ICT IN SCIENCE TEACHING INVESTIGATING THE SPREADSHEETS INTEGRATION INTO SCIENCE TEACHING TO PROMOTE BOTH CURRICULUM AIMS AND SCIENCE SKILLS VIA ICT STRANDS

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ABSTRACT
Spreadsheets can be implemented into Science teaching as learning tools. The issue is that whether such ICT integration (Spreadsheets) into science teaching can facilitate both the: a) Promotion of specific curriculum aims and b) development of Science Skills. Apart from that, the development of the ICT strands as the new requirements resulted from the implementation of ICT in education is a necessity. Having in mind the above three areas (Curriculum aims- Science Skills – ICT strands) this study investigates the role of spreadsheets as ICT educational tools into specific lessons of science teaching in promoting these pillars. Three specifically designed science lessons have been taught into a Cypriot primary classroom. Semi-structured interviews from 30 students were conducted as well as systematic observation fields notes and Documentary-Written work analysis were completed collecting qualitative data to answers research questions. The analysis of data revealed the following main results summarized below:

- The great majority of students (26 out of 30) indicated positive attitudes towards group working with the use of ICT in science teaching. Students revealed strong willingness to work collaboratively during experimental stage with the use of spreadsheets in science teaching.
- Almost all students felt that these ICT integrated science lessons help them to develop specific science skills. Students appeared to apply science skills in the experimental procedure using spreadsheets within Science teaching
- Student also indicated that such activities can support both the achievement of curriculum aims and development the five strands of ICT.

KEYWORDS
ICT in education, spreadsheets in science teaching, Computer-based Collaborative Cooperative Learning (C.C.CL), ICT strands, science skills

INTRODUCTION- REVIEW OF LITERATURE

ICT in Education

The use of ICT in education can support the quality improvement of the learning process facilitating both the promotion of curriculum aims and the development of educational skills (Barton, 1998; Hotle, 1998). ICT used as a tool in teaching and learning can increase students': concentration, communication, metacognition, motivation and creativity (Monteith, 1998; Becta, 2001a; Leask and Pachler, 1999). ICT can facilitate students to communicate their experience and understanding (Strack, 1995). Additionally Cox (1997) states that ICT can support collaborative - cooperative learning (CCL).

Science Education
Science Education is one of the core subjects in any curriculum (Driver, Leach, Millar, and Scott, 1996). Science is a very important subject in the Cypriot National Curriculum (CNC) too. The main goal of science education in the CNC is that students develop the scientific method in solving problems and acquire scientific knowledge (CNC, 1994). Precisely science is part of the curriculum since it helps students to both acquire knowledge and understanding of scientific phenomena and understand the scientific process or methodologies (Mathews, 1994; Millar and Lubben, 1996).

Via science Education students are expected to have opportunities to develop science skills such as questioning, observing and interpreting observations, classifying, designing experiments and investigations, measuring, hypothesizing, communicating, identifying and generalizing (Martin, 1994; Bybee, 1995; Osborne and Simon, 1996; Edwards, 1997; Bybee and Deboer, 1997; Clifford, 1997; Goldworthy, 2000).

ICT and science
ICT has an important part to play in enriching science education, (Heppell, 2001; Walton, 2000) since it can be used as instructional and supportive tool in science teaching and learning (Marsh, 1994). ICT use can enhance the science's objectives and goals (Jimoyiannis and Komis, 2001) and at the same time encourage the development of some science skills. Nevertheless, there may be some disadvantages of using ICT to support science teaching and learning. Classroom ICT applications can be time-consuming especially in the minimal time teachers have for science lessons, particularly the data recording on screen sometimes followed by paper and pencil work (Webb, 1997). Jonassen (2000) underlines that ICT in science teaching can facilitate the promotion of both science skills and the five ICT strands in a meaningful context (see below).

Spreadsheets and science
Based on that, an open generic software application called spreadsheets can be implemented into Science teaching as learning tools (Jonassen, 2000; Andalora and Bellomote, 1998). Spreadsheets can be used for repetitive arithmetic/logical functions: division, subtraction, square roots, financial analysis, statistical functions, average and means by entering formulae (Becta, 2001a). Therefore spreadsheets use in science is possible and effective for enhancing and supporting experimental and investigative work (Becta, 2001a).

Consequently there is a strong connection between science curricula and spreadsheets use in science (Gratto-Smith and Blackburn, 1997). Furthermore, spreadsheets provide students with opportunities not only to develop communication skills, independent learning and critical thinking but also to concentrate on higher-level skills rather on the mechanics of calculating (Beare, 1991; Gardner et al.,1994).

Therefore the issue is that whether such ICT integration (Spreadsheets) into science teaching can facilitate the:
- promotion of specific curriculum aims (Collaborative Learning – Communication – Creative thinking);
- development of science skills (questioning, interpreting observations designing experiments and investigations, measuring, predicting, hypothesising communicating, identifying and controlling variables, generalising) (Barton, 1998; Hotle, 1998).

COMPUTER-BASED COLLABORATIVE COOPERATIVE LEARNING AND COMMUNICATION (CCCL)

Collaborative/Cooperative learning is students' working in heterogeneous and homogenous groups achieving common goals (Docterman, 1993) although there might be differences among group-members (Kennewell, 1998). Even though there are different kinds of collaborative learning, computer-based group-work appears to be an effective kind of collaborative learning since students use ICT as a tool (Williams, 2000).

Collaboration appears to enhance learning, verbal reasoning, social skills, creative, communication, leadership skills and cognitive changes (Mayer, Schustack. and Blanton, 1999). Collaborative/cooperative learning also promotes students' acceptance of differences and the development of self-esteem and unconditional self-acceptance (Crook, 1994). Analytically in collaborative/cooperative/computer learning students share the same goal and vision and accept responsibility of completing the task. Additionally through this approach students learn actively via investigation applying various strategies. Finally students initiate and stimulate cognition, reflection, creativity and increase their understanding. (Lafer, 1994; Wild, 1996; Richardson, 1998; Loveless, 1998; Jonassen 2000).

A second area of benefits from the collaborative/cooperative/computer learning is the development of verbal (communicative) and reasoning-social skills (Lloyd and Beard, 1995). Collaborative computer-based work can help students to interact face-to-face (communicate and share ideas, messages and feelings) as well as to increase motivation, self-esteem, self-reliance and self-confidence. It is important that they can not only clarify differences of opinion but also to have mutual acceptance, appreciation towards the other group-members (McNamus and Aiken, 1996; Richardson, 1998; Jonassen, 2000).

Apart from the above existing context of Science (aims-skills), spreadsheets integration into science teaching needs the development of the so called ICT strands as the new requirements resulted from the implementation of ICT in education (Shield, 1996). ICT strands refer to the following:

- Communicating ideas and information (textually, orally, pictorially),
- Handling information (store, retrieve, alter and present),
- Modeling (modeling abstract concepts for hypothesizing and investigating),
- Measuring and Controlling (using computers for controlling devices),
- Making Applications and effects (studying, experiencing and reflecting on issues of ICT applications for analysing and solving problems), (Hemsley, 1994; Kozma, 1991; Becta, 2001b, Woodford, 1995).

Since the integration of ICT in teaching and learning requires the development of the above ICT strands, it is important to examine how spreadsheets use into science teaching can support the achievement of these new curriculum requirements.

SETTING THE SCENE – METHODOLOGY

Having in mind the above three areas (Curriculum aims- Science Skills – ICT strands) this study investigates the role of spreadsheets as ICT educational tools integrated into specific lessons of science teaching in promoting these pillars.

The research is considered to be a case study since it refers to the development of detailed, intensive knowledge about a single 'case' such as a Cypriot primary classroom (Cohen and Manion, 1991) in an attempt to investigate the following inquires:

- Aims of the lessons and ICT strands development,
- Collaborative/Cooperative/Computer learning and communication,
- Science comprehension with the help of ICT.

Three specifically designed science lessons have been taught. The main teaching method of these lessons based on the integration of spreadsheets activities into science topics of Mirrors, Expansion/Contraction and Friction. An experimental procedure has been adopted via ICT strands in a collaborative and communicative educational setting. These three science lessons have been taken place into an 11-year old Cypriot primary class with 30 students (16 girls and 14 boys) within a period of two weeks in the year 2001-2002. Since there were six machines in the school's computer-laboratory, there were five-member groups into a computer.

Based on the research questions, the following methods of collecting data were prepared and employed:

- systematic participant observation fields notes of the three Science lessons;
- documentary written work analysis (30 students written work);
- semi-structured interviews from 30 students.

Students' attitudes towards CCCL and Science skills development were measured based on data provided from their comments in completing the documents as well as from the explanatory answers in the semi-structured interviews. Examples of the interview questions are presented below:

- Do you like working on the computer for science activities?
- With which science skills did the computer help you?
- What do you find easier to collaborate on the bench for the experiment or on the computer?

Furthermore students were asked to write an essay explaining their feelings towards ICT working in science lessons. They were given key words such as "group work in front of the computer", "group work on the bench", "expressing feelings such as like, prefer, very useful, I was bored, hate, interested in, I would prefer".

These enable both the collection of qualitative data to answers research questions (see Methodology Framework) as well as triangulation of data as a way of guarding against threats to both reliability and validity (Hopkins1993)**.** Data collection followed the procedure below:

- Observation of Lesson 1 – Topic: Mirrors
- Interviews from 10 students after Lesson 1
- Observation of Lesson 2 – Topic Expansion/Contraction
- Interviews from 10 students after Lesson 2
- Observation Lesson 3 – Topic Friction
- Interviews from 10 students after Lesson 3
- Document written work from all (30) students

Qualitative data collected both from interviews and observation was divided into content groups based on research questions**.** Data was presented in tables to bring up their quantitative aspects. Both descriptive and inferential analysis were applied for the interpretation (Cozby et al, 1989) providing answers for research inquiries. Document analysis was based on the key words grouping small related phrases as well as and the reference of some other words as Haymann (1998) suggested.

RESEARCH FINDINGS

Computer-based Collaborative Cooperative Learning and communication (C.C.C.L).

The analysis of data revealed that the great majority of students (26 out of 30) express their likeness in C.C.C.L. In related vein NCET (1996) characterizes ICT use as an excellent opportunity for C.C.C.L although requiring careful organization. Analytically students indicate the following reasons for their likeness:

1. Better understanding (15/30)
2. Easier and faster task completion (9/30)
3. Task sharing (4/30)
4. Discussion of the instruction (2/30).

The following students' statements provide evidence to support the above reasons:
1st reason: "discussion helped me to understand the difficult issues*"*.
2nd reason: "When there is C.C.C.L, the task is finished on time, faster and easier since we all contribute according to our abilities, enjoy the procedure and learn from each other".
3rd reason: "I like C.C.C.L because I do not have to do it all myself since we separate the task to small tasks and then we discuss it together and there is the answer".
4th reason: "Sometimes I have difficulty in understanding instructions and when there is C.C.C.L I am sure of what to do".

Additionally observation revealed students' enjoyment in C.C.C.L on experiment-conduction and computer-use. Precisely students seem to share the same goal in groups, accept responsibility of completing the task, investigate and experiment according to the students' sheet guidance. They also seem motivated to discuss and work since there were small competitions among the groups and among the members of the group for better results.

Expressions such as "We could help each other" and "Turn the screen so that you can see" indicate C.C.C.L during the lessons. Additionally students using expressions and phrases showing C.C.C.L usually looked at each other in a smiling friendly mood. Nevertheless some students appear to dominate the group (making decisions without consulting, telling others what to do, dominate keyboard and materials).

Furthermore the following table1 presents the verbs that indicate positive, neutral and negative attitudes towards C.C.C.L extracted from document analysis.

Table 1. Verbs that reveal attitudes towards C.C.C.L in science and in computer work

Positive	**Neutral**	**Negative**
• Enjoy, Prefer, Would like • Want to work longer and in other lessons • Want to work in smaller groups so as using the keyboard more frequently	• Does not make difference • Do not mind	• I do not want to work in groups since I do all the work on my own

It is clear for the above that the majority of verbs used were "positive" indicating mainly positive attitudes towards C.C.C.L. Even though there were some "negative" verbs these do not necessarily mean not liking of using the computer but an expression of better conditions in using it (eg smaller groups or individual work). Students express the wish to have smaller groups. Martin and Wray (1990) proved that the group number on the computer should be preferably two or three.

In sum the great majority of students seem to have positive attitudes towards group working using ICT in science teaching. Students reveal strong willingness to work collaboratively during experimental stage with the use of spreadsheets in science teaching.

Science skills development

Data analysis revealed that there is a great students' preference in spreadsheets use in Science. Specifically 90% of the students express positive attitudes towards integrated spreadsheets activities in Science teaching and learning. These positive attitudes towards Science appear to be the first step for science skills development. Students' opinions also are supported by observation ensuring their enthusiasm involving in spreadsheets activities in science. Longman and Agar (1999) also underline the ICT use in science facilitates students learning in a pleasant environment. Apart from the general positive situation only two negative comments expressed such as: "I do not prefer working with spreadsheets in science and I would prefer if we worked at the classroom as other times".

Analytically more than half of the students (18 out of 30) indicate their preference of spreadsheets activities in science since such integration facilitates further discussion and better understanding. Additionally ten students out of thirty support that via spreadsheets use the completion of science tasks is faster and easier compared to the hands-writing. The remaining two students state that integrated spreadsheets in Science teaching help them in answering the science question.

Furthermore classroom observation provides indication that the use of spreadsheets in science facilitates both decision-making and worksheets' completion by students. Gardner's (1994) research findings in this area indicated the similar results.

Additionally 28 out of 30 interviewed students agree that spreadsheets activities in science lessons contribute to the development of both science skills and the scientific procedure. Analytically Table 2 presents the number of students identifying every single science skill developed by the use of spreadsheets in each lesson.

Table 2. Students answers on science skills application via spreadsheets activities

	Science Skills enhanced in taught- lessons	**Number of students (out of 30)**		
Code		**Lesson 1**	**Lesson 2**	**Lesson 3**
1	Questioning	#	#	#
2	Observing	4	3	2
3	Classifying	#	#	#
4	Designing experiments and investigations	#	#	#
5	Manipulating-recording observation and measurement data	10	10	10
6	Analyzing and discussing investigation data	6	7	8
7	Communicating results in graphs and tables	8	7	9
8	Answering what if questions	7	4	8
9	Measuring	#	#	#
10	Testing hypothesis and predictions	8	8	9
11	Detecting relationships and patterns	7	10	9
12	Identifying and controlling variables	5	8	8
13	Inferring and generalizing	9	8	10
14	Manipulating computations	10	10	10

#. *Refers to science skills enhanced by non electronic spreadsheets activities*

It is clear from the above table that most students reveal the ability to identify the science skills applied via spreadsheets activities. Students express a list of phrases indicating the positive effect of spreadsheets use in the science learning in compare to the traditional way of doing science. Statements such as "like using Spreadsheets (SP) for", "prefer using SP than doing it all alone", "think better and faster" and "feel more confident" provide evidence for this. The above phrases apply to the following science skills (5, 6, 7, 8, 10,11, 13, 14) (see Table 2 codes)

One the other hand, some negative phrases such as " not helpful", "can not think of a way that SP can help me" and "not like it- not prefer it" indicated by students for other science skills (1, 2, 3, 4). It is clear that spreadsheets integrated activities can have positive influence on the development of science skills; however this does not appear to happen to all the areas.

Moreover the observation indicates that while students have been working on the spreadsheets at the same time they applied the following science skills: a) manipulating, recording, discussing data, b) testing hypothesis and predictions, c) detecting relationships and patterns d) manipulating computations and finally e) inferring and generalizing.

Analytically students' phrases show that spreadsheets integrated activities into science teaching may enhance science skills development. The phrase "Let's change the number on the table to see what happens" which was repeated several times in group working is an indication that students may enhance the ability of Prediction and asking "what if" questions. In addition comments such as "The formula is helping us with the calculations" reveal the possible development of the ability in Manipulating calculations. Furthermore the phrase "Look the product is always 360° therefore we can find the angle and the number of corks" mentioned in all groups. This is a sign of the development of students' skills in Detecting relationships and patterns. In addition, a possible development of other skills such as

Communicating results in tables and graphs revealed by the comment "Now tell me what you found to make the table".

In sum, students indicate the positive attitudes towards integrated spreadsheets activities in Science teaching and learning. This appears to facilitate the procedure for the science skills development. An indication of enhancement of various science skills via spreadsheets integration into science teaching is revealed.

Curriculum aims achievements

Furthermore spreadsheets integrated activities in planned lessons seem to enhance some other curriculum aims. Students appear to develop intellectual skills by following guidelines to curry out an operation (conduct an experiment and investigation and prepare graphs and tables). They can also develop cognitive skills such as designing investigation, discover new ideas in learning, setting goals, planning their work and finding analogies and metaphors to explain a phenomenon in real life situations. Additionally some motor skills might have enhanced since students were engaged in using materials. Science activities help the development of skills of these three kinds (Hudson, 1994; Wellington, 1998).

Observation revealed that spreadsheets integrated activities enable students to discuss more and in-depth since they do not have to pay attention to mechanic computations. Therefore language skills appear to be developed leading also to cognitive development (Barton, 1998).

Students also appear to work constructively showing ability to relate new information to existing knowledge (Fensham et al., 1994; Jonassen, 2000). Students start to depend more on themselves and the other group-members than on the teacher who acts as a knowledge facilitator. The ICT-supported learning environment creator allowing learners think critically and creatively and develop personal ownership and appreciation of knowledge constructed rather than a knowledge presenter (Kwok-Wing, 1993; Goldworthy, 2000). Students as Kyprianou (1995) also explains acquire also skills of self-observation and self-assessment and self-educating since as observation has revealed students are able to understand and assess their work more strictly than the teacher.

The spreadsheets use into science teaching seems to have a possible positive impact towards the fulfillment of the above curriculum aims.

ICT strands development

As it is mentioned before apart from the aforementioned existed curriculum aims, the ICT application in education creates the need of new skills. ICT strands considered as a substantial new area of knowledge and skills required development (Kozma, 1991)**.** The analysis of qualitative data in this study provide an indication that such spreadsheets activities integrated into science teaching may support the questioning, designing experiment, observing and measuring. The spreadsheets activities adopted in these three science lessons appear to facilitate students' development of the ICT five strands:

- Handling information (store, retrieve, alter and present information),
- Modeling (explore and experiment, hypothesize, investigate effects and changes)
- Measurement and Control (students control the computers)
- Applications and effects (understand why ICT was useful)
- Communicating ideas and information (communicate ideas and information).

In sum almost all students felt that these ICT integrated science lessons help them to develop specific science skills. Additionally the use of spreadsheets in science appears not only to facilitate the achievement of the existing curriculum aims but also the development of the newly required ICT strands.

CONCLUSION AND RECOMMENDATIONS

Spreadsheets can be implemented into Science teaching as learning tool. Specifically spreadsheets integration into science teaching can facilitate both the promotion of specific curriculum aims as well as science Skills development. However spreadsheets use into science teaching needs the development of ICT strands as the new requirements resulted from the implementation of ICT in education (Shield 1996).

This case study reveals that great majority of students (26 out of 30) indicated positive attitudes towards group working using ICT in science teaching. Students revealed willingness to work collaboratively during experimental stage with the use of spreadsheets in science teaching.

Almost all students felt that these ICT integrated science lessons can help them to develop specific science skills. Students appeared to apply science skills in the experimental procedure using spreadsheets within Science teaching. Specifically most students supported that spreadsheets integrated activities may help them with manipulating and recording observations and measurements, communicating results through graphs and tables, answering what if questions, testing hypotheses and predictions, manipulating computations, identifying and control variables, detecting patterns and relationships and inferring and generalizing.

Moreover there was an indication that spreadsheets integration in science can support students to develop the new requirements called the ICT strands.

These findings and results suggest that Spreadsheets use in science may enhance science aims (scientific procedures), cover other curriculum aims and develop the five strands of ICT. Nevertheless ICT and especially spreadsheets use in science teaching appears to be limited for the moment in the Cyprus primary classroom. Therefore some important steps need to be taken for the improvement of Science teaching via ICT and especially spreadsheets:

- Reconstruction of the science curriculum so as to include ICT and specifically spreadsheets in science topics
- INSET for teachers
- More research in this area to reveal opportunities and difficulties.

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