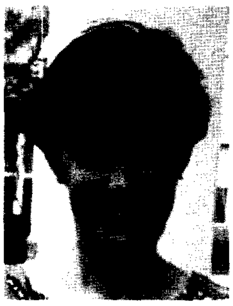
Learning theories and their influence on the development and use of education...
Anne Semple
Australian Science Teachers Journal; Sep 2000; 46, 3; Education Module
pg. 21



Learning theories and their influence on the development and use of educational technologies.

Anne Semple BSc, Dip Ed, FSTAV, FACE

Anne has had extensive cross-sectorial experience as a teacher of science in the UK, NSW and Victoria. She was Head of Science in the Independent system for many years and specialised in teaching biology. She has presented at many conferences in her subject field, assessment and other aspects of professional growth. She has developed and written curriculum materials for both general science and biology; is a contributing author to award winning junior science texts and to years 11 and 12 Biology texts; she has developed online advice to teachers. Anne is currently at the Board of Studies where she has written for the science CSF II and is developing materials for teachers of science to support the implementation of the CSF II.

Anne has held office in the Science Teachers' Association of Victoria, is a past president of the Australian Science Teachers Association and is currently an elected member of the National Council of the Australian College of Education. She was a member of the ASTA National Standards Committee responsible for drafting the National Professional Standards for Teachers of Science.

Abstract

Computer technologies have made an impact on every aspect of society and culture. Though children are used to controlling and manipulating such a technological and interactive environment, educational systems and teaching have been left relatively unchanged. Though lack of overall policy directions, resourcing and educational assessment requirements have contributed to this situation it is argued that the way we think about learning and instruction influences the way educational technologies are designed and used. This article traces the development of theories of learning and their impact on educational technologies. It argues that the constructivist approach to learning provides the opportunity for authentic, computer-based learning environments to be established. However, change will not be effected if the significance of teacher professional development and support for effective use of educational technologies to improve student learning is overlooked.

For several decades electronic technology has made an impact on every aspect of society and culture. Computers make it possible to access huge amounts of information and to process it almost immediately. Communication over great distances can occur almost immediately. Interactive technology is now found in shopping malls, libraries, arcades, museums and living rooms. Children are used to controlling and manipulating such an environment. Strommen (1992) argues that the technological changes that have affected society have left educational systems largely unaltered and the process of teaching relatively unchanged. Though there has been progress since Strommen's time of writing, there is still cause for concern about the extent to which educational technologies are used in classrooms and how they are used.

Though lack of policy directions and limited resourcing have indeed contributed to this situation, simply thinking up clever ways to use computers in traditional courses is not the answer. Technological advances offer new learning opportunities. Interactive multimedia in particular provides a powerful tool for both teachers and learners in the design of environments which enable student learning. This article argues that what is needed is a fundamental change in educational theory to guide reform, a view in agreement with that of Wild and Quinn (1995) and Boyle (1997). For effective use of these technologies, practitioners must be given training, professional development and continuing support (Blease 1988, Maor 1999).

Literature review

There is a plethora of literature on psychological theories of learning, educational instructional design, and software selection (generally described as evaluation) that purportedly enhances learning. Less is available, seemingly, which integrates the three dimensions mentioned and includes reference to implications for training and professional development for teacher educators and teachers. The Internet is a rich resource for information, though some papers have not been able to be attributed fully.

The rapid rate of development of technologies has made some of the earlier writings (particularly research findings), if not irrelevant then outdated in terms of the current situation. However, they are important in reflecting the thinking of the time and support the argument that underlying educational theories affect the way in which computer technologies are used in an educational setting.

Definition of terms

Though the term educational technologies encompasses a wide range of computer tools and media types, for the purpose of this article, educational technologies will largely refer to computer software - computer applications that may incorporate the use of multimedia in an educational setting. This article adopts Dyrli and Kinnaman's (1995) definition of multimedia that it is the 'seamless *digital* integration of text, graphics, animation, audio, still images, and motion video in a way that provides individual users with high levels of control and interaction'. It is worth noting that not all computer software necessarily integrates all of these assets. Mention of particular kinds of technologies will be made in relation to their use in science education.

Much of the literature uses the term 'instruction' in relation to programs, such as computer-assisted instruction (CAI), instructional design (ID) and instructional programs. 'Instruction' tends to convey a very directed and controlled approach to teaching and learning which was certainly characteristic of earlier pedagogical practice and use of computer technologies (Boyle 1997). Traditional ID provided a systematic and formal set of guidelines for the designer to produce computer-assisted programs. Wager and Gagne (1988) describe instruction as the 'arranged external events that *will* make learning readily occur'. That it should be so easy! In recent years, terms relating to instruction have been increasingly replaced by 'computer-assisted or computer-based learning' (CAL, CBL) indicating a change in emphasis from instruction to 'teaching' and 'learning' with a correspondingly more flexible approach to using computers, software and other facilities in creating student-centred learning environments.

Theories of learning and implications for computer-based instructional design

The way we tend to think about instruction says a lot about our underlying beliefs (Wilson, 1995) and that the educational philosophy of the time is reflected in the way in which educational technologies are designed and used.

Behaviourist theories of learning

Educational computing followed the introduction of 'programmed learning' by machines in the 1950s and 1960s. These were based on the psychological theory of behaviourism whose major proponent was B.F. Skinner. This theory viewed learning (and therefore education) as changing the behaviours of individuals in a process involving some exploration and trial and error until a positive event occurred. The positive event was rewarded whereas an error was not rewarded. Skinner's ideas were generated from his experiments with animals and he referred to it as 'operant conditioning' (Skinner, 1938, cited Squires and McDougall, 1994).
Learning was considered to have taken place if there were observable changes in behaviour. Behaviourists are not concerned about what is happening inside the learner, as this is not available for direct observation. Participation by the learner is largely a passive, stimulus-response process and knowledge is seen as objective, given and absolute.

Skinner listed four important things about learning. Firstly, each step in the learning process should be short and should arise from previously learned behaviour. Secondly, learning should be rewarded and reinforced regularly, at least in the early stages, as behaviour is shaped by the pattern of reinforcements in the environment. Thirdly, feedback should be as immediate as possible and fourthly, the learner should be given 'stimulus discriminations' (Child, 1981, cited Blease, 1986) for the most likely path to success.

These principles are evidenced in the formal design of the more traditional computer-based teaching systems. In keeping with behaviourist principles, appropriately designed drill and practice and tutorial programs give packets of information, carefully sequenced, and provide regular and positive feedback to the user. Simpler tasks are practised and mastered before more complex ones in a precise procedural model (Boyle, 1997) of linear or branching programs, the latter providing opportunities to follow different routes and allowing for remedial loops. The program may give the appearance of being interactive rather than reactive but if the user follows the same path again, the same responses occur (ref *Barbie the detective*). The locus of control actually lies with the designer and the computer program rather than with the user.

Well designed programs of this type avoid the pitfall of trying to supply negative feedback that may prove more entertaining or interesting than the positive, encouraging inappropriate reinforcement. Both drill and practise and tutorial programs could have the facility for keeping a record of the user's progress for diagnostic or motivational purposes (Blease, 1986).

Justification for the use of drill and practise and tutorial programs lies in their ability to teach new skills, employ rote learning, strengthen already learned associations and reinforce knowledge or skill acquisition (Wagner and Gagne, 1988, Squires and McDougall, 1994). By incorporating several levels of difficulty and a great number of examples able to be randomly generated, the program's use is increased.

Cognitivist theories of learning

Behaviourist theories tried to explain learning in terms of observable behaviour without taking into account mental processes. Many felt that the strict focus on observable behaviour was too limiting and that 'thinking' should be the object of study. According to Cognitivist theories, learning is viewed as making symbolic, mental constructions involving active mental processing on the part of the learner. The development of computers and software with a strict input-processing-output architecture reflects these ideas.

Gagne (1984, 1985, cited Wager and Gagne, 1988), identified five kinds of learning capabilities or outcomes expected of instruction: intellectual skills, verbal information, cognitive strategies, motor skills and attitudes. This learning theory and the research arising from it formed the basis for proposing nine internal processes of learning and the nine types of external events that may support it (Price, 1991 cited Wager and Gagne, 1988, Boyle, 1997). The nine events represented the sequence of steps that should be incorporated in instructional design, including the use of educational technologies, that normally should be followed through. However, Price urged common sense in terms of developing prototypes and using feedback for modification before releasing the final product.

According to cognitive theories of learning, computer technologies are cognitive learning or mind tools amplifying human abilities such as memory and processing, rather than instructional media (Ontario Institute for Studies in Education, 1995 cited Greening, 1998). The computer performs 'inauthentic' labour enabling the learner to concentrate on essential concepts referred to as 'authentic' labour (Taylor, 1980, cited Squires and McDougall, 1994). Jonassen (1994) argues that children cannot use them without thinking deeply about the content that they are learning; the cognitive tools activate thinking and learning takes place through the process of using the tool.

Computer-based tools, for example *Inspiration*, a graphic organiser, may support the more sophisticated use of techniques such as linear chains, flow charts and hierarchy maps (Boyle 1997) even though basic ones can be drawn on paper. Databases can hold vast amounts of information that can be interrogated in a variety of ways by the user; word processors can manipulate text and graphics to suit the individual and datalogging software collects and records repetitive experimental data over extended periods of time.

Instead of designing instruction in the form of predetermined instructional goals as in tutorial software, each matched with an 'event', the learners themselves are able to express their thinking and organise their personal knowledge through using these tools (Jonassen, 1994). Children construct their knowledge individually and design and express their representations or models of understanding by manipulating conceptual models on the computer (Wild and Quinn, 1998, Jonassen 1994). The locus of control is less with the designers and more with the user - a perceived advance on the behaviourist model of computer instructional design.

Constructivist theories

Piaget's theories of cognitive development propose that concept formation follows an unvarying pattern. A series of clearly definable stages must be experienced and passed through by the child in a set sequence. Through assimilation and accommodation, concrete experiences become organised into patterns of behaviour which eventually are internalised to become 'abstract models' or 'schemata'. Piaget's ideas have been criticised but his work had, and still has, an enormous influence on educational thinking and on the development and selection of educational software.

Papert and his book *Mindstorms* (Papert, 1980, cited Blease, 1988) are associated with applying Piaget's theories to educational computing. Papert criticised much of what was done with computers in schools, believing the computers programmed the children rather than vice versa. Papert devised the programming language LOGO, designed specifically for children to develop the thinking processes as described by Piaget. It is not appropriate here to describe the program in detail but enough to state that the child gives a set of instructions to a turtle robot, for example, to do something such as drawing particular shapes. In a subsequent program, procedures may be combined to draw more complex shapes building on concepts previously mastered. In developing her/his powers of thinking, the child builds up new insights. Any mistakes are treated as opportunities to learn rather than as errors -an important feature of constructive learning (Boyle 1997).

One of the distinguishing features of the constructivist theory of learning is that children construct their own knowledge. Piaget and Papert argued that children construct their own knowledge through defined experiences in accordance with their cognitive development. To some extent this approach assumes that development is a biological process much the same for all individuals regardless of gender, class, race or social or cultural context in which learning takes place (Vadeboncoeur, 1997, cited Wilson, 1998). The teacher organises and supports appropriate learning environments according to the child's cognitive state, from concrete activities to the more abstract. This particular view has been described as psychological constructivism as it focuses on personal exploration and expression with internal development (Squires and McDougall, 1994).

A major criticism of Piaget's theory is that he did not take into account the effect of social interaction and the influence of cultural transmission. Social or Vygotskian constructivism (Vygotsky, 1962, cited Boyle, 1994) situates the child within a sociocultural context, a process described as 'situated learning'. Individuals construct knowledge in transaction with the environment and in the process both are changed. Vygotsky proposed that the functions which first appear as social phenomena later become internalised as psychological phenomena (Boyle, 1997). The two theories, psychological and social constructivist theories, can be regarded as complementary rather than conflicting as they both emphasise the role of interaction and constructive development processes in learning though the nature of the interaction is different in each. Learning is considered to be an active process rather than the passive process proposed by the behaviourists and the power of the technologies is invested more in the user or learner (Jonassen, 1994) than in the designer.

It is evident that there are variations within constructivist philosophy and psychology (Phillips, 1995, cited Greening, 1998) though certain principles or features can be derived from the theoretical framework which have significance for learning and teaching. This is despite the statement of Wilson et al (1995) that the shortage of constructivist contributions **to** design models represents a 'cop out'. They contend that as constructivism is so context-dependent and shies away from formalised plans for practice, it is a way of thinking **about** design. However, constructivist principles about learning do emerge and have a bearing on practice (Greening, 1998). These principles are summarised below:

- knowledge is constructed from the experience of the learner
- knowledge resides in the mind rather than externally
- learning is a personal interpretation of the world in that learner's beliefs and values are used in interpreting objects and events
- learning is an active process of making meaning from experience
- learning takes place in contexts relevant to the learner
- reflection is an essential part of learning
- learning is a collaborative process in which multiple perspectives are considered

The learning theory underpinning software determines, to a considerable degree, the extent to which the designer has delegated control to the learner. It is also evidenced by the complexity of the material to be considered, the range of processes to be exercised and the intrinsic rewards gained on successful completion of the task (Squires 1994). The computer 'microworlds' of Papert (1980), usually graphically orientated, are developed to simulate how specific aspects of the world work (Nickerson 1995) in a way not otherwise accessible to students, for example in exploring gravity on extraterrestrial planets or manipulating genes. A microworld can be useful in helping students to operate within particular principles and concepts and to learn to negotiate these concepts for themselves (Department of Education, Victoria, 1999). Interactive simulations and systems modelling allow students to examine the effects of changing the parameters of representations or to develop and manipulate their own systems.

Many of the examples given above tend to be for the individual learner, though creative teachers can modify them for group work, particularly if off-computer activities are designed. Collaboration is a key feature in applying constructivist principles to learning. Collaboration can be between the teacher and the student in a 'cognitive apprenticeship' relationship (Berryman, 1994) whereby the teacher provides the scaffolding or supportive framework for the student to acquire the appropriate target or skill or to access appropriate resources. The teacher gradually removes this support in a process of 'fading', encouraging the learner to become increasingly independent in problem solving (Collins et al,1989). Software programs for science and engineering, designed using these techniques, are cited by Boyle (1997, p96).

Collaboration can also occur between the students themselves in a 'community of peers' who may be physically present or who may be 'electronic' collaborators. Children come to view peers not as competitors but as resources (Strommen, 1992). Learning is enhanced by communication, resulting in new knowledge, re-organised knowledge or additional understanding, with groups of students learning how to use the tools of their culture in a collaborative learning environment. If the technologies are used merely to present, electronically, the same information that they would present in a traditional, non-electronic format, there has been no fundamental change in the philosophy driving learning.

Constructivism recognises that not only the knowledge and understanding children bring to learning but the characteristics of the learners themselves influence learning. The special features of students include their cultural and socio-economic background, their values and beliefs and their motivation and expectations in the learning environment (Chen, 1995). Students bring different skills, including computer-based skills, and learning styles to the learning process. Gardner (1983) has categorised learning styles in terms of seven multiple intelligences, extended to eight in 1995 by including naturalist intelligence: kinaesthetic or bodily, spatial or visual, musical or rhythmic, verbal or linguistic and intrapersonal and interpersonal. People have preferred ways of learning and the way students learn and understand doesn't always fit the dominant intelligence implicit in most teaching practices, which tend to be verbal or linguistic or logical and mathematical. Multimedia has the ability to cater for individual preferences and support what can be described as constructivist pedagogy in a number of ways.

The use of multimedia authoring tools is entirely compatible with the open-ended, non-linear, constructivist model of learning. The technologies allow teachers and students to create interactive lessons, presentations and projects through the integration of images, graphics, text, animation, audio and motion video. Using multimedia also facilitates educational and cognitive processes including co-operative learning, group problem solving, critical thinking, reflection, analysis, inquiry, process writing and public speaking. Multimedia authoring tools are inherently metacognitive in that they help students think about thinking. Electronic communication stretches physical boundaries, enables networked learning communities to be established and the pooling of information in collaborative knowledge building data bases, independent of time or distance. Links can be made to real-world situations or experiences providing meaningful activities and learning contexts (NSW Dept Education and Training, 1997).

There is a considerable gap between what we know about learning, teaching and educational technologies and what is done in our schools. Teachers tend to teach in the way they were taught using linear, teacher-centred methods. Kinnaman (1995) states that "the challenge is to recreate school in ways that tap the power of technology to close the gap between education knowledge and school practice".

New tools alone do not create educational change. Systemic lack of awareness, limited budgets and limited experiences of educators and administrators have contributed to slow penetration. Assessment-driven practice does not lend itself to the different approaches expected of constructivist theory. New forms of assessment, acceptable to system requirements, need to be developed.

Unless teachers find educational multimedia easy to use, they will be uncomfortable using the products as learning resources, or encouraging others to use the products (Department of Education, 1999). New tools alone do not create educational change. The need for teacher training is frequently overlooked in technology initiatives. It is assumed that teachers know and understand theories of learning and can apply them in a learning environment. It is assumed that they can incorporate educational technologies and use them appropriately. When trying to create systematic reform in the classroom, professional development can influence student learning through its impact on teaching.

The significance of professional development and support

Research recently conducted by Maor (1999) focused on a professional development program that involved the use of a multimedia package to facilitate teachers' use of computers in science classrooms and to develop teachers' understanding of a constructivist epistemology in science education. The series of three three-hour workshops, comprising the professional development over three weeks, put the teachers in the role of learners. The workshops attempted to enhance change and subsequently influence the teachers' adoption of constructivist approaches to teaching through using the multimedia program, *Birds of Antarctica*. This is an interactive program developed on constructivist principles. By using the program, the student is able to travel on a simulated voyage to Antarctica and conduct scientific investigations based on authentic data on seabirds and environmental conditions collected from research expeditions to Antarctica. It simulated authentic learning environments, provided multiple representations of data and engaged students in personal constructions of reality. It enabled students (in this case the teachers) to generate their own questions and investigations, promoted social interactions and provided opportunities for reflection upon real life issues (Maor, 1999).

Three teachers who participated in the workshops were followed in an attempt to ascertain the extent to which the workshops influenced the teacher's role in the classroom. The first teacher provided observations of his students' experiences with the program. In the second teacher's class, Maor taught the students and conducted research with the help of a research assistant and the third teacher implemented the program independently of the researchers

The first teacher's criteria for use of the program in his classroom were relevance, motivation and inquiry-based learning. Immediately following the workshops, he implemented action research with his students - a group of year 10 biology students of average to low ability. He gave much of the locus of control to his students by asking them to take ownership of their questions and investigations and work collaboratively, modelling the process in the workshops.

The second teacher's criterion for use was for her students to experience biological information in a technological and unstructured setting, both experiences different from the usual.

The third teacher created a learning environment different from the one she experienced in the workshops. Students worked individually and were asked to follow closely the curriculum materials designed to guide them in using the program. They were not encouraged to explore nor to discuss their investigations among themselves. She continued to work with her students in a didactic way.

The assertions made by the researchers (Maor, 1999) following analysis of comprehensive descriptive data, including video records, obtained during the follow up, were as shown below.

- Firstly, experiences of teachers-as-learners encourage teachers to promote group work and to discuss the nature of learning with their students.
- Secondly, innovative teachers may be interested in providing their students with constructivist-oriented multimedia programs which provide opportunities for inquiry-based learning in the science classroom.
- Thirdly, after participating in a professional development workshop a teacher may need fur

ther support to implement a constructivist-ori entated program successfully.

The study suggests that teamwork, clear instructions for working with the program and familiarity with the multimedia interface were pre-conditions for successful inquiry-based learning. The study also indicates that placing teachers in the role of learner in a novel situation is a strategy which has the potential to bring about change. Future professional development programs need to include classroom-based support, provided during and after the completion of the workshops phase (Maor, 1999). Though the generalisability of the findings has yet to be gauged, from my personal experience and that of colleagues, the assertions hold good.

Conclusion

Different types of CBL have been discussed in relation to the theories of learning which underpin them and which were dominant at a particular time. The use of educational technologies, as much as the application of particular theories of learning, is a matter of fitness for purpose. There is no one approach which is necessarily better than another and there is no one medium that should be applied in preference to another just for the sake of it. A teacher well versed in the various theories of learning, with a thorough knowledge of his or her students and a high level of competence in using and applying a range of educational technologies, will create appropriate learning environments. Many needs, often competing, have to be met including those of students, curriculum frameworks, assessment regimes and education systems. This demands a high level of accomplishment of teachers, which can only be expected if appropriate pre-service training is given and ongoing professional development is the norm.

References

Berryman, S, Designing effective learning environments: Cognitive apprenticeship models. In: The Institute for Learning Technologies: Pedagogy for the 21st Century URL, 1994.

http://www.ilt.columbia.edu/ilt/papers/ILTpedagogy.html [22 October 1999]

Blease, D, *Evaluating educational software*, Croom Helm, UK, 1986.

Boyle, T. 1997, *Design for multimedia learning*, Prentice Hall Europe, Hertfordshire, UK, 67-83

Chen, Q. 1995, Effects of learners' characteristics and instructional guidance on computer assisted learning. In: Watson, D. & Tinsley, D. (eds) *Integrating information technology into education*, Chapman Hall, London, UK, 193-201
Collins, A. 1989, *Cognitive apprenticeship and instructional technology* (Technical Report No 474) BBN Laboratories, Cambridge, MA, 1989

Department of Education, Victoria, 1999 *More than a game*, Department of Education, Victoria.

Dept of Information Science, University of Bergen, Norway, *Computer Supported Collaborative Learning (CSL) - A brief overview & interesting links for further study*, Dept of Information Science, University of Bergen, Norway URL http://www.uib.no/People/sinia/CSL/web-struktur-4.htm [28 September 1999]

Dyrli, O. E & Kinnaman, D. 1995, Moving ahead educationally with multimedia, *Technology & Learning* 15 (7), 46-51, URL http://www.coe.uh.edu/~mcf/m1refer.html [26 October 1999]

Gardner, H. 1983, *Frames of mind: The theory of multiple intelligences*, Basic Books, New York

Greening, T. 1998, Building the constructivist toolbox: an exploration of cognitive technologies, *Educational Technology*, March-April 1998

Jonassen, D. 1994, *Technology as cognitive tools: Learners as designers*, ITForum Paper #1, http://itech1.coe.uga.edu/itforum/paper1/paper1.html [22 October 1999]

Maor, D. 1999, Teachers as learners: The role of a multimedia professional development program in changing classroom practice, *Australian Science Teachers' Journal*, 45 (3), 45-50

Nickerson, R. 1995, Can technology teach for understanding? In: Perkins, D., Schwatz, J. West, M. and Wiske, M. (eds), *Software goes to school*, Oxford University Press, New York, 233-254

NSW Department of Education and Training, 1997, *Computer-based technologies in the English KLA*, NSW Department of Education and Training, Curriculum Support Directorate.

Papert, S. 1980, Computer-based microworlds as incubators for powerful ideas. In: Taylor
Papert, S. 1980, *Mindstorms:Children, computers and powerful ideas*, Basic Books, New York

Phillips, D. C. 1995, The good, the bad, and the ugly: The many faces of constructivism. *Educational Researcher*, 24 (7), 5-12

Reibel, J. 1994, *The Institute for Learning Technologies: Pedagogy for the 21st century*, http://www.ilt.columbia.edu/ilt/papers/ILTpedagogy.html [22 October 1999]

Roblyer, M.D. 1996, The constructivist/objectivist debate, implications for instructional technology research, *Learning and Leading With Technology*, October 1996

Skinner, B. F. 1938, *The behaviour of organisms: an experimental analysis*, Appleton-Century-Crofts

Squires, D. & McDougall, A. 1994, *Choosing and using educational software*, The Falmer Press, London, UK

Squires, D. 1996, *Can multimedia support constructivist learning?*URL http://www.eliz.tased.edu.au/acec96/disk1/squir.htm [25 August 1999]

Strommen, E F. 1992, Constructivism, technology, and the future of classroom learning URL http://www.ilt.columbia.edu/k12/livetext/docs/construct.html [28 September 1999]

Turkle, S. 1997, Seeing through computers: Education in a culture of simulation, *The American Prospect* (March-April 1997): 76-82 URL http://epn.org/prospect/31/31turkf.html [28 September 1999]

Wager, W. & Gagne, R. 1988, Designing computer aided instruction. In: Jonassen, D. (ed) *Instructional design for microcomputer courseware*, Lawrence Erlbaum Associates, Hillsdale, New Jersey

Wild, M. & Quinn, C. 1998, Implications of educational theory for the design of instructional multimedia, *British Journal of Educational Technology*, 29 (1), 73-82

Wilson, B., Teslow, J. & Osman-Jouchoux, R. 1995, The impact of constrictivism (and postmodernism) on ID fundamentals. In: Seels, B. (ed) *Instructional design fundamentals: A review and reconsideration*, Englewood Cliffs NJ: Educational Technology Publications, 137-157. URL http://ouray.cudenver.edu/~jlteslow/idfund.html [29 September 1999]

Bibliography

Forman, G & Pufall, P. 1988, Constructivism in the computer age: A reconstructive epilogue. In: Forman, G & Pufall, P. (eds) *Constructivism in the computer age*, Lawrence Erlbaum Associates, Hillsdale, New Jersey, 235-250

Maor, D. 1999, *Interactive multimedia Birds of Antarctica fits into the new curriculum framework*, URL http://www.curtin.edu.au/dept/smec/staff/maor/boa.html [19 September 1999]

Murphy, E. 1997, *Constructivist learning environments*, http://www.stemnet.nf.ca/~elmurphy/emurphy/constructivism.html [26 October 1999]

Scott, J. 1999, *Desirable characteristics of interactive computer simulations*, URL http://www.logal.net:80/y/owa/page?p=teach.tech.scott.4 [28 September 1999]

Schofield, J. 1995, *Computers and classroom culture*, Cambridge University Press, UK

Snir, J. & Smith, C. 1995, Constructing understanding in the science classroom: Integrating laboratory experiments, student and computer models, and class discussion in learning scientific concepts. In: Perkins, D., Schwatz, J. West, M. and Wiske, M. (eds), *Software goes to school*, Oxford University Press, New York, 233-254

Snir, J., Smith, C. & Grosslight, L. 1995, Conceptually enhanced simulations: A computer tool for science teaching. In: Perkins, D., Schwatz, J. West, M. and Wiske, M. (eds), *Software goes to school*, Oxford University Press, New York, 106-129

Technology is rapidly changing the way students learn and how instructors teach. Computers have replaced chalkboards as the go-to tool in classrooms today. And itâ€™s not just happening in higher education; technology is part of education for children of all ages. Itâ€™s also a part of their daily lives. According to a research study by Common Sense Media published in October 2011, â€œcomputer use is pervasive among very young children, with half (53%) of all 2 to 4 year olds having ever used a computer, and nine out of 10 (90%) 5 to 8 year olds having done so.â€ As technology continues to evolve, it