A comparison between the ideas about computers, as held by acting teachers and by students training to become teachers, after some initial IT training

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Abstract

In the present paper a **comparison** between the ideas of serving teachers and teachers-to-be is presented: The ideas examined concern various aspects of information and communication technology (ICT). Some 164 acting teachers as well as 200 (teacher-trainee) students participated. All subjects have been given a course on computers and their uses, before their ideas have been examined. The computer course contained various computer literacy issues including basic aspects about the structure and function of computers. It must be stressed that although the course given to the teacher-trainee students could be considered as a comprehensive "IT literacy" course, the one given to the acting teachers could hardly be judged as such, although all basics were taught and all subjects attended laboratory classes on ICT.

From a ***constructivist*** point of view, when faced with the task of teaching computers to serving teachers and teachers-to-be, our first aim should be to ***study their ideas*** about computers and the impact of their usage.

The subjects' ideas on basic concepts like the functioning of microprocessors, the role of operating systems, and the distinction between hardware and software are compared. These are related with their ideas on the socio-economic impact of the proliferation of computers and on artificial intelligence and its relation with various aspects of human cognition. Their ideas on educational software and its uses were also examined and correlated with the above questions. Various interesting conclusions are drawn.

Περίληψη

Η εργασία παρουσιάζει μία σύγκριση των ιδεών των εν ενεργεία δασκάλων και των φοιτητών παιδαγωγικού τμήματος σε θέματα που αφορούν στην τεχνολογία πληροφορικής και επικοινωνιών (ICT). Στην έρευνα συμμετείχαν 164 εν ενεργεία δάσκαλοι και 200 φοιτητές (υποψήφιοι δάσκαλοι). Οι συμμετέχοντες είχαν παρακολουθήσει μαθήματα για τη χρήση και λειτουργία των Η/Υ πριν εξεταστούν οι ιδέες τους. Το πρόγραμμα μαθημάτων περιελάμβανε βασικές έννοιες για τη δομή, λειτουργία και χρήση των Η/Υ. Παρόλο που στην ύλη και των δύο ομάδων υπήρχαν οι βασικές έννοιες για το αντικείμενο, πρέπει να τονιστεί ότι το πρόγραμμα μαθημάτων που παρακολούθησαν οι φοιτητές ήταν επιπέδου εισαγωγής στον υπολογιστικό αλφαβητισμό (IT literacy course), ενώ αυτό που παρακολούθησαν οι εν ενεργεία εκπαιδευτικοί ήταν υπολογιστικού προαλφαβητισμού. Και οι δύο ομάδες παρακολούθησαν υποχρεωτικά εργαστηριακές ασκήσεις.

Σύμφωνα με την εποικοδομητική θεωρία της μάθησης (***constructivist theory)*** για να διδάξουμε υπολογιστές στους δασκάλους και τους υποψηφίους δασκάλους, πρέπει να ξεκινήσουμε ***μελετώντας τις ιδέες*** που αυτοί έχουν για τους υπολογιστές και την χρήση τους.

Εξετάστηκαν συγκριτικά οι ιδέες των υποκειμένων για τη λειτουργία των μικροεπεξεργαστών, του λειτουργικού συστήματος, το υλικό και το λογισμικό, όπως και για το εκπαιδευτικό λογισμικό. Συγκρίθηκαν ακόμα οι ιδέες τους για τις κοινωνικο-οικονομικές επιδράσεις της χρήσης των υπολογιστών καθώς και οι ιδέες τους για την τεχνητή νοημοσύνη σε σχέση με την ανθρώπινη. Στην εργασία παρουσιάζεται μία σειρά από ενδιαφέροντα συμπεράσματα.

Introduction

The ideas of serving teachers on various aspects of information technology (IT) have already been examined[1] after some initial training and were presented in a previous publication. Similarly, the ideas of arts students were also examined[2] after a course in ICT. In the present paper, a comparison amongst these two groups is attempted, with the aim of establishing the similarities amongst the two groups and any possible differences. Some 164 in-service teachers in addition to 200 students were used in the present study. The two groups compared represent (respectively) the present and the future in education, as the arts students of today will become the teachers of tomorrow. In fact, the arts students examined for the present study were primary-school teacher-trainees.

Computer literacy is essential so as every serving teacher will be able to handle the curriculum demands of using ICT in the classroom. Computers are a quasi-scientific[3] subject, and yet they need to be explained in simple terms to all teachers, most of which still are arts-based in their way of thinking and their training. Most of the people examined in the present study have little or no experience in either scientific methodology or scientific way of thinking. They also had little or no experience in ICT. This, therefore, represents quite a challenge in itself, if true computer literacy is the final educational aim.

Constructivism pays much emphasis on students' ideas, as these ideas represent the raw material that the students themselves are called-for to reconstruct. The teachers play a supporting role in this process, but the support they offer (their teaching) could be greatly improved if they had prior knowledge of their pupils' ideas. It is for this reason the pupils' ideas are examined and, in this case, compared. For, it is obvious that any possible differences found, apart from being in themselves quite interesting, would point out to possibly beneficial changes in teaching style or emphasis, so that the teaching would suit better the particular pupils' needs.

The research

The first difference dividing the two groups is that of age, the acting teachers varying from 33 to over 51 years old, while the students are about 20. The second difference amongst the two groups is that the level of education offered to the younger teachers-to-be is more profound. They are receiving the benefit of university education, and their selection should (in principle) be more rigorous than that of the past. In fact, our teachers-to-be group should not be significantly different to any other arts-oriented freshmen student group today. It should be noted here that, as the computer course is a first-year university course, the students have only benefited by one semester of formal university education. It must also be pointed out that there was a difference in the depth of the IT training offered in these two groups before the ideas were examined. The in-service teachers' group pupils were given a pre-literacy course in ICT, whereas the teachers-to-be group was given a comprehensive computer literacy course. The main difference in the curriculum between the two groups was the one involving teaching of the computer programming essentials, which was (naturally) included in the comprehensive ICT literacy course. Overall, it was considered that the course delivered was at a level just appropriate for the following reasons: (a) The trainees would

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[1] Ioannidis G.S., Garyfallidou D.M., and Vavougios D.G.: Teachers' ideas on computers after some initial information technology (IT) training, in Valanides N. (Ed.) *Proc. 1st IOSTE Symposium in southern Europe "Science and Technology Education: Preparing future citizens"*, ISBN 9963-8519-2-4, (2001), Vol. 2, pp. 244 – 258.

[2] Ioannidis G. S., Garyfallidou D. M., Panagiotakopoulos C., Vavougios D. G, Ideas on computers as held by arts students, after a course on Information and Communication Technology (ICT), in Auer M. and Auer U. (Eds.) *Proc. ICL2001 workshop: Interactive Computer aided Learning - Experiences and Visions*, Villach, Austria, Kassel University Press ISBN 3-93146-67-4, (2001) 13 pages.

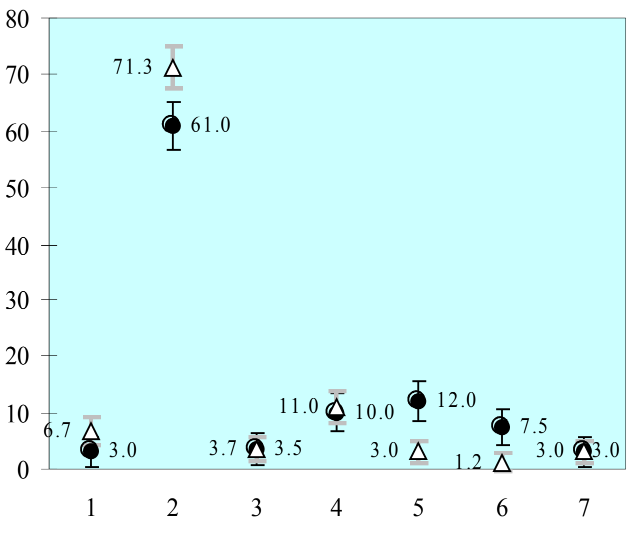
[3] Feynman R. P.: *Feymnan lectures on computation*, Hey A.J.G., Allen R.W.; Eds., Addison-Wesley, (1996) p. xiii.

have reached their own verdict on what a computer does and its usefulness. Also, (b) the trainees should have reached the point whereupon clear ideas on ICT and its functions would have been formed (if the teaching was at all successful). Both groups attended rigorous laboratory classes on ICT in general, with an emphasis placed in ICT use in the school.

Despite the above-mentioned shortcomings (and, to a certain extent, because of them), we believe that the present comparison is both valid and fruitful, within the limits of the experimental errors of the present study. These errors were painstakingly calculated, separately for each and every point in our diagrams, and are plotted in every histogram and noted in all tables presented.
All relevant statistics were calculated using specially constructed software, interfaced with a popular computational and plotting package. The statistical variance was computed and the Bessel-corrected standard deviation was calculated for all data points presented. No experimental measurement can avoid systematic errors. In the present study special care was taken (for reasons explained above) so that large systematic were avoided. We then went on to evaluate the systematic error remaining, and this was set at 1.5%, for the teachers' sample, while for the students; one was set at 2.5%. These figures are considered fair and are consistently comparable with all our statistical errors. This means that we believe our total error to be neither statistics-dominated nor systematics-dominated, and this holds for every single data-point presented. The total error was then found by adding in quadrature our systematic with our statistical errors, these two being independent, by definition.

Results are given (whenever possible) in terms of histograms, each point depicted on every histogram bearing the error-bar calculated for this particular point and/or in tables with the total errors given next to the point presented. All histograms represent percentages. In these, the points represented by triangles refer to the teachers (and have their numerical value on the left of the point). Respectively the points represented by circles refer to the students. When the results are presented in tables, the total error (as calculated) follows every measurement made.

The ideas of teachers and students on the functioning of microprocessors



△ triangles represent teachers
● circles represent students

1. A small computer of limited capability for personal use
2. A central processing unit (CPU) implemented on a single integrated circuit (chip)
3. An electronic unit of limited capability used as a component to construct computers up to 1965 or whereabouts
4. A program that can process data (numbers or characters) at high speed.
5. Answers (1) and (3) at the same time
6. None of the above
7. No answer given

The caption explains the categories in which answers where set. As the error bars depict the one standard deviation, we can see that by a quite significant percentage the teachers and the students seem to hold the right idea on the nature of microprocessor and its function. Acting teachers seem to be less confused and more precise about the function of microprocessors.

Ideas on hardware and software

Hardware	Correct example		Wrong example		No example		Total	
Description	rate	error	rate	error	rate	error	rate	error
Good	21.3	4.8	0.0	1.5	3.8	2.6	25.0	5.1
Average	2.5	2.3	0.0	1.5	5.0	2.9	7.5	3.3
Mediocre	8.8	3.5	0.0	1.5	15.0	4.3	23.8	5.0
Wrong	0.0	1.5	1.3	2.0	15.0	4.3	16.3	4.4
No answer	0.0	1.5	0.0	1.5	27.5	5.2	27.5	5.2
Total	32.5	5.5	1.3	2.0	66.3	5.5	N=80	

Software	Correct example		Wrong example		No example		Total	
Description	rate	error	rate	error	rate	error	rate	error
Good	10.0	3.7	0.0	1.5	8.8	3.5	18.8	4.6
Average	5.0	2.9	0.0	1.5	12.5	4.0	17.5	4.5
Mediocre	5.0	2.9	0.0	1.5	15.0	4.3	20.0	4.7
Wrong	0.0	1.5	1.3	2.0	16.3	4.4	17.5	4.5
No answer	0.0	1.5	0.0	1.5	26.3	5.2	26.3	5.2
Total	20.0	4.7	1.3	2.0	78.8	4.8	N=80	

TEACHERS

Hardware	Correct example		Wrong example		No example		Total	
Description	rate	error	rate	error	rate	error	rate	error
Good	25.5	4.0	0.5	2.5	5.0	2.9	31.0	4.1
Average	11.5	3.4	0.5	2.5	3.0	2.8	15.0	3.6
Mediocre	8.0	3.2	0.0	2.5	5.0	2.9	13.0	3.5
Wrong	1.0	2.6	2.0	2.7	10.0	3.3	13.0	3.5
No answer	3.5	2.8	0.0	2.5	24.5	3.9	28.0	4.0
Total	49.5	4.3	3.0	2.8	47.5	4.3	N=200	

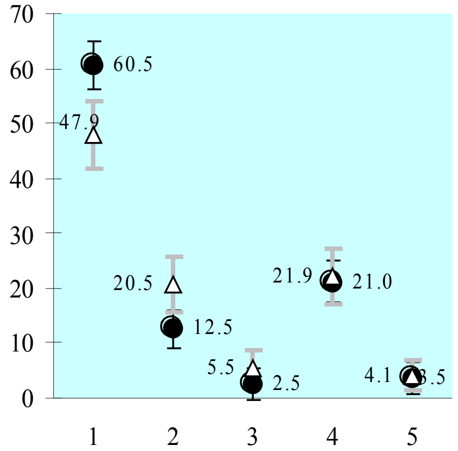
Software	Correct example		Wrong example		No example		Total	
Description	rate	error	rate	error	rate	error	rate	error
Good	29.0	4.1	0.0	2.5	12.0	3.4	41.0	4.3
Average	7.5	3.1	1.0	2.6	7.0	3.1	15.5	3.6
Mediocre	2.0	2.7	0.5	2.5	4.0	2.9	6.5	3.1
Wrong	0.5	2.5	3.5	2.8	7.5	3.1	11.5	3.4
No answer	0.5	2.5	0.5	2.5	24.5	3.9	25.5	4.0
Total	39.5	4.3	5.5	3.0	55.0	4.3	N=200	

STUDENTS

The pupils were asked to *describe* what they mean by the term hardware and software and to give one or more *examples* of hardware and software. The descriptive answers as well as the examples were assessed and categorised by the researchers. All sorts of combinations emerged, regarding pupils' ability to define what constitutes hardware (and software), in relation to their ability to select a proper example. The answers where combined in tables. Each experimental point is followed by the total error associated with it and this is given in the darker background column next to the rate column. In two-dimensional binning, the number of points in every bin decreases, resulting to the corresponding increase in the statistical error component. For this reason all available data are summed up on the edge of the tables. We observe that most of the pupils who were able to pick up a correct example (of either hardware or software), were also able to give a fair description of the relevant term using words. On the contrary, most of those students who had no example to offer, could not give a reasonable description of the concept either. Comparing the data of the two sets we observe that although these are comparable, the students fare better overall. The answers form the teachers sample was particularly poor in dealing with software. All the above demonstrate a need for more examples to be presented to the trainees (including longer and more varied lab time).

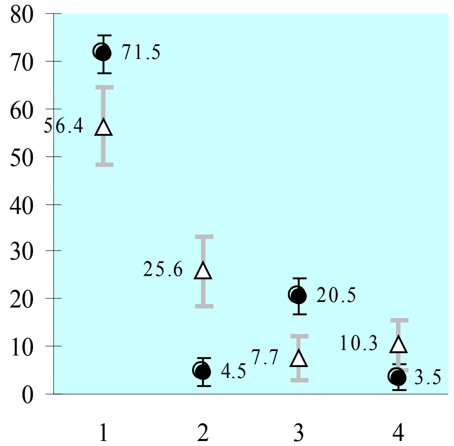
Ideas on the function of the operating system (OS)

Data on pupils' ideas on the operating system were collected using three different approaches. The captions to the right each figure correspond to the pupils' answers relating to their ideas. In each figure the first point correspond to the orthodox (e.g. correct) point of view and the others follow in decreasing order of relevance. The first figure answers to the question of <u>what</u> an O.S. <u>is</u>. The second figure relates to the interfacing function of the O.S. and it examines the ideas on <u>what parts</u> of the computer system are interfaced by the OS. The third figure shows what the pupils think an O.S. <u>does</u> or <u>can</u> <u>do</u>, which appears to bring out the greatest amount of confusion. There is a significant difference in the percentage of students who answer correctly to the first two approaches. The reason for this could be attributed to the longer exposure of the students' sample to computers in the laboratory.



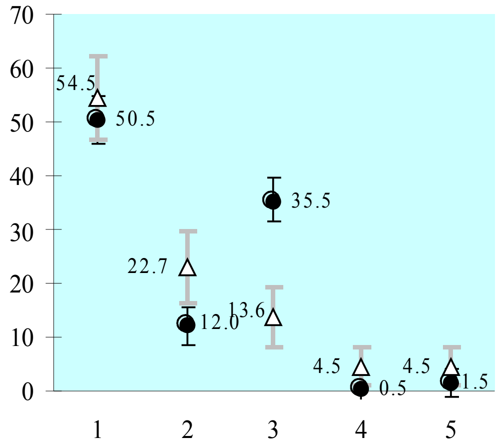
∆ triangles represent teachers
● circles represent students

1. Correct
2. Hold the idea that the O.S. interfaces the computer peripherals with parts of the CPU answer given
3. Vague idea on services offered by O.S.
4. Hold the idea that the O.S. interfaces hardware components
5. No answer



∆ triangles represent teachers
● circles represent students

1. Correct
2. Hold the idea that the O.S. interfaces the computer peripherals with parts of the CPU. Confusion over the functions of application programs and those of the O.S.
3. Failure to conceive the O.S. as made-up from many system programs.
4. No answer

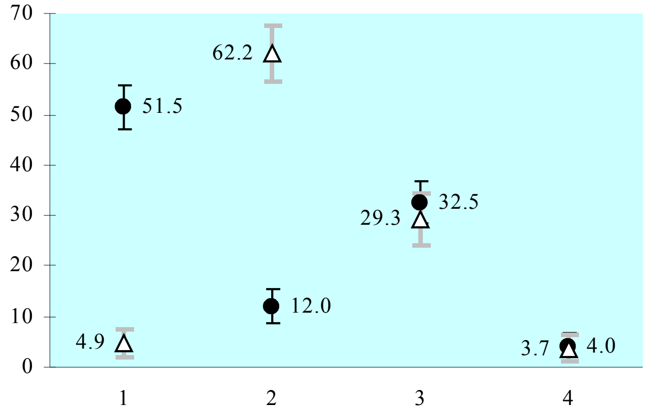


∆ triangles represent teachers
● circles represent students

1. Correct
2. The job scheduling task of the O.S. is seeing as its' only function while the real-time and multi-tasking features are not understood
3. Confusion over the functions of application programs and those of the O.S.
4. Serious confusion over the function of O.S.
5. No answer

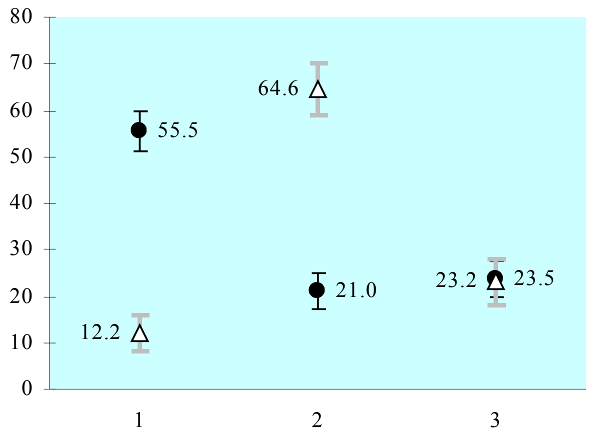
Ideas on the socio-economic impact of the proliferation of computers. The use of PC will:

Pupils' opinion on future impact of IT proliferation was investigated along two different lines: employment and communication. A trend can be seen here which is, at first, very surprising. Students hold very traditional (e.g. against IT) views. This trend affects even the communication aspects of ICT – students believe that computers impede personal communication (despite all the mobile phones and the SMS messaging they use). Quite the opposite trend can be seen on the teacher's sample that holds, in general, quite liberal views. All teachers thought highly both of the communication aspects offered and of the increase of productivity offered by the use of IT. We now believe that the trend is very much age-based.



∆ triangles represent teachers
● circles represent students

1. Will create increasing problems of mass unemployment in almost all professions
2. Will create problems in only some professions, whereas others (e.g. teachers) will not be replaced and could even benefit from it.
3. Opinion b, and in addition many new job opportunities will be created in some new specialised fields
4. No answer given



∆ triangles represent teachers
● circles represent students

1. Will alienate humans thereby creating an inhuman civilisation centred on machines
2. Will increase the communication amongst people due to increased communication capabilities and more spare time for leisure
3. No answer given

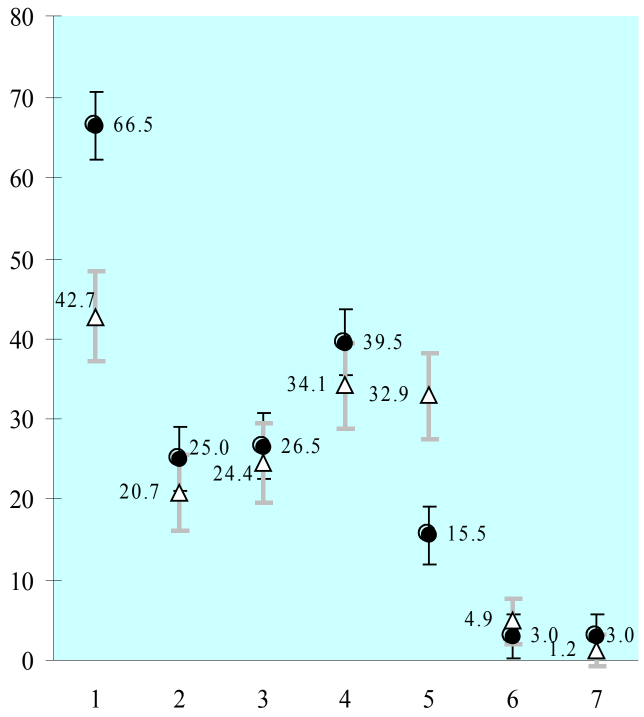
Even within the teachers' group it was noted[4] that the older teachers hold more liberal views on this subject. The present comparison comes to conclusively prove this hypothesis. The younger the pupils, the more insecure they feel about the employment situation. The high unemployment rate, endemic in much of Europe during past decades, does not help. There is a lot of food for thought here.

Ideas on artificial intelligence (AI)

In this part of the study, we probed the pupils' beliefs on intelligence as being an exclusively human quality and computers' ability to develop artificial intelligence, and also perhaps to learn from their own mistakes. Concepts like soul, creativity, and sentiment were used to test how easily could the pupils dissociate from these being exclusively human properties, and very important ones for that. The points of view offered (in the questionnaire) range from a hard-line dogmatic approach (where no arguments are accepted on philosophical grounds), to hard-line humanistic (but nonetheless

[4] Ioannidis G.S., Garyfallidou D.M., and Vavougios D.G.: Teachers' ideas on computers after some initial information technology (IT) training, in Valanides N. (Ed.) *Proc. 1st IOSTE Symposium in southern Europe "Science and Technology Education: Preparing future citizens"*, ISBN 9963-8519-2-4, (2001), Vol. 2, p. 254.

backwards and very traditional), to just humanistic and traditional, and continuing to more enlightened points of view. As we, therefore, progress from answers 1 to 6 the opinions change in that order, from very traditional to modernist beliefs. It is therefore possible to even attempt to draw a continuous curve through these data-points.



∆ triangles represent teachers
● circles represent students

1. Intelligence is an exclusively human quality and there is no sense to talk about intelligence in a soulless contraption, like computers are
2. Computers are in a sense like a large and fast calculator from which "human" properties like creativity and sentiment are lacking. The computers would therefore never be able to substitute man.
3. Computers would always be dependent on man's will, because they are his creations.
4. Computers were developed from calculators (without being such) but at the same time computer programs are not constrained to develop creativity on their own free will.
5. Answer 4, and in addition there already exist some programs which can create works of art, write their own poems and take decisions while playing chess (for example). They can even improve upon themselves by learning from their own mistakes, which in itself is a learning process.
6. None of the above
7. No answer

The data were processed so as the pupils were able to select whether they agreed or not with one or more from a number of points of view, described in the caption. This above figure depicts the choices of the pupils, concerning the points of view tested. Please note that as the pupils could select more than one answer as being a fair description of their opinion, the percentages in each figure do not add up to 100.

Taking these figures overall, we can deduce that traditional beliefs concerning intelligence and creativity as being exclusively human traits still hold fast. It can be observed that the most prevalent point of view is the first one e.g. the hard-line dogmatic opinion. We, therefore, hold the view that no amount of verbal argumentation could convince the great majority of students that AI (although artificial) in nonetheless real. A more hands-on didactic approach is called for, perhaps. The laboratory use of a software package with a high AI content could be, possibly, very valuable in transforming pupils’ opinion, by administering a shock treatment to them.

Ideas on educational software

The pupils were asked to give their opinion and describe *what* (they think) constitutes educational software (vertical axis). They were also asked to give examples illustrating their opinion and provide explanatory support of their point of view as to *why* what they describe really is educational software (horizontal axis). During the course, this subject had been explained and some examples were, also, exhibited in the laboratory. We observe that quite a lot simply fudged the question, and gave a much too general an answer, or offered no answer (a trait much more obvious in the students’ sample). As all answers were descriptive, the use of a systemic network was necessary so as to categorise students' opinions and beliefs. As a definition of the categories of application software that could be used in education, we used the categorisation already published by some of the present authors[5, 6].

Three categories of software used in education were defined:

A) Programs lacking educational target, per se: Word processors, spreadsheets and programs for statistics, data base management systems (DBMS), encyclopaedias, dictionaries, geographical atlases, thesauri, information processing,

”Ideas of what constitutes “educational

Justification for the ideas held about what constitutes educational software										
	Correct		General		Wrong		No		Total	
	rate	error	rate	error	rate	error	rate	error	rate	error
a	0.00	1.50	1.18	1.91	2.35	2.23	0.00	1.50	3.53	2.51
b	1.18	1.91	1.18	1.91	0.00	1.50	0.00	1.50	2.35	2.23
c	2.35	2.23	2.35	2.23	2.35	2.23	0.00	1.50	7.06	3.17
abc	8.24	3.35	2.35	2.23	2.35	2.23	0.00	1.50	12.94	3.96
general	7.06	3.17	10.59	3.68	12.94	3.96	7.06	3.17	37.65	5.50
wrong	0.00	1.50	1.18	1.91	15.29	4.20	5.88	2.97	22.35	4.79
no answer	0.00	1.50	0.00	1.50	0.00	1.50	14.12	4.08	14.12	4.08
total	18.82	4.52	18.82	4.52	35.29	5.43	27.06	3.49	Total = 85	

Teachers, N=85

”Ideas of what constitutes “educational

Justification for the ideas held about what constitutes educational software										
	Correct		General		Wrong		No		Total	
	rate	error	rate	error	rate	error	rate	error	rate	error
A	0.0	2.5	0.0	2.5	0.0	2.5	0.0	2.5	0.0	2.5
B	0.0	2.5	0.0	2.5	0.0	2.5	1.0	2.6	1.0	2.6
C	1.5	2.6	0.0	2.5	1.5	2.6	1.0	2.6	4.0	2.9
ABC	3.0	2.8	0.0	2.5	5.5	3.0	1.5	2.6	10.0	3.3
General	3.0	2.8	1.0	2.6	10.0	3.3	31.0	4.1	45.0	4.3
Wrong	0.5	2.5	0.0	2.5	3.0	2.8	8.0	3.2	11.5	3.4
No answer	0.0	2.5	0.0	2.5	0.5	2.5	28.0	4.0	28.5	4.1
Total	8.0	3.2	1.0	2.6	20.5	3.8	70.5	4.1	Total N=200	

Students, N=200

B) Presentation software, including any type of authoring tool. This software does not have specific education content but, with some additions by “authors”, it can acquire some. Limited in flexibility, scope, and presentation potential, this category creates “electronic books” (sometimes glorified) and forms the middle category leading to fully-fledged educational software.

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5 Garyfallidou D. M. and Ioannidis G. S., Educational software multimedia and Internet a comparison with traditional methods (in Greek) in *Proc. 1st International conference on Science Education*, ISBN 9963 – 0 – 9062 – 1, Cyprus (1999), pp. 281-296.

6 Ioannidis G. S. and Garyfallidou D. M., Education using Information and Communication Technology (ICT), and ICT education: categories methods and trends, in Auer M. and Auer U. (Eds.) *Proc. ICL2001 workshop: Interactive Computer aided Learning - Experiences and Visions*, Villach, Austria, Kassel University Press ISBN 3-93146-67-4, (2001) 13 pages overall, p. 3-6.

C) Educational software: Drill and practice, tutorials, educational programs and educational games, simulators. All written using high-level languages, quite often of the object-oriented variety.

In addition to these distinct categories, for the purpose of the present analysis some further categories were defined to categorise pupils' opinion. These were grouped as "ABC", implying the collective use of all the three software categories (defined above) and, also, a distinct "general" category, which contained all opinions that were vague enough to be judged as *fudged*. Some answers were specific but where judged "wrong" and these form their own category.

When the pupils were asked to mention *examples* of relevant software that they knew of, a full set of examples were collected (from those who bothered to offer an opinion, that is). Judging from the overall shape of the data from our total sample, we cannot help but conclude that data are mostly disappointing and that pupils are confused on what constitutes educational software.

By comparing the two samples we observe that the teachers do much better, overall. They give more specific answers, they appear less confused, and most significantly they offer a proper and clear justification for their own opinion on educational software. Experience shows here (even if this is not directly related to ICT). The younger are confused, perhaps by adverts in the mass media.

Discussion and conclusions

Looking overall at the data of this study, we can conclude that when knowledge and ideas were evaluated at the end of the course, most pupils were inclined to express their own opinion rather than to reproduce whatever was taught during the course. Quite a number of them were self-opinionated (some quite stubborn). This is in line with all the Science Education theories and all the experimental data from this field of research. The researchers are convinced that (within the limits of the experimental errors posted), the numbers express the pupils' ideas.

The task of searching for pupils' ideas on IT is a complex one and we do not pretend that the present study is exhaustive, let alone definitive. Nevertheless, certain conclusions can be drawn.

1. A by-product of the present research is relating to the treatment of all data collected. Even with sample sizes like the present ones (by no means negligible for a science education study), if all errors (statistical and systematic) are taken into account properly, the researcher becomes (as he should be) very cautious in trying to draw any conclusions from scant evidence. The effect becomes more noticeable when, as in the present study, one tries to correlate different sets of the data. To convincingly demonstrate differences, the total errors of both the data-points correlated have to be combined. In doing so any feeble evidence vanishes, be that with small systematics and sizable statistics available. The authors are by no means unaware of the effect; they simply draw attention to this fact, to serve as a reminder to those who confuse wishful thinking with true scientific methodology.

2. The good news is that, irrespective of pupil's age, some of the very basic concepts concerning IT can be reliably taught to pupils during an IT literacy or IT pre-literacy University course. This applies even to those pupils who have been subjected to the vast misinformation onslaught of the mass media. As expected, some more advanced concepts seem to be harder to grasp.

3. Another conclusion it that it is possible to teach computers to serving schoolteachers, even if this is done after hours in their spare time. This result is comforting, especially in the face of the latest EU attempt to introduce each and every serving teacher into IT, utilizing the teachers' spare time

4. Serving teachers do not seem to be in any particular disadvantage as opposed to younger students. In fact, in some respects they seem to gain from their experience.

5. Serving teachers exhibit, also, a more liberal mind, something especially obvious when dealing with questions relating to the socio-economic effects of the use of ICT, as well as AI.

6. The same ICT curriculum can be used for both categories (students and teachers).

7. On the question of emphasis during teaching, it would seem, from the evidence presented, that acting teachers have a greater need of laboratory lessons so that they get to grips with the concepts presented there.

8. It would also seem that questions related with AI and the socio-economic effects of ICT should be stressed more to the younger students. One would have thought that after all this public discussion about ICT, people would be convinced that ICT is of net benefit to them as it both increases their communication capabilities and their own effectiveness. This does not seem to be coming through at all. As to the reasons for this, it is thought that a future research could deal with the adverse influence of factors of a totally different nature in shaping pupils' opinion. Looking at concepts relating to AI, pupils' ideas continue to be highly conservative. Previously-held information (or misinformation) is of not helping them, as it contains quite a high amount of imprecise or even wrong ideas. It is thought that a lot of care should be paid on the above mentioned points, so that the younger generation of teachers does not become the neo-ludites of the 21st century.

9. It would seem that to attempt to teach ICT to acting teachers, 30 hours is just not enough. More time (especially laboratory time) is needed if a comfortable IT pre-literacy level is to be reached.

10. Further training time seems to be necessary if ***true*** IT literacy is to be reached, as (a) this necessitates a minimum of an introduction to procedural programming to be included in the curriculum and (b) further exposure to more advanced IT concepts, necessary to effect the desired conceptual change to pupils' ideas on many of the simpler and basic everyday IT concepts

11. As a final (didactical) observation it can be submitted that pupils' ***attitude towards ICT*** seems to be by far the larger factor affecting their performance: those who come *ready* to be converted *are converted,* and they get on progressing in ICT.