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The Outcomes of Research and Development (R&D) Centers in Public Sector Universities of Pakistan

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Abstract
Despite widespread practices, high productivity of R&D centers has been lacking in higher education institutions. Present article reports that R&D centers are bit active in providing human resource management, skilled manpower and research experts to society and research institutions accordingly. But, these are not playing an effective role in making need-based assessments of research projects, providing trained manpower to local industry, preparing expert artisans for strengthening labor market, developing bridge between research institutions and community, and facilitating public sector institutions through research activities. The province-wise and discipline-wise comparison of R&D centers points out that their progress varies from province to province as well as from discipline to discipline. The study identifies major causes of low productivity and suggests solutions.

Keywords: *R&D centers, higher education institutions, public sector, outcomes, productivity*

1. Introduction

Research and development[1] (R&D) is the backbone of higher education institutions. It has been considered as a special cog of research centers, functional institutions and industrial sector. R&D is a systematic process used to update classical processes, systems, tools, techniques, devices, services, materials and products. It boosts up available practices in a more reliable, feasible and better way. It provides the latest knowledge which is helpful in exploring hidden facts of this universe (Bako, 2005; Bartlett & Burton, 2009).

Research and development (R&D) centers are the valuable sources to generate advancement and innovations at higher education institutions. These perform incredible role in offering first class graduates' studies and motivating their best brains. These play a crucial role in quality education, promoting research culture and providing new methods of learning and teaching at higher education institutions. These are also much effective in training new generation of research fellows and scientists (Gay, 2005; Matos, 1999).

Over the last three decades, R&D-intensive firms are struggling to solve fundamental problems of R&D and trying to produce science-based technologies in higher education institutions. Many large R&D-intensive enterprises are now making their best efforts to establish collaborative links with higher education institutions for the economic reasons (Brostrom, 2010). This is especially true in the advanced nations like USA, UK, Germany, France, and Japan. In order to compete in international marketplace, rapidly industrializing countries such as South Korea, Indonesia and Brazil have national policies in place for developing indigenous R&D.

In United States, the federal share for R&D has been decreasing over the period of last 10 years. However, this decrease in federal share for R&D has been compensating by corresponding increase in industry share at national level. In recent good days of US economy, the investments in research and development has grown by 6.5 %. Over a period of last two decades, US have adopted a strategy to make use of global science. In this way, US companies have invested about three times more in foreign cooperative research and development than similar domestic expenditure. It has resulted in an increase of 20 % in co-authored research publications with foreign collaborators as compared to just 12 % a decade earlier (Brown, 1998).

In United Kingdom, the expenditures on research and development have been decreasing, as a percent of GDP, since the last two decades. However, this decrease has been compensating by considerable increase in higher education expenditure on R&D (HERD). Despite a modest recovery at the beginning, there was an overall fall of total gross expenditure on R&D (Shelley 2010). Due to the world financial crisis, the higher education R&D in UK has also been declining. Since the beginning of crisis, the UK's principal competitors have increased R&D of higher education at a faster rate. Similarly, the relative contribution of business enterprise for funding R&D, in higher education system, has also been declined significantly (Hughes, and Mina 2012).

In spite of facing many problems, Pakistan has been ranked thirty-fourth for their R&D spending in the list of world's countries (OECD, 2002). In 1998, there were thirty-two universities and degree awarding institutes in public[2] and private sectors. Out of hundred and fifty-five major R&D organizations, 41 % were working in the field of agriculture. These were administered by thirteen controlling agencies at federal level. Total citation of research papers was four hundred and ninety-nine and its share in the world's authorship was 0.08 %. Only 2 % of 18 to 23

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age groups were enrolled at university level and about 98 % of youth had no access to higher education in Pakistan (HEC, 2013).

According to Naim (2001), all universities and centers of excellence in Pakistan have collectively produced nine-hundred and eighteen PhD scholars. Eleven-hundred and seventy scholars had sent abroad. Out of these seven-hundred and seventy scholars, seven-hundred and forty scholars have returned back to motherland, five-hundred and eighty-one got employed while rest of them remained jobless. In 2005, total number of R&D manpower was fourteen-thousand and five-hundred. Among fourteen-thousand and five-hundred, twenty-five hundred and twenty eight PhD scholars have completed their researches in science subjects. Out of total thirty-five thousands patents, registered by Pakistan patent office, only 35 % were of the engineering sciences. Moreover, few science and technology protocols have been signed with Iran, Egypt and Romania (UNESCO, 2012).

Pakistan Council for Scientific and Industrial Research (PCSIR) has published four hundred research papers. One hundred and ten scientists, undertaking research at PCSIR research laboratories, have received PhD degrees from Pakistani universities. In Pakistan, discipline-wise distribution of research scientists working in R&D organizations was; 43.85 % Agricultural Sciences, 10.44 % Chemistry, 0.21 % Computer Sciences, 1.91 % Health and Medicine, 0.85 % Biotechnology, 0.31 % Mathematics, 3.62 % Earth Sciences, 12.58 % Engineering, 5.44 % Meteorology, 6.47 % Physics, 13.52 % Biology and 1.07 % others (Pakistan Council for Science and Technology, 2005). In present research, an attempt has been made to evaluate the outcomes and productivity of research and development centers working at the higher education institutions.

1.1 Objectives of the Study

Objectives of the study were; (a) to analyse the productivity and effectiveness of R&D centers working at higher education institutions, and (b) to suggest certain measures to improve existing situation of research and development at higher education institutions.

2. Research Methodology

This research was descriptive in nature and survery method was used to gather informantion from Research supervisors, chairmen, heads of the departments, deans of faculties, and chairmen of Board of Advanced Studies and Research of some selected public sector universities of Pakistan. Data were also gathered from heads and officials of research and development centers and quality assurance cells of some selected public sector universities of Pakistan.

2.1 Sampling Method and Sample Size

The probability methods were used for sampling in this research. Hundred percent was considered to be the appropriate sample size for survey studies according to Gay's statement (2005), "for smaller population, say N = 100 or fewer, there is little point in sampling, survey the entire population. The size of sample was rationalized according to Manion *et al*. (2008). For example, if the population of a research study is 100,000 or more, then appropriate size of sample should be 384. However, 690 participants were considered as a sample for this research. Thirty respondents, from each university, were randomly selected as a sample including; 10 research supervisors, 5 chairmen and heads of the departments, 5 deans of faculties, 1 R&D head, 5 R&D officials and 4 quality assurance personnel. The greater sample size was actually suggested in accordance to Best and Kahn's statement (2006), "the sample would be larger enough than experimental researches to represent the population in survey research". The greater sample size also reduces the chances of errors.

2.2 Instrument

The problem was explored in a quantitative way because the current practices of research and development (R&D) at university level could be analyzed better through the questionnaire than other research tools. The respondents were free to respond regarding the outcomes of research and development centers at higher education institutions in; making need-based assessments of research projects, supplying trained manpower to the local industry, providing human resource management for the research centers, preparing expert artisans for strengthening the labor market, developing bridge between research institutions and community and facilitating public sector institutions through research activities, furnishing skilled manpower to the research institution and offering research experts to the society. Therefore, a questionnaire was designed for the research and development directors and officials, and the deans of faculties, chairmen and / or heads of the departments, and research supervisors of some selected public sector universities of Pakistan.

3. Data collection

After validity of the research instrument, the data of research was collected by means of face-to-face personal interviews, observations of the body language and document analyses of the respondents. The researcher also invited, trained and involved some learned persons in data collection from 23 public sector universities.

3.1 Data analysis and interpretation of the findings

The data were treated by Statistical Package for Social Sciences (SPSS) Software, Version 17. After Statiscal treatment, data were tabulated and interpreted (see Table 1-8).

Table 1. Role of R& D centers in making Need-Based Assessments of Research Projects

Item	Formula	Responses					Total	S.D[f]	Mean
		SDA[a]	DA[b]	UD[c]	A[d]	SA[e]			
Need based assessment	Frequency	54	301	9	249	77	690	1.248	2.99
	Percentage	7.8	43.6	1.3	36.1	11.2	100		

Note. [a]strongly disagree; [b]disagree; [c]undecided; [d]agree; [e]strongly agree; [f]standard deviation

Regarding the role of R&D centers in making need-based assessments of research projects (see Table 1), 43.6 % and 7.8 % respondents were disagreeing and strongly disagreeing, respectively. While, 36.1 % and 11.2 % respondents were agreeing and strongly agreeing with the abovementioned statement, respectively. However, 1.3 % respondents were uncertain about this statement. Generally, 51.4 % respondents were unsatisfied to the performance of R&D centers.

Table 2. Role of R&D centers in providing Trained Manpower to the Local Industry

Item	Formula	Responses					Total	S.D[f]	Mean
		SDA[a]	DA[b]	UD[c]	A[d]	SA[e]			
Trained manpower for local industry	Frequency	53	310	14	247	66	690	1.248	2.95
	Percentage	7.7	44.9	2	35.8	9.6	100		

Note. [a]strongly disagree; [b]disagree; [c]undecided; [d]agree; [e]strongly agree; [f]standard deviation

Concerning the role of R&D centers in supplying trained manpower to the local industry [refer Table 2], 44.9 % and 7.7 % respondents were disagreeing and strongly disagreeing, respectively. While, 35.8 % and 9.6 % respondents were agreeing and strongly agreeing with the aforesaid statement, respectively. However, 2 % respondents were not sure about this statement. In overall, 52.6 % respondents were not satisfied to the performance of R&D centers.

Table 3. Role of R&D centers in offering Human Resource Management for Good Governance of the Institutions

Item	Formula	Responses					Total	S.D[f]	Mean
		SDA[a]	DA[b]	UD[c]	A[d]	SA[e]			
Human resource management	Frequency	68	276	7	237	102	690	1.315	3.04
	Percentage	9.9	40	1	34.3	14.8	100		

Note. [a]strongly disagree; [b]disagree; [c]undecided; [d]agree; [e]strongly agree; [f]standard deviation

Keeping in mind the statement that research and development centers provide human resource management for good governance of the institutions (see Table 3), 40 % and 9.9 % respondents were disagreeing and strongly disagreeing, respectively. While, 34.3 % and 14.8 % respondents were agreeing and strongly agreeing with aforementioned statement, respectively. However, 1% of the respondents were confused over the staement. Generally speaking, 49.9 %

Table 4. Role of R&D centers in preparing Expert Artisans for strengthening Labor Market

Item	Formula	Responses					Total	S.D[f]	Mean
		SDA[a]	DA[b]	UD[c]	A[d]	SA[e]			
Experts for labor market	Frequency	83	309	8	220	70	690	1.276	2.83
	Percentage	12	44.8	1.2	31.9	10.1	100		

Note. [a]strongly disagree; [b]disagree; [c]undecided; [d]agree; [e]strongly agree; [f]standard deviation

respondents were just satisfied to the performance of R&D centers.

In results of Table 4, 44.8 % respondents were disagreeing and 12 % respondents strongly disagreeing with the statement that research and development centers prepare expert artisans for strengthening labor market. While, 31.9 % and 10.1 % respondents were agreeing and strongly agreeing with the statement, respectively. However, 1.2 % of the respondents were unclear about the statement. In general, 56.8 % respondents were not satisfied with the performance of R&D centers.

Table 5. Role of R&D Centers in developing Bridge between Research Institutions and Community

Item	Formula	Responses					Total	S.D[f]	Mean
		SDA[a]	DA[b]	UD[c]	A[d]	SA[e]			
Bridge with social sector	Frequency	64	283	9	266	68	690	1.250	2.99
	Percentage	9.3	41	1.3	38.6	9.9	100		

Note. [a]strongly disagree; [b]disagree; [c]undecided; [d]agree; [e]strongly agree; [f]standard deviation

According to data regarding the role of research and development centers in developing bridge between research institutions and the community (see Table 5), 41 % and 9.3 % respondents were disagreeing and strongly disagreeing with the statement, respectively. While, 38.6 % and 9.9 % of the respondents were agreeing and strongly agreeing with the statement, respectively. However, 1.3 % respondents were not sure about it. In overall, 50.3 % respondents were not satisfied to the performance of R&D centers.

According to the data in Table 6, 42.3 % and 8.6 % of the respondents were disagreeing and strongly disagreeing with the statement that research and development centers facilitate public sector through results of research activities, respectively. While, 35.7 % and 11.3 % of the

Table 6. Role of R&D Centers in facilitating Public Sectors with Research Activities

Item	Formula	Responses					Total	S.D[f]	Mean
		SDA[a]	DA[b]	UD[c]	A[d]	SA[e]			
Facilitate to public sector	Frequency	59	292	15	246	78	690	1.255	2.99
	Percentage	8.6	42.3	2.2	35.7	11.3	100		

Note. [a]strongly disagree; [b]disagree; [c]undecided; [d]agree; [e]strongly agree; [f]standard deviation

respondents were agreeing and strongly agreeing with the statement, respectively. However, 2.2 % of the respondents were doubtful about it. Generally, 50.9 % respondents were not satisfied to the performance of R&D centers.

Table 7. Role of R&D Centers in providing Skilled Manpower for the Development of Society

Item	Formula	Responses					Total	S.D[f]	Mean
		SDA[a]	DA[b]	UD[c]	A[d]	SA[e]			
Skilled manpower	Frequency	53	276	9	273	79	690	1.248	3.07
	Percentage	7.7	40	1.3	39.6	11.4	100		

Note. [a]strongly disagree; [b]disagree; [c]undecided; [d]agree; [e]strongly agree; [f]standard deviation

In Table 7, 40 % and 7.7 % respondents were disagreeing and strongly disagreeing to the statement that research and development centers provide skilled manpower for development of society, respectively. While, 39.6 % and 11.4 % respondents were agreeing and strongly agreeing with statement, respectively. However, 1.3 % of the respondents were undecided about it. In general, 51 % respondents were not satisfied with R&D centers.

Table 8 illustrates the role of research and development centers for providing research experts to the universities and research institutes. According to the data, 43.2 % and 14.2 % respondents were agreeing and strongly agreeing with the statement, respectively. While, 34.5 % and 7.1 % respondents were disagreeing and strongly disagreeing with the statement, respectively. However, 1% respondents were not sure about it. In overall, 57.4 % respondents were not satisfied to the performance of R&D centers.

Table 8. Role of R&D Centers in supplying Research Experts to the University and Research Institutes

Item	Formula	Responses					Total	S.D[f]	Mean
		SDA[a]	DA[b]	UD[c]	A[d]	SA[e]			
Research experts	Frequency	49	238	7	298	98	690	1.257	3.23
	Percentage	7.1	34.5	1	43.2	14.2	100		

Note. [a]strongly disagree; [b]disagree; [c]undecided; [d]agree; [e]strongly agree; [f]standard deviation

The data in Table 9 illustrate region-wise or province-wise comparison of research and development centers at higher education institutions. According to the data, 59.12 % respondents were agreeing with the role of research and development in universities of Punjab province. The

Table 9. Region-Wise / Province-Wise Comparison of the productivity R&D Centers

Sr. No.	Region/Province	Responses					
		Disagree		Agree		Total	
		Frequency	Percent	Frequency	Percent	Frequency	Percent

1	Punjab	7260	40.88	10500	59.12	17760	100
2	Sindh	3272	49.13	3388	50.87	6660	100
3	Baluchistan	1227	55.27	993	44.73	2220	100
4	Khyber P.K.	7807	50.24	7733	49.76	15540	100
5	Federal area	3945	44.42	4935	55.58	8880	100

data show that 50.87 % respondents were agreeing with the performance of research and development in the universities at Sindh province. The data describe that 55.27 % were disagreeing to level of success of research and development centers in Baluchistan province. The data depict that 50.24 % respondents were disagreeing to the achievements of research and development in Khybar P.K. The data portrays that 55.58 % of the respondents were agreeing to the effectiveness of research and development centers in Fedral area. In overall, 59.12 % respondents were satisfied to the productivity of research and development centers in the universities at Punjab province (see Table 9 and Figure1).

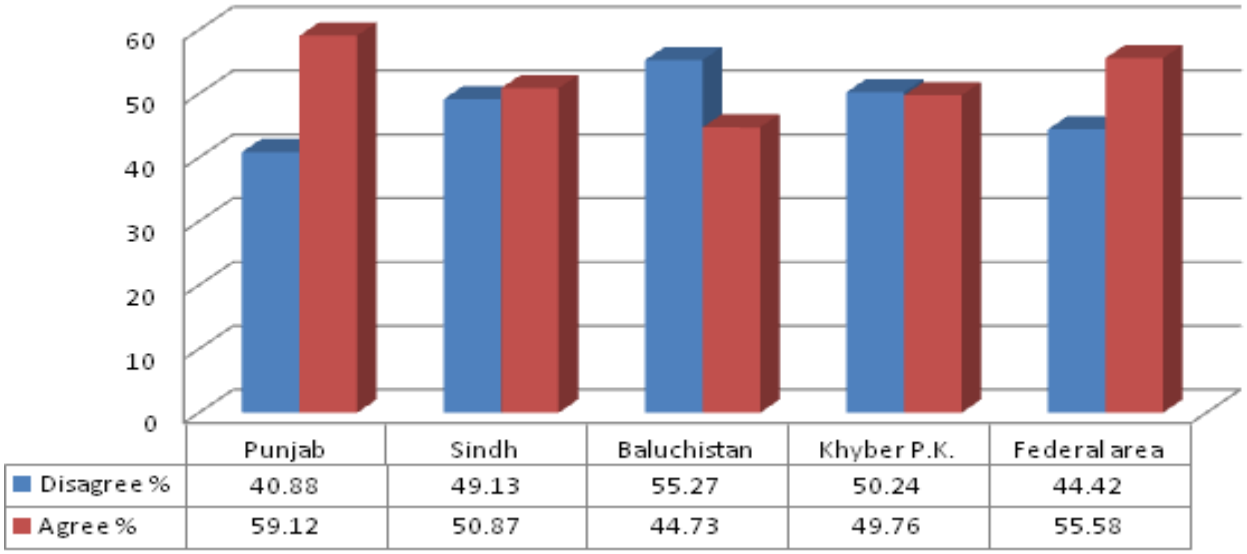


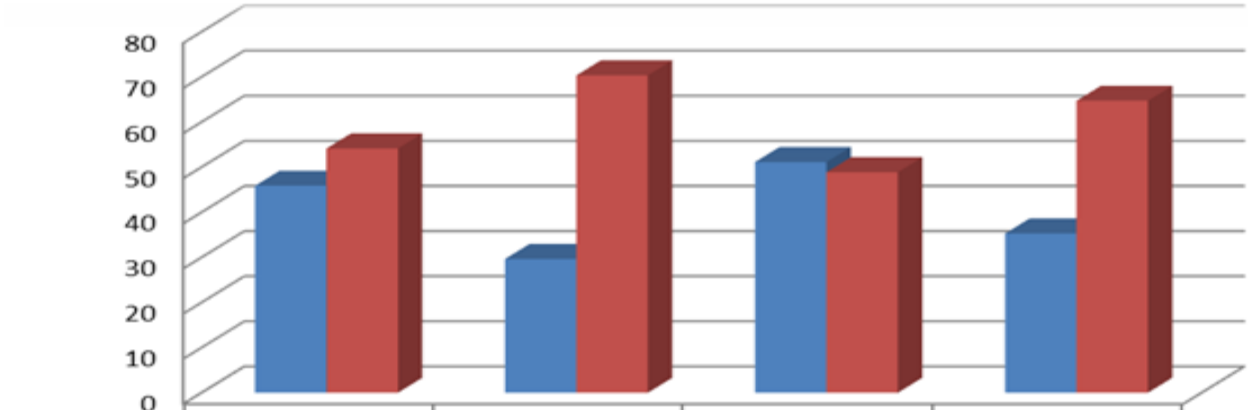
Figure 1: Region-Wise / Province-Wise Comparison of the Productivity R&D Centers.

As far as the discipline-wise or faculty-wise role of R&D centers is concerned, 54.13 % respondents were agreeing to the quality of research work in social sciences (see Table 10). The data also express that 51.13 % of the respondents were agreeing to the quality of research work in arts and humanities. The data described that 64.71 % of the respondents were agreeing to the quality of research work in research and development centers and quality assurance departments.

Table 10. Discipline-Wise / Faculty-Wise Comparison of the productivity R&D Centers

Sr. No.	Discipline /Faculty	Responses					
		Disagree		Agree		Total	
		Frequency	Percent	Frequency	Percentage	Frequency	Percentage
1	Social Sciences	5465	45.87	6449	54.13	11914	100
2	Natural Sciences	3532	29.65	8382	70.35	11914	100
3	Arts & Humanities	6092	51.13	5822	48.87	11914	100
4	R & D / Q.A	5405	35.29	9913	64.71	15318	100

In general, 70.35 % of the respondents were satisfied to the efficiency of research and development centers in natural sciences research and development centers in natural sciences (given in Table 10 and Figure 2).



	Social sciences	Natural sciences	Arts and humanities	R&D / Q.A
Disagree %	45.87	29.65	51.13	35.29
Agree %	54.13	70.35	48.87	64.71

Figure 2: Discipline-Wise / Faculty-Wise Comparison of the Productivity R&D Centers.

4. Discussion

The present research was conducted to examine the outcomes of research and development centers at higher education institutions under the following aspects:

- Role of R&D centers in making need-based assessments of research projects.
- Role of R&D in providing trained manpower to the local industry.
- Role of R&D centers in offering human resource management for the good governance of the institutions.
- Role of R&D centers in preparing expert artisans for strengthening the labor market
- Role of R&D centers in developing bridge between research institutions and community.
- Role of R&D centers in facilitating public sectors with research activities.
- Role of R&D centers in providing skilled manpower for the development of society.
- Role of R&D centers in supplying research experts to the university and research institutes.
- Region-wise / province-wise comparison of the productivity R&D centers.
- Discipline-wise / faculty-wise comparison of the productivity R&D centers.

The productivity of R&D centers in making need-based assessment of research projects at higher education institutions is not very high. Similarly, research and development centers at higher education institutions are not playing an active role in supplying trained manpower to the local industry. However, the role of research and development centers in providing human resource management for good governance of the institutions is little bit satisfactory. But, their output in preparing expert artisans for strengthening the labor market is comparatively low. Furthermore, the performance of research and development centers in developing bridge between research institutions and the community is not so good. Moreover, their performance in facilitating public sector with research activities is also not satisfactory. However, R&D centers are bit efficient in providing skilled manpower for the development of society. Whereas, these are not furnishing research experts to the universities and research institutes.

The region-wise or province-wise comparison of the productivity of research and development centers at higher education institutions illustrates that the role of research and development centers of the Punjab province is relatively better than the other provinces. Whereas, performance of research and development centers at higher education institutions of Baluchistan province is not better as compare to other provinces. Similarly, discipline-wise or subject-wise comparison of the outcomes of research and development centers at higher education institutions shows that performance of natural sciences is much better than other disciplines. On other side, the effectiveness of R&D centers in arts and humanities group is comparatively less than the other disciplines.

5. Conclusion

In light of the findings of this study, it may be concluded that the performance of R&D centers at higher education institutions is not up to the mark. These are lacking need-based assessments of research projects, trained manpower for the local industry, expert artisans for labor market, coordination with research institutions and community, and productive research activities. It is also interesting to note that these deficiencies, in R&D mechanism, are more prominent in some provinces such as Baluchistan and Khyber P.K., and also in some disciplines like art and humanities.

It is concluded that R&D centers' productivity, performance and the outcomes are not up to the level of excellence. Therefore, R&D centers are require too much improvements in their mechanism / process to overcome the shortcomings.

5.1 Recommendations

Research and development is the focal point in higher education and its success is linked to the productivity of research and development centers at higher education institutions. So far as the productivity of research and development centers is concerned, the present study recommends following suggestions distilled from the face-to-face discussion, observations of the body language and document analyses:

- Proper planning and consistent research policies should be made and followed during the course of research and development process.
- Trained manpower and expert artisans should be provided to the research and development departments.
- Research activities, seminars, conferences, and research trainings should be arranged at public sector higher education institutions.
- A strong bridge between the research institutions and community should be developed.
- Board of management for research and development should be established at higher education institutions to implement research policies but having no authorities to interfere in functioning and decision making of R&D centers.
- Instead of individual boards of directors, an executive director of research and development centers must be introduced with full authorities of hiring and firing. The success and failure of the R&D centers should be judged from the usefulness of their services.
- Research and development centers must be funded and the cash generated through their productivity should be used to enhance their productivity and outcomes.

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Notes

[1] The major purpose of research and development is not to formulate or test theory but to develop effective products for use in educational institutions.

[2] The government sector universities are considered as public sector universities.

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