National
College of
Ireland

*The college for a
learning society*

Integrating ICT into the Second Level Mathematics

Curriculum:

An Investigation of the Obstacles That Exist

Sabrina Keenan

Lejla Rovcanin

Integrating ICT into the Second Level Mathematics Curriculum:

An Investigation of the Obstacles That Exist

Sabrina Keenan, sabrina.keenan@ibts.ie
Leja Rovcanin, National College of Ireland, lrovcanin@ncirl.ie

0.   Abstract

This study looks at the integration of Information and Communications Technologies (ICT) into teaching and learning in second level schools in Ireland, and at the issues relating to their incorporation into the curriculum. Particular emphasis is given to the integration of ICT into mathematics teaching.

The theory of constructivism, as it relates to the teaching and learning of mathematics is discussed, and the ability of ICT to facilitate a constructivist learning style is investigated. It is suggested that constructivism is well suited to the teaching and learning of mathematics given its 'building blocks' nature.

The current status of the ICT initiative in Ireland is then described and issues presenting obstacles to its progression are discussed. Particular attention is given to the issue of pedagogy and technology. It is suggested that the Irish ICT initiatives have focused on trying to integrate ICT into education without first putting the correct pedagogical framework in place to support it.

1.   Introduction

The purpose of this research, with emphasis on the teaching of mathematics, is to investigate:
- What issues are causing obstacles to te integration of ICT into Irish schools
- What are the pedagogical issues relating to their integration.

Throughout the research particular emphasis is given to the teaching and learning of mathematics at second level.

Mathematics is one of the most important subjects that Irish students study while at school and for many it is also the most difficult. The breadth and depth of the second level mathematics courses at both junior and senior level coupled with a generally very dry and abstract 'traditional' teaching method, leaves many students at the end of their second level careers with little in the way of lifelong or transferable skills in the area of mathematics.

In recent years however, there has been a move towards a more constructivist learning methodology.

" In constructivism, learning is seen as a constructive process in which learners have an active role and learning is based on their cognitive functioning. The learners obtain new knowledge by constructing it on the basis of their earlier knowledge, upon their active functioning in continuous interaction with the surrounding reality and other learners."

(Ruokamo-Sari & Pohjolainen, 1997)

Mathematics is a perfect candidate for this new methodology; it is a subject which builds new knowledge onto prior knowledge from the very basics of counting at primary level to differential and integral calculus at senior level. Without making connections and building on their existing knowledge students cannot hope to progress in mathematics. A constructivist approach would allow the student to explore the relationships between the different areas of mathematics and mathematical ideas and discover the connections for themselves in a way which would better slot into their existing schemas.

The use of ICT in the teaching and learning of mathematics is one way to encourage this constructivist style. Tapscott (1999) identified a number of ways in which the integration of ICT into teaching and learning could have beneficial effects including moving, from
- Linear to hypermedia learning
- Instruction to construction and discovery
- Teacher centred to learner centred
- School to lifelong learning
- 'One-size-fits-all' to customised learning

The move to integrating ICT into education is worldwide. (Freeman & Gilleran, 2001) The worlds of business and entertainment have been utilising technology for many years now so it stands to reason that if we are the educate our young people to function in this technological age that we must introduce them to the technologies as part of their formal education. There are however a number of barriers at both the macro and micro levels to integrating and incorporating new technologies into our schools. These barriers include issues like lack of hardware and software in schools, not enough training for teachers about how to use the technology, lack of guidelines and support materials and within many schools issues with access and timetabling.

2. A Review of the Literature

Mathematics Teaching and Constructivism

There has been much debate in recent years about current practices with regard to mathematics education at second level, both the junior and leaving certificate courses cover a broad range of mathematics with a large emphasis on Algebra and Trigonometry at both junior and senior levels and also Calculus at senior level. In schools throughout the country these topics and most of the mathematics curriculum are taught in an abstract manner, which has little relevance or meaning for most students and they are often left with no idea what any of it is used for. Oldham (2001) believes that a large number of students at Leaving Certificate in particular are trying to learn material which is too abstract for their current stage of development and that the competitiveness of the exams means that teachers and students are under enormous pressure to cover content for the final examination rather than focusing on "deep understanding and contextualised application" of the material.

This is obviously far from an ideal situation and the problems with current practices are acknowledged by the fact that for some years now consensus has been moving towards learner centred education where learning is viewed as an

"internal process which the learner, when presented with a problem mentally links the problem with existing knowledge. Meaning is the outcome of adding this newly learned concept to an existing structure of knowledge. In this way the learner has the ability to construct knowledge in his/her own mind" (O'Callaghan, 2000). This is the basis of the constructivist learning theory. Mathematics and problem solving lends itself very naturally to a constructivist approach. McNamara et al (1997) define the constructivist approach as one in which the emphasis is on collaboration, open discussion and reflection throughout the development of a project. The quality of learning experience which students could potentially have in this type of environment, will far surpass their present experiences based on the behaviourist model where students are treated like "little vessels ready to have imperial gallons of facts poured into them until they were full to the brim." (Dickens, 1995)

ICT and its Role in Facilitating a Constructivist Learning Style

Introducing technology into the mathematics classroom is essential to the development of this constructivist style of learning. Among the benefits of employing technology as a tool in the learning of mathematics is the opportunity it provides for students to learn from feedback- solving by means of trial and improvement, observing patterns – because of the speed at which technology works students can, as with trial and error, try many examples and notice patterns, seeing connections – students can observe connections between formulas, data and graphs, working with dynamic images – which can be extremely useful for topics like geometry, and the exploring data – students can deal with real data sets and focus on analysis and interpretation.(WWW1,1998) These opportunities are fundamental for students to become actively involved in the learning process and to construct their own knowledge.

Irish ICT Initiatives

In the last six years the Irish government has introduced a number of policies – Schools IT 2000 (DES, 1997) and The Blueprint for the Future of ICT in Irish Education (WWW2, 2001) to bring technology into the classroom. In the Schools IT 2000 document it was noted that,

"Ireland lags significantly behind its European partners in the integration of information and communication technologies into first and second level education. The need to integrate technology into teaching and learning right across the curriculum is a major national challenge that must be met in the interests of Ireland's future economic well being"
(DES, 1997)

The IT 2000 initiative, which was launched in 1997 involved expenditure of £40 million over three years to support the development of ICT in Irish schools. This money was spent predominantly on infrastructure. The current initiative outlined in The Blueprint for the Future of ICT in Irish Education has made a commitment to invest a further €107.92 million over the period 2001 – 2003. Almost 75% of this money is again capital expenditure to include "developing wiring –networking infrastructure and the provision of broadband access to the Internet." (WWW2, 2001)

While all of these infrastructural investments are a necessary part of the process the point has been made that, "now that the infrastructure for computer usage in Irish schools is being put in place, there is an urgent need for more resources to be allocated at a national level to support curriculum development." (Information Society Commission, 1999).

Issues Relating to the Integration of ICT into Teaching

While Ireland is making progress in the area of ICT in education in so far as the initiatives have been put in place and are working towards providing all schools with the required infrastructure and hardware, there are a number of major barriers to integrating technology into teaching.

Pelegrum (2001) reported on a worldwide survey among national representative samples of schools from 26 countries. One area that the data analysis explored was the area of difficulties relating to integrating ICT into teaching.

Among the most commonly reported difficulties were,
- Insufficient numbers of computers
- Teacher's lack of knowledge/skills
- Difficult to integrate in instruction
- Scheduling computer time
- Insufficient teacher time
- Not enough training opportunities
- Lack of technical assistance

Pedagogy before Technology

It is clear from the research that these issues are not just local to the Irish ICT initiative. And although a number of factors are listed here perhaps the most fundamental one relates to pedagogy.

"Technology alone cannot improve teaching and learning ... technology use must be grounded firmly in curriculum goals, incorporated in sound instructional process, and deeply integrated with the subject matter content."(Baker, Herman and Gearhart, 1996)

In a critique of the Schools IT 2000 initiative, Conway (2000) argues that, "IT 2000's rationale for integrating ICT is primarily focused on perceived economic outcomes. IT 2000 underestimates the curricular scope of computer literacy and although it is not a curriculum document the inattention to the curricular scope of ICT integration is problematic"

A very real difficulty for teachers in general and more specifically in Ireland is now that they have the computers, what are they supposed to do with them? As Goddard (2002) so succinctly puts it "educators propose, instructional design theories develop and technology conforms". The drive towards integrating ICT into education should be coming from the educators and the curriculum designers and the technology should then be used to support new curriculum ideas.

4

"The proper approach is essential. We should start with clear educational objectives, analyse the teaching and learning methodologies best suited to these objectives, then establish the relevance of computing to these methodologies, and then design the courseware required. We should not, as so often happens in schools nowadays, buy a particular machine and end up doing what the machine wants to do, rather than what the children should be doing"(Mackey 1987)

ICT and the Mathematics Curriculum

Aside from learning IT as a subject in itself, mathematics is one of the most obvious subjects taught in schools that could benefit from the integration of currently available technologies. The push towards constructivist learning in mathematics in particular could be facilitated to a great degree by the incorporation of ICT. Guidelines in this area are however, sadly in short supply. The only ICT that the Junior Certificate curriculum mentions specifically is the calculator, which has recently been introduced at junior level. The Leaving Certificate curriculum is just as lacking, the sum total of discussion about ICT in Leaving Certificate course comes in a note at the bottom of the list of aims and objectives as follows, "computers (equipped with appropriate software packages) may of course be used in the teaching and learning of mathematics " (DES, 1995)

There are no specific requirements in relation to ICT in either curricula. The Department of Education and Science Junior Certificate Mathematics Guidelines for Teachers (DES, 2000b) encourages 'active learning' which is a fundamental part of the constructivist theory of learning, and provide a number of possible methodologies that could be used by teachers to achieve this aim. Included among them is the use of information and communication technologies. There is a brief overview of work that is currently being undertaken in some mathematics classrooms with the aid of various software packages such as Mathematica, Geometers Sketchpad and Maple and a number of suggestions are given for sample lessons, which could be taught with the aid of ICT. While this is a positive step forward there is still a serious lack of any comprehensive policy document from the Department of Education to guide teachers in integrating ICT into their teaching.

At senior level there is little or no information available and there are no guidelines for teachers of mathematics as per Junior Certificate. Many of the projects that are currently running, for example the Geometers Sketch pad package is being used as part of a SIP (Schools Integration Project) project in junior level classes in four schools, exist only because of innovative and enthusiastic teachers. With the current structure of the second level mathematics curriculum, given its breadth and depth it seems that it is the innovative teachers only who will take the time and effort to integrate ICT into an already packed curriculum.

Hogan (2000) states that "although teachers are expected to adopt new technologies in their teaching, resulting in changes in style and pedagogy, the subject syllabus and its means of evaluation have not changed."

Judging by the Junior Certificate Mathematics Guidelines for Teachers document, it appears that the Department of Education, while recognising the

benefits of active learning and utilising ICT in the teaching of mathematics (and equally other subjects), have chosen to 'sit on the fence' for now! The Guidelines talk about how both traditional and progressive teaching methods can be successful and while they give examples of how to employ active learning methodologies in the mathematics classroom they are careful to say,

"Naturally, these approaches are meant to *augment*, not *replace*, existing ones. In particular, provision of opportunities for frequent practice (so that students' procedural skills become, and then remain, appropriately fluent) will still be an integral and essential feature in the teaching of mathematics." (DES, 2000b)

This approach confirms the mistake that the Department of Education and Science is making. The current technologies available could revolutionize the way students in Ireland learn but in order for this to happen curriculum and assessment has to change. ICT can't simply be tagged on to the present curriculum structure to 'augment' existing approaches.

3.   **Methodology**

Simple Random Sampling

Simple random sampling was used in order to collect data to investigate the research questions. In simple random sampling all elements of the population (the complete set of subjects, events or scores that have some common characteristic) have an equal probability of being selected for the sample of N observations.

The population chosen in this case was based on a sampling frame selected from the most current listing of all post – primary schools in Ireland as listed in the Department of Education and Science Listing of Post Primary Schools 2001 –2002. (DES, 2002)

Given the limited time available to conduct the research, the sampling frame selected was all post primary schools in Dublin city and county as listed in Department of Education and Science document. This provided a sampling frame of 187 schools, which constitutes the population for the purpose of this research. Out of this population of 187 schools a random sample of 20 was selected using a random number table

The random number table consists of rows and columns of random numbers. The numbers are random in the sense that for any single digit position, each of the 10 numbers from 0 to 9 has an equal chance of occupying that position. This means that every digit was selected independently of every other digit. Further, not only are all the single digits random, but all two, three and N-digit numbers are also random. (McCall, 1998) To use the table to select a sample of 20 schools from a list of 187, each school was assigned a number between 1 and 187. The table was then blocked off into three digit columns and the columns read down until 20 three digit numbers that fall between 001 and 187 inclusively, were obtained. The schools assigned numbers corresponding to these 20 numbers constituted the random sample.

Choosing the Data Collection Instrument

Once the elements of the sample were identified the next step in the data collection process was deciding which data collection tool to use. Again given the time constraints of the research, the use of a postal questionnaire was decided to be the most efficient method of obtaining information from the sample population.

The questionnaire is a highly flexible instrument, however it does lend itself quite readily to bias and error. It is therefore acknowledged that the results obtained using a questionnaire will as best provide an approximation to reality. (Owen & Jones, 1994).

The Postal Questionnaire

The main benefit of the postal questionnaire is it's relatively low cost. It can be sent out to a large number of people relatively cheaply. Additionally, there is no risk of introducing bias or mistakes in the way that an interviewer might by influencing the respondent to give particular answers.

There are a number of weaknesses associated with the postal questionnaire also. The most debilitating of these is that very few people bother to complete and return the questionnaire. The average return rate for questionnaires returned without reminders is 20%.

In order to try and prevent a low return rate, the questionnaire sent to each school in the random sample was accompanied by a letter explaining the purpose and importance of the questionnaire, briefly outlining what was hoped might result from it and requesting their co-operation. A stamped addressed envelope was also supplied to make it as convenient as possible for the respondents to return the questionnaire.

Designing the Questionnaire

When designing the questionnaire care was taken to follow a number of key rules for the construction of the questions as outlined by Owen and Jones (1994),

- Keep the questions short
- Use simple language
- Avoid questions which lead to a particular answer
- Make sure that the respondent has the information
- Consider if the respondent would be willing to tell the truth
- Consider the order of the questions
- Try to ensure that the answers given are capable of being interpreted in one way only

The final questionnaire comprised 4 questions some of which were multiple choice and some of which were open ended.

The Questions

No details about respondent identity were requested, as they were deemed irrelevant to the research. This also meant that respondent confidentiality was guaranteed.

Questions 1 and 2 were constructed as simple multiple choice questions with the purpose of gaining an insight into the different mathematics year groups the respondent teaches and the percentage use they make of ICT in their teaching.

Question 3 was designed as an open ended question to obtain more detailed information about what areas of the mathematics curriculum the respondent uses ICT to help teach and whether they encountered any particular difficulties or found any major benefits in using ICT in these areas.

The final question, question 4 was constructed as a multiple-choice question. It provided the respondent with a number of options to choose as many as they felt were relevant in connection with the broad areas of difficulty that exist with trying to utilise ICT in the teaching of mathematics at post primary level. This list was compiled based on a review of the literature. It also included an open-ended section to provide details of any other issues they might feel were important that had not been included in the multiple-choice list.

4. Analysis and Discussion

Response Rate and Spread of Respondents

20 questionnaires were sent out and of these 20 only 8 were returned. The represents a 40% return rate. For a postal questionnaire where no reminders were sent out this represents quite a good return rate.

Three of the eight respondents teach only junior or senior classes, whereas the remaining five teach mathematics classes in both the junior and senior cycle. This is more often the case in Irish second level schools and so is encouraging in terms of getting a broad view of mathematics teaching through a school from junior to senior level.

Analysis of the Questions

Given that the sample size selected was very small it is acknowledged at this point that statistical analysis would be meaningless. The questionnaire was designed to collect mainly qualitative data and at best it is hoped that any analysis of the responses given might act as an indicator of areas for further study.

Question 2 – *What percentage of your maths classes incorporate ICT (Information and Communication Technologies)?*
The respondent was given a number of options to choose what percentage best reflected the amount of ICT they incorporate into their teaching of mathematics. 5 of the 8 respondents answered 0% - they do not use ICT in their mathematics teaching at all. The remaining 3 answered that 25% of the time they might incorporate some ICT into their mathematics teaching. No respondents selected a higher percentage than 25%.

Question 3 – *What topic(s) have you taught with the aid of ICT and what benefits/problems did you find for the students?*
The three respondents who answered that they do incorporate some ICT into their teaching went on to elaborate about what they taught and what tool they

used. In all three cases the teachers used spreadsheets, one mentioned excel 2000, which was most likely the spreadsheet package used by the other two teachers also. All three teachers used it to teach statistics – averages, charts etc but one teacher surprisingly used it to teach quadratic and cubic graphs also. Statistics is an obvious topic to teach with the aid of spreadsheets but teaching quadratic and cubic equations with the aid of a spreadsheet is surprising. Generally equations be they quadratic/cubic are taught in the same way as most algebraic content in the mathematics curriculum - using drill and practice, the students do equation after equation, graphing them by hand until they learn to recognise each type and how to deal with it. The processing power of a computer spreadsheet makes the plotting and graphing of quadratic and cubic equations much less cumbersome and gives the teacher and student more opportunity to explore the characteristics of these types of equations.

When asked what they considered to be the benefits of teaching their particular topic with the aid of a spreadsheet one respondent replied that it was a "nice change from a blackboard and book" another mentioned the accuracy you can obtain in graphing and charts when using a spreadsheet tool which facilitates more accurate readings by students and the third respondent mentioned the flexibility of the spreadsheet tool – being able to change the input data and immediately see the change reflected in the chart or graph.
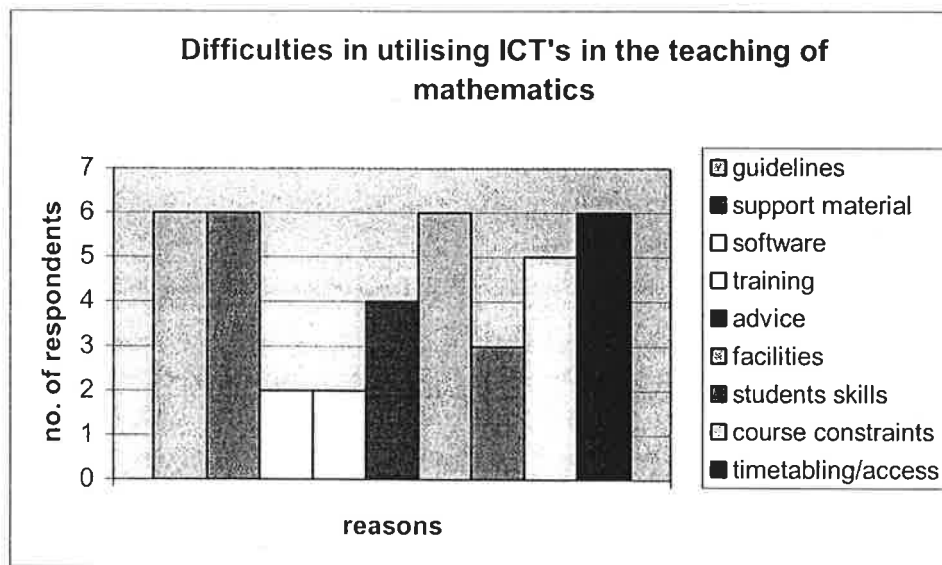
With regard to any problems experienced, the respondent teaching statistics and quadratic/cubic equations reported no problems. The other two respondents mentioned issues with more class time being required to teach with the spreadsheet tool. Is it interesting that there was no mention of difficulties with students using the spreadsheet package, this is perhaps indicative of the prevalence of computers and in particular common tools such as Excel. The majority of students would have had some exposure to this type of computer tool.

Question 4 – *Please tick any of the following which you feel are relevant.* **It is difficult to utilise ICT in the teaching of mathematics because of ...**
Question 4 was relevant to all respondents regardless of whether they had utilised any sort of ICT in their mathematics teaching. The question was concerned with what problems and difficulties teachers find as obstacles to them using ICT in their teaching. The question provided a number of reasons from which the respondents could choose as many as they felt were relevant and it also left room to add any other comments they had. The list of problems/difficulties provided was as follows,
- No guidelines from the department
- Lack of support material
- No suitable software
- Lack of training
- No advice on use
- Lack of facilities
- Different levels of computer skills among students
- Time constraints of the course
- Timetabling and access constraints on the computers

The following chart shows the number of respondents who found each reason relevant.

Difficulties in utilising ICT's in the teaching of mathematics

Chart legend:
- guidelines
- support material
- software
- training
- advice
- facilities
- students skills
- course constraints
- timetabling/access

Y-axis: no. of respondents (0 to 7)
X-axis: reasons

While there was no one category that all respondents agreed was a particular difficulty in trying to utilise ICT in their teaching, a number of issues appear to be more prominent than the others. These are,

- No guidelines from the department
- Lack of support material
- Lack of facilities
- Timetabling and access constraints

Also quite prominent is the issue of the time constraints of the course. Looking at each in turn,

No guidelines from the department – Despite the fact that the Department of Education and Science has invested so heavily in the integration of ICT into education it is perhaps worth considering that 'integration' is a long way off from where schools are at present. Millions of pounds and euros have been invested -predominantly in infrastructure but now that the schools have the computers what are they supposed to do with them? There is no official policy documentation detailing how teachers should incorporate ICT into their teaching for any subject's at junior or senior level. There are some suggested methodologies listed in the Junior Certificate Mathematics Guidelines for Teachers document (DES, 2000b) and some sample lesson ideas but it's a long way from any sort of comprehensive national policy. It appears that the Department of Education and Science in their rush to catch up on other European countries who have had ICT policies for a number of years have put the cart before the horse and schools now have facilities but are unsure about what to do with them. The issue of guidelines is also connected with the next issue topping the list, that of support materials.

Lack of Support materials - Even after we tackle the problem of obtaining guidelines from the Department of Education and Science teachers still need materials and resources for teaching with. There are many innovative teachers working within the second level system producing materials for use within their own classrooms and schools but again there is no national strategy for sharing, documenting and developing materials.

Lack of Facilities – It is very clear that despite the infrastructural investments made so far as part of the Schools IT 2000(DES, 1997) and Blueprint for the Future of ICT in Irish Education (DES, 2001) initiatives, that many schools are still lacking basic computing facilities. It should be highlighted that ICT' s - Information and Communications Technologies are not just computers, they should include overhead projectors, TV and video sets etc.. Many schools are lacking even these facilities which could also go a long way towards helping them begin to integrate technology into their teaching.

Timetabling and access constraints – This particular issue appears to be prevalent in many schools and stems to some degree from the decision of the majority of schools to build a 'computer lab' to house all of their computers. This approach has advantages and disadvantages. It is useful to have a room where a teacher can take his or her class and all of the students in the class can have access to either their own or a shared computer. But the downside to this is that the computer lab is often booked up with classes learning IT skills so the individual subject teachers find it difficult to get a free period to bring their class to the computer lab. The students often get the benefit of learning about computers but not learning with computers.

The next issue which ranked highly in the respondents list was the issue of course constraints. This issue is not just particular to the mathematics curriculum but since the respondents were all responding as teachers of mathematics and our area of interest lies in the mathematics curriculum also, this is the one we will focus on.

The issue of course time constraints is a considerable one. The mathematics curriculum at both junior and senior level is extensive in both its breadth of topics and the depth to which they are required to be covered. Teachers often find themselves in the awkward position of having to teach to the exam particularly at leaving certificate level. The mathematics curriculum, while it has had recent revisions, has not changed all that much in many years. As long as teachers feel under pressure to complete the course content they will be unlikely to try 'experimenting' with incorporating ICT into their teaching. It is unknown territory for many teachers with unknown outcomes. They cannot be certain that using ICT will help them cover the material or provide the students with a better understanding of the concepts they are learning and they don't have the time to find out!

This issue is of course linked to assessment and the way the Department of Education and Science has been assessing students for many years. The current situation where a student's mathematical knowledge is assessed based on one exam, does little to encourage teachers or students for that matter to try exploratory learning with or without the aid of ICT. Until the curriculum and assessment is revised to reflect the possibilities and opportunities that ICT could afford the students in their learning, until the focus is moved away from a final examination and the curriculum is restructured to allow for a more constructivist style of learning – one which will ultimately provide students with more transferable skills such as critical thinking, problem solving and collaboration, teachers will continue to bow to the pressure and teach to the exams leaving little time for trying to integrate ICT into their teaching.

With regard to the availability of suitable software, this doesn't appear to be a major issue. For mathematics teachers a spreadsheet tool can be used to great effect in the teaching of some topics like statistics and since a spreadsheet tool is part of the standard application bundle supplied with most operating systems, teachers might feel they have the software they need. This however may be more to do with teachers not being aware of what is available.

A further point that was made by one of the respondents was of particular interest.

Utilising ICT is "Not required by [the] department as part of the course. Until this happens there will be little use of ICT in mathematics."

This comment ties in with many of the issues that ranked highly as areas causing difficulties in our data. The current mathematics curriculum (or any other subject curriculum) does not require students to use ICT as part of the course, nor does it specifically assess any skills which a student may learn whilst using ICT as part of the course. The current and previous governments have stated their commitment to introducing and integrating ICT into education but despite their commitment they have yet to tackle the major issues of curriculum and assessment. Issues, which until they are addressed will always contribute to the overall failure of any ICT initiative.

5.   Conclusions and Recommendations

Conclusions

Based on a review of the literature and the findings of the small sample selected for this research the following conclusions were made.

One issue reported as a major obstacle to the integration of ICT in both the literature and the data collected was that of timetabling and access constraints. As noted in the analysis and discussion chapter this problem stems in some way from the tendency of schools to put all of their computing facilities into one room, a 'computer lab'. This leads to timetabling problems when a subject teacher needs access to the computers and the lab is booked up with students 'studying computers'. Watson (2001) notes that it is ironic that teachers have to try to book a set time period to use the computer lab when the purpose of the technology is to allow open-ended exploratory work.

An alternative approach to the computer lab situation is to spread the computers around the school so that individual subject teachers at least have the benefit of being able to demonstrate to their classes. Becker (2000) reported that learning improves more with even a modest number of computers in classrooms rather than when they are deployed directly in a dedicated lab. The ideal would of course be to have both a computer lab and technology in the classrooms.

It is worth noting also that although computer studies is a subject on the second level curriculum, it is not examinable. Computer skills are better learnt in context and incorporating the learning of IT skills into specific subjects could provide that context.

It is very obvious from the literature and the data collected supports this, that probably the primary obstacle to integrating ICT into the curriculum in Ireland is the lack of policy and guidelines about how they should be used. With reference to the mathematics curriculum in particular (although the same can be said for most subjects) there has been no room made in the curriculum to incorporate ICT. The mathematics curriculum at both junior and senior level has been reviewed and revised in recent years but no allowance has been made for the integration of ICT. There is little mention of them in the curriculum documents and only suggestions for using them as part of a more constructivist 'active learning' methodology in the Junior Certificate Guidelines for Teachers. The curriculum must change to allow for this constructivist 'discovery learning' methodology which is being encouraged by researchers and policy makers alike. Mathematics is a prime candidate subject for this type of teaching and learning and ICT can provide the tools to implement this. Until the curriculum is revised to explicitly state how ICT can be utilised in the teaching of mathematics (and other subjects) and the methods of assessment are changed to fit with this, ICT will never truly be integrated into teaching and learning in this country.

Closely related to this is the issue of obsolete technology. Irish ICT initiatives have been so concerned with providing the infrastructure, the hardware and internet connections etc to schools, that there is a large possibility that the technology will become obsolete by the time the Department of Education and Science takes the time to review the current educational structures with a view to genuinely integrating ICT into the curriculum.

Recommendations

It is acknowledged that the scope of this piece of research is very limited and although conclusions have been drawn they are perhaps best viewed as pointers to areas for further study. To this end a number of recommendations for future research and issues that could be investigated are presented now.

In an effort to evaluate the success of ICT integration it would be useful to look more closely at existing projects for example some of the SIP projects as mentioned in the literature review. These projects could potentially contribute towards formulating policies about how to integrate ICT into teaching and learning also.

Returning to the issue of suitable software for mathematics, (this sort of investigation could be conducted for any subject), it would be an interesting project to investigate just what software is being used by the teachers who are teaching with technology. A survey of what suitable software is available and what awareness teachers in general have about what is available could provide very useful information for educators and policy makers alike.

Finally, in relation to the situation that Irish schools are presently in, many with some computing facilities and now idea what to do with them, and many still without any facilities at all – it is perhaps time to stop and consider where we should go from here. The investment in infrastructure has been and is being made, the computers are in many schools. Unfortunately they arrived before the frameworks where put in place for their use, but given that this is the situation and it cannot be reversed a major area for consideration now is how

to proceed. We cannot leave the technology in its boxes until the Department of Education and Science develops a national strategy and policy across the whole curriculum. We need to look at ways of integrating ICT into the curriculum as it stands so that some benefit at least can be gained from the technology. It is far from ideal but unless the initiative is taken, we may find ourselves having to start from scratch further along the road.

References

Baker, E.L., Herman, J.L. & Gearhart, M. 1996. Does Technology Work in Schools? Why Evaluation Cannot Tell the Full Story. Education and Technology: Reflections on Computing in Classrooms. San Francisco: Jossey-Bass, 1996.

Becker, H. 2000. Access to Classroom Computers. Communication of the ACM, Vol 43, No.6. June 2000.

Commission of the European Communities. 1996. Educational Software and Multimedia. Luxembourg: Office for Official Publications of the European Communities.

Conway, P. 2000. Schools Information Technology (IT) 2000: technological Innovation and educational Change. Irish Educational Studies, Vol 19, 2000.

Department of Education and Science. 1997. Schools IT 2000 A Policy Framework for the New Millenium. Dublin: The Stationary Office.

Department of Education and Science. 2002. List of Post Primary Schools 2001-2002. Dublin: The Stationary Office

Department of Education and Science.1995. Leaving Certificate Mathematics Syllabus. Dublin: The Stationary Office.

Department of Education and Science. 2000a. Junior Certificate Mathematics Syllabus. Dublin: The Stationary Office.

Department of Education and Science. 2000b. Junior Certificate Mathematics Guidelines for Teachers. Dublin: The Stationary Office.

Dickens, C. 1995. Hard Times. Wordsworth Editions Ltd.,

Freeman, E. & Gilleran, A. 2001. 'Breaking the Moulds'. A Discussion of some of the Issues Emerging from the use of ICT in Education. Paper presented at the ESAI Conference Limerick September 2001.

Goddard, M. 2002. What Do We Do with These Computers? Reflections on Technology in the Classroom. Journal of Research on Technology in Education, Vol 35, No. 1, 2002.

Hogan, L. 2000. ICT in Second Level Schools: Removing the Barriers. Thesis for the MSc. In Computer Application for Education. Dublin City University, 2000.

Information Society Commission. 1999. Building a Capacity for Change, Lifelong Learning in the Information Society. Dublin: Stationary Office.

Mackey, B. 1987. Information Literacy: An Integrated Approach to Information Literacy. Oideas, Fomhair, 1987.

McCall, R.B. 1998. Fundamental Statistics for Behavioral Sciences. Brooks Cole Publishing Company.

McNamara, G., O'Hara, J. & Rousi, H. 1997. The Pedagogical Challenges of Constructivist Theory and Empowerment in Learning and Information Technology. Irish Educational Studies, Vol 17, 1998.

Oldham, E. 2001. The Culture of Mathematics Education in the Republic of Ireland: Keeping the Faith? Irish Educational Studies, Vol 20, 2001.

Owen, F. & Jones, R. 1994. Statistics. Fourth Edition. Pitman Publishing.

O'Callaghan, S. 2000. Assessing the Effectiveness of Using Internet Based Learning Tolls in Transition Year Mathematics. Thesis for the MSc. In Computer Application for Education. Dublin City University, 2000.

Pelgrum, W.J. 2001. Obstacles to the integration of ICT in education: results from a worldwide educational assessment. Computers & Education 37 (2001) 163 – 178.

Ruokamo-Sari, H. & Pohjolainen, S. 1997. Pedagogical Issue for the Design of a Hypermedia-Based Learning Environment. Proceeding of IFIP WG 3.3. Working Conference, Sozopol, Bulgaria, 1997.

Tapscott, D.1999. Educational Leadership. Published by the Association for Supervision and Curriculum Development. February 1999.

Watson, D.M. 2001. Pedagogy before Technology: Re-thinking the Relationship between ICT and Teaching. Education and Information Technologies, 6:4, 2001.

[WWW1] Mathematics and IT – A Pupil's Entitlement. 1998.
http://vtc.ngfl.gov.uk/resources/cits/maths/entitlement/section_1.htm
Accessed January 2003.
[WWW2] Blueprint for the Future of ICT in Irish Education. Three year Strategic Action Plan 2001-2003. 2001.
http://www.ncte.ie/AbouttheNCTE/ICTPolicy/
Accessed June 2003.