

Ownership of Knowledge and Its Implications for Teacher Education

Alec Couros
Faculty of Education
University of Regina
Regina, Saskatchewan, Canada.
Email alec.couros@uregina.ca

Abstract: ‘Knowledge’ is a concept that educators struggle to provide for their students, but is rarely fully understood. In recent years, there has been a growing, strongly accruing, realization that students often possess unique and relevant knowledge that has evolved from a source outside of the classroom. In the information age, we are challenging the ways in which information is delivered, and educators and students struggle to assess what information is relevant and worth internalizing in a formal school situation. Many educators have illustrated a knee-jerk reaction to this realization and have championed ways of filtering information, which they deem irrelevant. The enlightened few have recognized that learning does occur in significant ways outside of the classroom, and roles of schools are changing towards promoting research and problem solving based learning outcomes. It is in the recognition of these new voices of education, heard through innovative channels, that I believe, effective change will occur in our schools.

Introduction

The roles of teachers are changing, as are society’s expectations upon them. Teachers are now expected to incorporate instructional technology into living practice with IT skills leading the way to success for their students. As requests for educational reform increase, comprehensive changes in traditional teacher roles seem an inevitable part of the total restructuring package. In this paper, I seek to explore these new roles and responsibilities presumed for our modern teachers, and endeavor to explore the changing nature and role of knowledge in our contemporary classrooms, and how this revolution implies real change in our teacher education programs.

It is increasingly clear that the teacher of tomorrow can no longer rely on outdated methodologies to effectively teach the 21st century student. William Clark states in his article referring to the “high-tech classroom of the future” that the evolution of the

classroom “will be characterized by the steady replacement of traditional basal programs by multiple media programs and collections of supplemental materials. Some of these materials will be classroom resident. Others will flow through various manifestations of the information highway” (1994, p. 62).

Distance Education, multimedia, web-based learning, instructional technology; these are terms commonly heard by the modern teacher, but rarely completely understood. Not only are the technologies themselves misunderstood but more significantly, their underlying pedagogical implications are scarcely realized. Marita Moll, a strong critic of information technology in schooling, states “I believe that information technology can be extremely empowering, extremely motivating and extremely conducive to creating new and exciting classroom environments. However, we need to develop a better understanding of how new technologies will effect our learning environment -- both positively and negatively” (1997, p. 4). This criticism comes as tremendous amounts of dollars continue to be allocated towards technology upgrades for schools. However, at the same time there are lesser dollar amounts contributed towards teacher training in learning theories, research of instructional technologies, or investigations into technology learning outcomes. Ironically, due to the unprecedented speed of technological change, administrations now can only reasonably push for the technologically ‘average’ school. However, in the same push, teachers are left inadequate in their instructional skills and understanding. Still, the wheels of change roll relentlessly.

While in-service teacher development, in theory and application, has proved to be helpful, I strongly believe that real change must come earlier, at the root of teacher

education programs, for pre-service teachers. That is, we must address the very foundational issues in our programs, at the university level, which have tremendous bearing on our applied pedagogical approaches. In particular, we must reexamine the notion of knowledge and its foundational implications.

The Changing Perceptions of Knowledge

In recent years, it has become apparent that computers and technology have helped to revolutionize the notion of knowledge ownership. The effects of this development are seen widely in business, and in copyright and intellectual property disputes. In the recent book, Owning the Future, Shulman (1999) criticizes the United States' federal bureaucracy for being unable to cope with patent, copyright, and ownership issues. The original policy makers could never have envisioned the problems that we are having today in these areas, as many of the contemporary policies were created in an era, over one hundred years ago, when invention, and the governmental desire to protect that invention, meant concrete things (e.g. the light bulb). Government officials now must reexamine the unimagined, the ownership of the conceptual, and the ownership of knowledge.

Knowledge is different, Shulman maintains. He writes: "Quite simply, the ownership of knowledge seems to operate differently from the ownership of tangible goods. ... today the emphasis is shifting from toasters to tollbooths: players are learning to cash in on new concepts by requiring royalty payments from anyone who wants to do business in a given area" (1999, p. 17).

New questions begin to arise. When is a software code truly new and unique? Is there promise in the 'open-source' movement? Can a living organism be patented for certain uses? And how about the genetic building blocks of human life? For the most part, the arguments have remained within the legal, ethical, and political arenas. Business and industry have primarily fought these battles, as they will continue in the future. They are often the players perceived as with the 'most to lose' and adequate enough financial resources to dispute inside of courtrooms for years.

To a large degree, innovation is based on the availability of shared knowledge. For instance, if a company can lay claim to the basic building blocks of the human body, it can drastically constrict important innovations to prevent or cure disease. Shulman illustrates these relationships using several examples. For instance, the author illustrates the case of a Vermont eye doctor who is required to pay royalties to an Arizona surgeon for using a certain type of incision that the Vermont doctor himself helped to perfect. Another examples is illustrated through a patent claim for a very basic method used by many companies doing business with consumers on the Internet. Additionally, Shulman also relays an agricultural example of the claims made on farmers when using genetically altered, more agile, seed.

I thought this was about Teacher Education?

Now what does this have to do with education, teaching, and learning? And how does this affect Teacher Education and the modern classroom? I would argue that this perhaps is one of the most important issues educators face in the classroom everyday. With the integration of technology into the classroom, there is a deeper side of the issue

that educators have begun to face in the past few years. The dynamics of the classroom are continuing to transform, and knowledge ownership is an issue teachers and administrators must understand to effectively adapt to the changing landscape of the classroom.

The key epistemological questions that arise include all of the following: What is knowledge? How does one achieve knowledge? How do we use knowledge effectively? Who holds knowledge? Who ultimately owns knowledge? How is knowledge created? These key interrogations are transformed into questions more relevant to teachers, administrators, and students. Educators begin to ask the same, but specifically tailored, questions. What is official knowledge? What is school knowledge? How are these different? How is 'outsider' knowledge of the student valuable to our schools? And perhaps the most important of these questions: how does the changing perception of knowledge affect knowledge/power relationships in the classroom, and once defined, how does this change the way in which we *should* teach?

It is increasingly evident that educators are ill prepared for the knowledge age. One of the clues to this is our use and ambiguous definition for key words in our practice. Where human traits and feelings have a vast number of words describing them, and as well scientific and technological jargon often multiplies exponentially, educators use words such as 'learning', 'information', 'knowledge', 'technology', and 'teaching' to blanket many different, exclusively separate, concepts. Each of these words is so broad in its pedagogically appropriate meaning that they are often misunderstood and become ineffective. For instance, technology for one group of teachers would exclusively

translate as computers, while for others, there is a much more expansive meaning. The implied semantics need to become explicit.

The term knowledge, itself, exists as a dualism. In casual conversation, educated people will usually make good sense when speaking about knowledge. It is only when they must be carefully systematic in their approach that there is often confusion and the discussion of ideas may mesh. When knowledge is accepted as an object, an idea real in itself, these people will speak of knowledge contained in books, the advance of knowledge in society, the state of knowledge in the field, or the sharing and dissemination of knowledge amongst colleagues. On the other hand, the same discussion may suddenly take a more subjective approach, and knowledge may be discussed as students having knowledge of a particular subject, or students having trouble acquiring or retaining knowledge.

At some point, historians, educators, linguists, or epistemologists must choose a way to deal with the concept. In failing to acknowledge either side of the coin, some theorists have embraced sociocultural or situative cognition theories. In this way, knowledge does not exist in itself, or as a subject, but exists only in cultural practice, constituted in communities of practice, and embodied in tools of such practice. Although illuminating in many ways, I am somewhat pessimistic that these theories will satisfy all of the conditions of the information age.

The current model of ownership of knowledge in our traditional universities speaks volumes about the academy itself, as well as that of our high schools, private, and government educational institutions. The business-like model of our academies often deviates from the Socratic traditions of their foundation. From this viewpoint, we see

students and faculty within institutions accessing and trading knowledge packets, accumulating them, and using them for advancement in forms of degrees, certificates, convocation, or tenure. The underlying sustainability of this model lies in question in the information age as we ask, what happens to this 'business' when knowledge production, distribution, and barter are no longer profitable. What happens to the 'value' of this knowledge? What happens to the producers of this knowledge? The 'author' itself loses its meaning as the 'authority', and thus loses value. Instead of resisting the inevitable, perhaps we should begin to improve the dated design of our educational institutions.

[T]he time it takes to earn the degree in education today is based on an increasingly outdated model: so many hours in a classroom entitle a student to a receipt in the form of a grade, and so many receipts can be redeemed for a credential in the form of a degree... [B]ut the model guarantees little about what the student will know or be able to do, once the degree is in hand. Education today is just beginning to think of shifting the basis of certification from time served to skills and knowledge obtained. (Virginia State Council on Higher Education, 1993)

Early implications of the effects of the information age on authorship are observed in the wide dispersment, and invisibility of 'author' or 'authority', in many web publications. In 1977, Barthes wrote "Death of the Author" which predicted that this 'death' would lead to the "birth of the reader". (According to Barthes -- no, I must not say 'according to Barthes.' Moreover, I must not say 'I'; or if I do, I must acknowledge that as soon as I write the pronoun, it ceases to bear any relation to the extra-textual human being who wrote it.) Writing is that ... space ... where all identity is lost, starting

with the very identity of the body writing. There is only the text. Barthes goes on to imply that what really is important is who responds, and how we respond to literature, as this would take on a much greater significance.

And indeed, the entire reader response movement and, more recently, the focus on reception theory elaborate on this question, exploring the ways in which readers construct meaning and the ways in which particular texts are read, understood, and deployed in particular times and in particular places. (Lunsford, Rickly, Salvo, West, 1999)

To take a slight but worthwhile detour, Esther Dyson wrote and published the online e-commentary “Intellectual Property on the Net”. Dyson points out that because of certain products of the Information Age, primarily the Internet, the replication of content has become a nightmare in particular for software designers. Dyson argues that “that the newly revealed physics of information transfer on the net will change the economics and perhaps ultimately the laws governing the creation and dissemination of intellectual property ... call it content to avoid the presumption of ownership” (1994, p. 1).

I would have to agree with Dyson that the economics in the Information age have changed drastically. Further more, I concur with Dyson’s solution to success for an author in this unpredictable age. Her words gleam in the ultimate triumph of process over product – though it may be a triumph few of us will be ready or willing to embrace.

We believe the answers include services (the transformation of bits rather than bits themselves), the selection of content, the presence of other people, and assurance of authenticity -- reliable information about

sources of bits and their future flows. In short, intellectual processes and services appreciate; intellectual assets depreciate. (1994, P. 2)

If Dyson is anywhere near right in her presumption, and I think she is, educators should be aware of what then translates into the growing and real need for critical literacy. Critical literacy, the ability to discriminate amongst vast amounts of data, to sort through specious information, to test knowledge claims, and to perform high-level critical thinking, will be a crucial element of success to our education system.

Media and Knowledge Relationships

Before we are able to understand more about the dynamically defined concept of knowledge, we need to take a much closer look at media. We should assume that media itself carries with it transformational powers. Our long traditions of transference of knowledge have witnessed several incarnations of media which each, of themselves, carry fundamental and irremovable values. These types of media could be classified generally as oral, literary, and electronic forms. Marshall McLuhan called attention to the transformation powers of media in his magnum opus *Understanding Media* (1964). In this passage, McLuhan very clearly shows us that it would be imprudent to separate the media from its content for analytical purposes.

Our conventional response to all media, namely that it is how they are used that counts, is the numb stance of the technological idiot. For the “content” of a medium is like the juicy piece of meat carried by the burglar to distract the watchdog of the mind. (p. 18)

For instance, if we were to evaluate the authority of the oral tradition as a viable modern medium, many critics would first take issue with the inherent weaknesses in its

mechanism for transfer, storage, and retention. The oral tradition, in most cases, attempts to preserve the collective memory of human groups through an individual consciousness. In doing so, the weakness of the individual intellect can distort the past in several ways. Some such ways include all of the following. First, since the brain simplifies sensory input, by selecting and rejecting certain data, it irreversibly limits data stored. This can be due to what exactly the individual considers significant at the moment of storage. Second, memories tend to be stored in stereotyped patterns, and recollection occurs in “stock motifs and genres”. “Further, every rehearsal of an event freezes it in its stock genre and perfects it and moves it further from reality.” (Linton, 1994). Thirdly, other phenomena occur regularly such as events overwriting each other in memory, which often leads to the misrecall of names, dates, and places. Related to this, some research suggest that if prompted or ‘coached’, people can ‘recall’ events that never occurred, as well as change specific details of their recollection of the past. (Loftus, 1994) Indeed, the greater the distance in time of an event, the more likely is its recollection to be influenced by misinformation. Not only does memory select data for retention but it interprets all that it experiences and subordinates its interpretation of an event to a preexisting world-view. With time, changing world-views will alter recollection of experiences. Therefore, individual memory as a whole can be very fluid and very unreliable.

However, looking at the above ‘faults’ of the oral tradition, can we not apply virtually all of the same limitations to our literary tradition to a great extent? Although, literature is a more permanent record of history, to write maintains much of the same mental and physical limitations or oral retention. Our conscious and unconscious efforts to translate our experience into a literary form, our biases and misinterpretations of the

facts, our dynamic world view; these are limitations of any medium in which humans use to record and disseminate information. And these are limitations before there has been ANY interpretation done by a recipient of the text. Thus illustrated is an inherent and terminal flaw associated with the transfer of content or knowledge between individuals and groups. There is just too much room for humanness in the conveyance.

If in fact knowledge can truly be separated from the knower, it could therefore become a commodity, which could be bought and sold. If one were to argue that this separation was impossible, then the commodity could not reasonably exist. However, in literate societies, with the advent of the printing press, this separation becomes a reality.

[F]or it was the printing press that finally severed the connection between the creation and the transmission of knowledge. For transmission was now a mechanical act, performable by a machine. Originality, once a deadly danger to a society that had to struggle to maintain its equilibrium, could now be seen as more valuable than performance. To claim originality for what was only a re-performance become a serious breach of the values of the society (Brent, 1991, p. 3).

Perhaps the substance of knowledge in itself has been misinterpreted or misconstrued. The term 'knowledge' has its roots from the Icelandic 'knewleche'. It has been defined as 'that familiarity which is gained by actual experience; practical skill; as, a knowledge of life.' The suffix of the word, 'leche', is an abstract noun, which translates to play or sport. Teachers have traditionally attempted to transfer information from the transmitter (teacher) to the receiver (student). This has worked to some degree in classrooms over the years, but many professionals have placed this objective model

under scrutiny as an ineffective approach to teaching and learning. Thus the recent rise of constructivist approaches to teaching and learning.

There has been much research as to the psychological and sociological value of 'play' to enhance knowledge acquisition and retention. This I believe begins to give the term 'knowledge' its originally intended meaning as illustrated above. Therefore, knowledge becomes something that must be acted with or upon, as it is no longer a static concept. With much recent research into interactive and multimedia-learning environments, especially with computer-based learning experiences, (e.g. hypertext/hypermedia; examples include: Blanchard & Rottenberg, 1990; Jonassen, 1991a, 1992; Locatis, Letourneau & Banvard, 1989; Yoder, 1994) the concept of play is becoming recognized as a viable learning strategy. However, 'play' has carried with it definite misconceptions as a negative value of work, where production of knowledge and skills cease. Such misrepresentations are unfortunate because there is extensive research on play with children and adults in anthropology, psychology, and education, which indicates that it can be an important technique for learning and socialization throughout life (Csikszentmihalyi, 1990; Provost, 1990;). With the infinite possibilities of virtually explorable environments available through computer technology, it may now be the time to legitimize the role of play in the field of instructional technology.

Reexamining Social Roles in the Classroom

Play is one of a few innovative strategies that have caught the attention of teacher educators in recent years. Another key strategy, which I would like to discuss, is learning by teaching. This strategy is not an exclusively modern didactic method. In fact, over

2000 years ago the Greek philosopher Seneca wrote, *docendo discimus*: "We learn by teaching."

The 'learn by teaching' model may sound simple enough to implement, but we must consider the current popular model of education, and the role of knowledge in the classroom. In 1972, Freire coined the 'banking' model of education. In such a model, knowledge is seen as being possessed by the teacher and transmitted or deposited more or less intact to the learner.

Education therefore becomes an act of depositing, in which the students are the depositories and the teacher is the depositor. Instead of communicating, the teacher issues communiqués and 'makes deposits' which the students patiently receive, memorize, and repeat (Freire, 1972, pp. 46-47).

In this transmittance model, educators have assumed that only the teacher has any knowledge of value that should be received by the student. There are no compensations made for student knowledge to be received and valued by the teacher. Thus you see a very hierarchical system of learning results with an unequal power relationship.

An important aspect of power-knowledge relations in schools is the imbalance between teacher and learner in terms of whose knowledge is given legitimation and importance. In general, it is only the teacher's, which matters, while students are expected to discount or put to one side what they have learned outside the school (McNeil, 1986, p. 12).

At the Faculty of Education, University of Regina, Canada, we employ the 'learning by teaching' method in elements of our Education Professional Studies courses.

Professors have senior students facilitating technology modules to first and second-year students early in their programs. The initial results of this method saw the increased motivation of senior students as well as those who were taught. The offsetting of the authoritative body from the classroom increased solidarity in the learning environment. Students are able to relate more to the new classroom dynamics, as it seems to come more naturally. Other results include the evaporation of the class division into an authority, the teacher, and a passive audience. The professor remained in the classroom and, of course, the final expert and could always interrupt and correct. However, this happened rarely as the professor felt perhaps less comfortable with the content than did the student teacher. Another key dynamic that emerged is the pupil assuming many of the other tasks formerly routinely and unnecessarily carried out by the instructor. The materialization of a learning community soon became evident.

Learning Communities and Owned Knowledge

Our modern learning institutions or systems need to be strongly learner driven; guided by a vision of learners and of the related communities that these learners help to create and sustain. In our teacher education program, we must remember that we are educators of future educators, and we need to model the appropriate pedagogy; the approach that learning is the interaction of the learner with knowledge, effectively scaffolded by the teacher. These are the critical interactions. It is the learner who must remain autonomous in their learning and have control of their knowledge construction.

Today's technology, education research, and social expectations now call, and support, the move of educators and communities whose purpose for schooling children is

to foster their intellectual capacities and creativity in many diverse ways and at higher levels, and who are willing to monitor, and temper, their own need for control to the benefit of learners' acquisition of autonomy for collaboration. (Breuleuz, Laferrière, Robert Bracewell, 1998)

In 1996, SchoolNet published their *Vision of Learners in the 21st Century* vision statement. It outlines the beliefs of several leading Canadian educators on what learning may look like in the coming century. The report strongly suggests the model of learning communities, not through adoption, but through acceptance. The document is not an implementation policy by any means, but reflects perhaps the direction technology has brought us along the path to global, communal, and lifelong learning.

Learning follows a developmental sequence from childhood through adulthood and maturity. We begin in families, and communities where we learn our sense of personal identity, language, and cultural heritage. As time goes on, we interact more and more with other learners in the community, in learning institutions, and in other kinds of institutions. We make more use of technology and communication to expand our visions and range of knowledge. (SchoolNet, 1998)

Embracing the ideas of learning communities breaks through the distinction between 'school' and 'outside' knowledge, or in other words, what is thought to be legitimate knowledge, and what is not. Paechter (1998) has an excellent approach to analyzing the differences between these two kinds of knowledge. The author suggests, rightly so, that for learning to occur, new information must be linked to existing concepts 'owned' by the learner. However, where educators have traditionally stopped short, is to

legitimize the value of non-school knowledge that the student may possess, and rather, attempt to link to knowledge that the student *should* possess (official school knowledge). Paechter, although optimistic, leaves us with the question “How can we cross the barrier between owned and school knowledge?” I think that the obvious answer is through the effective growth of learning communities within our institutions.

Afterthoughts and Conclusion

As I attempt to compile this paper, it is amazing to realize how connected we have already become, and what knowledge ownership and construction has begun to mean to educators. As I sit in my otherwise isolated office, I see the occasionally student or faculty member walk by, but the majority of the interruptions come electronically. I am bombarded with information through email, instant messengers, telephones, and voice mail. It's inescapable.

But is this a learning community that I am a part of, or is it just an annoying maze of intricate novelties. As I ask myself that question, I hear a familiar sound ‘uh-oh’ from my ICQ (instant messenger) signifying to me that ‘Skip’ is online. Skip is the on-line name of a 12 year-old boy I met, while on a research assignment, who lives approximately two hours away (by car). Skip is wondering if I want to download a movie from his FTP site. In fact, it is a full motion picture that is not currently out yet in the theatres. I politely decline as I have discussed this matter with Skip several times (the legalities and ethics of the situation seem to bore the 12 year old). It is not until later that I fully realize the full significance of this event and others like it.

Let me give you a brief bit of history. Skip has created an FTP server, which basically hosts different types of media (music, movies, software, etc). The other fact of notice, is that Skip, because of his advertisement of this FTP site, currently brings in about \$300 U.S. per week because of this 'business'. Still, this is not entirely what I believe to be remarkable. What I see as being remarkable, is that Skip is of average ability (he is not a child genius), and Skip has already learned, from sources on the Internet to set-up an FTP site, to market his service on-line, to calculate costs associated with business (bandwidth vs. advertising revenue), to network resourcefully with other Internet users, and to of course use high-tech communication and file transfer tools (these are of course beyond the everyday use and familiarity of a home computer). I am not implying that I agree with the nature of Skip's project. However, I believe if teachers could simulate such incredible motivation for students to learn independently in the classroom, if teachers could have students network resources and people like Skip has done, the learning outcomes would be truly amazing. This is only the beginning.

Rather than to conclude on an entirely positive note, I believe a strong caution needs to be exercised here. In the future, the type of online learner that Skip represents will be the norm, and not the exception. More and more students are 'growing up digital' (Tapscott, 1998), and as educators, we must begin to realize what this implies for our field. By failing to nurture the growth of communities of learners in our classrooms, and in not allowing the sharing of the expert knowledge of students in our classrooms, we are losing an incredible resource, the students themselves.

References

Barthes (1977), R. The Death of the Author. *Image, Music, Text*. Ed. and trans. Stephen Heath. New York: Hill.

Blanchard, J. S., & Rottenberg, C. J. (1990). Hypertext and hypermedia: Discovering and creating meaningful learning environments. *The Reading Teacher*, 43, 656-661.

Brent, D (1991). Oral Knowledge, Typographic Knowledge, Electronic Knowledge: Speculations on the history of ownership. *Ejournal*, 3(1), 3.

Breuleux, A., Laferrière, T., Bracewell, R. (1998). *Networked Learning Communities in Teacher Education*. URL: http://www.coe.uh.edu/insite/elec_pub/HTML1998/ts_breu.htm

Clark, W. (1994, October). The high-tech classroom of the future: What will it be like? *Curriculum Product News*, p. 38.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper & Row.

Dyson, E. (1994) *Intellectual Property on the Net*, Release 1.0
URL: http://www.eff.org/pub/Intellectual_property/ip_on_the_net.html

Freire, P. (1972) *Pedagogy of the Oppressed*. Harmondsworth: Penguin

Geertz, C (1983) Common Sense as a Cultural System. *Local Knowledge: Further Essays in Interpretive Anthropology*. New York: Basic, 73-93.

Jonassen, D. (1991a). Hypertext as instructional design. *Educational Technology Research & Development*, 39(1), 83-92.

Locatis, C., Letourneau, G., & Banvard, R. (1989). *Hypermedia and instruction*. Educational Technology Research & Development, 38(2), 41-49.

Linten, M (1994), Phoenix and Chimera: The Changing Faces of Memory. *Memory and History*, ed. J. Jeffrey and G. Edwall [Lanham: University Press of America], 79

Loftus, E.F (1994)., Tricked by Memory. *Memory and History*, ed. J. Jeffrey and G. Edwall [Lanham: University Press of America] 18

Lunsford, A., Rickly, R, Salvo M., West, S. (1999). *What Matters Who Writes? What Matters Who Responds? Issues of Ownership in the Writing Classroom*.
URL: <http://english.ttu.edu/kairos/1.1/features/lunsford/title.html>

McLuhan, M. (1964) *Understanding Media: The extensions of Man*. New York: McGraw-Hill

McNeil, L. (1986) *Contradictions of Control*. New York: Routledge & Kegan Paul.

Moll, M. (1997, Spring) Information Technology in the Classroom: Pits and Pendulums – A Poe-esian Look at Planning! *Education Canada*, Canadian Education Association, Toronto, Ontario, Canada.

Paechter, Carrie. (1998) Schooling and the ownership of knowledge. *Curriculum Studies*, Open University, 6(2)

Provost, J. A. (1990). *Work, play, and type: Achieving balance in your life*. Palo Alto, CA: Consulting Psychologist Press.

Rieber, L. P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology Research & Development*, 44(2), 43-58.

SchoolNet (1996). Vision of learners in the 21st century.
URL: <http://www.tact.fse.ulaval.ca/fr/html/svision.html>

Shulman, S. (1999). *Owning the Future: Inside the battles to control the new assets – Genes, software, databases, and technological know-how – That make up the lifeblood of the New Economy*. Boston, MA: Houghton Mifflin.

Tapscott, D. (1998). *Growing Up Digital*. McGraw Hill. Toronto, Ontario, Canada.

Virginia State Council of Higher Education, 1993. The Continuum of Education. House Document 11.
URL: <http://www.schev.edu/html/reports/continuum.html>

Weizenbaum, J. (1976). *Computer power and human reason*. New York: W. H. Freeman.

Yoder, S. (1994). Math, microworlds, and hypermedia. *The Computing Teacher*, 21(8), 18-20.