Use of Information and Communication Technologies in Teaching of Science: A Perception and Practices of Science Teachers

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ABSTRACT
Information and Communication Technology (ICT) has become one of the basic building blocks of modern society. This research attempts to highlight the use of ICT by science teachers with respect to their classroom practices, administration, personal use and professional development. The data was collected from 30 science teachers working in schools of Delhi/NCR. To collect the data on the above cited domains a self-made questionnaire was administered. Prior permission and consent was taken to collect the data from the selected subjects. Obtained raw data was first tabulated and then statistically analysed by using descriptive as well as chi square tests. The findings of statistical analysis revealed that browsing internet to collect learning material and to prepare science lessons were practiced by teachers more frequently. Many teachers have undergone either introductory or equipment-specific training, however very few of them have received training in advanced courses on internet use (creating websites, video-conferencing, etc.). As far as perception of science teachers regarding use of ICT in science teachers was considered, findings revealed that most of the teachers were found very optimistic in using ICT while teaching.
Keywords: administration, classroom practices, personal use, professional development, ICT, science teaching

INTRODUCTION

In this digital era, it is hard to ignore the use of Information and Communication Technology (ICT) in our everyday life. Within a very short span of time, ICT has become one of the basic building blocks of modern society. Human beings are surrounded by different media sources such as television, radio, computers etc., from waking up in the morning till they sleep. This reflects how much ICT has infiltrated in our life. In fact many countries have now accepted the fact that understanding ICT along with reading, writing and numeracy, and mastering the basic skills and concepts of ICT are the core part of education.

Here, it is important to know that UNESCO (2002) refers the term ICT as the *"forms of technology that are used to transmit, process, store, create, display, share or exchange information by electronic means. This broad definition of ICT include technologies such as radio, television, video, DVD, satellite systems, computer, network hardware, software, as well as the equipment and services associated with these technologies, such as videoconferencing, electronic mail."*

In National Policy on Information and Communication Technology in School Education (2012), it is mentioned that *"ICT enabled teaching-learning encompasses a variety of techniques, tools, content and resources aimed at improving the quality and efficiency of the teaching-learning process. Ranging from projecting media to support a lesson, to multimedia self-learning modules, to simulations to virtual learning environments, there are a variety of options available to the teacher to utilise various ICT tools for effective pedagogy. Each such device or strategy also involves changes in the classroom environment, and its bearing on effectiveness. Availability of a wide range of such teaching-learning materials will catalyse transformation of classrooms into ICT Enabled classrooms".*

Studies suggested that ICT enabled classrooms have more impact on the students' learning (Osborne & Hennesy, 2003; Wellington, 2003; Hogarth et. al., 2006). In the same line the studies which conducted to analyse the impact of integration of ICT in science education suggests that ICT integration makes learning environment more engaging, pragmatic, relevant, self-directed, reflective as well as it encourages the learners to study topics in a way

that leads to deep and understandable knowledge based on learning objectives (Osborne & Hennesy, 2003). It also boosts motivation, interest and participation in teaching-learning activities (Denby & Campbell, 2005).

ICT in science education can create an environment where students may visualise and manipulate complex models, 3-D visuals for better understanding of scientific concepts and can assist students in focusing on important concerns, making underlying abstract concepts more salient (Denby & Campbell, 2005; Dori & Barak, 2001; Rogers, 2006). ICT also enable users to access high-quality and useful resources (web-pages, documents, videos, simulations etc.) for scientific learning (Osborne & Hennesy, 2003). Furthermore, use of ICT encourages experimentation and inquiry by offering quick visual feedback which can also help students in learning how to use ICT or develop their digital literacy (Newton & Rogers, 2001; Osborne & Hennesy, 2003).

Hogarth et al. (2006) documented that use of ICT simulations by students greatly enhanced their knowledge of scientific concepts as compared to non-ICT activities. With tools like data-logging, blogs and wikis, podcasts, simulation software, YouTube videos and digital microscopes, teachers are now using ICT to make science lessons more engaging and practical (Murphy, 2009). On the contrary, Huang et al. (2021) in their study found a negative relationship between students' ICT use in learning and their science performance and they stated that *"…in order to provide more concrete evidence of the impact of ICT use on students' academic achievement in general, and on students' science performance in particular, a more comprehensive model is needed to investigate multiple influencing factors"*. Also, findings of Hu et al. (2018) revealed that ICT availability for students at school is positively associated with students' academic success, however ICT availability at home was negatively associated with their academic success.

Review of all these studies cleared the fact that, rapid developments in hardware and software paved way for new possibilities. Yet there are considerable gap between the aspirations of the experts and the classroom reality. Researches have been done to analyse the effectiveness of using ICT in science teaching and to what extent it is being used by the school teachers (Osborne & Hennessy, 2003; Newton & Rogers, 2001; Juuti et al., 2009), but country like India needs more researches to be conducted in order to understand the contribution of teachers' role in determining the effectiveness of ICT in science lessons. Thus, this investigation aimed to analyse usage of ICT by science teachers for their classes, administrative purposes, personal use and professional development while teaching science at school.

METHODS AND MATERIALS

In this section, the details of participants of the study, tools and techniques used, procedure and analysis of data collection is mentioned.

Participants

A total of 30 science teachers were recruited from the 10 secondary schools of Delhi/NCR to work on the objective. A multistage random sampling technique was adopted to first select 10 schools then 30 science teachers from those schools.

Tools and Techniques

A questionnaire on "Use of ICT in Science Teaching" was developed to collect data from the selected science teachers. Few items of the developed questionnaire were adopted from the work of Alturki and Ahmad (2014), Almaghlouth (2008) and TQICT. The statements (questions) in the questionnaire was arranged into 4 sections, namely- Classroom practices, Administration, Personal Use and Professional Development having both closed as well as open-ended questions. The questionnaire was validated by a panel of experts working in the field.

Procedure of Data Collection

The data was collected from 10 selected schools situated in Delhi/NCR. To initiate the data collection procedure, a prior permission was obtained from the principals of the respective schools. After obtaining permission, the researcher approached the concerned science teachers and obtained their consent as well for responding on the questionnaire. A brief instruction and purpose of the study was explained to each participant before commencement of data collection, and after that their filled questionnaires were collected back. On an average, the respondents took 8 minutes to fill the questionnaire. Around 2 months were spent to collect the data from 30 science teachers.

Statistical Analysis

Obtained raw data was entered and tabulated into MS Excel sheet for data analysis procedure. After entering data into excel sheet, the data was exported to SPSS-(v.23) and descriptive statistics, percentage analysis and chi square were computed for final interpretation. An Alpha level of 0.05 was set to know the significance difference.

RESULTS

The science teachers were asked to respond on the most appropriate options provided in the questionnaire indicating their use of ICT on the areas: Classroom Practices, Administration, Personal Use and Professional Development. Results of the statistical analysis are presented in the following tables and graphs.

As far as Classroom Practices were concerned, this section included 7 closed-ended questions and 3 open-ended questions. The science teachers' responses on each item are given below in Table 1.1.

Table 1.1: Responses of Science Teachers on their use of ICT with respect to their Classroom Practices

S.No.	Statement	Daily	Weekly	Monthly	Once or twice a year	Never	Chi-square
1	"Browsing or Searching internet to collect information to prepare Science lessons"	7 (23.3%)	12 (40%)	4 (13.3%)	4 (13.3%)	3 (10%)	8.98
2	"Browsing or Searching internet to collect learning material or resources to be used by students during lessons"	9 (30%)	8 (26.7%)	8 (26.7%)	1 (3.3%)	4 (13.3%)	7.64
3	"Using applications to prepare presentations for Science lessons"	4 (13.3%)	9 (30%)	6 (20%)	2 (6.7%)	9 (30%)	6.32
4	"Creating your own digital learning materials for students"	3 (10%)	7 (23.3%)	3 (10%)	6 (20%)	11 (36.7%)	7.32
5	"Posting Science home work for students on the school website/ Learning Management System"	2 (6.7%)	5 (16.7%)	2 (6.7%)	8 (26.7%)	13 (43.3%)	14.3*
6	"Using ICT to provide feedback or assess students' learning of Science concepts"	1 (3.3%)	7 (23.3%)	4 (13.3%)	3 (10%)	15 (50%)	19.9*
7	"Downloading, uploading or browsing materials from Open Educational Resources for Science Teaching and Learning"	5 (16.7%)	7 (23.3%)	4 (13.3%)	5 (16.7%)	9 (30%)	2.64

*Significant at 0.05 level Tabulated $x^2_{0.05}(4)=9.488$

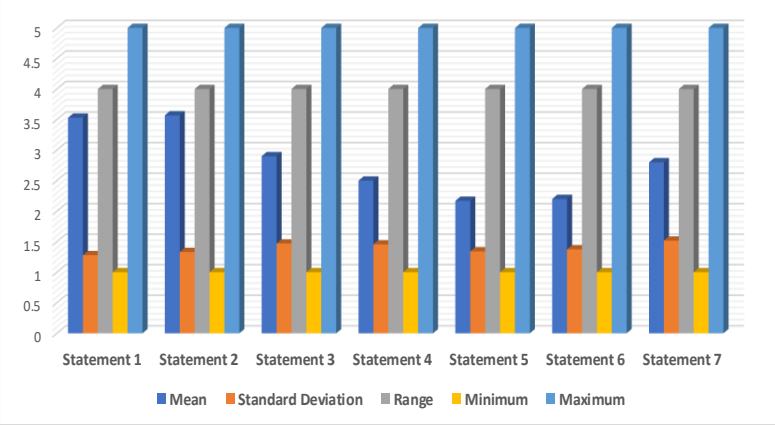

Figure 1.1: Graphical illustration representing responses of science teachers on their use of ICT with respect to their classroom practices

The findings documented in Table 1.1 and Figure 1.1 indicates that, there was no significant difference in expected and observed frequencies for the items 'browsing or searching internet to collect information to prepare science lessons', 'browsing or searching internet to collect learning material or resources to be used by students during lessons', 'using applications to prepare presentations for science lessons', 'creating own digital learning materials for students' and for 'downloading, uploading or browsing materials from Open Educational Resources for science teaching and learning'. Hence it reveals that these activities are practiced by science teachers quite frequently. However, the calculated chi-square value for the items 'posting science homework for students on the school website/LMS (Learning Management System)' and 'using ICT to provide feedback or assess students' learning of science concepts' was more than the tabulated chi-square value which implied that there was a significant difference among the responses of the science teachers on these statements and therefore, it reveals that these activities were least practiced by science teachers.

Further, **three open-ended questions** were also asked to the science teachers about their use of ICT for classroom practices. The **first open-ended question** was related to the perception of teachers about using ICT in Science for better understanding of the concepts. All the thirty teachers agreed that using ICT in science is better for understanding of the concepts. Provided reasons of the science teachers were grouped based on similarity and it is presented in Table 1.2.

Table 1.2: Perception of teachers about using ICT in Science for better understanding of the concepts

S.No.	Statement	Frequency	Percentage (%)
1	Biology: Structure of DNA, RNA, Structure of a cell, Tissues, Cell Division, Genetics, Microorganisms, Digestive System, Respiratory System, Circulatory System, Evolution	17	56.7%
2	Physics: Electromagnet, Electroplating, Sound, Light, Electricity, Magnetic effects of Electric Current	7	23.3%
3	Chemistry: Chemical bonding, Chemical Reaction, Atoms and Molecules	6	20%

Table 1.2 shows that, more than half of the science teachers (53%) reported that ICT in Science leads to better understanding of the concepts as it provides visualization of the different concepts of science. According to 16.7% teachers, ICT in Science helps in making learning effective and efficient. Around 13% of the science teachers believed that whole class can be involved as students enjoy learning through ICT. Whereas, rest of the 16% science teachers indicated that ICT can help average students understand the concept and a lot of study materials can be accessed through ICT that can be used for science teaching and learning.

In the **second open-ended question**, the science teachers were asked to list the topics of science which were best understood only by using ICT. Obtained responses are presented in below Table 1.3.

Table 1.3: Perception of teachers about topics of science best understood only by using ICT

S.No.	Statement	Frequency	Percentage (%)
1	Yes, because it provides visualization of the different concepts of Science	16	53.3 %
2	Yes, it helps the average students understand the topic much better	3	10%
3	Yes, a lot of study materials can be accessed through ICT	2	6.7%
4	Yes, ICT in Science helps in making learning effective and efficient	5	16.7%
5	Yes, whole class can be involved as students enjoy learning through ICT	4	13.3%

Readings of Table 1.3 indicates that, the topics such as Structure of DNA, Structure of a cell, Cell Division, Genetics, Microorganisms, Digestive System, Respiratory System, Circulatory System, Electromagnet, Electroplating, Sound, Light, Magnetic effects of Electric Current, Chemical bonding, Chemical Reaction, Atoms and Molecules etc. are some of the topics that were best understood only by using ICT, as reported by the teachers. Science teachers also reported that, the frequency of topics related with Biology (56.7%) was more as compared to the topics related to Physics (23.3%) and Chemistry (20%).

In the **third open-ended question**, the teachers were asked to give suggestions as how ICT can be used effectively in Science, its results are provided into below mentioned Table 1.4.

Table 1.4: Suggestions given by teachers about effective use of ICT in Science

S.No.	Statement	Frequency	Percentage (%)
1	Different concepts of Science can be taught using Projectors, Laptops & Internet	5	16.7%
2	Creating Presentations, Video Clips, Animations	3	10%
3	ICT can be effectively used for preparing Lesson Plans	4	13.3%
4	Availability and Adequacy of ICT Resources	6	20%
5	By showing them 3D pictures/models and correlating the concept with real life examples	3	10%

6	Providing training in ICT	2	6.7%
7	Authentic data can be accessed through ICT	2	6.7%
8	Quiz and tests can be prepared	3	10%
9	ICT can be used for teachers' self-learning	2	6.7%

According to the readings of Table 1.4, the suggestions given by the teachers indicate that effective use of ICT in Science can only be possible if there are adequate ICT tools available in the schools. Other suggestions by science teachers include, the use of ICT helpful in Lesson Planning, for developing Quiz and Tests for the students, Need for training of ICT for self-learning and authentic data accessibility.

The second major section of the questionnaire was Administration. In this section 7 closed-ended question were included. The teachers' responses regarding each item of this section are given below in the Table 2.1. Frequency, percentage and chi-square value has been calculated for the same.

Table 2.1: Responses of Science Teachers on their use of ICT with respect to Administration

S.No.	Statement	Daily	Weekly	Monthly	Once or twice a year	Never	Chi-square
1	Typing exam papers	0	4 (13.3%)	16 (53.3%)	2 (6.7%)	8 (26.7%)	26.64*
2	Writing student reports	0	6 (20%)	9 (30%)	6 (20%)	9 (30%)	9
3	Recording students' Science grades	0	3 (10%)	12 (40%)	13 (43.3%)	2 (6.7%)	24.32*
4	Recording students' attendance	15 (50%)	4 (13.3%)	5 (16.7%)	3 (10%)	3 (10%)	17.32*
5	Checking school timetable or notices	14 (46.7%)	4 (13.3%)	6 (20%)	1 (3.3%)	5 (16.7%)	15.64*
6	Contacting colleagues via emails	3 (10%)	4 (13.3%)	2 (6.7%)	10 (33.3%)	11 (36.7%)	11.64*
7	Communicating online with parents	2 (6.7%)	2 (6.7%)	3 (10%)	8 (26.7%)	15 (50%)	20.98*

*Significant at 0.05 level Tabulated $x^2_{0.05}(4)=9.488$

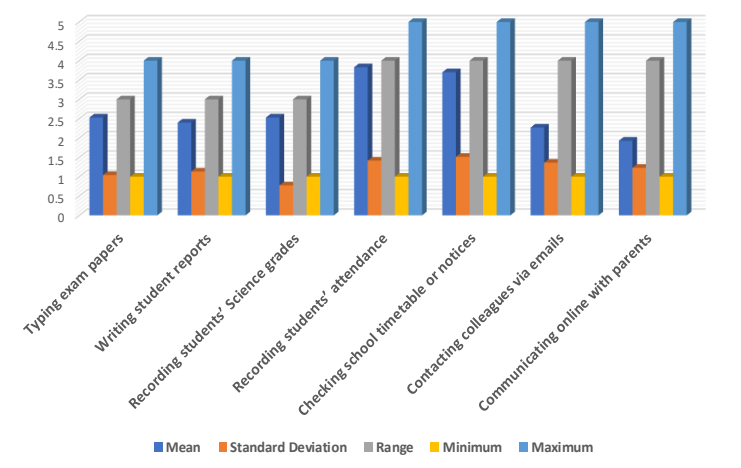

Figure 2.1: Graphical illustration of the responses of science teachers on their use of ICT with respect to administration

According to the findings given in Table 2.1 and illustration provided in Figure 2.1, the science teachers reported that they use ICT quite often for 'recording students' attendance', 'checking school timetable or notices', 'typing exam papers' and 'recording students' Science grades'. Whereas, 'communicating online with parents' and 'contacting colleagues via emails' were less frequent. On calculating the chi-square value for these items it was found that, there was no significant difference among the responses of the science teachers on the item 'writing student reports' whereas there was a significant difference for the rest of the items of this section i.e., Administration.

The third section of the questionnaire was dedicated to Personal Use. This section of using ICT for Personal use included 7 closed-ended questions. The science teachers' responses regarding each item are given below in the Table 3.1.

Table 3.1: Responses of Science Teachers on their use of ICT with respect to Personal Use

S.No.	Statement	Daily	Weekly	Monthly	Once or twice a year	Never	Chi-square
1	WhatsApp	30 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	120*
2	Facebook	12 (40%)	9 (30%)	2 (6.7%)	1 (3.3%)	6 (20%)	14.32*
3	Instagram	9 (30%)	2 (6.7%)	3 (10%)	0 (0%)	16 (53.3%)	28.32*
4	Twitter	6 (20%)	2 (6.7%)	2 (6.7%)	0 (0%)	20 (66.7%)	43.98*
5	YouTube	24 (80%)	4 (13.3%)	2 (6.7%)	0 (0%)	0 (0%)	69.32*
6	Google	22 (73.3%)	3 (10%)	1 (3.3%)	0 (0%)	4 (13.3%)	54.92*

*Significant at 0.05 level Tabulated $x^2_{0.05}(4)=9.488$

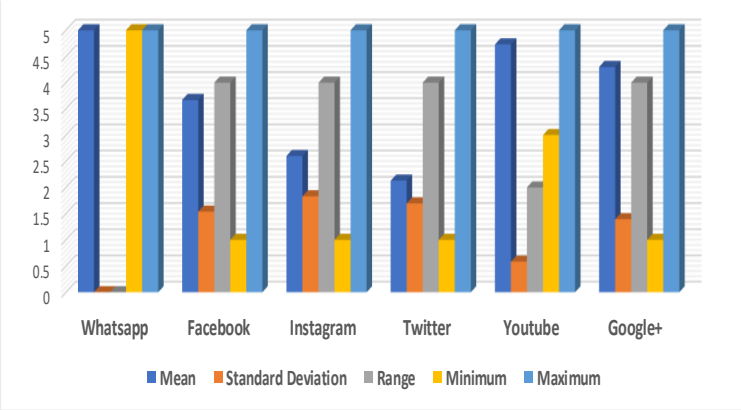

Figure 3.1: Graphical illustration of the responses of science teachers on their use of ICT with respect to personal use

Table 3.1 and Figure 3.1 reveals that there was a significant difference among the responses of the science teachers on all the items of this section and it was quite evident that use of WhatsApp (100%) and YouTube (80%) daily by the teachers was most frequent. Next to that is Google, which was used by 73.3% of the teachers on a daily basis and Facebook (40%). Twitter (42%) was found least used by the science teachers among other options provided in the list.

Last section of the questionnaire contain questions related to Professional Development. This section included 9 closed-ended questions. Science teachers were asked to indicate if they have undergone any professional development training (in-service training) in the last two years of school. The teachers' responses regarding each item of this section of the questionnaire are indicated in the Table 4.1 and Figure 4.1 in percentage.

Table 4.1: Responses of Science Teachers on their use of ICT with respect to Professional Development

S.No.	Statement	Yes	No	Chi-square
1	"Introductory courses on internet use and general applications (basic word-processing, spreadsheets, presentations, databases, etc.)"	17 (56.7%)	13 (43.3%)	0.52
2	"Advanced courses on applications (advanced word-processing, complex relational databases, Virtual Learning Environment etc.)"	10 (33.3%)	20 (66.7%)	3.32
3	"Advanced courses on internet use (creating websites/home page, video conferencing, etc.)"	6 (20%)	24 (80%)	10.8*
4	"Equipment-specific training (interactive whiteboard, laptop, etc.)"	13 (43.3%)	17 (56.7%)	0.52
5	"Courses on the pedagogical use of ICT in teaching and learning"	11 (36.7%)	19 (63.3%)	2.12
6	"Subject-specific training on learning applications (tutorials, simulations, etc.)"	15 (50%)	15 (50%)	0
7	"Course on multimedia (using digital video, audio equipment, etc.)"	11 (36.7%)	19 (63.3%)	2.12
8	"Participate in online communities (e.g. mailing lists, twitter, blogs) for professional discussions with other teachers"	11 (36.7%)	19 (63.3%)	2.12

9	"Other professional development opportunities related to ICT"	7 (23.3%)	23 (76.7%)	8.52*

*Significant at 0.05 level Tabulated $x^2_{0.05}(1)=3.841$

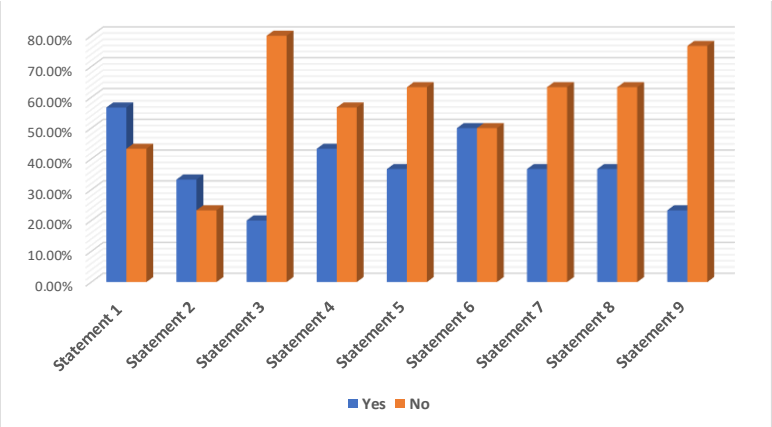

Figure 4.1: Graphical illustration of the responses of science teachers on their use of ICT with respect to professional development

The findings related to the fourth section of the questionnaire is presented in Table 4.1 and Figure 4.1, and it shows that 56.7% of the science teachers have undergone training in "introductory courses on internet use and general applications (basic word-processing, spreadsheets, presentations, databases, etc.)", half of them (50%) in "subject-specific training on learning applications (tutorials, simulations, etc.)" and 43.3% in "Equipment-specific training (interactive whiteboard, laptop, etc.)". Whereas, only 20% teachers have undergone "training in advanced courses on internet use (creating websites/home page, video conferencing, etc.)". There was a significant difference among the responses of science teachers on the items "Advanced courses on internet use (creating websites/home page, video conferencing, etc.)" and "Other professional development opportunities related to ICT" however, there was no significant difference for the rest of the statements.

DISCUSSION

This study was undertaken to analyse the use of ICT by science teachers in their classroom practices, administration, personal use and professional development. Findings related with classroom practices revealed that majority of the respondents browse internet to collect information to prepare science lessons and to search learning material or resources to be used by students during lessons either daily or weekly. Levonen (2008) throws light on benefits of using Learning Management System (LMS) and states that distance learning approaches which includes lecture notes, homework projects, online books and complete courses in science, physics, chemistry or biology are available on the Web. The whole course can be managed by the Science Teacher through a Learning Management Systems (LMS). However, it was also found that not many of the respondents of this study uses LMS or other tools to post homework or learning materials.

The science teachers revealed that use of ICT in science leads to better understanding of the concepts as it provides visualization of different concepts of science. The findings are consistent with Rogers (2006). Other benefits, as reported by them, includes ICT making learning effective and increases students' engagement as they enjoy learning through ICT. They also believe that ICT can help average students understand the concept and a lot of study materials can be accessed through ICT that can be used for science teaching and learning. The findings are consistent with Osborne and Hennessy (2003) which suggests that ICT in teaching and learning increases interest, motivation and engagement in activities, provide access to a number of resources that are of high quality and relevant to scientific learning.

The science teachers also reported that ICT resources were used to teach Biology concepts more as compared to Physics and Chemistry. This might be due to the fact that the visual representations help in better understanding of the concepts (Dori & Barak (2001); Rogers, 2006). When teachers were asked about suggestions for effective use of ICT in science, many of them indicated that availability and adequacy of ICT resources are important in this regard. Also, different concepts of science can be taught by showing students 3D pictures/models and correlating the concept with real life examples. Furthermore, the teachers also reported that ICT can be effectively used for preparing lesson plans and for preparing quiz and tests for assessment and therefore, providing training in ICT would be highly beneficial. The findings are consistent with Tondeur et al. (2007), which says that supportive ICT use includes preparing lesson plan, worksheets and developing evaluation activities.

As far as ICT use for administrative purposes by science teachers were concerned, it was found that teachers used ICT tools quite frequently for recording students' attendance and for checking school timetable or notices. The findings are in line with Newton and Rogers (2003) which highlights the importance of using ICT by teachers as it is good for handling data and it is also time saving. On the contrary, it was found that many of the respondents do not use ICT tools much to communicate online with parents or for contacting colleagues via emails. For personal use, WhatsApp, YouTube and Google are the most frequently used applications, as indicated by the respondents. Through WhatsApp groups they coordinate with students as well as their colleagues. Often learning materials or even notices were shared through such platforms. Google and YouTube were frequently used by them to search learning materials that can be used for making lesson plans as well as for sharing additional resources to students for extended learning. The findings are consistent with Berk (2009) and Seilstad (2012) which examined the role of YouTube videos for teaching students.

The science teachers were asked to indicate if they have undergone any professional development training in the past two years in school. Findings revealed that more than half of the respondents have undergone training in introductory courses on internet use and general applications. However, only a few of them have undergone training in advanced courses such as creating websites/homepage or conducting video conferencing. Some of them indicated that they have received training for understanding how to use interactive whiteboard, virtual learning environment, use of multimedia in teaching-learning process etc. In addition, some teachers also reported that they have received subject-specific training on learning applications such as simulations. It is observed that due to lack of training, teachers feel hesitant in integrating ICT in their lessons and for using it for various purposes that would be beneficial for them (Becta, 2004). The reasons for not undergoing any training can be either their resistance to change (Habibu et al., 2012; Juuti et. al., 2009) or due to time constraints (Becta, 2004; Juuti et. al., 2009) . ICT is not used by teachers to such extent as it could be appropriate according to the potentials reported in the literature because sometimes the teachers have insufficient time to learn about the use of ICT and its applications in classrooms and they have no confidence in using ICT (Juuti et. al., 2009). However, it is important for teachers to undergo training so that they can use ICT along with their professional skills during lesson to maximise its potential.

CONCLUSION

It is believed that students' grasp and retention of scientific knowledge improves when science concepts are taught through ICT. This research was an attempt to understand the perception and practices of science teachers towards using ICT for classroom practices, administration, personal use and for their professional development. Within the limits and limitations, it can be concluded that when compared to traditional ways, incorporating ICT in science lessons can help science teachers in lesson preparation, in managing students' data (marks, attendance etc), in communicating with students and sharing learning resources with them. Furthermore, it has the potential to make the teaching-learning process more engaging and motivating which may lead to achieving better learning outcomes. In order to enhance their knowledge and skills, science teachers can use various software and they can keep themselves updated with the technological advancements in their field (specialization).

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