AN AFFORDABLE AND EFFICIENT IN-SERVICE TRAINING SCHEME FOR THE SCIENCE TEACHER

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ABSTRACT
In this paper a scheme for continuing in-school training of primary and secondary school Science teachers is presented. This system, using extensively the Internet and based on distance education methods, exhibits significant advantages compared with other forms of training. The proposed system may also be used as an on line help provider to the school personnel, a feature not possible under most of the current teacher training schemes; this feature is useful for schools in isolation or at hard to reach areas. This system has the advantage to be affordable to all the teachers, irrespectively of the location of their schools, and uses wisely time, resources and human capital. It requires a good operational scheme, which may be developed, and an infrastructure, which is already present in the schools. It eliminates the teacher mobility due to personnel participation in short term training schemes. This characteristic is very important to the school operation. The operational scheme and the infrastructures required for the operation of the proposed scheme may also be used for the communication – cooperation within the framework of other school activities or participation to (competitive) programs, e.g. COMENIUS.

KEYWORDS
INTERNET, training, in-school training, Science teacher training

INTRODUCTION

Research[1] and development[2] interest on the effective Science and Technology Teaching is continuously increasing. Due to the rapid advances the necessity of a literacy in Science and Technology has emerged as fundamental worldwide crucial matter, a right to the democracy[3]. This literacy may be achieved in a generalised way, addressed to all the prospective citizens, only through the compulsory education. This perspective necessitates to raised expectations on the specific skills[4] from the compulsory (primary and secondary) Science and Technology teacher. The primary teacher, usually, teaches all the subjects of the curriculum ("general teacher") and his (her) education is mainly based on psycho-pedagogic matters. The secondary teacher is usually a "specialty teacher" with an assumed sound knowledge of his (her) field but not specifically educated as a teacher. In both cases the skills referred to previously are not included to their initial education and have to be developed through further individualised training. It seems that although some teachers may posses some of the skills, prevailing more significant skills do not exist; all are required for an effective teaching[5]. These observations may explain, partly, the peculiarities of the Science and Technology teacher education[6,7]. In all modern, technologically advanced societies, special measures are taken for an effective Science teaching[8] with the necessity for a generalised Science and Technology Literacy an explicit objective[9]. This literacy, in order to be useful as a right to the Democracy must be focused on principles and methodology rather and not being limited to factual knowledge on specific data, techniques or themes. This implies that in order to be understandable and assimilated by the students, the scientific knowledge that the Science and Technology teacher possess has to be transformed appropriately to teaching activities but it seems that teachers lack, in general, this skill. As a consequence, Science and Technology are considered as difficult subjects[10] although they are rather simpler[11] and possess inherent advantages[12]. This constitutes a significant problem in most of the advanced countries (see reference 3). Another relevant matter is the existing outline of the Science and Technology subject matter and the way of teaching. In the majority of the cases the subject matter does not include advances like relativity or quantum physics that are known for more than 5 generations and require a (qualitatively) different approach than the Aristotelian one of classical physics[13.] The teaching is in general narrative[14] with the teaching book as the only resource[15]. This practice implies that scientific inquiry skills, an explicit common objective of the Science curriculum, are not developed. As a further consequence, a difficulty seems to exist to discriminate between observations' data and their interpretation[16]. The remedy of the situation described previously may be achieved through a new planning:

1.-Of the education and initial training of the Science and Technology (S&T) teacher in the compulsory, especially, education.

2.-Of the continuous in-school training of S&T teacher in order to maintain and improve their proficiency.

3.-Of the teaching approaches, a matter closely related to teacher's proficiency.

On the education and initial training (point 1.- above) see existing studies elsewhere[17]. The other two points may be met efficiently through the appropriate training of the S&T teacher. As these points refer to the acquirement or the development of practice skills, for which apprenticeship teaching is more advantageous, the continuous informal in-school training is more appropriate. In-school (or on the job) training programs, in order to be effective:

- Must be individualized to the needs of everyone of the trainees,
- Must be focused on very specific themes of the subject and its teaching,
- Must be from the school's program (daily teaching) in order to easily link "theory" and "practice",
- Must be on a large scale,
- Must be incorporated into the daily teaching in order to avoid interferences on the school activities,
- Must be affordable on their requirements on cost, human potential (trainers), operation, development and infrastructure,
- Must meet adequately the lack of experienced teacher trainers,
- Must be based on the assumption that every trainee works on his own, not relying, in general, on peers help (the day to day operations of schools, even in the highly populated urban areas, leave, in general and the S&T teacher especially, to work with his (her) class in isolation from his (her) peers. Assembling teachers together, in order to cope with this problem hinders the individualization of the training, interferes with the school operation, requires training centre facilities, etc.).

These requirements may be solved by the training scheme proposed in the following sections and combining INTERNET with Open and Distance Education techniques. This training scheme is presented in the following sections together with some comments on its feasibility.

AN IN-SCHOOL TRAINING SCHEME FOR THE S&T TEACHER

In Diagram 1 a conceptual model of the basic parts of the training scheme proposed is depicted. The basic functions of the INTERNET server is to provide a reliable communication system to support the

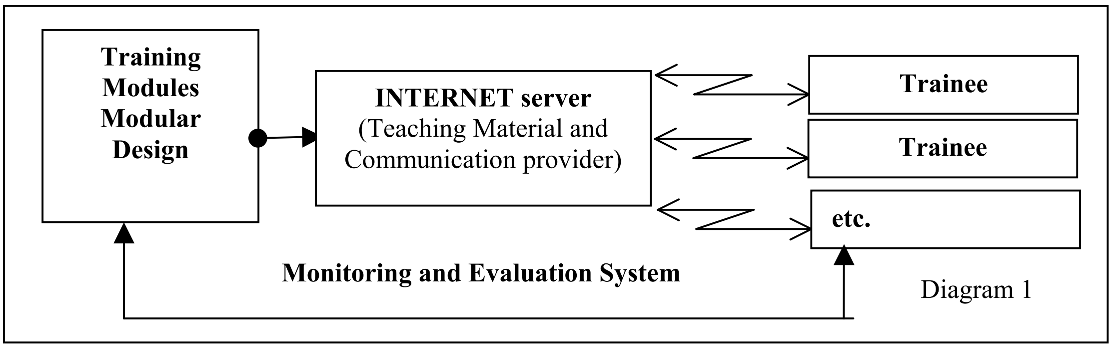

Diagram 1

training with the use of distance education modules. On this server, a database of training themes may also exist to be used either as reference material or as training assignments. The system may be developed in continuous stages as depicted in Diagram 2 with the advantage that every developed module may be used immediately. It may be implemented within a context of in-school training and it uses equipment and facilities already existing in schools.

The monitoring and evaluation system will include also a number of officials ("councillors") who will regularly visit the training centres (i.e. the schools) to provide face to face guidance to the trainees, especially during their first encounter with the system, and to collect information relevant to the operation of the system. They could be the education inspectors or councillors or just experienced fellow trainees.

The main characteristics of this system are:

- It may be evolved gradually and put into operation from its early development stages.
- Every theme may exist in more than one modules addressing different teaching strategies, and (or) teachers' backgrounds.
- Its development may be continuous without interference to its operation.
- It is easily integrated to the daily school operation which may be improved without the interferences due to replacements for the teachers on training.
- It may be operated within the existing infrastructure without the need for special resources in equipment, buildings, etc.
- It requires high managerial skills (see next section).
- It meets adequately the problem of the lack of experienced teacher trainers[18],
- It may be upgraded easily. Every new module may be added to the existing ones so that, gradually a database may built up. Teachers using it may add their experience a very significant characteristic for the adaptation of the training to different school contexts.
- There is no need for the trainees to suspend their work in order to attain training. Consequently the cost of replacement personnel and the interference to school operation due to the personnel mobility are minimised[19].
- The trainees may remain in their work places (in their schools) and, hopefully, will be able to implement directly their training into the teaching of the day.

Diagram 2. Development of the training scheme proposed
1.-Locate training themes,
2.-Development as teaching modules in an Education at a Distance form,
3.-Implementation through the INTERNET,
4.-Monitoring and evaluation,
5.-Enriching – adaptation and addition of more themes.

- The trainees may manage their time more effectively. Also, every trainee may access the training themes database and build his (her) own training program from the existing modules, the links between these themes and the expertise of previous trainees.[20]
- Requirements in buildings, equipment, operation costs[21], etc are minimised because the scheme uses the existing infrastructure of the schools and the training may be incorporated in the daily school operation.
- If universities are involved in this scheme a synergy (and cross-fertilization) process may be an added value[22].
- It treats teachers in isolated areas on a parity basis with the ones near the training centres.
- An added value also may result from the use of the system in order to establish a fast communication system between the teachers in schools so that peer discussions may arise. The same system may also be used as a fast communication between every school and the (central) administration.

Although the characteristics described above are possible, their actual occurrence depends on many factors which may disable the whole operation of the training scheme. The most prominent of these “feasibility factors” are discussed in the next section.

FEASIBILITY FACTORS

Management

The management of the system is crucial. It includes:

- The administration of the INTERNET server as a service available continuously. The experience from other activities (i.e. web site developments, e-commerce, etc) is valuable. On this level a problem may be the hiring of personnel able to develop and maintain the site.
- The coordination of the team developing initially the training themes. The experienced teacher who will supply the fundamentals of the training themes has, in general, to be supported by an expert on distance education and both of them will probably need the services of a computer specialist in order to produce training modules that could be used by the average teacher in the school.
- The set up and operation of a system that will interlink related training themes. In order for such a system to be useful it has to be complete but not complicated. It must also incorporate the trainees experience from the use of the different modules of the system and any necessary adaptations[23].
- The construction of individualized training patterns, the guidance and the monitoring of the progress of every trainee is a requirement of the education authorities who, normally, will finance the whole scheme.

Reliable communications

It is the prerequisite for the whole operation. Communications must be inexpensive, reliable, fast[24], with high availability and easy of use. This type of communications is more or less available to the schools and, in any case, its cost is, in general, significantly lower than the cost of commuting to a training centre. Modern web techniques permit the concurrent transmission of text, sound, images, motion, hyperlinks and other hypertext in real time conditions while the various kinds of applets permit more complicated tasks in an easy way. The problem is to find the correct balance between the flexibility of operation (implying the use of dynamic programming e.g. scripting) and the protection from malicious attempts to the system software (viruses, hacking, etc). Another problem that may arise here is the lack of tradition (“culture”) to consider this operation as a service with reliable and uninterruptible availability, for example, in a way similar to the provisions of electricity[24].

Support centres

The schools themselves may be used as support centres for periodic face to face discussions and monitoring purposes. As local agents school inspectors or councillors may also be used.

Equipment

The necessary “client” equipment is cost affordable and accessible to the trainees on a private (and possibly subsidized) basis. Alternatively the available school equipment may be used. However there is a need for fast, reliable, powerful computer systems to be used as the INTERNET server of the training scheme. The capacity of the system must be high enough to serve trainees request which are expected to show high demand peaks in pace with the school timetable.

Computer literacy skills

They refer to the use of computers from the trainees. It is a temporary problem and may be easily solved e.g. by a small scale practice or resorting to the advice of a colleague. The appropriate user interface may also facilitate the situation.

Self-discipline and concentration
It refers to the trainees and is crucial. Whenever it appears, its solution may be facilitated by the system monitoring the progress of the trainees. The delivery of the training modules in the form of consecutive projects may also be useful and is consistent with the framework of the S&T teaching (see later on).

Possibility of practice
This is inherent in the proposed scheme provided that the trainee possess the skill to adapt his (her) teaching to new challenges[25].

Cost
In comparison with traditional training, the proposed scheme's cost avoids completely the cost: of buildings, of delivering the training modules, of commuting of trainers and trainees, of replacement teachers, of the print (of the training modules). The cost of the (initial) development of the training modules is estimated to be less or comparable to the cost of developing traditional training material, even when taking into account the necessity of cooperation of more than one person (e.g. subject specialist, distance education specialist, computer specialist). The cost for the maintenance and adaptation of the training of materials is significantly smaller. The cost for materials (consumables) and equipment may be kept minimum provided that the training is used to the daily classes of the trainee. A new cost is the cost of INTERNET communication which is estimated to be significantly less than any of the avoided costs. It may be reduced more by special arrangements (large scale activity → scale economies) or by a combination of on-line and off-line communications.

CONTENT OF THE TRAINING MODULES

Apart from the type of its delivery, the effectiveness of any training depends heavily on its content, especially its format and subject matter. It should be:

1. Flexible in order to have the possibility of individualisation to the needs and requirements of every trainee. Consequently, a modular form is necessary. This modular form may be accompanied with examples of training patterns (sequences) to follow.
2. Effective in order to be useful. Effectiveness of science teacher education is indicated when teachers show[26]:
   - Good understanding of the required subject matter, professional knowledge and skills;
   - Proficiency in choosing suitable teaching-learning strategies and available resources;
   - An emphasis on developing students' comprehension and problem-solving skills;
   - Enthusiasm in promoting positive attitudes to science and technology in society

Format of training modules
Project based training is the most appropriate form to develop the skills required from the S&T teacher. It is also compatible with distance education methods and, also, may serve as a real example for the actual teaching of Science and Technology in schools[27]. Project based teaching is also appropriate for the development of problem-solving skills and creative thinking, in general. It seems as the natural choice for the training modules to be developed as it also facilitates the monitoring of the study progress of the trainees. In these modules, the scientific inquiry steps[28] should be incorporated. In order for these modules to be really valuable, they must include experimental activities. Distance education methods are not, in general, appropriate for teaching including experimental activities and, in general, for the development of psycho-motive skills. In this case, however, this is not a real problem because:

- On the issue of equipment and facilities needed, the school equipment and facilities (e.g. laboratories) may be used.
- The issue of the (minimum) psychomotive skills required from the trainee in order to conduct experiments. It may be met by optional general introductory courses with many audio visual explanations, a very inexpensive feature to produce, adapt and maintain with modern web communication techniques. As the trainees are already teachers, their physique should not show relevant defects.
- Issues of safety could possibly be a problem. However, for the elementary Science and Technology, data are mostly collected from observations and, in most of the elementary school

curricula, the necessary (small scale) experimentation do not exhibit problems of safety. The secondary education school teacher is by his (her) education trained to this issue.

Subject matter of training modules
The training modules' subject matter should preferably:
Be chosen from the school curricula in order to become easily incorporated to the daily classes. In this way the benefits of immediate feedback of the training will be enhanced with a minimum to the school activities. From this view point, the use of "Polymorphic Practice" [29] is useful.

Be developed with a focus either on different teaching strategies, on different teaching patterns referring to differences in the organization of the school curriculum or on the subject matter itself. The inclusion of common misconceptions and of methods to spot and cope with them is necessary.
Should use everyday observations[30] and experimentation with simple equipment from the students' environment to the maximum possible extent. This way the relation and consequences of Science and Technology to the everyday life becomes direct. Should include topics on modern (and recent) advances either dispersed into the modules with a related content or as separate modules. Apart from being used as reference sources to the teacher (trainee) they may also be used as an experimentation towards their introduction to the school curriculum.

REFERENCES

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[2] See in University of Cyprus, '1st IOSTE Symposium in Southern Europe – Science and Technology Education: Preparing Future Citizens', Paralimni-Cyprus 29/4-2/5 2001, proceedings Vol. I & Vol. II.

[3] See for example a/UNESCO, The project 2000+ declaration the way forward. UNESCO, France, Paris 1994 (http://www.unesco.org/education/educprog/ste/projects/2000/index_2000.htm), b/Holbrook, J. & Rannikmäe, M. 'Supplementary teaching materials-Promoting scientific and technological literacy. Paris, France: International Council of Associations for Science Education/ UNESCO, c/ICASE. SEAMEO-RECSAM, UNESCO, The. Training of Trainers' Manual for Promoting Scientific and Technological Literacy (STL) for All. Bangkok 2001: International Council of Associations for Science Education, Southeast Asia Ministers of Education Organisation; Regional Centre for Education in Science and Mathematics and UNESCO Principal Regional Office for Asia and the Pacific.

[4] for example a good knowledge of the basic principles and the skill to relate this knowledge to cases from the everyday life, the skill of using experimentation and scientific inquiry towards the development of creative thinking, the skill to contact teaching through the assignment of projects, etc.

[5] Deborah Loewenberg Ball, 'Research on Teaching Mathematics: Making Subject-Matter Knowledge part of the Equation' pg. 3 in 'Advances in Research on Teaching', Vol. 2, 1991 'Teachers' Knowledge of Subject Matter as it relates to their Teaching Practice', Jere Brophy (ed.), JAI Press Inc.

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[7] P. G. Michaelides, "Polymorphic Practice in Science", pp 399-405 of the proceedings of the 1st Pan-Hellenic Conference on the Didactics of Science and the introduction of New Technologies in Education, University of Thessaloniki, Thessaloniki May 29-31, 1998.
[8] see for example a synopsis for the case of England in Susan Barker and Pilar Reyes, 'Why be a Science Teacher?', pp.57-68 of Vol. II of the proceedings of the University of Cyprus, '1st IOSTE

Symposium in Southern Europe – Science and Technology Education: Preparing Future Citizens', Paralimni-Cyprus 29/4-2/5 2001.

[9] See for example: a/for the USA the activities of the 'Institute for Science Education and Science Communication' related to the teaching of Science and Technology to students of a non Science related career, b/for England and Wales, 'Science: The National Curriculum for England', c/for a more general review, Karidas A and Koumaras P. 'Scientific (and Technological) Literacy for All: Presentation of a Research Model and an Attempt to Constructing a Relevant Proposal', pp.89-97 of Vol. I of the proceedings of the University of Cyprus, '1st IOSTE Symposium in Southern Europe – Science and Technology Education: Preparing Future Citizens', Paralimni-Cyprus 29/4-2/5 2001.

[10] Krystallia Halkia, 'Difficulties in Transforming the Knowledge of Science into School Knowledge', pp. 76-82, of Vol. II of the proceedings of the University of Cyprus, '1st IOSTE Symposium in Southern Europe – Science and Technology Education: Preparing Future Citizens', Paralimni-Cyprus 29/4-2/5 2001.

[11] As may be inferred from the fact that, in history, they appear and advance earlier than other sciences.

[12] For example their subjects of study are easily perceptible through the senses, an irrefutable advantage for most of the compulsory education students who, in a Piagetian context, have not as yet reached the formal logic stage.

[13] For the necessity on the modernisation of the Science curriculum see George Kalkanis 'Which (and How) Science and Technology Education for Future Citizens?', pp. 199-214 of Vol. II of the proceedings of the University of Cyprus, '1st IOSTE Symposium in Southern Europe – Science and Technology Education: Preparing Future Citizens', Paralimni-Cyprus 29/4-2/5 2001.

[14] Deborah C. Smith and Daniel C. Neale 'The Construction of subject-Matter Knowledge in Primary Science Teaching', pp.187-243 in 'Advances in Research on Teaching', Vol. 2, 1991 'Teachers´ Knowledge of Subject Matter as it relates to their Teaching Practice', ed. by Jere Brophy, JAI Press Inc.

[15] A. Athanassakis "Environmental education and teachers' tendencies", Department for Primary Teachers' education of The University of Crete, Ph.Ed. dissertation, 1992 (in Greek).

[16] P. G. Michaelides, "Understanding difficulties in Science observations", oral presentation, 2nd Pan-Hellenic Conference on the Didactics of Science and the introduction of New Technologies in Education, University of Cyprus, Nicosia May 3-5, 2000 , book of abstracts page 26 (in Greek).

[17] See for example P. G. Michaelides, "Education of the Informatics Primary School Teacher", proceedings of the 6th Pan-Hellenic Conference on the Didactics of Mathematics and Informatics in Education, University of Thessaloniki, Thessaloniki October 12-14, 2001 (in Greek). For Science see references 1, 6, 7, 16.

[18] The few experienced teachers who are appropriate to be used as in-service trainers ("masters to train their apprentices"), in order to retain their expertise must not be absent from their professions, e.g. being elsewhere in order to train other teachers . With this scheme their expertise may be useful to a wider group without the need to suspend their work for extended periods.

[19] This could be proved an inconspicuous drawback in cases where teachers (and would be trainees) consider their training as part of their duties (consequently it has to be done in replacement of their work) and not as a means towards their personal development or towards improving their job skills. The fact that in-school training is mostly informal (no certification or other formal assessing mechanism is, in general, envisaged) may enhance this drawback.

[20] This could prove an inconspicuous drawback if there is a lack of willingness and self-discipline.

[21] Consumables, equipment etc are the same that are used for the daily school operation. As long as a training theme is developed there is no more any need for a multitude of trainers to deliver it (one or two are still necessary in order to maintain, adapt and enrich it).

[22] Many tertiary education departments (e.g. departments of education) whose a substantial percentage of their graduates may become teachers in schools can incorporate the development and maintenance of training themes into their education and research activities. Apart from the benefits of the immediate links with educators in pre-tertiary education, they would have a supply of data, useful to their work and to their students.

[23] Care must be exercised in order to avoid issues of copyright conflicts.

[24] For techniques to improve communication speed see in P. G. Michaelides, "4th Conference: A Test for Electronic Communication" Opening Speech to The University of Crete, 4th Pan-Hellenic Conference on the Didactics of Mathematics and Informatics in Education, Rethymno, October 1-3, 1999, proceedings pp 14-19.

[25] When used for in-service teacher education, exemplar STL materials can be incorporated into day seminars or short residential courses in the same way as they are used in a full-time teacher education programme. However, time constraints will require that the modules should be used very selectively for this purpose. The advantage of this opportunity, however, is scope for participants to try out and evaluate the materials in their own school, whereas full-time students on teaching practice do not normally have freedom for such initiatives. Distance-learning programmes provide even better opportunities for micro-studies of the use of STL materials. The ideal situation would be to incorporate one selected module into the programme, provide participants with detailed guidance for its evaluation, and ask them to write account of the project in their school (from UNESCO's Project 2000+ at http://www.unesco.org/education/educprog/ste/projects/2000/in_service.htm).

[26] Project 2000+, a partnership between eleven major international agencies and inter-governmental organisations with particular concerns and responsibilities for research and development in the field of science and technology education (http://www.unesco.org/education/educprog/ste/projects/2000).

[27] Project based teaching facilitates the socialisation of students from different social classes, with different skills or abilities or from different cultures (as the cases with schools with immigrants) especially when combined with groupwork. Groupwork is a common aim in many school curricula.

[28] (Planning of observations), data collection, data manipulation in order to locate patterns and relations, hypothesis forming and (experimental) testing, formation of models and induction.

[29] Polymorphic practice (measurements, experiments...) in Science includes a common psychomotive activity (doing measurements, experimentation...), which consequently is morphed into different levels depending on the (previous) cognitive attainment and/or the mentality of the students (see reference 7).

[30] P. G. Michaelides, "Everyday observations in relation to Natural Sciences" στο Learning in Mathematics and Science and Educational Technology, University of Cyprus July 2001, Volume II pp. 281- 300.

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