1982

The teaching of computing in schools

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ABSTRACT

The paper considers five questions in the context of teaching computing in schools.

(i) What is computing ?
(ii) Who should teach it ?
(iii) What training do they require ?
(iv) Where and when should this training be given ?
(v) How can this be achieved ?

Based on an analysis of the first four points and a summary of the problems raised therein, solutions are offerred which make use of the currently available over-supply of teachers and the endeavours of Colleges of Advanced Education to retain viability by expanding into new fields.

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1. INTRODUCTION

I am speaking to the wrong group of people. This is a conference of the Australian Association of Mathematics Teachers and I am addressing the question of teaching computing. Why are you here? I assume that the answer lies in the historical association of computers with numerical calculation and hence with mathematics. Despite this historical tie, which should and MUST be broken, I will continue since all is not lost for I believe that although your subject matter is mathematics you are, beneath it all, teachers of children and so what I have to say will be of relevance to you.

The major problems in the teaching of computing as I see them are:

(i) What is computing in the context of teaching computing ?

(ii) Who should teach it ?

(iii) What training do they require ?

(iv) Where and when should this training be given ?

(v) How can this be achieved ?

2. WHAT IS COMPUTING ?

In the context of teaching computing in schools, what is really meant by the term "computing" ? Each of you have a conception of what is meant, but I wonder whether in discussing the topic with each other we are talking about the same thing ? If we are not then there is no point in proceeding. "Computing" is one of those terms like "numeracy" and "literacy" which we use because "everybody knows what we mean by it" **even though** there are no dictionary definitions and in those publications where an attempt has been made to define the terms, those definitions are somewhat lacking in precision.

"A person is literate when he has acquired the essential knowledge and skills which enable him to engage in all those activities in which literacy is required..."
UNESCO "World Campaign for Universal Literacy"
Report to the UN General Assembly May 1963.

If one looks in a dictionary we find *compute - to reckon* and *computer - electronic device which computes* and so, by inference, *computing - the task of reckoning carried out by an electronic device* (No wonder this paper is being presented here!)

We are not alone in being unsure of what we mean. At the Second Australian Computer Science Conference,(Yuen 1980) part of a session on "education" was a panel discussion entitled **What is Computer Science ?** The position papers by Arthur Sale, John Bennett and Jeff Rohl, together with the edited transcript of the discussion which followed, give a good cross-section of views.

Throughout the world there have been attempts to come to grips with the concept underlying the word. In many cases the solution has been to replace this undefined term by another (equally undefined), or to use some variant which supposedly has a subtle difference implied. This applies at all levels and in all fields which claim some relationship with whatever is at the core of this term. Thus we have University departments of Computing, Computing Science, Computer Science, Information Science, Information Processing and Informatics among others, all purporting to be dealing fundamentally with the same area of knowledge but perhaps subtly differing.

At the highest international level, the organisation charged with the responsibility for acting as a co-ordinator, collater and disseminator in this field is **IFIP** the International Federation for Information Processing. The members of **IFIP** are national bodies representing their country's interests and their names reflect the diversity of interpretations of, or their aspirations to clarify, what is the essence of their interests.

The names can be broadly grouped into three major categories which to some extent reflect the historical development of the field. Many evolved at a time when those who used the computer were closely related with the development of the machines themselves and so there are a large number of Computer Societies, such as the Australian **Computer** Society, all modelled to some extent on the British Computer Society. In the United States the national association representing them on **IFIP** is **AFIPS** (American Federation of Information Processing Societies) which is a reasonably new confederation having as one of its members the older **ACM** (Association for Computing **Machinery**.)

From these groups alone we can see a trend from object based (computer/machinery) titles to process based (information processing) titles, which of course occurred via restricted process titles such as data processing. The third group, becoming more and more widespread, contains many European societies which use the term *Informatics* coined to represent the idea that the task of a computer, described as broadly as possible, is to process information and the study of that task is Informatics.

Informatics itself does not quite have the ring to it that the original French term *Informatique* has, but in the conservative English speaking world the anglicised version is more acceptable (slightly). It is unfortunate that the term *Information Science* is not available since this has in many cases been appropriated by the librarians for their discipline yet as J.M. Bennett said "it is the nearest equivalent with wide acceptance in the English speaking world to *Informatics*." (Bennett 1979)

From all of the foregoing can we yet identify some common theme which we can use to describe *computing* ?

We have the idea of computing as numerical calculations, as the study of the equipment, as the study of some specific processs (data processing) or the study of a generalised process (information processing) which has had a name coined to represent it *Informatics*.

It is this last term – **Informatics** – which has been adopted by the IFIP Technical Committee (TC3) charged with the responsibility for the area of study described as "Computers in Education".

If you accept the proposal that *computing* is *information processing* there are still two points which must be clarified:

(a) Why did I use "information" rather than "data" ?

(b) What is the depth and breadth of the study ?

The difference between data and information is trivial. Data contains information. Data is a collection of elements which are useless until their information content is extracted and interpreted.

The second is a rather more complex issue since computing in schools is often categorised into:

(i) teaching **about** computers

(ii) teaching **with** computers

(iii) teaching **by** computers

(iv) teaching computing.

It is easy to rationalise out of our considerations in this paper (ii) and (iii) since *teaching-with-computers* relates to teaching in general using the computer as an educational technology and *teaching-by-computer* relates to using the computer as an educational delivery medium. Both of these categories refer to teaching in general and are **not** subject specific, hence they may be eliminated from the main thesis of this paper. Before doing so, however, let me say that I consider them to be categories which should be included in the pre-service education of ALL teachers, irrespective of their expected subject specialty or level of teaching. It is ridiculous to have advanced technology available which, properly understood, can enhance the learning environment and which can add power to a teacher's pedagogical arsenal, and yet not provide the means by which the teacher can make effective use of it.

We have already erred with other technological advances such as films, television, and even the overhead projector by failing to provide adequate instruction on their strengths and limitations and on effective use of them within a general teaching strategy.

This leaves categories (i) *teaching about computers* and (iv) *teaching computing*.

Teaching about computers seems to me to be an area which may overlap many disciplines depending upon the content included and the depth to which the study is pursued. To clarify this perhaps I could compare it to *teaching about spelling* versus *teaching spelling*.

Teaching about spelling would certainly be part of the job of specialist teachers but it may also be properly carried out by others:– Social Science teachers may wish to include some aspects of spelling either to illustrate a historical/geographical link or to develop a communications theme; Physical Education teachers may wish to include a mention to assist pupils to appreciate terms like "decathlon" and "pentathlon"; Mathematics teachers include similar teaching about spelling in developing an understanding of the metric system prefixes such as *kilo* and *milli*. Analagous situations can be found in all areas.

In a similar fashion teaching about computers can and should occur in all disciplines but the bulk of the teaching ought to be carried out by specialists within the framework of teaching computing.

In a paper presented to IFIP Congress 80, Professor Jurg Nievergelt stated that the goal of his paper was an analysis and recommendation of what he saw as an emerging consensus of the core of computer science as an academic discipline. He did this by stating a number of postulates of the form *X is important* and, in order to avoid the charge of being meaningless, included a list of candidates that in comparison with X are not important. (These have been summarised in an article in the Australian Computer Bulletin (Pirie 1981a)). His suggestion as to what is computer science is "*the careful study of small-software*". He concludes "*we should base our instruction on deep understanding of large numbers of these* (elegant toy problems) *rather than on skimming the surface of a few real-life case studies.*" (Nievergelt 1980)

My definition encompasses several of the views propounded in the foregoing discussion and is that *teaching computing* is:

> The teaching of knowledge, understandings and skills from all areas which relate to the processing of information by means of a computer. The areas include *inter alia*:
>
> Programming -
> - problem solving
> - algorithm design
> - data structures
> - an implementation language
> - testing
> - debugging
> - documenting
>
> Computing environment -
> - understanding both the software and hardware environment in which a program runs in terms of the fundamental components of the environment and their relationships.
>
> Computer applications -
> - selected representative applications of the technology
>
> Implications -
> - the way in which the use of the technology interacts with the society which created and sustains it.

At the school level the problem is that of determining which elements are suitable (or perhaps essential) for inclusion in an already crowded curriculum hedged around by many non-educational constraints.

It is not desirable, nor I think possible, to include here a list of specific topics and levels of treatment which would form a "core" curriculum in computing. Firstly there is insufficient time to cover the entire field and secondly the provision of such a list, even if qualified by some phrase such as "*the sort of things which should be included*", tends either to become a sacred cow or a whipping boy.

To enable you to isolate those elements which should be included in a school curriculum let me use another analogy. In teaching a child to swim, the teacher includes those elements which are necessary and sufficient to enable the pupil to survive in those situation which the pupil can be reasonably expected to experience. The teacher does **not**, in general, try to teach to all pupils all varieties of strokes nor to ensure that all pupils can swim distances in world time, nor be able to swim to safety in every conceivable situation.

However the teacher **will** ensure that all pupils are confident in swimming situations in which they are likely to find themselves, have reasonable competence in a (limited) repertoire of techniques, have a sound understanding of basic principles and how to apply them to new situations, and be able to use effectively a limited number of swimming skills. In all cases the choice is based on perceived educational needs and only after this selection has been made are the other constraints considered during the planning of the implementation.

In the same way, when selecting material for inclusion in school computing curricula, the designers must first identify the needs of the pupils in terms of those computing situations which most can be expected to encounter.

Much of the material to be included will thus fall into the *teaching-about-computers* category especially in the junior grades and will involve the truth (albeit not necessarily the whole truth) about what computers can and can not do; about the fact that **humans** design computers, write programs to be obeyed by computers and interpret the information produced by computers; about ways in which computers can be used to improve human life-style; and about the mechanics of how a computer carries out the task of processing data.

As we progress to the more senior grades the emphasis will move towards topics more properly thought of as lying in the category of *teaching computing* especially if there is built in to the curriculum an opportunity for students to select levels or strands which reflect their perceived needs in line with their different aspirations.

To identify specific levels and topics I refer you to material which has been, or is about to be, published. **IFIP TC3** has produced a draft curriculum for informatics in schools, which is currently being distributed for comment, and which should be published early in 1982. In addition the **TC 3** Working Conference *Updating Training for Teachers of Vocational Informatics Courses* held in Vienna in July of this year expects to publish several documents including:

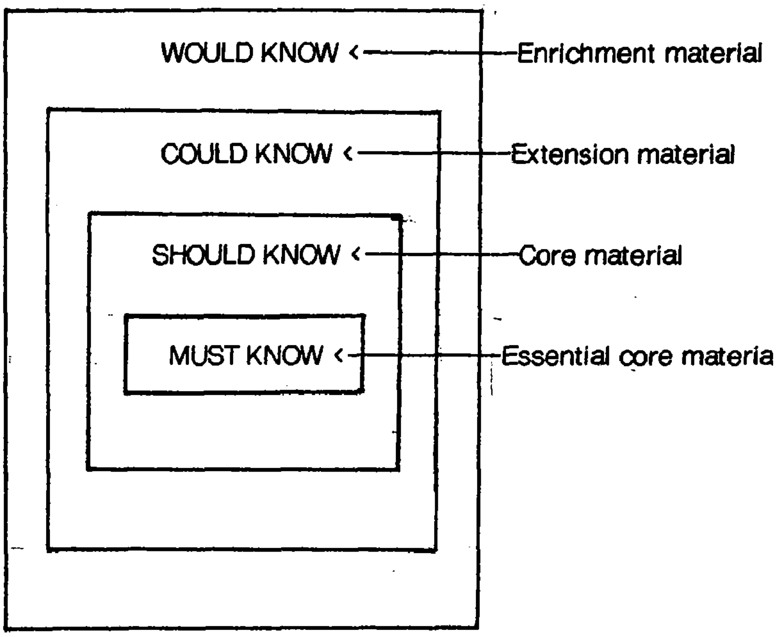
(a) An introduction to programming – a teacher's guide.

(b) Outline of a self-instructional manual for teachers of computing courses.

(c) A report on the "computer literacy" approach to training courses for teachers.

There is also the earlier booklet (**IFIP TC3** 1972) booklet *Computer Education for Teachers in Secondary Schools – Aims and Objectives in Teacher Training* and the two **ACM** definitive publications *Curriculum '68* and *Curriculum '78*.(**ACM** 1968 and **ACM** 1978)

The papers presented at the Second Australian Computer Science Conference, and later articles also in *Australian Computing Science Communications* mentioned above, give a general view of the structure of computing science. Perhaps the model proposed by Arthur Sale (Sale 1979) may be the simplest to consider especially if the following general model of a subject's structure is superimposed:



In summary then, teaching computing in schools refer to the teaching of material from the whole area which deals with the processing of information by computer, selected in accordance with the perceived needs of the pupils in order that all pupils:-

(a) are **confident** in computing situations in which they are likely to find themselves;

(b) have a sound **understanding** of basic computing principles and how to apply them in new situations; **and**

(c) have **reasonable competence** with a limited repertoire of computing skills necessary to meet their foreseeable needs.

3. WHO SHOULD TEACH IT ?

It should be obvious from my remarks in the preceding section that I believe that all teachers should be capable of teaching about computers just as all teachers should be capable of teaching about spelling.

> *The introduction of computer education for all teachers is specially justified by the contribution computers have brought and can bring to education* (IFIP TC3 1972)

But their knowledge and understanding of the subject should be sufficient so that what they teach is strictly correct and does not conflict with the wider knowledge base held by the specialist.

Returning to the analogy with teaching about spelling, I am reminded of a lecturer in my college days in one of the scientific disciplines, explaining to us that **biology** was a word derived from the Greek **bi** meaning **two** and **ology** meaning **study**, hence **bi-ology** was a subject formed from the combination of **botany** and **zoology!**

Obviously then I am advocating that the major task of teaching **about** computers should be carried out by specialists with a broad knowledge base, but that where overlap occurs between "informatics" and any other discipline, then the specialist in that discipline should be sufficently well grounded in informatics to be able to transmit knowledge and skills and be able to draw correct inferences and conclusions.

From this there is the implication that "teaching about computers", if sufficient depth and breadth are incorporated and the teaching is not just incidental to some other issue, may be considered part of the other area "teaching computing".

This of course means that all teachers-in-training, irrespective of their discipline or excpected level of teaching, should be exposed to some courses aimed at developing at least basic understandings and competencies in the broad area of computing.

Who currently teaches computing in schools ? In many instances the task is taken on by "enthusiastic-amateurs" usually from the field of mathematics. They do so because they themselves are interested in the subject and/or they realise that if they don't do it no-one else will and the children for whom they are responsible will suffer. Others, also mainly from mathematics, are dragooned into the job on the basis that "some-one has to do it and it would look good on your next promotion report".

Why from mathematics ? Why not ? As we saw, computing,according to the dictionary, is all about reckoning, and computing is an abstract science much like mathematics. Anyway no-one else understands binary arithmetic so it must be mathematics teachers who do it if there is no one better qualified available.

What a well constructed logical argument! Let's apply it to some other subject. Suppose a school decides to run courses in Vietnamese as there is a need for them. Obviously then this is a task for the staff of the English department since Vietnamese is a language (as is English) and they both have vocabularies, grammars, rules of syntax and so on therefore as there is no specialist available the children will never get the opportunity to learn Vietnamese unless an "enthusiastic amateur" or "volunteer" from the English staff takes on the job.

Perhaps **something**,even if provided by an untrained non-specialist, is better than **nothing** (this is debatable) but if there is a widespread need then surely there must be ways to provide trained specialist staff to meet that need.

Computing **is** a discipline in its own right and is a very broad subject with developmental depth like all of the traditional disciplines. The need is certainly there for courses at various levels as indicated above hence specially trained teachers should be provided to teach the subject effectively.

4. WHAT TRAINING DO THEY REQUIRE ?

I was re-reading a paper which I presented to the Third Biennial Conference of the Mathematics Education Lecturers' Association on basic numeracy skills for teachers and found that much that I said then is equally applicable to the training of teachers in any subject discipline and so I will paraphrase the appropriate sections here. (Pirie 1979)

Any beginning teacher must have sufficient knowledge, skills and **understanding** of the subject, to be fully confident in his ability to teach correct concepts to others. He must **not** be placed in the situation where his preparation for teaching has him "one page ahead" of the class.

Children learning something new (and if this is not the case then why have a teacher ?) will have sufficient problems grappling with the "unknown" without the teacher confusing the issue by supplying erroneous and/or unrelated bits of information or cluttering the basic concepts which have to be grasped, with extraneous material. This disastrous situation too often arises when the teacher has insufficient understanding to realise just what is essential to the learning which is to take place.

At all times the teacher must impart the truth – it may not be the whole truth but it must be the truth. The teacher with limited knowledge of the subject and who lacks a clear understanding is often unable to differentiate between fact and fiction or to identify misconceptions in his own knowledge which he has believed to be true since he was first "taught" them and hence perpetuates some computing myth.

If we can not guarantee that the beginning teacher will always tell the truth then, as the child's own knowledge and understanding of the subject increases (in spite of the teacher's efforts?), not only will the pupil be faced with conflict situations but also his respect for the teacher's knowledge will be eroded. This in turn will undermine the teacher's self-confidence even further and hence perpetuate this highly undesirable cycle.

It is for these reasons that I have stressed the need for an **understanding of the subject** to be the essential ingredient in the preparation of all teachers of computing. Knowing specific facts and having facility with individual skills are necessary but they will never be sufficient for an effective teacher. To be an effective teacher requires that, in addition, he knows and appreciates the underlying structure of the subject, knows the relationships which exist between the (apparently) isolated skills and knowledge elements and knows these at a level well in advance of that which he expects of the children.

The teacher who does not reach this level, one who knows so little of his subject that he can only present a piece of information in one way (the way in which he was taught) has little chance of successfully imparting that item to all of his pupils. If, on the other hand, he fully understands the subject, its structure and relationships, then he will be able to present the same piece of information in a variety of ways so that each and every pupil will be able to comprehend at least one of his presentations.

5. WHERE AND WHEN SHOULD THIS TRAINING BE GIVEN ?

Much discussion continues to take place on an international level of some of the problems created by the explosion in computer related technologies. Many of these discussions relate to questions of teacher education.

At the Lausanne meeting of **TC 3** this year most of the Working Conferences proposed in the next 6-year plan have some bearing on the problem:

Informatics in Pre-Secondary Education	*Germany 1983*
Computer Science for all Students at University	*Holland 1983*
Involving Micros in Education	*UK 1983*
Evidence of Social Change caused by Computers in Education	*Canada 1984*
Changing requirements for Training and Education in Informatics	*USA 1985*

At the same meeting E.Brunswic from **UNESCO** pointed out that **UNESCO** has now created an instrumentality to deal specifically with the area of computers in education. In presenting **UNESCO's** perspective and seeking **TC 3's** co-operation Mr Brunswic made the following points (among others) for consideration:(Pirie 1981b)

(a) Problems of CAL and computers in education generally are **not** isolated but are related to the difficulties of any large scale innovation in the area of education.

(b) Computers in education and CAL must be placed in correct perspective with respect to other methods.

(c) Costs are not well understood and are too high hence will widen the gap between developing and developed countries.

(d) There is a need for both national and international strategies for introducing new methods and new technologies into education.

(e) **Teacher training both at pre-service and in-service levels is vital especially in the compulsory pre-service levels since most training in computers in education is of a voluntary nature at the in-service level.**

(f) **Such teacher training needs to be based in teacher training colleges which implies that there is a need for trained staff in these institutions.**

Some of these problems were adressed at **WCCE 81** in Lausanne both by way of presented papers and by round-table breakfast meetings. Four such papers are of immediate interest, two by Australians and two which report responses to problems in the United Kingdom.

(a) Computer Education for Teachers: A Postgraduate Approach (Frew 1981)

(b) Inservice Teacher Training about Microcomputers (Preece 1981)

(c) Problems in the Preparation of Computer Studies Teachers (McDougall 1981)

(d) Computers in Elementary and Secondary Schools in Western Australia (Penter 1981)

Why is there this emphasis on the need for pre-service teacher education in computing topics ? The obvious answer is that currently the task is left to volunteers who are given little or no encouragement by the Education Instrumentalities to upgrade their qualifications other than by voluntary, short in-service courses.

In Australia, as far as I am aware, only Tasmania has a recognised component in pre-service teacher training courses which entitles those teachers to be classified as teachers of computing. (See Wills 1981) Admittedly Tasmania has the most advanced formal structure of courses in computing together with the essential support services provided by the Department of Education through the Elizabeth Computer Centre. Other states too have well developed and developing support services.

Obviously then there must be a two pronged attack on the problem of producing sufficient, well qualified teachers. In the short term much of the work will by necessity have to be carried out by stepping up in-service education for those teachers already in the service who want to obtain some knowledge in the area. The stepping-up which I envisage is rather more than simply increasing the number of one-week courses run during vacations or the number of six-week courses running one evening per week.

Having been involved with such courses it is obvious that the time available is insufficient to do more than simply eradicate some common misconceptions and to scratch the surface of a somewhat limited range of topics. Even allowing for the fact that the audience is highly motivated (why else would they give up their spare hours?) and consists of educated people, there is insufficient time to present material and allow for assimilation before the next new concept is presented.

What is required is an on-going program of courses which are *in-service* merely by the fact that they are available to teachers employed in the teaching profession but which do not require teachers to sacrifice their own time. Rather they should be undertaken in lieu of normal teaching responsibilities, or be in the nature of post-graduate courses which, although requiring some sacrifice in time, offer compensation in terms of qualifications and/or status.

The second prong is more long term in its effect but should be introduced concurrently with the *in-service* programs. This is naturally the provision of courses within the compulsory pre-service training programs.

As Brunswic pointed out above, these courses (both in-service and pre-service) should be provided by those institutions charged with the task of training teachers. These include not only the Colleges of Advanced Education but also the Universities and, to some extent, Institutes of Technology and Technical Colleges.

There will certainly be more problems in arranging such a training program for teachers who are preparing for Primary Schools (C.A.E.based) than for those who are peparing for Secondary Schools (university based) especially while Primary teachers are required to be competent in all subject areas. Policy decisions will have to be taken as to how the pre-service curriculum can be altered to provide an adequate coverage of all subjects based on the needs of the children who will be taught.

For those training for Secondary schools the problem is much simpler since in many university undergraduate degree programs, subject patterns already exist which would supply the trainees with the required understanding, knowledge and skills in computing if they were encouraged to undertake them.

What is required then, is to include courses in computing within the C.A.E. programs for teachers preparing for Primary school grades and to encourage trainees preparing for Secondary grades to undertake available university course patterns which will give them the necessary background.

6. HOW CAN THIS BE ACHIEVED ?

This is probably the hardest question to answer. I would assume that most educators would agree (and have done for at least the last decade) with the foregoing sections.

The problem of meeting these needs however appears to be a chicken-and-egg situation. To introduce such courses into the schools we need qualified teachers. These should be produced by the teacher education institutions. The teacher education institutions, in general, do not have sufficient qualified staff (if any) and hence there is a need for the universities to produce more graduates in the field so that they can qualify as computer educators.

Computing science or informatics as a discipline in its own right is relatively new.Many staff at universities in computing science departments hold no formal qualifications in the subject since such qualifications did not exist when they were appointed. I can remember the chairman of one department who, when nominating a colleague for membership of BCS was asked "What qualifications do you have ?", replied "None - I simply profess the subject." This is no longer the case. Universities have been producing graduates well qualified in computing for several years who have been rapidly absorbed into the general computing workforce.

But university computing departments are already swamped by the flood of undergraduates taking (at least first year) computing science as a means to expanded job opportunity, and those who do complete a degree in the field are seduced by industry away from the universities thus limiting still further the possible expansion of teaching staff. (See for example (Bennett 1980) (Lions 1980) and (Montgomery 1980))

Bennett suggests that one source of recruits for the computing field is would-be teachers of mathematics (and science) based on the anticipated supply/demand figures for mathematics teachers in New South Wales (Coyte 1979 quoted in Bennett 1980)

Year	Intake – All schools	Estimated over-supply
1979	310	180
1980	300	240
1981	270	160
1982	260	190

The figures indicate that about two fifths of those training for mathematics teaching will be unrequired. Therefore let us make use of them.

This is a time of an oversupply of teachers (which will probably not extend beyond the mid-80's) which means that there is **now** available a large pool of under-utilised people with basic teaching qualifications. These teachers are qualified in a variety of fields and could be encouraged to undertake further training in the field of computing or could be used as replacements in the classroom for practising teachers so that **they** can undertake the further training.

The Colleges of Advanced Education are seeking ways to broaden their range of course offerings (particularly at the postgraduate level) in order to maintain viability by offsetting the decline in pre-service teacher training with an increase in the postgraduate sector. Many staff in the Colleges are facing a choice of being declared redundant or transferring to another institution or to a discipline other than the one which they profess. A large percentage of these, with many years experience in the College sector of tertiary education, would require minimal re-training in computer related courses which build upon their previous knowledge, experience and expertise. Now is the time to make use of these available human resources.

If action is taken now, when an opportunity exists to break the cycle described above, then the first links in the desired chain of events could be forged.

If Ministries and their Departments of Education made a public commitment to the phasing-in of computing studies as an acceptable matriculation subject within five years then the following effects could be anticipated:

(a) Staff in Colleges of Advanced Education seeking an alternative discipline with a secure career future could be expected to elect re-training in the field of computing.

(b) The relatively small number of staff who would be involved could be accommodated in existing university courses and would then be available within one or two years to implement appropriate courses in the Colleges.

(c) Qualified teachers already inclined towards computing and future trainees would be encouraged to opt for computing electives since the commitment made by the Departments would have as a corollary the necessary modifications to promotion criteria for teachers of computing to see a career path identical to that expected by teachers of any other discipline

(d) Syllabus committees would have ample lead-time to determine the needs of pupils and to plan appropriate curricula for implementation when the first of the new *Computing Teachers* are appointed to schools.

(e) The current dual role of university first year courses trying to meet two disparate objectives would disappear. Departments would be able to modify their teaching programs in the knowledge that those students entering first year after completing the matriculation level subjects would require much less time on fundamentals and could be placed directly into the base course of a major sequence. Other students could be placed immediately into a "service course" designed specifically to meet their needs.

(f) This division would allow more time in the major sequence devoted to material more properly thought of as being at university level with the consequence that graduates would have a deeper understanding of a broader range of topics than is currently possible. They would thus be better equipped to accept positions on graduation and, with the encouragement of career prospects in teaching, may be less susceptible to the attractions of industry.

Of course this will require capital investment in order to provide the Colleges with adequate computing facilities to present the new courses, but Colleges already require hardware for their efficient and effective administration. Until now one of two situations appears to arise when Colleges seek approval to obtain computing facilities: – either the equipment asked for has too limited a capacity (in order to attract funds) and is quickly in need of upgrading – or it has too large a capacity for current needs (to meet anticipated expansion) and hence is under-utilised.

By supplying Colleges with adequate equipment to meet the current and short-term needs of both academic and teaching commitments, better utilisation is possible immediately and upgrading is simplified by duplicating facilities thus allowing the two areas to develop in parallel using a common system. Once demand justifies an area's need for expanded computing capabilities, development work and experience on the existing system can be transferred to each of the newly independent systems. Support staff, particularly hardware and system maintenance personnel, will be able to maintain both parts of a duplicated system much more easily than would be the case if equipment expansion involved continual chopping and changing between different manufacturers, suppliers and software houses.

For university departments to keep pace with the **existing** demand for courses, university funding bodies and university administrations must realise that such departments are "heavy-user" departments when it comes to the allocation of funds for equipment and "housekeeping". Many Computing Science Departments are funded on the same basis as departments in Arts faculties and not as departments in Science or Engineering faculties.

The proposals above, I believe, aleviate the funding situation rather than exacerbate it. I am not suggesting that the current funding system should be maintained but simply that, by splitting the first year course into two, based on the level of knowledge students will bring with them from school, better use of the available facilities is possible. This will happen in two main ways:

(i) the current high wastage rate (of students who start but do not complete the first year) will diminish since a viable alternative will be available to them;

(ii) those students who elect to take the main stream base course will require less resources for trivial tasks which will have been treated in the schools.

All of the above hinges upon action being taken **now** to capitalise on the available human resources. Long term manpower and economic planning is required to identify the best way in which the details of the process outlined above is to be implemented. The process must be seen as an investment in the most valuable resource of all – people – and decisions are required now in order than the unique opportunities currently existing are not squandered.

The disillusionment of many qualified teachers unable to obtain jobs for which they have been specifically trained has an often neglected effect when the demand for such people returns. As Professor King describes it "it is easy to reduce supply when demand is low by turning off the tap, but this disillusionment means that when demand returns and the tap is turned on again the number of applicants is far less than expected and supply will not be sufficient to enable the new demand to be met" (King 1980). By using this existing pool of teachers in the ways described we can prevent disillusionment and secure an adequate supply in the future.

7. CONCLUSION

The paper has reviewed the concept of *teaching computing* and offered a definition that:

> *teaching computing in the school context relates to all those areas dealing with information processing by means of a computer*

Using this definition the paper presents a set of guidelines to be used when selecting topics for inclusion in school curricula based on the needs of the children and indicated a model which can be superimposed on the subject to identify the relative importance of individual topics and their depth of treatment.

Computing should be taught by specialist teachers trained specifically for the task and such training, in the short-term, can be given by stepping-up the provision of and opportunities to attend in-service courses, but in the long-term such training should take place in the compulsory pre-service training programs.

In order for this to be possible, decisions are needed **now** by educational instrumentalities which will commit them to the provision of matriculation subjects in schools within five years. As part of such commitment there must be provisions made for teachers to qualify as Computing Teachers with career and promotion opportunities identical to those available to teachers in any other discipline.

The benefits which will accrue to such a commitment include the utilisation of currently unemployed teachers, the useful expansion of courses in Colleges of Advanced Education with the concommitant redeployment of staff, better utilisation of facilities in university computing departments, more appropriate courses in these departments based on the knowledge level of new students and a general improvement in the knowledge level of the population.

Such a program will require capital investment to provide the necessary facilities but such expenditure should be viewed as an investment in the future since it is an investment in human resources.

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