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Learning and the Impact of Technology

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Abstract

This paper begins by defining educational technology. It continues by considering what is meant by learning, and the factors that promote successful learning. Learning in the information age may differ from that of the industrial age in terms of both methods and intended outcomes. The increasing importance of distance learning and the role of technology to support it are discussed. An attempt is made to identify the characteristics of successful applications of educational technology as well as the major issues of concern within the discipline. In conclusion some avenues for further research are suggested.

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Appendix A. Learning Theories and Styles

1. Introduction

Educational technology may be defined as any application of technology which contributes to the educational process.

Considered against that definition, educational technology is far from new. The first teacher to employ an abacus in his math class was making use of educational technology, as has every educator since who's used overhead projectors, tape recorders, television, movies etc. etc. to help their students better learn the content of their course.

However, the field of educational technology is currently attracting intense interest due, I believe, to two reasons. Firstly, the proliferation of the Internet, which is impacting upon just about every aspect of human life, education included. Secondly, the impact of technology as a whole, which is creating a society of rapid change and exponentially increasing complexity.

Numerous commentators have described the emergence of information and communication technologies (and particularly the growth of the Internet) as bringing about a transition as marked as that of the industrial revolution. We are said to be moving from the industrial age to the information age, in which radically different rules will apply in every aspect of society, education being no exception. (N.B. a Google search on the phrase "information age" retrieved some 725,000 results.)

2. What is Learning?

Learning may be defined as the process of gaining knowledge, skills or experience. To be of benefit the learner should be able to apply his/her newly acquired assets in authentic situations.

Learning is an active process. Learning can not occur without the effort of the learner. The best teachers are those that most successfully create the conditions under which learning may take place.

We all learn throughout our lives as a result of our experiences and our reflections upon them. However, this paper is concerned only with learning as a process that has been consciously chosen by the learner and/or the teacher.

There are a number of (competing) theories of how learning take place. Additionally, a number of different learning styles have been suggested (see Appendix A, Learning Theories and Learning Styles). Whilst psychology has yet to provide a definitive explanation of the learning process, it is clear that different people learn best in different ways. Computer technology has the potential to free the learner from rigidly predefined methodology and instead offer the means of study best suited to the individual.

3. What Makes for Effective Learning?

Learner motivation corresponds directly with the effectiveness of learning. Motivation may be direct, i.e. the learner wishes to grasp that being learnt in order to make use of it, or indirect, e.g. the learner needs to pass a certain exam to fulfil a broader ambition or experiences social pressure to succeed. The former case is more likely to lead to long-term retention and the ability to successfully apply that which has been learnt.

Coorough states "Research has shown that people remember 20 percent of what they see, 30 percent of what they hear and 50 percent of what they see and hear. However they remember 80 percent of what they see, hear and interact with" [Coorough Calleen; Getting Started with Multimedia; The Dryden Press 1998].

Confucius makes the same point even more succinctly: "Tell me and I'll forget. Show me and I'll remember. Involve me and I'll understand"

My own experience as a student of I.T. revealed that I learned least in formal lectures, a little more in organized tutorials, and most of all during the completion of assignments.

4. Childhood v Adult Learning

It is a requirement of most developed societies that children (compulsorily) undergo some degree of education to equip them with the essential skills needed in order that they may function as effective members of society.

Beyond the compulsory education of childhood many adults elect to further their education. This is most often, but not exclusively, in order to enhance their earning potential.

Since children are not born with the desire to pursue formal learning (as opposed to their natural curiosity about the world) it is necessary for the educators of children to persuade their charges of the benefits of learning. Too often this persuasion takes the form of sanctions being applied for failure to pay attention or uncompleted homework. Such an approach most likely has the effect of deterring its subjects from continuing their education voluntarily.

Adults learn for a variety of reasons and with a variety of expectations. Since adults are (usually paying) clients of the learning system it is appropriate that such a system be geared toward satisfying learners expectations as far as possible. However, as we frequently do not (by definition) know what it is we do not know it is also appropriate that the learning system provides some guidance for its learners in order that they make informed choices. In this sense the teacher acts as a guide to a new environment.

5. The Changing Nature of Learning

5.1 Traditional Learning

Traditional learning takes the form of a teacher delivering a predetermined syllabus to a group of learners. The delivery takes the form of:

- lectures - in which the teacher presents knowledge to the students;
- exercises - in which students attempt to use the newly acquired knowledge in some controlled scenario;
- feedback - which informs students how well they have applied their new knowledge and makes them aware of their strengths and weaknesses;
- assessment - an assignment is carried out or an exam sat which is formally compared to some benchmark to determine whether the student has attained some accepted standard of competency in the skills or knowledge under consideration.

5.2 The Advantages of Traditional Learning

A significant aim of the formal education of childhood and adolescence involves the development of the social skills needed for students to operate as members of society.

It seems likely, also for social reasons, that the traditional face-to-face education will continue to play a major role for students in their teens and early twenties. Indeed immersion within an academic environment likely focuses the mind in a way that is conducive to learning.

5.3 The Influence of Technology

The Internet, and particularly the World Wide Web, has, within the last decade, created a world in which a vast amount of knowledge is available, on demand, free of charge, to a vast number of individuals located virtually anywhere. That may initially appear a godsend to those who extol the value of education. But it may also appear a threat to those who make a living from teaching. Why should anyone pay anyone else to teach them what they can already find on the 'net?

The reality is that the 'net offers neither the promise of unlimited knowledge on demand, nor will it make redundant the business of education. Though it will almost certainly act upon it as an irresistible catalyst to change.

Though the web undoubtedly contains a huge amount of information, it also resembles something of an untamed jungle for those seeking knowledge on a particular subject. There is genuinely valuable content, and lots of it, but too often it is obscured by commercial sites and homepages of little interest to anyone beyond their creator. Additionally, since anyone who can access the Web can also contribute to it, the integrity of Web-published content must be treated with a higher degree of scepticism than that applied to printed material.

Search engines exist, and these can be useful, but try searching for just about any sensible topic and you will be overwhelmed with thousands of hits, most of which are of low value. There is little guarantee that the most worthy results will appear close to the top of the list. With search engine placement becoming such big business it is more likely that the top ranked sites will be trying to sell you something rather than increasing your knowledge.

There certainly remains a need for some guidance (i.e. a teacher) to locate that which is valuable for a specific context. However, it is likely the teacher's role will change radically.

Traditionally the teacher's role has been both to generate the learning materials and to support their students in their efforts to master them. The vast amount of ready made learning content in the public domain together with the ease of adding new content means the best teachers will most likely find niches; either as providers of content, or as supporters or guides of the learning process.

It has been suggested that the teacher will move from being the "sage on the stage" to become the "guide on the side" as new technologies serve to place greater power and responsibility in the hands of learners themselves.

As technology is changing the mechanisms of delivering education, so too is it changing the world in which the products of that education are employed.

When my father left school he expected to enter a trade, gain some on the job training, and continue in that same trade until he retired. Alas, those days no longer exist. My father was able to pursue his trade into his fifties, but the collapse of manufacturing in the UK left him to see out his working days pushing a broom. Today's school/college graduate can expect to continue the learning process all the way to the grave. Thus, the growing recognition of the need for the provision of lifelong learning.

For those privileged enough to attend university the idea of spending up to half their lives as students may be appealing. But we also need a continued income in order to provide basic necessities such as food and shelter for ourselves and our families.

The solution to this dilemma comes in the form of distance and open education.

Distance education provides the opportunity for study without the need to attend a specific place at a specific time. It allows ordinary people to study at a time and place that suits them and the demands placed upon them by work and family.

Open education provides flexibility in the way people learn. It enables learners to study what they want, when they want, where they want and how they want and may encompass self-study distance learning, drop-in open learning centres and face-to-face tuition. Or any combination of these study methods.

Distance education, open education and educational technology are not synonymous, but they are closely related. Distance and open education can take place solely from printed study guides, but how much more value can be added to them by the potential of modern information technology?

Full-time, on-campus studies are likely to remain, not necessarily because they are the best way of mastering one's chosen field, but because they provide opportunities to develop essential skills such as socialization, cooperation and mutual understanding which remain more difficult to acquire in a detached context. Educational technology has a role to play here, too. One that has been acknowledged for some time by the provision of computing facilities across faculties rather than just for those studying pure computer science.

A further, in-between, group can also be identified, those who attend campus sometimes but are not full-time on-site students. Such people might include those attending evening classes to enhance their prospects within

existing jobs, and full-time students taking time out on work experience. These "around campus" students can also benefit in specific ways from the appropriate use of technology.

Educational technology is increasingly impacting upon all ages and classes of students. For children undertaking compulsory schooling computers are becoming an increasing feature of classes, not just in computer studies, but also right across the curriculum. Regardless of whether these students enter technical or academic professions computer literacy will be as essential for them as mastery of the telephone or automobile has been for today's working generation.

Post-school students can be categorized as those studying for academic qualifications and those undertaking professional or vocational training. Both groups are likely to have their learning experience enhanced by appropriate applications of technology.

Educational technology is already being deployed to aid all kinds of learner identified above, with varying degrees of effectiveness. But there is always scope to review the application of technology to ensure it is being used to best effect.

5.4 The role of Distance Learning

Distance learning may be defined as any form of learning which takes place without the learner being required to physically attend a place of instruction or being in the physical presence of an instructor. It may range from so-called open learning where the learner has (more-or-less) complete freedom as to what is studied and to when where and how it is studied to a more formal program of study delivered to physically distant students.

The UK Open University began teaching degree-level courses by correspondence in the 1960s through printed texts supported by television and radio broadcasts. In the early 21st century distance learning is expanding rapidly as society becomes increasingly complex and demands lifelong learning from its members. Additionally it continues to exploit the ever-growing potential offered by information technology, namely the Internet and multimedia computing, to deliver its product in an increasing variety of innovative formats.

It seems unlikely that distance learning will replace the formal education of childhood and adolescence since a significant part of this process involves the development of the social skills needed for students to operate as members of society. It seems likely, also for social reasons, that the traditional face-to-face education will continue to play a major role for students in their teens and early twenties. Indeed it could be argued that immersion within an academic environment focuses the mind in such a way that learning is maximized.

5.5 Advantages of Distance Learning

- Learning opportunities are made available to those for whom further study would otherwise be impossible, e.g. those with work, family or other commitments.
- Learning opportunities are made available to those for whom traditional educational methods have been unsuccessful or are unappealing.
- The learner is empowered; e.g. he/she is not restricted to a limited number of course options and may study at whatever pace he/she finds appropriate. He/she is not restricted to academic institutions on the basis of physical proximity. Furthermore he/she may study at any time/place which is convenient to him/her.
- New technology and media allow material to be presented in stimulating and innovative ways.
- New technology and media allow material to be presented in an interactive manner. Presenting material by means of guided discovery and using interactivity to involve the learner in the learning process means retention and deeper understanding is more likely to occur.
- The collaborative capabilities offered by new technology such as the Internet permit synchronous and asynchronous communications between students and their teacher or peers to take place unhindered by spatial (or temporal) distance.

5.6 Potential Disadvantages of Distance Learning

- Distance learning cannot replace the practical hands-on training necessary in fields such as piloting a plane or carrying out surgery, although it can assist in training for these disciplines e.g. by providing simulations.
- There is a risk that distance learning students may experience feelings of isolation and/or become demotivated. The support and communication facilities offered by the effective distance learning

- package are thus vital in maintaining learner connectedness.
- Unlike the traditional classroom setting the teacher cannot directly gauge learner responsiveness to the material being presented. It is thus essential to positively welcome feedback from the learning population.

5.7 Features of Effective Distance Learning Presentation

The following features exploit the potential of modern technology to accentuate the benefits of distance learning whilst seeking to overcome its weaknesses.

- Flexibility. The student has control of what is studied and in what order. Sections may be repeated or skipped as required. The material is fully searchable.
- Simplicity. The material should be presented intuitively (e.g. a clear and consistent navigational structure should support material presented electronically) allowing students to concentrate on learning the material and not on how to use it.
- Stimulation. Full use is made of the available technology's potential to stimulate the learner.
- Interaction. The student actively participates in the learning process.
- Collaboration. Learners are actively encouraged to communicate and collaborate with fellow learners and teachers, e.g. using online discussions and Virtual Learning Environments (see [7.2](#) below).
- Support. Help is available quickly and easily.
- Feedback is given throughout the course so learners are aware of their progress.
- Feedback **from** learners is actively encouraged in order that assistance may be given where needed and future versions of courseware may be improved.
- A portal is provided pointing learners to discussions, further resources and quality-assured external information sources.

6. The Importance of Educational Technology

Society is undergoing rapid change as technological progress is impacting upon every area of our lives. Education can no longer be considered as something that ends when we graduate high school or university. Instead, we shall all be required to undergo a process of lifelong learning in order to adapt to the relentless upheaval around us.

That lifelong learning will need to be delivered to vast numbers in a variety of flexible ways. Technology-mediated open and distance learning will almost certainly provide the dominant means by which 21st education is received.

As the boundaries of technological potential continue to be pushed back, so novel educational applications continue to be developed. But are technology's really being exploited to add the greatest value to the learning process, or are there too many cases of technology being used simply because it's there? What are society's demands from education in the 21st century? And how can technology best be employed to really meet those demands?

I believe there is an urgent need for these questions to be addressed.

Learning objects have been suggested as the next educational revolution. The economic arguments are persuasive - learning materials of the highest quality available to all, teachers being enabled to devote greater time and effort to supporting students rather than redeveloping inferior versions of what already exists.

But what kinds of learning may best be supported by the learning object approach, and what kinds are unsuited to it? How should learning objects be developed to ensure the highest quality learning experience and maximum reusability? What kind of trade off exists between these ideals?

Education in the past, especially distance education, has most often been a passive experience for the learner in which knowledge is presented, hopefully absorbed, and the degree of retention assessed.

However, useful learning is more than mere retention, it requires building skills that can be usefully applied.

Simulations allow the learner to safely apply their knowledge during the learning process.

Given the pressures of time upon life it would be worthwhile to investigate whether active learning of this nature really is more effective learning. If this were found to be so, it would then be valuable investigating which kinds of topic might benefit most from the use of simulation, and which kinds of simulation are most effective at adding value to the learning process.

One of the major difficulties within the field of educational technology is the diversity of the skills of its participants. Subject specialists, educationalists and technologists all have their own specific skills, but generally have limited understanding of each other's assets. An interdisciplinary approach to the discipline might serve to increase mutual understanding between the various roles, as might a formalization of the technology-mediated course development lifecycle.

7. Some Facets of Educational Technology

7.1 Technology-Enhanced Courseware

Desirable features (in no particular order) include:

- Animated explanations of technical concepts, possibly with voice-overs, bringing to life printed explanations and static diagrams.
- Interactive self-assessment activities enabling students to identify their personal strengths and weaknesses. Ideally results should be stored and progress mapped over time.
- Interactive models allowing students to change input parameters and observe results.
- Facility to annotate study materials by means of notes, highlighting, creation of personal bookmarks, creation of personal notebook combining elements of the course with other resources.
- Facility to search course materials in a flexible way - e.g. phrase searching, Boolean conditions, thesaurus matching. It should be possible to select searches from any/all of course materials, personal annotations, the Virtual Learning Environment (VLE - see below), VLE resources and the Web.
- Lengthy blocks of text should be viewable on screen, printable and available in printed form.
- Hyperglossary - i.e. clicking on (highlighted) glossary terms reveals definition. Ideally this should be extensible by the student.
- Consist of Learning Objects (see 7.3 below, e.g. explanations, readings, diagrams, animations) drawn from a database to enable maximum reusability and ease of content management. Learning Objects should be appropriately packaged, customized and added to in terms of overall course objectives, assessments, unifying case studies etc., some of which will become learning objects in their own right.
- Available both online and as a hybrid CD (usable off-line but with links (online) to VLE etc.
- The visual style of the course (e.g. Learning Object package - see below) should be appealing and also carry a sense of identity, both of the institution and of the nature of the course material.

7.2 Virtual Learning Environments (VLEs)

A Virtual Learning Environment (VLE) may be defined as a computer-based (as opposed to physical) environment in which learning is supported, made possible or encouraged.

VLEs might be/provide some/all of:

- Repository of learning materials (i.e. enables efficiency of distribution)
- Portal to additional, quality assured, resources (e.g., links)
- Communication facility - a/synchronous, tutor-student, student-student. Could include inter-institutional seminars & guest lectures.
- Real-time VLE events could be archived for the benefit of those unable to participate at the time.
- Shell for interactive/multimedia course materials.
- Online assessments - both formative and summative.
- Collaborative working environment - e.g. communication facility plus shared document repository

- Links to administration systems; student records, fee payments, grade/progress tracking (in this case the VLE is often referred to as an MLE - Managed Learning Environment)

Distance and on-campus students will have differing requirements and expectations from a VLE. The communicative/collaborative aspects are of less importance to physically present students but fulfil a major need for the distance learners. Technological/bandwidth constraints are also of greater significance for external students and may prevent the full power of the technology (e.g. 3D simulations) from being fully exploited for this audience.

A choice must be made between developing one's own VLE and adopting an existing product. Existing products offer differing features. Before selecting one for a given programme/course consideration should be given to:

- How easy is it to use - for tutors & students?
- Can it be customized / accessed at HTML or server level?
- What content (e.g. publishers' content) is available for it?
- What does it cost?
- Does it conform to accessibility guidelines?
- Does it conform to/support learning technology specifications ?
Can it be used off-line (for distance students with poor connectivity), or is there an alternative such as e-mailed discussions.
- What is the minimum platform/connection required to run it?
- Will it link to the administrative database?
- Does it support single sign-on authentication - i.e. once logged in will students be able to access other resources from the course provider?
- Can closed access discussion areas be created for group work?
- Does it use the pull (e.g. bulletin board), push (e.g. mailing list) model or both for supporting communications? Ideally a combination of the two will be supported with learners receiving regular e-mails informing them of new additions to the VLE; additionally there will be a web-based, searchable archive of messages available.

7.3 Reusable Learning Objects

An in-vogue concept in the field of educational technology is that of reusable learning objects. The concept is a simple one. Learning material is packaged into discrete chunks for the purposes of being used in a variety of contexts.

The rationale for the learning object approach is very similar to that for the use of object oriented programming in computing. Rather than continually develop software to represent common entities such as people, orders, accounts etc., the software industry produces one (or a small number of) very good representation(s) of these entities. When a programmer needs to code people in his software he simply plugs in a pre-written, quality-assured person object, which he may refine as required.

Rather than every mathematics teacher develop their own way of introducing students to differential calculus, they are simply able to call upon one or more very good learning objects which do the job. The mathematics teachers may then devote their efforts to supporting students understanding of those objects.

Definitions of what constitutes a learning object vary.

The IEEE Learning Technology Standards Committee defines a learning object as " any entity, digital or non-digital, which can be used, reused or referenced during technology supported learning." [IEEE Learning Technology Standards Committee; http://ltsc.ieee.org/wg12/s_p.html] This is not very useful since absolutely everything can be referenced during technology supported learning.

Other, more precise definitions exist, e.g. Learning content management system vendor Knowledge Planet states "A learning object has four components: an objective, content, a means of assessment, and metadata." [Knowledge Planet product literature; http://www.knowledgeplanet.com/newsletter/kp_content%207-17-01.pdf]

Reusable learning objects are not new and have not, until recently, been seen as controversial. A textbook is a reusable learning object. A textbook on basic calculus might be used in courses on mathematics, physics, engineering etc. with different groups of students in numerous schools and colleges throughout the world. It may

be translated into different languages to further extend its reusability.

The IEEE's learning object metadata standard [IEEE 1484.12.1-2002 Draft Standard for Learning Object Metadata, 15 July 2002; http://ltsc.ieee.org/doc/wg12/LOM_1484_12_1_v1_Final_Draft.pdf] implies a hierarchy of levels at which learning objects may exist. These range from a set of courses leading to a qualification, down to raw media elements such as an image.

Stephen Downes makes a compelling case for the benefits of this approach in his essay "Learning Objects" [Downes, Stephen; Learning Objects; http://www.atl.ualberta.ca/downes/naweb/Learning_Objects.doc].

One criticism of this approach is the recognition that knowledge is inextricably related to other knowledge and cannot be completely isolated or compartmentalized. A further criticism is to question the degree to which an object that is designed to be reused in a variety of contexts compromises the quality of material designed for a specific purpose.

The representation of learning objects should separate content from presentation. When presented to students learning objects should conform to a consistent style.

The arguments in favour of learning objects are compelling, namely sharability and reusability. Numerous professors around the globe invest considerable time and effort in developing ways of presenting the same concepts to very similar groups of students. If there were to be a global repository of the very best of those presentations covering a multitude of disciplines, how much time could be made available for more fruitful pursuits? Indeed, how many professors already employ textbooks as an integral part of their teaching? Market forces will ensure the highest quality content will prevail.

The inevitable wider deployment of learning objects will see a separation between the two traditionally interlinked areas of learning content preparation and learner support. Those creating the content in future are unlikely to be the same people as those helping students get to grips with it.

A potential disadvantage of learning objects is that real knowledge is interrelated and does not split neatly into small packages. In a learning experience based upon a number of learning objects there is likely to be a need to assess retention and understanding across the collection of objects as well the desirability of illustrating the application of the content of several objects e.g. through case studies.

It seems likely that learning objects can and will play a major role in the delivery of learning in the 21st century and beyond, but it is a mistake to believe these may simply be plugged and played to provide a satisfactory learning experience. There will always be the need for adaptation of individual objects as well as the need to provide purpose, context and additional content to the package containing them.

The most successful learning providers of the 21st century will be those that can best adapt to the information age; that can find a niche in content creation or learner support; that can best adapt and contextualize the best of existing material; and/or that can develop process models for creating content for multipurpose, multi-modal delivery.

7.4 Interoperability and Specifications

The increased use of learning technology is likely to result in the development of a learning resource economy in which providers which excel at content production will be able to offer their products to course providers who will assemble and support learning components into courses made available to students.

Past experience with computer based learning led to much material being produced in software such as Toolbook which became obsolete.

In order to promote the creation of sharable, reusable learning materials a number of specifications are under development. Materials produced in accordance with these should be usable by a wide range of content providers, and should remain usable into the future. Similarly course providers which base delivery platforms on learning material specifications will have access to a wide range of content and the freedom to switch from one compliant platform to another.

7.5 Accessibility

Distance education and learning technology together have the potential to make the opportunity of learning available to a larger and more diverse audience than ever before and as such have the power to promote a fairer and more equal society. The issue of accessibility is concerned with ensuring that the opportunities offered by the technology truly are available to as large and diverse a group as possible.

However, accessibility concerns are not solely altruistic. The number of people worldwide with some form of disability represents a massive potential audience that few educational providers (or indeed commercial operations) can afford to exclude. Additionally much educational provision is, or will soon, be subject to accessibility legislation.

In the USA Section 508 of the 1998 Rehabilitation Act requires that Federal agencies' electronic and information technology (including Web) content is accessible to people with disabilities.

In the UK the Special Educational Needs and Disability Act will make it illegal to discriminate against disabled students by treating them less favourably than others. Institutions must make reasonable adjustments to provision where students with disabilities would otherwise be at a substantial disadvantage. The Act came into effect on 1 September 2002.

8. The Understanding Mismatch Problem

One of the major problems with the current state of educational technology is the sheer diversity of skills required throughout the lifecycle of any particular implementation project. These skills include:

- a) Expertise in the subject that is to be explained.
- b) Pedagogical expertise, i.e. an understanding of how to package and deliver the subject knowledge in such a way that maximum retention and ability to apply what has been learned will occur.
- c) Technological expertise, i.e. knowledge of how to give form to the pedagogical requirements.

Too often there is insufficient understanding between these three distinct skill-holders, resulting in the development of unsatisfactory products.

Recent years have seen the emergence of two new roles upon the educational technology stage, those of *instructional designer* and *learning/educational technologist*. Both roles may be seen as forming a bridge between subject expert and technology expert.

The instructional designer has an appreciation of pedagogy, the art and science of teaching. Most likely he will have taught for a living, and will have a critical awareness of what makes for a successful learning experience. He will have a good understanding of the potentials of new technologies, but will not necessarily be proficient in developing software applications himself. He does not necessarily require knowledge of the subject he is designing materials for, as this will come from subject specialist(s).

The learning technologist is someone with a broad knowledge of current technologies combined with a knowledge of, or interest in, education. He will not be an expert in every available technology, but will carry an awareness of the strengths or weaknesses of the major options. The learning technologist should be able to suggest the most appropriate technology(ies) for implementing a particular ideal, and advise whether such an ideal is realizable within a given budget. The learning technologist will be able to liaise with instructional designers, content developers and systems administrators.

9. Some Avenues for Further Research

Some of the many areas within this field which cry out for further investigation are:

9.1 Reusable Learning Objects

Instinctively I feel learning objects do have the potential both to improve the learning experience offered to

students and to make that experience available to a larger and more diverse audience. However, they do not represent an educational panacea.

There is a need to investigate to what extent learning materials may be developed as reusable learning objects and delivered in different contexts and across different media without compromising the quality found in materials developed for specific purposes. For example, one question which should be addressed is whether there are differences in the applicability of the learning object approach between arts and science subjects, introductory and advanced topics, or academic and vocational contexts.

Exploration should be made of different models for the creation, representation, storage, delivery and evaluation of learning objects. Such models would need to maximize the potential for reuse and multi-purposing of learning objects, not only within a given faculty or institution, but globally. This model would need to adhere to (or define) interoperability standards.

9.2 Use of Simulations in Educational Technology Applications

Simulation has the potential to provide a far more active learning experience which is likely to lead to greater knowledge retention and increased confidence in applying new skills than would result from expository learning materials.

Simulations range from the simple ability to change the parameters in a model and observing the results, through collaborative role-play activities to fully-immersive virtual reality experiences.

This would appear to be a currently undervalued area of educational technology. Riley [Riley, David; Simulation Modelling: educational development roles for learning technologists; Association for Learning Technology Journal Volume 10 Number 3 (2002)] describes how "Educational games, simulations, microworlds and modelling programs were in the mainstream of 1980's computer assisted learning", but "Since then, the technologies have improved by leaps and bounds whilst the adaptive and productive media seemingly have drifted into an educational backwater".

My own experience of educational technology applications supports this view. There is an abundance of expository products which leave the learner as a passive observer, but considerable scope for the development of learning experiences which engage the learner by giving them the chance to participate in the process.

As computer technology continues to improve in power and decrease in price so the potential of sophisticated simulations being made available to every learner is rapidly becoming reality. I should like to explore the various means by which this may be achieved.

9.3 Technology as Facilitator for Increased Learner Empowerment

The traditional model of learning requires learners to attend a particular place, at a particular time and to learn from a predefined syllabus, delivered in a predefined manner.

Distance Learning has long provided the means for learners to study part-time in the time and place most suited to their particular circumstances. However, a major disadvantage of distance learning is the sense of isolation experienced by learners. The support mechanisms available are somewhat limited compared to traditional modes of study. And distance learning materials also tend to follow predefined syllabus.

Technology used appropriately has the power to increase distance learner empowerment by offering both greater learner autonomy and increased options for support. Advantages offered by technology may range from simple e-mail lists, through multifunctional VLEs to fully adaptive learning environments enabling individual courses to be constructed from libraries of learning objects and adapted and delivered on demand according to learner preference and performance.

The aim here should be to research which technological possibilities really add most value to the learning experience and in the light of this knowledge to attempt to construct novel solutions best suited to meet the educational demands of the information age.

The preceding aim begs the question of whether there really is a difference in the requirements of education today compared with thirty years ago, an issue that should also be addressed.

9.4 Using Educational Technology to Deliver/Support Language Learning

This may be seen as a specialization of 9.3 (above).

With the increasing trend towards globalization there is likely to be an increasing need for a common language, i.e. the de facto international language of English. Given the likelihood of large numbers of new learners coupled with the need for such learners to study at the time and place of their choice, often with minimal or no contact with native speakers, technology can provide the means through which their learning occurs.

Within this context there is a need to identify the features of technology that really add value to the learning process, e.g. simply transferring the content of the printed page to a computer screen does not add value, but features like streaming media, audio/video-conferencing interactive simulations and tailored delivery on demand may.

There is a need to investigate how human-computer interaction considerations impact upon the effectiveness of the learning experience and the satisfaction derived from it.

This study should encompass areas ranging from the psychology of learning and the identification of different learning styles through to evaluating available technologies for their ability to implement and support educational products with regard to pedagogy, accessibility, interoperability etc.

Appendix A.

Learning Theories and Learning Styles

Learning Theories

A number of (often competing) theories of learning have been proposed.

Andragogy

Knowles (1913-97) differentiates the needs of adult learners from those of juveniles and uses the term andragogy to describe the specific methods which should be employed in the education of adults. Smith [1] summarizes Knowles' andragogy thus:

- The adult learner moves towards independence and is self-directing. The teacher encourages and nurtures this movement.
- The learner's experience is a rich resource for learning. Hence teaching methods include discussion, problem-solving etc.
- People learn what they need to know, so that learning programmes are organized around life application.
- Learning experiences should be based around experiences, since people are performance centred in their learning.

Andragogy requires that adult learners be involved in the identification of their learning needs and the planning of how those needs are satisfied. Learning should be an active rather than a passive process. Adult learning is most effective when concerned with solving problems that have relevance to the learner's everyday experience.

Behaviorism

Skinner (1904-1990) is associated with the approach to learning known as behaviorism. Skinner conducted experiments in which pigeons and rats were taught to obtain food pellets by performing certain actions, e.g. pecking a lever a certain number of times. Skinner asserted learning occurs through operant conditioning. This is based upon the idea that organisms operate on their environment. If an action has positive consequences for the organism it is more likely to repeat that action, if the consequences are undesirable then the action is less likely to be repeated [2].

Skinner's approach has been used "to teach mentally retarded and autistic children, ... in industry to reduce job accidents, and ... in numerous applications in health-related fields." [2]. However some kinds of learning are not easily explained by conditioning, e.g. "those cases where skills are used in a highly flexible way, as in the use of language; ... where people do things that lead only to intangible rewards; ... where people appear to learn passively by observing others' actions" [3].

Skinner's 1971 work "Beyond Freedom and Dignity" drew criticism because it appeared to deny the essential human attributes of free will and dignity and declared "man's actions were nothing more than a set of behaviours that were shaped by his environment, over which he had no control." [2].

According to Tennant [3] the influence of behaviorism on adult education is "most apparent in the literature on behavioural objectives". Behavioural objectives are formulated using language that refers to observable behaviour only, e.g. describes, identifies, explains, predicts... Criticisms of such predefined objectives include:

- they are inappropriate for certain types of learning, e.g. music, drama etc.;
- they fragment learning into many narrow categories and in so doing fail to address the whole;
- they are concerned only with the outcomes and not the process of learning;
- they cannot describe the acquisition of general ideas which are applicable in a variety of contexts;
- they cannot account for subjective outcomes, e.g. the development of self-concept;
- they ignore peripheral learning, i.e. that which lies beyond the formal syllabus but frequently occurs in any course of study;
- they do not account for changing learner needs as learning takes place.

Chomsky and Language Acquisition

A particular challenge to behaviorism comes from Chomsky's theory of language acquisition. Chomsky argues that human beings are endowed with an internal understanding of the fundamental rules of language that allow us to develop language skills far in excess of those which would result purely from environmental conditioning. Gross and McIlveen [7] give the following evidence supporting Chomsky's view:

- language acquisition appears to occur in a culturally universal and invariant sequence of stages;
- native speakers use language creatively, i.e. they are able to produce sentences of a form they have not previously encountered;
- children spontaneously use grammar rules they have never heard or been taught;
- the meaning of a sentence is more than the meaning of its individual words and varies according to context;
- babies as young as two days have been shown (by Eimas) to be able to discriminate between 'ba' and 'pa' sounds;
- studies of twins (by Malmstrom and Silva) have shown the existence of private languages intelligible only to the twins, such languages share certain features with ordinary languages.

Constructivism

Constructivism asserts that people construct their own individual mental models of the world in order to make sense of their experiences. Learning is the process of adding to or refining this mental model.

On Purpose Associates [4] describe how constructivism impacts on learning:

- There is no standardized curriculum. Curricula are customized to the students' prior knowledge, and hands-on problem solving is emphasized.
- Educators focus on making connections between facts and fostering new understanding in students. Instructors tailor their teaching strategies to student responses and encourage students to analyse, interpret, and predict information. Teachers also rely heavily on open-ended questions and promote extensive dialogue among students.
- Assessment is part of the learning process and students play a larger role in judging their own progress. There are no grades or standardized testing.

Learning Styles

Just as individuals exhibit different personalities it has been suggested that people learn (most effectively) in different ways. A number of different learning styles have been identified.

Field Dependence/Independence

Tennant [3] describes Witkin's work on field dependence/independence. Essentially field dependent people are significantly influenced by context in making judgment whilst field independents pay little or no attention to context (i.e. are able to isolate their point of interest). Witkin suggests that field dependence/independence forms a continuous distribution, and that an individual's field dependence/independence changes with the context in which they find themselves.

Field dependents tend to learn better in a social setting, e.g. class discussion, group work etc., and where direction and structured material are provided for them. They tend to specialize in work and study requiring interaction with people. Field independents tend to be more self-directed and better able to make sense of unstructured material. They are more likely to favour impersonal disciplines such as science and mathematics. Studies have shown that learners can modify their style of learning with appropriate guidance.

The field dependence/independence of the teacher will tend to influence their teaching style, e.g. field dependent teachers favour class discussions and field dependents favour more impersonal lectures. It is suggested that more effective learning takes place when the styles of the teacher and students match, however other commentators state that the conflict arising from mixing teacher and learner styles creates a challenge that ultimately enhances the learner's experience.

Whilst it is impractical to create classes according to learning style, and in any case this would present the learners with a very artificial environment, it is beneficial for the teacher to be aware of the different styles and to teach in a manner that is accessible to the majority of students.

Neuro-Linguistic Programming

Neuro-Linguistic Programming (NLP) is "a set of models of how communication impacts and is impacted by subjective experience" [5]. It was first developed in the 1970s by John Grinder and Richard Bandler. The models used by NLP have arisen because they have been observed to work rather than being based on any deep underlying theory.

One NLP technique identifies a set of learning styles based upon an individual's dominant sense.

- Visual learners learn best from what they see.
- Auditory learners learn best from what they hear.

- Kinaesthetic learners learn best from physical manipulation.

Since any group of learners is likely to consist of members with different styles the most effective lessons will include elements suited to each.

Multiple Intelligence Theory

Gardner's multiple intelligence theory suggests that human beings perceive and understand the world in a number of ways. Gardner proposes a not necessarily exhaustive list of seven such intelligences:

- Verbal-Linguistic - the ability to use words and language.
- Logical-Mathematical -The capacity for inductive and deductive thinking and reasoning, as well as the use of numbers and the recognition of abstract patterns.
- Visual-Spatial -The ability to visualize objects and spatial dimensions, and create internal images and pictures.
- Body-Kinesthetic -The wisdom of the body and the ability to control physical motion.
- Musical-Rhythmic -The ability to recognize tonal patterns and sounds, as well as a sensitivity to rhythms and beats.
- Interpersonal -The capacity for person-to-person communications and relationships.
- Intrapersonal -The spiritual, inner states of being, self-reflection, and awareness.

Source [6].

Experiential Learning Model

Kolb and Fry (referred to in [3]) identify a four-stage learning cycle (experiential learning model) comprising concrete experience, reflection and observation on that experience, the formation of a theory and the testing of that theory under new conditions. From this learning cycle Kolb and Fry propose two dimensions, one ranging from concrete experience to abstract conceptualisation (theory formation) the other from reflective observation to active experimentation. They further state that individuals will tend to favour one of the two extremes in each dimension and will in fact fall somewhere on the continuum between the two.

From the combination of an individual's preference on the two dimensions Kolb and Fry identify four learning styles, namely converger, diverger, assimilator and accommodator. Kolb and Fry consider each style to be equally valid and assert that the most effective learners are those who learn to apply each of the styles to their learning experiences.

References for Appendix A

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