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Information and Communication Technology in Learning Physics at Secondary School Level in Pakistan

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Abstract

Schools throughout the world are faced with the challenge of developing teaching approaches which can take advantage of new technologies and integrate these into the learning experiences of future generations. In developed countries, this has moved forward rapidly. However, in developing countries, the pace of change has been held back by inadequate resources. In all countries, teachers have had to develop new skills while, in many countries, the school students are often far more advanced than their teachers in the skills of using smart boards, smart phones, iPads and laptops. This study explores the issues relating to the use of Information and Communications Technology (ICT) in Physics in secondary schools in Pakistan and, working with large samples, the perceptions, experiences and aspirations of teachers and students were surveyed by means of questionnaires and interviews. The findings showed a clear picture where teachers were enthusiastic to embrace the new technologies although they were not fully aware of the potential in all areas. It was essential that adequate resources are made available to teachers in their own teaching areas and not in central locations while training issues involved technical expertise as well as credible pedagogical expertise was necessary. There were clearly considerable inequalities across the two main school sectors and there was a pressing need to reduce curriculum overload and the over-emphasis on memorization and recall, allowing the teachers and students to engage with an understanding of the materials being studied.

Keywords: ICT, learning of physics, science education, secondary school

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Introduction

Information and communication technologies is defined by Hussain and Safdar (2008, p.1) as a "set of tools that can help provide the right people with the right information at the right time". Salehi and Salehi (2012, p.40) quoted Roblyer and Edwards about their believe in the use of Information and Communication Technology (ICT) in teaching learning process that the use of information and communication technology in education has emerged from two main approaches, namely directed and constructivist instructional methods. Theoretically the directed instruction mainly based on the behaviouristic learning approach while the constructive approach relying upon the principle of learning based on cognitive theory of learning. It is observed that the use of ICT is comparatively difficult in teaching learning process; even schools throughout the world are faced with the challenge of developing teaching approaches which can take advantage of the new technologies and integrate these into the learning experiences of future generations. Furthermore, Henessey et al., (2010) added that the ICTs offer specific opportunities to stimulate growth and increase innovation in every local setting, thereby enabling individuals and institutions to interact more productively with the global economy and the wider world.

In developed countries, this has moved forward rapidly. However, in developing countries, the pace of change has been held back by inadequate resources. In all countries, teachers have had to develop new skills while, in many countries, the school students are often far more advanced than their teachers in the skills of using smart boards, smart phones, iPads and laptops.

Background

One of the dangers in integrating the new technologies is to assume that, simply by using them, learning will be enhanced. There is no certainty that learning will be enhanced. It depends on how the new technologies are employed. Ajayi and Ekundeyo (2008) also assumed that ICT will improve teaching and learning. While it is to be hoped that the use of new technologies may enrich the entire learning process, there is no guarantee that this will be so.

Similarly, Aladejana (2007, p.114) expresses the view that,

> "ICT can promote students' intellectual abilities through higher order thinking, problem solving, improved communication skills, and deep understanding of the learning tool and the concepts to be taught. ICT can promote a supportive, interactive teaching and learning environment, create broader learning communities, and provide learning tools for students".

However, this is perhaps wildly optimistic. Is there any evidence that higher order thinking skills are enhanced? Indeed, the development of some communication skills may actually be hindered while understanding concepts is unlikely to be enhanced in the simplistic way suggested.

It is important to recognize in this that the role of teachers is critical. The technological developments have been frighteningly rapid. Many teachers were often educated and trained in a very different world. Appropriate hardware and software needs to be made available to schools and made accessible for learning. Appropriate support needs to be made available for teachers who are faced with the daunting task of developing new approaches while still being required to continue normal teaching.

Teo (2008) has indicated many studies relating to the attitudes of teachers and there is no doubt that teachers' attitudes are important. Perhaps, however, there are other more important factors: accessible resources, training, technological support, and, perhaps recognition that the new technologies are actually changing the nature of education.

In the 19th century, education was seen simply as the transfer of factual knowledge from the head of the teacher to the heads of the learners, later to be regurgitated on to examination papers. This is to be seen in the Charles Dickens novel entitled 'Hard Times' where the school teacher pronounces: 'Teach these boys and girls nothing but Facts. Facts alone are wanted in life.' (Dickens, 1854). Sadly, examinations in many countries, especially developing countries, still reflect that understanding of education: most of the questions simply seeking factual responses (Al-Madani, et al, 2012).

The way modern technologies make information available simply at the press of a button is likely to change the very nature of how education is conceptualized. It is now much less important what the school student knows. It is much more important that the student understands and can use that knowledge effectively. It is also vital that the student can evaluate knowledge to be able to sift through all that is available online to grasp what is important, relevant, valid, reliable and worth pursuing.

The new technologies can change the very nature of how education is seen. They can change the way teaching and learning take place. In subject areas like the sciences, they can change the very nature of the way experimental information is handled. Data can be captured directly from experiments; experimental data can then be processed quickly avoiding tedious and repetitive calculations, while the outcomes can be presented visually and graphically. All this releases time for the learners to

explore the meaning of what they are finding, to discuss and ask questions, perhaps to grasp complex concepts more quickly without becoming mired in the detail of data processing. However, there may be educational losses as well. Learners can gain much from these computational processes. Intellectually fighting through complex ideas may lead to deeper understandings while the actual skills of data processing may be lost.

The Key Role of Teachers

The literature has a tendency to focus its research and comment on teachers and their attitudes. Those outside the classroom often are quick to see the teachers as the key and they suggest ways by which the teaching could be improved. Thus the teachers of science design and manage the learning environments that provide students with the opportunity needed to learn science. They structure the content and pace of lessons, introducing new material, selecting various instructional activities better suitable towards students learning.

This study was focused on teaching of physics in Pakistan where efforts have made to strengthen school education more meaningful. It is generally observed that science teachers in general are not using the new technologies and therefore, the long list of major problems like the lack of training received by teachers and major problem of frequent load-shedding, In this regards, Mumtaz (2000, p. 321) sees the answers mainly in terms of training and avoiding the cutoff of electricity during teaching process. However, it is observed that training will, of itself, change the situation. There is much that suggests that training, even very good training, does not alter things unless some of the controls placed on teachers are altered. Thus, in her careful study in a developed and a developing country, El-Sawaf (2007) showed that very high quality training, totally supported by highly committed teachers, changed little in the classroom simply because the curriculum and assessment systems imposed restrictions on what was possible.

In addition, who offers the training on the use of ICT in the classroom? Only teachers have the necessarily skills and experiences with the learners and those with little or no classroom experience will be totally unaware of the realities of teaching and learning. There is an issue of credibility here.

Training can be seen in two ways: the technical training in using new technologies (using computers, searching the internet efficiently, using specific pieces of software and hardware); pedagogical training (how to use the new technologies effectively in enhancing learning). The former requires trainers skilled in hardware and software resources; the latter needs those skilled and experienced in the actual processes of teaching and learning and who have a deep understanding of the very nature of learning itself.

Pervaiz (2008) notes that the Ministry of Information and Technology in Pakistan and the Provincial Education Departments had been working to adopt new strategy to integrate information and communication technologies in the education system of Pakistan but the strategy is set in very general terms. The policy assumes that ICT will extend educational opportunity, enhance student learning and that it will strengthen the quality of teaching and educational management. The real question is whether it can be implemented.

In Pakistan, the Intel Teach Programme was launched in 2001. While some teachers have been trained, the impact has been limited. Physics teaching in Pakistan is still dominated by a lecture approach, new technologies are rarely used and even laboratory work has a limited role (Intel Teach Programme, 2007).

The Present Study

The aim of the study described here is to explore the perceptions of Pakistani teachers of Physics (and the wider sciences) relating to the employment of ICT in teaching and learning. Specifically,

- How do the secondary school teachers and students see the use of ICT in learning of physics?
- What are the problems faced by the Physics teachers in using ICT at secondary school level?

In the light of the findings arising from the above two objectives, some practical measures to improve the use of ICT in teaching of Physics at secondary school level may hopefully be identified.

Research Approach

The following approach was adopted:

Table 1
Tools of Research with Sample Size

Data Gathered	Sample	Format	References
Survey of Physics teachers	148	27 Likert items plus one open question	Likert, 1932
Wider survey of science teachers	279	9 questions, using diverse formats	Osgood et al, 1957; Skryabina, 2000; Shah, 2004; Al-Hamali, 2007; Suzuki, 2007; Ali and Reid, 2012
Survey of grade 10 students studying physics	360	12 yes-no questions	Reid, 2003

Teachers and students were selected from an approximately 10% random sample of the 1088 secondary schools which followed the examinations offered by the Multan Board of Intermediate and Secondary Education, including both English medium and Urdu medium schools, and both genders. Validity for the surveys was check by consulting experts and undertaking pre-training while reliability followed the directions given in Reid (2003, 2006).

In handling the data from the surveys, it was recognized that the data were ordinal in nature and, therefore, only non-parametric statistical techniques were employed: chi-square and Kendall's tau-b (non-parametric correlation). In looking at reliability, the spurious use of Cronbach's alpha was rejected as this only measured internal consistency and this is not a desirable feature in most questionnaires. The statistical approaches adopted have been discussed extensively in Reid (2006, 2011).

Findings

Overall, the first survey revealed very little that was new or unexpected. Physics teachers were found to be, in general, positively disposed towards ICT and saw considerable potential in its use on teaching. Inevitably, in an educational system where, to a great extent, teaching is lecturing and success is measured in correct recall, they saw the ICT contribution very much in terms of multimedia projection. The problems in using ICT do not appear to rest with the teachers but with the lack of resources and a reliable supply of electricity.

In order to gain a more detailed picture, the second survey, using a wider range of formats, was developed and employed. This is shown in full, in English, in the appendix.

Question 1 asked the teachers to indicate the three main reasons making the use of ICT in classrooms difficult. The reason most frequently chosen were lack of classroom computer (67%), lack of classroom data projector (58%), unreliability of electricity supply (41%), lack of training in use of ICT (41%). Almost a quarter of the teachers chose lack of suitable software and curriculum overcrowding. The approach adopted by Johnstone (2010) is worth considering. Subject curricula could be pruned quite drastically, releasing time for much more educationally productive activities. In question 2, the teachers were asked to think about their students, using the powerful semantic differential (Osgood et al., 1957) question format (all data shown as %).

The following scale shows the responses of scale from High to Low:

Most students can use computer at home	31	7	5	6	7	45	Few students can use a computer at home
They are fascinated by computers	61	14	11	3	3	10	They are bored by computers
The students are confident computer users	47	10	10	5	4	22	The students lack confidence in using computers
Most students can use internet on their phone	22	7	7	7	4	53	Few students can use internet on their phones
They like to use computer	73	14	5	4	1	4	They do not like to use computers
They are confident to use the internet	43	15	10	5	4	24	They are not confident to use the internet

In most of the items, the responses are very highly polarized: significant numbers have chosen both extreme positions. In general, the teachers think that the students hold positive views about computers although the lack of resources is an issue.

However, there are some marked differences in the response patterns between sub-groups (using chi-square as a contingency test: see Al-Ahmadi, 2008: p. 299-300), but this largely reflected the very different social intakes for English-medium and Urdu-medium schools and the very different social intakes for private and government schools. There were few gender differences.

Question 3 asked teachers about possible ways by which ICT can be used in their teaching. Offered seven choices, they were invited to select the three way that interested them most. The most frequently selected (each about 60%) all related to the preparation and presentation of teaching materials. However, they saw the potential of the web (40%) and in data handling (39%). There were almost no significant differences based on gender, medium or school type.

When asked about using ICT in their teaching (question 4), they responded to 10 items which used the semantic differential format. Again, all data are shown as %.

Table 2
Use of ICT in Teaching

Developing ICT skills is a priority for me	66	15	6	2	1	10	Developing ICT skills is NOT a priority for me
I am NOT convinced that ICT will improve my teaching	32	7	6	5	4	46	I am convinced that ICT will improve my teaching
My school does NOT have enough computers	52	9	6	4	5	24	My school has enough computers
The internet is useful in teaching in my subject	63	13	6	4	4	10	The internet is NOT useful in teaching in my subject
Use of ICT will help my students to learn better	57	14	9	4	4	12	Use of ICT will not help my students to learn better
I cannot see many possibilities using ICT in my teaching	28	12	4	8	9	39	I can see few possibilities for using ICT in my teaching
Initial teacher training must include ICT training	65	10	5	2	3	13	Initial teacher training need not include ICT training
I need to be able to develop my own software	44	19	9	3	5	20	I do NOT need to be able to develop my own software
I have seen no software that is helpful	32	8	9	7	9	25	I have seen much software that is helpful
My school Head supports the use of ICT	61	9	5	3	2	19	My school Head does NOT support the use of ICT

The views are again much polarized. The teachers appreciate the support of their Heads, and the need for training in initial teacher education but the real problem lies in lack of resources. In every way, the teachers see the potential of ICT in enriching their teaching and the learning of their students.

Question 5 focused on training in the use of ICT. Teachers were offered 7 possibilities and all drew sizeable responses. Three drew very high numbers (68%, 63% and 52%). These are very revealing. They lacked training before qualifying as teachers but, perceptively, they saw training as pointless unless the resources were made available. What is very important is the training needs to be related to their own specific subjects, suggesting that generic training is not seen as very valuable and that those who offer the training need to be teaching subject specialists. Two other responses drew high numbers (48%, 47%). Nearly half had received some training since qualifying and they found the training useful.

There was only one gender difference, with more men saying that they had received in-service training (χ^2 = 9.2, df1, p < 0.01). Teachers in Urdu-medium schools were much more aware that training is of little use without have access to computers (χ^2 = 9.0, df1, p < 0.01). Indeed, training is of no value without the equipment to use and the teachers in the Urdu schools were less well provided for.

Question 6 used the Likert format (Likert, 1932) and explored how they saw computers in their own teaching. Data as %;

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I can use a school computer when I want	32	25	10	19	14
I have a computer in my classroom	12	13	9	30	37
I have a computer in my laboratory	23	17	17	17	26
My school has a computer room	57	25	5	8	5
I am confident in using a computer	40	31	12	12	5
Using a computer has changed my teaching	40	31	12	12	5

The answers here are quite revealing. It shows quite an element of polarization. While the majority of schools have computer rooms, it is clear that, while some teachers have access to computers in their own rooms or laboratories, large numbers lack these resources. This offers a key: teacher need to have access in own teaching spaces. However, they say they are confident and are aware of the impact of computers on their teaching.

In question 7, the teachers were asked to suggest one thing they would do to make sure that ICT can be used in their teaching? Nearly two-thirds identified the need for computer resources as the key issue while nearly one quarter seeking training. Question 8 asked them what one thing they needed to equip them to use ICT effectively. Two responses stood out: the need of actual computer resources while training is also important for using ICT. Question 9 explored the actual use they might make of ICT in the teaching in their subject. While nearly one quarter saw 'note preparation' as the key use, almost one third simply wanted a multi-media projector in their teaching area, illustrating the central role for accessible resources.

Kendall's tau-b correlation† was used to relate length of teaching experience to response patterns in questions but few patterns emerged. Overall, it can be deduced that experience in teaching has very minimal effect on perceptions related to the use of ICT.

Question 2 allowed the teachers to think of their students in relation to ICT, using the semantic differential format. There were six items and principal components analysis, using varimax rotation, generated 3 factors, explaining 70% of the variance. Table 3 shows the factor loadings, only those above 0.4 being shown for clarity. The possible identification of the factors is shown at the foot of the table. This suggests that the questions asked reflected three main issues: student interest in ICT, their use patterns and their confidence in using computers.

Table 3
Factor Loadings for Question 2

Item (left-hand-side only)	Factor 1	Factor 2	Factor 3
Most students can use a computer at home		0.82	
They are fascinated by computers	0.83		
The students are confident computer users	0.44		0.55
Most students can use internet on their phones		0.80	
They like to use computers	0.77		
They are confident to use the internet			0.91
Possible Nature of factors	Interest	Use patterns	Confidence

Question 4, also in semantic differential format, explored the way teachers used ICT in their teaching but no factor structure was obtained.

† There are three methods of correlation and Kendall's Tau-b has to be used when there are ordinal data, with limited numbers of categories.

Question 6 also explored the way teachers used ICT in their teaching but used the Likert format. There were six items and principal components analysis, using varimax rotation, generated 3 factors, explaining 70% of the variance. Table 4 shows the factor loadings, only those above 0.4 being shown for clarity. The possible identification of the factors is shown at the foot of the table.

Table 4
Factor Loadings for Question 6

Item (left-hand-side only)	Factor 1	Factor 2	Factor 3
I can use a school computer when I want	0.50		0.45
I have a computer in my classroom	0.85		
I have a computer in my laboratory	0.74		
My school has a computer room			0.95
I am confident in using a computer		0.88	
Using a computer has changed my teaching		0.73	
Possible Nature of factors	Accessibility	Use pattern	Resources

It is clear that the teachers separated the existence of a computer room in their schools from the key issue of having computers accessible to them in their own teaching areas. Understandably, their confidence in using the new technology clearly relates to the effect of that technology on their own teaching.

360 students (aged 14-16) studying physics were selected randomly (table 5).

Table 5
Sample Details

Sample	Frequency	%
Male	228	63
Female	132	37
English medium	154	43
Urdu medium	206	57
Total	360	100

Each question will be discussed in turn. As before, data will be presented as percentages for clarity but any statistics uses frequency data.

Table 6
Use of Computer in Student Context

N = 360, all data as %		Yes	No
1	Do you have computer at home?	66	33
2	Do you use the internet at home?	36	64
3	Do you use the internet at school?	66	33
4	Do you play computer games?	66	34
5	Does your teacher use computer while teaching Physics?	16	84
6	Do you expect your teacher to use computer during teaching	68	32
7	Does the use of computer make things easier to learn?	94	6
8	Do your parents encourage the use of computer during your studies?	67	33
9	Do your teachers encourage you to use computers in the school?	54	46
10	Do you afford to purchase personal computers?	64	36
11	Do You prepare your study notes / material		
	a. using books?	84	16
	b. using teacher notes?	61	39
	c. using internet?	20	80
12	Do you learn the use of computer		
	a. from parents?	39	61
	b. from school?	43	57
	c. from internet club?	5	95
	d. from friends?	47	53

The aim here was simply to gain an overall view of the student context. Much is unsurprising. About two thirds have a computer at home (item 1), with no gender differences. However, there is a very marked disparity between the two school types. English medium schools draw from the better off parents (fees are usually involved) and their access to computers were markedly higher. Boys are very much more likely to use the internet at home and those in the Urdu-medium schools are highly disadvantaged (item 2). It is clear that computers are rarely being used during teaching physics (item 5) although their use is much greater in the better-endowed English medium schools. However, they expect computer use in school (item 6).

Given the financial constraints, it is interesting to see so many thinking that they can afford to make a purchase (item 10) although there is a vast disparity between the social intakes (and financial status) of Urdu medium and English medium schools. There is a touching faith in that they think computers will make learning easier (item 7).

In preparing study notes, textbook dominance, supplemented by teacher notes, is obvious (item 11). However, the privileged position of the English medium school students is very apparent. It is interesting to see that the see their learning on the use of computers coming mainly from three sources and the schools does not dominate (item 12).

Conclusions

The new technologies are advancing at an ever-increasing rate and ICT is making a huge impact on educational provision at all levels. This study was designed to look at the place of ICT in the teaching and learning of Physics (and science) at secondary school level in Pakistan. The focus was primarily on teachers. How did they see the new technologies? How did they see the new technologies in their own teaching? What are the key problems hindering the use of ICT?

Physics teachers are, in general, positively disposed towards ICT and see considerable potential in its use on teaching. Inevitably, in an educational system where, to a great extent, teaching is lecturing and success is measured in correct recall, they saw the ICT contribution very much in terms of multimedia projection. In other words, they saw ICT predominantly in terms of a tool that would allow them to replace a lecture by a presentation driven by computer-generated slides. There is no evidence that this will improve education and, indeed, it might prove less cost-effective in terms of teacher time and student understanding.

If computers are to play a major part in the teaching of physics in Pakistan, the facilities to do this must be available in every classroom. The other major issue is that of training. It is likely that it will involve the actual use of IT equipment, the use of specific software and the way IT equipment might be used in making physics real. However, training is pointless unless the resources were made available.

In looking at the comparison between various subgroups, it is interesting to note that there are almost no gender differences. However, there is marked inequality between the two language systems and between the two school systems, an issue of equity. Clearly, the teaching force is enthusiastic to embrace the new technologies but resources problems dominate. Overall attitudes towards ICT were universally and broadly positive.

It is possible to bring together all the findings under six broad headings and these are summarized in figure 1.

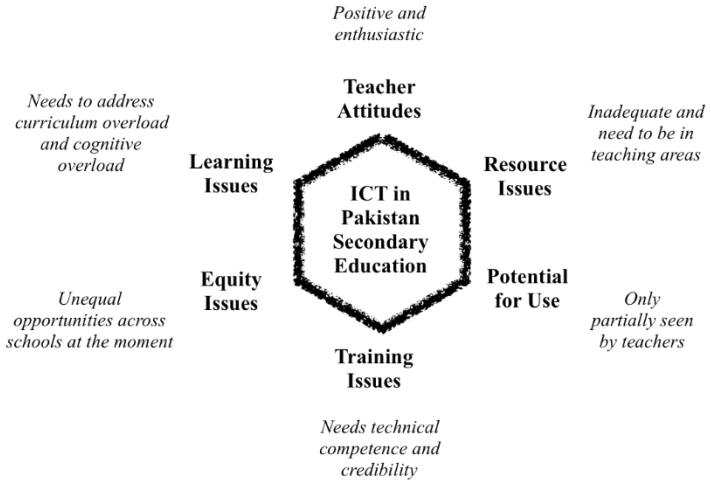

Figure 1 Main Issues Identified

Figure 1 reveals some issues related to use of ICT in Pakistan at Secondary level which are followings; resource issues, learning issue, training issue and potential for use of technology by teachers were generally observed and the major issue was identified by the teachers was the role of textbook and notes and the way they see teaching as lecturing. This reveals that they still are conforming to a model of leaning which was common in the 19th century where the task of the teaching is seen as the source of information, that information having to be transmitted to the learners in as efficient a way as possible.

Learning is now seen to be conceptualized as meaning-making. In other words, the goal is understanding, not memorising. The findings over many decades has demonstrated that this is the natural way to learn and that understanding (meaningful learning) is unrelated to whether the teaching is teacher-centre or learner-centered in the sense of teacher direction or discovery (see Inhered and Piaget, 1958; Ausubel and Robinson, 1957; Johnstone, 1997).

Indeed, the extent of meaningful learning is not related to any specific teaching strategy. This is the point stressed so strongly by Kirschner et al. (2006) when they demonstrate that the key to successful understanding lies in taking into account the limited cognitive resources of the learners. This is seen in terms of limited working memory capacity and the insights of Johnstone, over many decades, have proved to be immensely valuable as well as offering predictive power (Johnstone, 1997).

The question is how all this affects ICT in education. If ICT is simply seen as the replacement of the traditional lecture by presentations driven by the computer and a data projector, then the key issue of meaningful leaning is not addressed. Indeed, it may be made worse in that efficient computer presentations may well overload the working memory even further. Indeed, the screens on many web-sites will cause working memory overload, if understanding is the goal.

The key issue is not the introduction of ICT in teaching and learning but the use of ICT in such a way that cognitive overload is reduced and understanding is enhanced. However, this will only work if the curriculum is less overcrowded and if the national assessment system starts to reward students for understanding and not the correct recognition or regurgitation of information.

It has to be recognized in this study that the attitudes of secondary teachers are NOT the problem in the development of the use of ICT in teaching in Pakistan secondary schools. The problems largely lie outside the schools: overcrowded curricula, lack of resources in teaching areas, perhaps an unsupportive education culture. However, there are some issues that can be addressed easily and it is recommended that these be undertaken:

- Ensure that what ICT resources are available are placed in teaching areas and not in central locations;
- Set up short-life working groups to sift through software and make recommendations;
- Introduce both pre-service and in-service training of high quality offered by those with credibility, either as computer experts or experienced teachers who have developed high ICT capabilities;
- Introduce both pre-service and in-service training that shows how the research evidence on learning offers precise insights that can inform and enhance learning.

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