Impact of Information and Communication Technologies on Open and Distance Learning: A Discriminant Function Approach

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Abstract : *The present study aims at analysing the global efforts towards application of information technology in the manpower development activities. It attempts to evaluate (i) the quantum of investment on education and IT related activities, (ii) the growth pattern in the information and communication infrastructure (ICT), (iii) the extent of achievement of literacy, (iv) the interaction of IT with education, (v) the status of the countries in the establishment of IT infrastructure, and (vi) identification of the IT factors that have caused discrimination among the sample regions. The entire study is based on the time series (1980-95) and cross section (1995) data for thirty countries drawn from different socio-economic backgrounds. Trend analysis is adopted to show the growth in the development of IT parameters while computation of a composite index is used to evaluate the penetration of IT infrastructure. Spearman's rank correlation is employed to identify the status of the countries with respect to IT investment and the achievement of literacy. The log linear regression model is adopted to identify the impact of the IT variables on human resource development and the Discriminant Function Approach (DFA) has been adopted to test the equality of mean difference between the various countries with respect to the adoption of IT for HRD.*

Introduction and objectives

The invasion of education and communication technologies in the educational environment has been very much felt in the last two decades due to the revolution in the global information infrastructure, the world communication network and the growing demand for education. The emergence of IT and the increasing interest in ODL has effected a 'home and job based' education, that has facilitated the learner to lean on the terminal to determine what printed materials, TV programmes, computer aided learning kits are to be consulted to meet his educational needs. The strategic use of IT has not only empowered the individuals but also improved the quality and equity of access to education. Though IT is considered as an essential parameter for the overall development of the nations, its role is very much predominant in the educational system, without which the latter cannot be productive in future days. The present study aimes at a comparative analysis of the selected countries with regard to their efforts in integrating the IT infrastructure in their manpower development activities. It attempts to see (i) the quantum of investment on education and IT related activities, (ii) the growth in information and communication infrastructure, (iii) the extent of achievement of literacy, (iv) the

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interaction of IT with eduction, (v) the status of the countries in building up the IT parameters, and (vi) the identification of the IT factors causing discrimination among the different group of countries.

Methodology

The study was carried out for two different levels by adopting time series data (1980-95) and cross section data (1995) for thirty countries reprsenting various socio-economic backgrounds. Since ODL has been associated with human resource development (HRD), its status has been analysed through the (i) investment on education and the (ii) literacy level achieved. The adoption of IT for ODL purposes has been measured through the availability of IT infrastructure. The IT variables selected for this study include : (i) newspaper, (ii) radio, (iii) television, (iv) mobile phone, (v) fax, (vi) personal computer, (vii) internet host, (viii) telephone mainline, (ix) telecom subscription, and (x) amount spent on IT services for every 1000 population. The growth rate of each one of these variables has been calculated by using the formula: $1/n[\Delta y/y) \times 100]$.

A composite index has been developed for assessing the IT development in the various countires selected for the study. Since the IT variables are in different units of measurement, they have been converted into uniform scale values by fixing the extreme values of each variables into 'zero' and 'one' scale, and then, a correlation analysis has been performed on these values. the avarage correlation coefficient values have been used as a weighted score for the individual IT parameters to arrive at the composite index for the entire set of data on IT infrastructure. To identify the status of the countries with resepct to their (i) investment on education and (ii) IT infrastructure as input parameters and the level of literacy acheived, as an output factor, Spearman's rank correlation has been employed. The long linear regression model is adopted to identify the impact of these input variables on human resource development. The Discriminant Function approach (DFA) has been adopted to isolate the IT factors causing discrimination in the selected groups. The test statistic ('dk') is used to test the equality of mean differences between the various countries with respect to the adoption of IT for HTD.

Results

Investment on Education

Since the expenditure on education is considered as one of the major factors that could contribute significantly to the human resource development (literacy), its status in the selected countries has been analyzed and presented in Table 1. It is interesting to note that those countries spending heavily on education have been able to achieve a higher percentage of HRD. The parallelism between these two factors has been noticed in a majority of the countries. In the eighties, the percentage share of investment on eduation is found to be high in countries such as United

States, Japan, and Germany and a corresponding development in HRD is also noticed. Similarly, in the ninties, the countries that have invested more on education have succeeded in bringing out a higher level of literacy. An analysis of the growth pattern of education during the last fifteen years has brought to focus two important factors: firstly, there has been a considerable rise in the investment on eduation among all the countries taken for study; secondly, education has become an essential component in the market economy where, economic growth and the development of civil society rest on the capacity of the well educated workers and citizens who could adapt to changing situations.

Table 1 : Investment on education and the level of literacy

S.No.	Countries	Investment on Education $ Million			% of Literacy		
		1980	1995	GR	1980	1995	GR
1.	China (LIN)	9491 (1.48)	27528 (1.60)	137.1	32.45	36.30	7.45
2.	Egypt, Arab Rep.	1665 (0.26)	3620 (0.21)	14.5	34.75	45.45	8.72
3.	India	9398 (1.46)	20531 (1.19)	14.6	25.45	34.25	8.97
4.	Indonesia	7548 (1.18)	20805 (1.21)	18.4	31.30	36.75	7.78
5.	Pakistan	1505 (0.23)	3409 (0.20)	15.1	16.55	22.25	8.96
6.	Philippines	1954 (0.30)	4709 (0.27)	16.1	48.75	53.95	7.38
7.	Sri Lanka	303 (0.05)	680 (0.04)	15.0	34.20	41.85	8.16
8.	Thailand	1858 (0.29)	10012 (0.58)	36.0	33.55	37.80	7.52
9.	Zambia	136 (0.02)	227 (0.01)	11.1	20.05	26.35	8.76
10.	Zimbabwe	335 (0.05)	1230 (0.07)	24.5	16.40	35.10	14.27
11.	Brazil (MIN)	7690 (1.20)	23150 (1.34)	20.1	32.35	37.35	7.70
12.	Costa Rica	187 (0.03)	321 (0.02)	11.4	43.95	48.15	7.30
13.	Greece	13375 (2.08)	2463 (0.14)	1.2	51.75	46.40	5.90
14.	Hungary	940 (0.15)	2142 (0.12)	15.2	48.10	52.75	7.30
15.	Ireland	1489 (0.23)	3060 (0.18)	13.7	56.30	69.25	8.20
16.	Korea, Rep.	1733 (0.27)	26190 (1.52)	100.8	50.95	70.60	9.24
17.	Malaysia	658 (0.10)	3734 (0.22)	37.8	32.10	39.40	8.18
18.	Mexico	2762 (0.43)	9469 (0.55)	22.9	42.95	44.45	6.90
19.	Turkey	1748 (0.27)	5427 (0.31)	20.7	27.65	42.00	10.13
20.	Venezuela	5391 (0.84)	1196 (0.07)	1.5	32.90	41.55	8.42
21.	Australia (HIN)	19149 (2.98)	47918 (2.78)	16.7	54.00	65.95	8.14
22.	Canada	15701 (2.45)	84884 (4.92)	3.6	70.15	96.55	9.18
23.	France	29137 (4.54)	82617 (4.79)	19.0	58.55	76.90	8.76
24.	Germany	62088 (9.68)	133093 (7.72)	14.3	60.05	67.90	7.54
25.	Hong Kong	2070 (0.32)	6207 (0.36)	20.0	44.30	50.85	7.65
26.	Japan	82156 (12.80)	357240 (20.72)	29.0	61.00	61.55	6.73
27.	New Zealand	1829 (0.29)	5334 (0.31)	19.4	58.90	72.35	8.19
28.	Singapore	594 (0.09)	7137 (0.41)	80.1	52.40	63.45	8.07
29.	United Kingdom	58337 (9.09)	141222 (8.19)	16.1	51.20	64.25	17.13
30.	United States	300449 (46.82)	688287 (39.93)	15.3	73.40	88.75	8.06

The annual average growth rate of expenditure on education indicates that, it is higher for China (137%), followed by Korea (100%), Singapore (80%), Malaysia (38%), Thailand (36%), Canada (36%) and Japan (29%). The countries that have witnessed a moderate growth rate include Zimbabwe (25%), Mexico (23%), Turkey (21%), Brazil and Hong Kong (20% each). The lowest rate of investment on education is noticed in countries like Greece (1.2%), and Venezuela (1.5%). In short, a high spectrum of growth on education expenditure is seen in the Asian countries, demonstrating their effors to build up the manpower development in the past decades. Since the developed countries have an established education infrastructure, their investment is found to be moderate and the exception to the trend is noticed in Greece and Venuzuela where the growth is found to be negligible.

Considering the proportion of expenditures, the high income nations (HIN) could afford to spend 88 to 90 percent on education and there by achieved 58 to 71 percent of literacy. On the contrary, the low and middle income countries have invested less than the mean average on the education sector, that has ended up in a higher percentage of illiterate and semi-illiterate manpower in these countries.

The other parameters that have contributed indirectly towards human resource development is the investment on computer, telecommunications and other IT related services. With the emergence of information technology, it is now believed that broad and equitable access to education and training is possible to the entire human community. This study makes an attempt to assess the availability of IT infrastructure in the sample countries which could facilitate universal education.

Investment on Information and Communication Technologies (IT)

Among the various IT parameters taken for the present study, the availability of telecom services (V9) is found to be high at 63 percent. The order of priority of the other services includes the telephones (39%), mobile phones (36%), television (32%), radio (26%), personal computers (24%), fax (24%), newspapers (18%) and internet hosts (12%). The Composite index reflects the status of the individual countries with regard to their IT capabilities. It is observed that more than forty percent of the countries have possessed an IT infrastructure above the median level (28%) and it signifies that these countries have already started exploring the potentialities of IT for the development programs and what is required at present is to strengthen further the existing infrastructure. However, in the low income countries, the IT facilities remain far less than ten percent and this situation warrants serious attention. Among the middle income countries except for new countries like Venezuela, Turkey, Mexico, Costa Rica and Brazil, the other countries have more than 20% of IT facilities. It is noted that high income nations have invariably possessed a strong IT base, and their range falls between 45 to 86 percent.

Comparision of IT Environment in the Low (LIN), Middle (MIN) and High (HIN) Income Countries

The IT potentialities of the various groups of countries have been analyzed to measure their level of participation in this dynamic environment. It is interesting to observe (vide Table 2) that there is a notable difference in the provision of IT infrastructure among the groups. While comparing the provision of IT among the low (LIN) and middle income (MIN) groups it is noted that the MIN group seemed to have developed the various IT units more systematically than the LIN group of countries. The mean differences ('t' statistic) of majority of the IT variables in the MIN have been found to be statistically significant, revealing that the middle income countries have better IT infrastructure than that of the LIN. But, these two groups are found to be on the same footing with respect to the development of certain IT variables like fax facilities (V5), telecom (V9), and investment on communication services (V10). In the same way, the mean differences ('t') between the middle and high income group of countries has been found to be significant, exhibiting the disparity in their IT development. However, the position of all these groups remain equal with regard to the development of telecom (V9) services, and making investment on communication and other IT related activities.

Table 2 : Comparison of mean difference of IT indicators between the low, middle and high income countries

S. No.	Variables	Group 1 & Group 2			Group 1 & Group 3			Group 2 & Group 3		
		Mean		t-value	Mean		t-value	Mean		t-value
		G1	G2		G1	G3		G2	G3	
1	News paper per 1,000 people	33.40	168.00	\$3.81	33.40	369.90	\$5.03	168.00	369.90	\$2.70
2	Radios per 1,000 people	162.20	391.70	\$2.97	162.20	1069.00	\$7.01	391.70	1069.00	\$4.60
3	Television sets per 1,000 people	111.10	272.40	\$3.71	111.10	565.30	\$9.53	272.40	565.30	\$5.40
4	Mobile phones per 1,000 people	3.34	22.16	\$3.62	3.34	92.34	\$7.77	22.16	92.34	\$5.70
5	Fax machines per 1,000 people	0.54	4.43	\$1.83	0.54	31.17	\$7.05	4.43	31.17	\$5.54
6	Personal computers per 1,000 people	4.37	46.64	\$2.84	4.37	194.56	\$9.21	46.64	194.56	\$5.83
7	Internet hosts per 1,000 people	0.62	13.04	\$2.20	0.62	129.96	\$4.33	13.04	129.96	\$ 3.85
8	Telephone main lines per 1,000 people	23.90	228.20	\$4.43	23.90	525.40	\$29.58	144.73	525.40	\$ 6.13
9	Telecom subscribers per 1,000 people	102.70	98.00	0.11	102.70	197.10	1.45	98.00	197.10	1.58
10	Communications, services	24.71	36.68	1.51	24.71	33.77	1.35	36.65	33.77	0.60

Note : Group 1 & 2 Low Vs middle Income Countries
Group 1 & 3 Low Vs High Income Countries
Group 2 & 3 Middle Vs High Income Countries
Significant at 5% = 2.10
Significant at 1% = 2.87

\$ Indicates the significant variable causing discriminant

The above analysis has highlighted the close correlation that exists between the socio-economic status of the countries and the importance attached to the development of the IT environment and vice-versa. It has also revealed that the differences between the groups have been caused by the extent of importance given to the newspaper, radios, television, mobile phones, fax, personal computers, internet hosts, and telephone services rather than the telecom and communication services. In other words, the former set of IT parameters alone have shown a high discriminant power between the groups and the variabilities for the last two have been limited, implying that there is no differences between the groups with respect to telecom and communication services.

Discrimination Function Analysis

The discriminant model between three pairs of groups viz: low & middle, low & high, and middle & high have been worked out and presented in Table 3. It is noted that the eigen values are found to be more than '1' for all the groups, revealing that there is a higher order of discrimination existing between them with respect to their IT potentialities. However, among the pairs of countries, the eigen values are higher for the second (48.6) followed by the third (3.1) and the first (1.09) pairs indicating that a high discriminant function exists in the second pair representing the low and high income countries than in the other pairs. The canonical correlation value also helps to measure the differences between the pairs of groups and it is found to be maximum with regard to the middle and the last pair. On the whole, the high correlation values indicate the higher degree of associations between the groups. The Lambda values helps to see the proportion of the total variances in the discrimination scores, not explained by the differences among the groups. The small value of Lambda (0.20) in the second pair explains that the variability is higher between the groups rather than within the groups. The value of Lambda can be tested by using the Chi-square (x^2) distribution.

Table 3: Test statistic vector in the discrimination function model

S. No.	Groups Classification	Eigen Values	% of variance	Cumulative variance	Cannonical correlations	Wilk's lambda	X^2	df	Significance
1	Low Vs middle income group	1.092	100	100	0.7225	0.478	12.91	1	0.0003
2	Low Vs High income group	48.6177	100	100	0.9899	0.020	68.326	1	0.0003
3	Middle Vs High Income Group	3.1446	100	100	0.8710	0.2412	24.171	2	0.0000

The findings of the foregoing analysis reiterated the fact that discrimination between the groups is due to the significant differences in the availability of the IT factors considered for the study. A further analysis attempts to isolate the IT factors that play a prominent role in causing variation between groups.

Measuring the Contribution of the Individual IT Parameters

The relative importance of the individual IT factors has been measured from their percentage contribution to the total distance measured between the groups. This analysis has thrown light on two aspects viz., (i) Identification of IT factors causing discrimination between the groups and (ii) the magnitude of their discrimination power. It was observed that between the low and middle income countries, the percentage contribution of IT indicators has been found to be in the order of telephone mainlines (45%), radios (18.9%), newspaper consumption (13.16%), television sets (11.5%), personal computers (5.9%), and others (5.6%), and they indicate the level of importance of the factors tending to create discrimination. The same set of IT indicators also (with slight variations in their magnitude) have caused discrimination between the low and high income countries. As against this, the dominant factors, that discriminate the middle and high income countries are identified as: the availability of mobile phones (37%), radios (25%), telephone (17%), personal computers (7%) and internet hosts (4%).

Impact of Information Technology on Human Resource Development

The application of IT in achieving literacy has been attempted and the results are presented in Tables 4, 5, 6. The pervasive influence of IT on HRD in the last two decades has been noticed from the R^2 values given in the first two equations, It shows that about 71% of changes in HRD could be made possible by both (i) improving the IT infrastructure and (ii) enhancing the investment on this parameter. It is interesting to observe that during the eighties, the implementation of IT infrastructure seemed to have gained importance, while in the later period, the focus is shifted to streamlining the IT investment towards reengineering HRD factors.

Table 4 : Impact of IT on HRD

Equation 1 1980	Y =	28.865 X^3 +	0.000021 X^2 +	0.00013 X +	0.4605
	(S.E)	(2.25)	(0.000037)	(0.0002)	(0.091)
	n = 30				R = 0.713
Equation 2 1995	Y =	33.865 X^3 +	0.594 X^2 +	0.00004 X +	0.0002
	(S.E)	(3.03)	(0.11)	(0.00003)	(0.00015)
	n = 30				R = 717
Equation 3 Low Income countries	Y =	32.14 X^3 +	0.00093 X^2 +	0.0003 X +	0.494
	(S.E)	(10.4)	(0.001)	(0.0004)	(1.82)
	n = 10				R = 0.34
Equation 4 Middle income countries	Y =	27.1 X^3 +	0.0005 X^2 +	0.00007 X +	0.92
	(S.E)	(5.7)	(0.0007)	(0.0004)	(0.32)
	n = 10				R = 0.7828
Equation 5 High income countries	Y = 109.96 X^3 + 0.0003 X^2 + 0.0001 X = 0.7				
	(S.E)	(69.8)	(0.0005)	(0.0001)	(1.1)
	n = 10				(R =-0.21)

Note: X = Investment on IT X^2 = Investment on Education X^3 = IT Infrastructure

Table 5: Percentage change in HRD during 1980 and 1995

Variables	1980				1995			
	dk	x	k	%	dk	x	k	%
Investment on IT	0.0000020872	0.0003	0.0000000006262	0.0000000034812	0.594	28.24	16.77456	99.9
Investment on Education	0.000131260	0.0061	0.0000000800686	0.000000615	0.0000063917	0.0005746	0.0000001212125082	0.0000000126
IT Infrastructure	0.4608000000	28.24	13.012992	99.999 100.00	0.000019910	0.0001925	0.0000000003832675	0.0000000228 100.00

Note: dk = Regression coefficient x = Mean k = Regression coefficient *Mean % = Percentage

An analysis of the effect of these input factors on the sample regions also have reflected that irrespective of the socio-economic background, these countries have depended to a larger extent on it for manpower development. It is noticed that the percentage change in HRD due to changes in IT factor is found to be the same in the various groups of countries selected for the study.

The above analysis has reiterated the fact that, the global information networks and the satellite and other wireless technologies have been looked upon as a suitable medium to achieve the target of educating the entire community. The emerging satellite schools' the widespread efforts to connect institutes of higher education and libraries have reflected the growing faith in IT for improving the HRD.

Findings and Conclusion

This study has revealed that information technology has no longer been considered as a backdrop of the educational development (HRD), but it is taken as an integral factor. The popularity of Open and Distance Learning has been facilitated through the widespread use of computers and wide area networks that electronically link the teacher and the taught. The growing importance of IT is seen from the enormous rise in the investment made on IT infrastructure, and the wide spread application of IT in the educational system. The correlation between HRD and IT has been established from the R^2 values. No wonder then that having realized the inevitability of IT in education and training, the entire global community is moving towards IT for its betterment.

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Table 6: Percentage change in HRD due to change in IT factors among the selected group of countries

Variables	HIN				MIN				LIN			
	dk	x	k	%	dk	x	k	%	dk	x	k	%
IT Investement	0.000031	0.0005	0.000000155	0.00000038	0.0005	0.006	0.000003	0.000016	0.0002	0.004	0.0000008	0.0000033
IT Infrastructure	0.7	58.24	40.768	99.9	0.92	20.22	18.6	99.9	4.3	5.6	24.08	99.9
Investment on Education	0.0001	0.00002	0.000000002	0.0000000049	0.00007	0.008	0.00000056	0.00003	0.00014	0.0092	0.0000013	0.0000054
			40.768000157				18.60000356				24.0800021	

Note: dk = Regression coefficient x = Mean k = regression coefficient* mean % = percentage