delhi has taken several initiatives to promote undergraduate research like the Innovation Projects, Innovation Plaza, and the Delhi University Journal of Undergraduate Research and Innovation for promotion of UR in its affiliated colleges (Author et al., 2017). The scheme of Innovation Projects is the first of its kind in India and with the University funding of this magnitude, perhaps the first in the world. It was introduced with the aim of promoting creative thinking and analytical skills in young undergraduates, promoting a research culture in colleges and fostering an innovation ready mindset in students and college researchers. A group of ten students along with two to three teachers undertake year-long projects with funding of upto Rupees Ten Lakhs (~15,500 USD) from the University. The projects are usually aimed to address a real life challenge and find solutions for it. The resources of the college and of the University's laboratories, libraries and centres could be utilized for meaningful outcomes. An external mentor from another institution or the industry advises on the direction, knowledge base and progress of the project. The aim of the scheme is to provide research opportunities to the teachers and students; to promote interdisciplinary and innovative enquiry; to help students and faculty pick up professional and life skills; and to generate social impact.

The Innovation Projects scheme was launched in May 2012 with 113 projects. An Innovation Desk was set up as the administering authority (Research Council, 2015). The second round (2013 - 15) had 227 projects and the third round (2015- 16) that concluded in December 2016 with 317 projects saw 62 affiliated colleges participating, with over 900 teachers and over 3000 students involved. An Innovation Plaza was organized for the first two cycles where each project was provided stall space to showcase the outcomes and share with the University community and society. In the last cycle, the most promising projects were invited to present posters at the University Convocation.

Design components

The structural elements of the Innovation Projects in relation to the dominant theories that inform URPs are as follows:

- Co-curricular (year-long)
- Mentored projects (with varying levels of faculty involvement and an external mentor)
- Open to all UG students (Honours, non-Honours and also vocational degrees) and faculty members
- Collaborative and interdisciplinary group projects (with students, teachers and external mentors from different disciplines)
- University funded, along with a small stipend and honorarium for students and mentors respectively.

The scheme is accommodative of research in a wide variety of fields and ensures adequate representation of projects from all subject areas including Sciences, Humanities and Social Sciences (Research Council, 2015). The programme does not restrict the nature of the student-teacher or student-knowledge engagement and is open to projects of all kinds. Outcome-oriented projects that show the potential for finding solutions for societal problems, developing innovative ideas, business ventures, filing patents and resulting in peer-reviewed research publications are given priority. However, projects that focus on student learning and

use the project as an alternative pedagogy for learning and skill enhancement are also welcome. The provision for inviting a scholar or industry expert as a mentor allows for institutional collaborations and acquisition of necessary resources in terms of knowledge, network and also laboratory facilities.

METHODOLOGY

This study undertook a cross-sectional impact assessment with mixed design in two parts. Firstly, all participants of the 2015-16 cycle were emailed for an online survey two months after project completion in which 434 teachers (48% response) and 606 students (19% response) from 270 projects (85% of all projects) participated. The teachers and students had separate questionnaires which were pre-tested and modelled around the tools used in an earlier study (Author et al., 2017). Secondly, the project reports of all 317 projects were analysed for collecting data regarding total number of research publications, number of participants and financial expenditure. Some projects were purposively sampled from the 2015-16 cycle and also the earlier 2013-15 cycle for case studies based on the surveys responses. Telephonic interviews with students and/or teachers were undertaken in case studies, if required. Permission for the study was obtained from the Research Council, University of Delhi.

RESULTS

Empirical evidence of the working of this programme/scheme and its outcomes were categorised into three broad heads modelled on the main objectives of the programme:

1. Research Culture − promoting a research culture in the University that engages students and college faculty alike.
2. Skill Enhancement − helping students develop career and life skills that conventional taught university programmes cannot impart, and helping college teachers in professional development.
3. Social Impact − giving back to the local communities through sustainable solutions, workshops and awareness campaigns.

SAMPLE DISTRIBUTION

The Course-wise distribution of the students and discipline-wise distribution of teachers who participated in the online survey are given in Table 2. Students from fifty colleges and teachers from fifty four colleges completed the survey. 86% (552) students came from honours courses 11% (68) from non-honours courses (including vocational degrees). More than 69% (423) students were from Science and Applied Sciences, while about 27% (167) were from Humanities and Social Sciences. 43% (189) teachers were from Basic Sciences, 25% (111) from Applied Sciences, and 28% (123) from the Humanities and Social Sciences. Response rate of students and teachers from Science disciplines was higher as compared to the Social Sciences.

Table 2: Sample Distribution

	Course	***n, n%***
Course-wise distribution of students	**Honours Courses**	**522, 86.1**
	B.Sc. (Hons.)	*307*
	B.Tech	*81*

	BA (Hons.)	*106*
	B.Com (Hons.)	*28*
	Non-honours and Vocational courses	**68, 11.2**
	B.Sc. (Programme)	*35*
	BA (Programme)	*12*
	BA (Vocational)	*3*
	B.Com (Programme)	*4*
	Other	*14*
	Blank	**16, 2.6**
	Total	**606**
Disciplinary distribution of Teachers	**Discipline**	***n, n%***
	Basic Sciences	**189, 43.5**
	Physics	*27*
	Chemistry	*64*
	Mathematics	*16*
	Botany	*39*
	Zoology	*43*
	Applied Sciences	**111, 25.5**
	Biochemistry	*11*
	Computer science	*21*
	Electronics	*20*
	Home Science	*12*
	Other	*47*
	Humanities and Social Sciences	**123, 28.3**
	Commerce	*28*
	Economics	*21*
	Geography	*14*
	Management Studies	*11*
	Political Science	*12*
	Other	*37*
	Blank	**11, 0.02**
	Total	**434**

RESEARCH CULTURE

Research output: There have been hundreds of research publications and conference presentations resulting from these projects. Table 3. gives details of resulting research output from all the three cycles as of December 2016.

Table 3: Research Output from Innovation Projects (as of December 2016)

Dissemination medium	**Total number**

Peer-reviewed publications	288
Books	24
Conference presentations (National and International)	375
Patents accepted	6

Table 4: Research Culture

	Indicator	Response	*n, n%*
Students (N = 606)	**Prior research experience**	**Yes**	**176, 29.0**
		Previous cycles of Innovation Projects	*56, 9.2*
		Students-run/independent research	*122, 20.1*
		No	**430, 70.9**
	Motivation to take up further research	Yes	588, 97.1
		No	18, 2.9
Teachers (N = 434)	**Prior research experience**	**Yes**	**228, 52.5**
		Doctoral/Junior Research Fellowship	*24, 5.5*
		Postdoctoral/Senior Fellowship	*20, 4.5*
		Externally funded projects	*65, 14.9*
		Past Innovation Projects	*119, 27.3*
		No	**200, 45.9**
		Blank	**6, 1.3**
	Motivation to take up further research	Yes	428, 98.6
		No	6, 1.3
	Enhancement of Research Aptitude	**Scale point**	***n, n%***
		5 (a lot)	*276, 63.5*
		4 (considerable)	*113, 26.0*
		3 (little)	*38, 8.7*
		2 (very little)	*4, 0.9*
		1 (negligible improvement)	*3, 0.6*
		Mean, SD	**4.51, 0.75**

	Scale point	*n, n%*
Enhancement of Publication skills	*3 (improved a lot)*	*234, 53.9*
	2 (improved a little)	*175, 40.3*
	1 (negligible improvement)	*25, 5.7*
	Mean, SD	**2.48, 0.60**

Prior research experience. Of the 29% (176) students who reported having prior research experience, 56 (9.2% of all) said they have participated in the previous cycles of Innovation Projects whereas 122 (20.1% of all) said they undertook independent research, which subtly indicates that UR is not non-existent in the colleges, albeit unrecognised. This was the first funded research project for 75% of the teachers who responded. With a 48% response rate this amounts to 36% of all teachers who undertook Innovation Projects in this cycle. With few teachers having experience of previous externally funded research projects (10%), the scheme has benefited many who would not otherwise have access to external funding (Table 4).

Motivation received. 97% (588) students and 98.6% (428) teachers reported that they were strongly motivated to take up further research activities (Table 4). Around 53% (321) students reported applying for research internships/fellowships after the project completion. Ten students also mentioned that they took up research intensive Masters courses and that the project helped them choose their Masters subject. This is in line with results from Seymour et. al. (2004).

Enhancing research skills. More than 90% teachers reported that their research aptitude and publication skills were considerably enhanced by participating in a mentored undergraduate research project (Table 4).

Student-teacher roles. Another point to be noted with regard to developing a vibrant research culture is that of student-teacher involvement in these projects. Again, as in Levy's IBL framework (2009), the role played by teachers is pertinent to the kind of learning experience received by the students. The model of Innovation projects mandates that students be active participants, not just in data collection, but also in its analysis and reporting. In many cases, students have also taken part in framing the very objectives and methodology of the project. At least 25 projects were identified where students were actively involved in every step of the process, from drafting the proposal to presenting papers. *ARSD-305* is an instance where a couple of final-year students of Electronics took the initiative and convinced an Assistant Professor in their own department to mentor them. He then put together the team and invited a tenured faculty member from the Commerce department to take charge as the PI. The PI guided the project in the survey and market research aspects whereas the focus of the project was still within the electronics discipline (Bansal et al., 2016).

Alternate Pedagogy and Skill Enhancement. In addition to fostering a culture of research and developing an orientation towards research in future, the Innovation Projects also resulted in being considered as an alternate pedagogy and a means of enhancing skills of both teachers and students. These projects also facilitated teaching topics beyond the purview of the structured syllabus. *ANDC-203* was a project on learning to use archival astronomic data like NASA's Kepler. The aim was to engage the students in an advanced contemporary field and also resulted in a publication (Dey et al., 2015; Deb et al., 2015).

The learning experience and this method of gaining/imparting knowledge were rated very highly both by students and teachers. On a 5 point scale, mean students' rating of learning experience was 4.36 and teachers' rating of this method of imparting knowledge was 4.59 (no blanks). The respondents were found to be very enthusiastic of having such research projects as part of the regular curriculum, especially the students (Table 5).

Table 5: Willingness to include projects in curriculum

Scale Point	**Response**	***n, n%***	
		Students *(N = 606)*	**Teachers *(N = 434)***
3	*That'd be great*	425, 70.1	248, 57.1
2	*That'd be fine*	149, 24.6	144, 33.2
1	*That probably won't be good*	32, 5.3	42, 9.7
	Mean, SD	**2.65, 0.58**	**2.47, 0.66**

Table 6: Skill Enhancement

Skills gained/enhanced	***n, n%***	
	Students *(N = 606)*	**Teachers *(N = 434)***
Multi-tasking	428, 70.6	347, 79.9
Communication skills	412, 67.9	253, 58.3
Time management	392, 64.6	328, 75.6
Analytical ability	359, 59.2	321, 73.9
Leadership	331, 54.6	278, 64.0

Creativity and Creative writing	320, 52.8	169, 38.9
Academic writing	258, 42.6	284, 65.4
None of these	9, 1.5	5, 1.1

Projects help both students and teachers inculcate useful skills for professional development and self-awareness. The soft-skills acquired as a result of undertaking these projects include communication, time management, multitasking, teamwork, leadership, creative and critical enquiry etc. Such skills are important for success in career and are directly linked to employability. Benefits for teachers were also traced along same lines. Table 6 shows number of respondents who reported enhancement of the given skill.

SOCIAL IMPACT

Innovation projects have enabled the young learners to engage in civic participation and assume social responsibility. The results from the survey show that more than 90% (391) teachers and 90% (547) students identified social impact as an important goal of the project. Moreover, 73% (318) teachers and 71% (435) students were also convinced that they indeed generated positive change in the target community, in their own humble ways.

One example is *SRCC-201* Project Azmat from the earlier cycle. Rampant social issues like of manual scavenging and caste discrimination, social and educational exclusion of women, and lack of proper sanitary facilities were addressed systematically. Using science and business skills in an innovative fashion they developed a sustainable business model for female scavengers in Nekpur village, Ghaziabad. They built eco-friendly toilets in the village, trained the women to produce detergents and created a brand called '*Neki*' (available in local stores in Nekpur and nearby villages). By collaborating with Enactus SRCC (college chapter of an international NGO), this project achieved actual change in the village and in the lives of the women (Project Azmat, n.d.). Azmat stands witness of the potential of Innovation Projects when it comes to social intervention.

Another case is that of the project *ANDC-307* in which students conducted a survey of two groups (students and professionals of the University community) and identified that students were more aware and willing to participate in the ongoing Indian national e-governance initiatives whereas the faculty and staff did not show much interest. Inhibitors from participation in e-governance were identified and faculty training workshops were organised in collaboration with MyGov.in - the Indian government's platform for crowdsourcing governance ideas from citizens (Narang et al., 2016). The *ANDC-305* project discussed earlier, was focused on prototyping a wearable obstacle detector for the Blind. While the project did not result in a patent application, the students of electronics got to visit more than forty non-profits working for the Blind. These interactions, as one of the students recounted (personal communication, April, 2017), were 'eye-opening' and 'made the group sensitive to the needs of differently abled persons.' These learning experiences through community engagement in the form of participatory action research, and action research in its broader construction, are great boosters of college impact (Moore, 2014).

DISCUSSION

The results align with Kuh (2008) and many other earlier studies on URPs. Innovation Projects can be and have been a high impact experience. This is reflected in the significant to overwhelming positive responses on various indicators like the motivation they had received to undertake further projects, willingness to inculcate research in curriculum, skills enhancement and real-world exposure they have gained.

There is plenty of scope in offering incentives as a result of involvement in these projects including generating alternate pedagogical tools, life and professional skills. Another incentive is co-authorship in the resulting publications. Working with UG students can be an enriching experience and teachers who participated in these projects, perceive it to be very important (Webber, Laird, & BrckaLorenz, 2013). UG students contributed meaningfully in the research agenda of the University (Zydney et al., 2002). More evidence of faculty's willingness to work with undergraduates was found in the quantitative studies (see Table 5). These benefits and learning experiences for teachers serve as incentives to undertake research with undergraduates. In fact, the investigators of *LSR-301* stated this in the acknowledgement of their report:

'*We would also like to extend thanks to the student research associates… who played an invaluable role in shaping the study, collecting data from the field and analyzing it. Working with such young bright minds reaffirms our faith that the future of education and indeed that of our country is very promising. Thank you for being our co-learners in this journey*.' (Dhawan et al., 2016).

The social impacts generated by some of the projects are exemplary. However, in the big picture, exposure to real-world problem and a hands-on knowledge of methods to overcome these problems is a crucial lesson for students and teachers who otherwise have little incentive venture beyond the walls of their classrooms. There is also the indirect impact of these projects through inspiring talented young minds into finding solutions for socially relevant issues. In fact, 90% of the respondents came from projects focusing on socially relevant issues. This reflects the influence the social aspect of the project had on willingness to participate in feedback for improvisation of the scheme.

The scenario of research attitude and aptitude in the University's colleges prior to the start of Innovation Projects has not been well-recorded leaving a lacuna. However the current cross-sectional study does give some insights. Almost two thirds of teachers who responded and at least one third of all participating teachers got to do funded research projects for the first time through this scheme. The 20% students who said they have undertaken independent research before subtly indicate the prevalence of an urge among students to conduct research. Despite many impediments, the research output from these projects is very impressive. This shows that those involved in the projects are performing excellently well and have gained significantly. If the University can offer trainings in research methodology and scientific communication, both the quantity and quality of research output can be enhanced.

CONCLUSION

The Innovation Projects model of institutional undergraduate research programme is suitable for all HEIs, especially community colleges and affiliated colleges in large university systems. It is flexible, accommodative and impactful, leading to enabling the teaching faculty to develop research skills, help improve graduate employability through skill enhancement, significantly increasing the University's research output and also diversifying the University's social outreach. Everyone - students, college teachers, the University and also local communities, stand to gain from these projects. Above all, the learning experience it brings to the students is at par with internationally acclaimed URPs, as evident from the publications and patents, and goes a step further in engaging these young minds in civic participation, in turning their energies towards pressing social issues. The results from the study show that the conceptual dynamics of the programme indeed have practical import while projects of a wide range, in terms of focus of inquiry and methods of research, have been promoted by the scheme. With all these facets in mind, Innovation Projects can be purported, with confidence, as a model for URPs, wherein the features of the model would be training in research methodology, institutional funding, co-curricular year-long mentored group projects, focus on social concerns, flexibility in student-teacher and student-knowledge interaction, co-authorship in research publications and creating a culture of research beneficial for all.

REFERENCES

1. AISHE. (2016). *Report of the All India Survey on Higher Education (2015 - 16).* New Delhi: Retrieved from http://mhrd.gov.in/sites/upload_files/mhrd/files/statistics/AISHE2015-16.pdf
2. Bhaskar, D., Divyadarshan, C., Aatman, A., Krishan, K. (2017). *VEINS: Impact Analysis of DU Innovation Projects*. New Delhi: Research Council, University of Delhi.
3. Baker, V. L., Pifer, M. J., Lunsford, L. G., Greer, J., & Ihas, D. (2015). Faculty as mentors in undergraduate research, scholarship, and creative work: Motivating and inhibiting factors. *Mentoring and Tutoring: Partnership in Learning, 23*(5), 394-410.
4. Baker, V.L., Greer, J., Lunsford, L.G. Pifer, M. J., & Ihas, D. (2017). Documenting the aspiration gap in institutional language about undergraduate research, scholarship, and creative work. *Innovative Higher Education, 42*(1), 127-43.
5. Bansal, et. al. (2016). *An Obstacle Detector Sensing Buzzer and Vibrator Device using Microcontroller for Blind and Blind-Deaf.* Project Report. University of Delhi.
6. Bauer, K. W., & Bennett, J. S. (2003). Alumni perceptions on the value of undergraduate research. *Journal of Higher Education, 74*, 210-30.
7. Bauer, K. W., & Bennett, J. S. (2008). Evaluation of the undergraduate research Program at The University of Delaware: A multifaceted design. In Taraban, R. & Blanton, R. L. (Eds.), *Creating Effective Undergraduate Research Programs in*

Science: The Transformation from Student to Scientist. New York: Teachers College Press.

8. Beckman, M., and Hensel. N. (2009). Making explicit the implicit: Defining undergraduate research. *CUR Quarterly, 29*(4), 40-44.
9. Boyer Commission. (1998). *Reinventing Undergraduate Education: A Blueprint for America's Research Universities*. Stony Brook: State University of New York.
10. Brew, A. (2006). *Research and Teaching: Beyond the Divide*. London: Palgrave Macmillan.
11. Caplan, A. J., & MacLachlan, E. S. (2014). An overview of undergraduate research in the CUNY Community College system. In N. Hensel, & B. Cejda (Eds.), *Tapping the Potential of All: Undergraduate Research at Community Colleges* (pp. 9-16). Washington DC: CUR.
12. Carpi, A., Ronan, D., Falconer, H., & Lents. N. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching*, *54*(2), 169-194.
13. City University of New York. (n.d.). For Students. Retrieved from http://www2.cuny.edu/research/student-resources/for-students/
14. Clark, B. R. (1997). The modern integration of research activities with teaching and learning. *The Journal of Higher Education*, *68*(3), 241-55. doi:10.2307/2960040.
15. Cole, D., & Espinoza. A. (2008). Examining the academic success of latino students in science technology engineering and mathematics (STEM) majors. *Journal of College Student Development*, *49*(4), 285-300.
16. Deb, et al. (2015). *Astronomy Using Archival Data*. Project Report. University of Delhi.
17. Dey, et al. (2015). Light curve modeling of eclipsing binaries towards the constellation of Carina. *The DU Journal of Undergraduate Research and Innovation*, *1*(1), 60-78.
18. Dhawan, et al. (2016). *Believe in Myself: Fostering Healthy Self-esteem in Female Adolescents.* Project Report. University of Delhi.
19. ENACTUS SRCC. (n.d.) *Project Azmat.* Retrieved from http://enactussrcc.org/projects/past-projects/azmat/
20. Healey, M. (2005). Linking research and teaching: Exploring disciplinary spaces and the role of inquiry-based learning. In R. Barnett (Ed.), *Reshaping the University: New Relationships between Research, Scholarship and Teaching* (pp. 67-78). Maidenhead, UK: McGraw Hill/Open University Press.
21. Healey, M., & Jenkins. A. (2009). *Developing Undergraduate Research and Inquiry. Research Report to the Higher Education Academy*. York, UK: Higher Education Academy.
22. Hensel, N. (Ed.). (2012). *Characteristics of Excellence in Undergraduate Research.* Washington DC: CUR.

23. Houghton, W. (2004). *Learning and Teaching Theory for Engineering Academics.* York, UK: Engineering Subject Centre, Higher Education Academy.

24. Hunter, A.B., Laursen, S. L. and Seymour, E. (2007). Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development. *Science Education*, *91*(1), 36–74.

25. INFLIBNET Centre. (n.d.). *About N-LIST.* Retrieved from http://nlist.inflibnet.ac.in/about.php

26. Katkin, W. (2003). The Boyer Commission Report and its impact on undergraduate research. *New Directions for Teaching and Learning, 9*3, 19-38.

27. Kuh, G. (2008). *High-impact Educational Practices: What they are, who has access to them, and why they matter.* Washington DC: Association of American Colleges and Universities.

28. Levy, P. (2009). *Inquiry-Based Learning: A Conceptual Framework*. Sheffield: Centre for Inquiry-based learning in the Arts and Social Sciences, University of Sheffield.

29. Levy, P., Little, S., Mckinney, P., Nibbs, A., & Wood, J. (2010). *The Sheffield Companion to Inquiry-Based Learning*. Sheffield: Centre for Inquiry-based learning in the Arts and Social Sciences, University of Sheffield.

30. Lopatto, D. (2004). Survey of undergraduate research experiences (SURE): First findings. *Cell Biology Education, 3*(4), 270–77.

31. Lopatto, D. (2007). Undergraduate research experiences support science career decisions and active learning. *CBE-Life Sciences Education, 6*(4), 297–306.

32. Moore, T. L. (2014). Community-University Engagement: A process for building democratic communities. *ASHE Higher Education Report, 40*(2). Jossey-Bass: Wiley Periodicals.

33. Multhaup, K., Davoli, C., Wilson, S., Geghman, K., Giles, K., Martin, J., & Salter. P. (2010). Three models for undergraduate-faculty research: Reflections by a professor and her former students. *CUR Quarterly*, *31*(1), 21-26.

34. Narang, et al. (2016). *Digital India: Challenges and Opportunities.* Project Report. New Delhi: University of Delhi.

35. Research Council. (2015). *Research Profile*. New Delhi: University of Delhi.

36. Russell, S. H., Hancock, M. P., & McCullough, J. (2007). The pipeline: Benefits of undergraduate research experiences. *Science, 316* (5824), 548-549.

37. Seymour, E., Hunter, A. B. Laursen, S. L., & DeAntoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education, 88*, 493-534.

38. Sharma, K. (2013). *Sixty Years of the University Grants Commission: Establishment, Growth, and Evolution.* New Delhi: University Grants Commission.

39. University of Houston Quality Enhancement Plan. (2008). *Discovery-Based Learning: Transforming the Undergraduate Experience through Research.* Houston: Author. Retrieved from https://www.sacs.uh.edu/qep.pdf

40. Webber, K., Laird, N., & BrckaLorenz, A. (2013). Student and faculty engagement in undergraduate research: Evidence from NSSE and FSSE. *Research in Higher Education*, *54*(2), 227-45.

41. Zydney, A. L., Bennett, J. S., Shahid, A., & Bauer, K. W. (2002). Faculty perspectives regarding the undergraduate research experience in science and engineering. *Journal of Engineering Education, 91*(3), 291-97.