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From assimilation to accommodation: a developmental framework for integrating digital technologies into literacy research and instruction

David Reinking and Linda D. Labbo
University of Georgia, USA

Michael C. McKenna
Georgia Southern University, USA

ABSTRACT

This article presents a developmental framework for interpreting and understanding how new digital technologies have been integrated into literacy instruction and research, and how they might be integrated in the future. The framework borrows the concepts of assimilation and accommodation from Piaget's classical developmental theory of learning, applying them to how individuals and groups involved in literacy instruction and research conceptualize and implement new digital technologies in their work. It is argued that assimilation and accommodation define a developmental reality that helps explain a variety of issues pertaining to new technologies in relation to literacy research and practice, such as how new technologies come to be used or not used in literacy instruction, and what research questions are asked or not asked by literacy researchers exploring the implications of new technologies for instruction. The influence of this framework on the authors' own work and on the work of others is illustrated.

INTRODUCTION

Neuman (1990) and others (e.g. Cuban 1986) have pointed out that new technologies can be integrated into instructional practice in qualitatively different ways. Specifically, computers can be appropriated in ways that minimally disrupt or change existing practice (e.g. adding a computer activity to an existing learning centre). Or, they can be appropriated in ways that alter fundamentally the instructional environment so that teaching and learning occur differently than before the technology was appropriated (e.g. when computer-based activities stimulate a move from textbook- and teacher-centered learning to a focus on student-initiated inquiry). Papert (1993),

lamenting the fact that computers have too often been integrated superficially into instruction, has argued that some schools treat new technologies like the human body treats an invading virus. For example, in his view, isolating computers in rooms called 'labs' ensures that teachers and students will have limited opportunities to use them in ways that might transform teaching and learning. Likewise, literacy researchers in particular have been criticised for asking the wrong questions about the role of new technologies in instruction (e.g. Reinking and Bridwell-Bowles, 1991) or simply to giving too little attention to the far-reaching implications of technology (e.g. Kamil and Lane, 1998).

In the case of literacy research and instruction we believe it is useful both to acknowledge and to consider that there are different levels and types of technological integration that can be achieved. However, we also believe that the various types and levels of integration need to be explained and understood. Infrequently considered are questions about why the range of responses to technology varies so much and why some of the attention to it sometimes seems superficial or unsatisfactory.

In considering such questions, we have found it useful to conceptualise the integration of technology into literacy instruction and research as a developmental phenomenon. Specifically, we have found that a developmental framework for understanding technological integration might be built around Piaget's classical theory of how learning develops through a process of assimilation and accommodation, although our use of these terms here is admittedly a simplification of Piaget's theories. In the familiar Piagetian model of learning, assimilation is the process by which new information is merged with existing knowledge structures without changing those structures. Accommodating new information, on the other hand, requires that existing knowledge be restructured to fit new information, which eventually transforms the way a learner views and understands the world. The Piagetian model is developmental because learners are viewed as gaining increasing levels of maturity in their knowledge as they pass through several distinct stages, each of which comprises an iterative process in which assimilation gradually gives way to accommodation. Likewise, in that model, learners at one stage of development may not be developmentally capable of accommodating certain information, having only the capability to assimilate it, which leads to responses that may be puzzling or frustrating to those who have achieved a more mature developmental level.

We believe that a similar distinction between assimilation and accommodation defines a reality that helps explain a variety of issues pertaining to new technologies in relation to literacy research and practice. Particularly, it suggests a framework for thinking about issues such as how new technologies come to be used or not used in literacy instruction, and what research questions are asked or not asked by literacy researchers exploring the implications of new technologies for instruction. Most importantly, a developmental framework provides a way to think about integrating technology into research and instruction that acknowledges a natural movement from the more transient posture of assimilation to a more long-term and substantive view characteristic of accommodation and eventual developmental maturity. In that regard, like Piaget's documentation of developmental stages, it leads to a more neutral and analytical stance toward less mature responses that can be accepted as milestones in a natural progression of development.

In this article we explain how we have used Piaget's concepts of assimilation and accommodation as the basis for a framework for understanding the qualitative

differences in the ways that new technologies can be integrated into literacy instruction and research. We also illustrate how a developmental framework has guided our own research into how new technologies might be integrated into classroom practice.

ASSIMILATING TECHNOLOGY

In the developmental framework that is the subject of this article, we suggest that technology will be assimilated into literacy instruction and research when it is conceptualised in relation to conventional literacy, and when it is implemented in ways that conform to existing curriculum, pedagogical goals, and instructional activities that are comfortable and familiar. In our view, assimilating technology is a natural outgrowth of a tendency to view new technologies first in terms of existing technologies and the familiar tasks to which they are applied. This has been observed by a number of writers, e.g. Stokes (1997) and Wartella and Reeves (1983). For example, before they were automobiles, vehicles powered by the internal combustion engine were called 'horseless carriages', resembling in appearance a technology more familiar at that time. It was only as the horseless carriage became an 'automobile' that it began to derive its own unique blend of form and function (e.g. the addition of headlights, windshields, and wipers) as this mode of transport became more than a novelty. Likewise, the computer was first called a 'computer', instead of a 'word processor', 'server', 'personal data assistant' or 'electronic book.' Similarly, literacy educators have, for the most part, tended to see new digital technologies first as a novelty (or nuisance) and gradually as a potentially useful tool for refining or extending what they have done all along. Thus, seeing new technologies through the lens of existing conceptions of literacy and familiar themes in research and instruction is a natural first, yet transient, stage of development.

A clear example of assimilating technology into literacy education is the often criticised drill-and-practice computer games that students might engage in as a 'reward' after having completed more conventional assignments (Smith, 1984). However, examples of assimilating technology need not necessarily be so mundane and superficial. The computer offers new capabilities that can conceivably enhance the conventional goals of reading instruction, such as increasing decoding ability, building vocabulary, stimulating an interest in reading books, and improving spelling. Mainstream literacy researchers have combined sound theory with the computer's unique pedagogical advantages to develop creative applications designed to further the goals of conventional instruction (e.g. Reitsma, 1988; Roth and Beck, 1987). In our own work (McKenna, 1998) we have explored the possibilities of having young children read 'talking books' that provide auditory pronunciations of words relating them to other words through the use of phonic analogies while they are reading highly regarded children's literature (see also Lewin, 1995). We are interested in determining how this capability might affect children's acquisition of sight words, their ability to generalise spelling patterns to decode other words, their attitudes toward reading, and how far they are willing to read above their off-line reading level with this type of support. Thus, as these examples illustrate, there is nothing inherently wrong with assimilation as an orientation to using new technology in guiding research and instruction.

However, recognising that assimilation must eventually give way to accommodation in a natural developmental progression lends perspective to theory, research, and practice related to new technologies and literacy, and it helps identify potential pitfalls in our thinking. For example, like Piagetian theory – in which learners must reach a particular level of cognitive maturity to understand and accept certain information and conclusions – researchers and practitioners who are at the stage of assimilation are limited to seeing new technologies only terms of conventional literacy and familiar practice derived from the technology of the printed page. The long-term work reported by Bruce and Rubin (1993) is a case in point. They found that QUILL, a comprehensive computer-based application designed specifically to promote purposeful reading and process writing, was typically implemented by teachers in a way that negated its purpose because the teachers were invested in other, sometimes contradictory, goals. In other words, new technologies alone cannot transform instruction when those integrating them into instruction see them only in terms of assimilation. Put another way, an application requiring accommodation will not be successful in an environment that is developmentally capable only of assimilation.

A perspective that fits developmentally into what might be called assimilation is also evident in a dominant orientation of research investigating new technologies and literacy. That is, assimilation inherently implies a competition between existing knowledge (or technologies) and the new knowledge with which it must be reconciled. In the case of technology, this perspective leads to the question: Why use a new technology to further conventional instructional goals if the new technology cannot out-perform existing technology? Much of the early research on new technologies and literacy was guided by this perspective, which often translated into simplistic, atheoretical comparisons of computer-based and conventional activities aimed at furthering existing goals of instruction (Reinking and Bridwell-Bowles, 1991). We have argued elsewhere (Labbo and Reinking, 1999) that the legendary story of John Henry competing with a machine that inevitably would replace him is apropos to understanding this perspective. Some technologies are destined to replace or substantially modify others, although it sometimes takes time for that realisation to occur or to be accepted. Notably, some researchers realised early on the futility of comparing reading and writing with printed or digital texts (e.g. Wright, 1986, who argued for intra- rather than inter-media comparisons). However, their perspective was not shared by most researchers who were beginning to ask questions about technology and literacy.

Studies investigating word processing are a good example. Early studies compared students' writing using a word processor or conventional writing tools to determine if students would write more, would write more accurately, and so forth. Today, when word processing is widely accepted as a mainstream writing tool, such studies seem naive. No amount of research would provide a convincing argument that word processing should be limited or abandoned. In other words, word processing today is integral to almost anyone's conception of literacy, which means that it has been accommodated, not assimilated, as we will explain more fully in the subsequent section of this article.

Inevitably too, assimilation can proceed uninhibited only when what is to be assimilated is not reasonably compatible with existing knowledge. This aspect of the developmental framework we propose accounts for the resistance that is sometimes

seen to integrating new technologies into literacy instruction and research, especially if new technologies cannot show demonstrably superior effects in relation to conventional thinking and practice. In its most obvious forms such resistance takes either the form of romanticised notions about conventional reading and writing, often centered on the sanctity of books (e.g. Birkerts, 1995; although there are equally romanticised arguments for new technologies, e.g. Gilster, 1997; Tapscott, 1998), or outright attacks on the dangers of digital forms of communication (e.g. Healey, 1998; Stoll, 1995).

So, assimilating technology, in the perspective we offer here, is a natural developmental process that acknowledges the need for literacy researchers and practitioners to reconcile new digital technologies with the dominant and long-standing technologies of print and the conventional thinking and practices literacy has historically entailed. Beneficial outcomes can result when technology is applied to literacy, even when it is only at the stage of assimilation. However, assimilation without accommodation entails some risk of misguided directions and interpretations. Perhaps the most prominent of these is the failure to understand that assimilation is a temporary and transient process that must eventually lead to accommodation.

ACCOMMODATING TECHNOLOGY

Accommodation implies that new information and experiences lead to a fundamental restructuring of thinking and a re-orientation that allows for viewing the world in new terms. When applied to new technologies and literacy, that means adopting an orientation that entertains the idea that literacy itself may be changing in light of those technologies, which are viewed on their own terms rather than simply as extensions of conventional print-based literacy (Lemke, 1998; Leu, in press). Accommodation implies thinking about entirely new content, new goals, new activities, and even radical shifts in educational philosophies that guide instruction (e.g. International Society for Technology in Education, 1998). It emphasises the transformative possibilities of new technologies, which may challenge the status quo (Reinking, McKenna, Labbo and Kieffer, 1998).

In a Piagetian model, accommodation is a developmental process that results when a blend of maturation and experience creates conditions that make assimilation alone inadequate. When accommodation is applied to new technologies and literacy, it might be argued that the requisite experience and maturation is in place. For example, despite the continuing evolution, refinement, and metamorphoses of digital technologies, generically speaking they are no longer entirely new. The computer has been acknowledged as an integral part of all aspects of modern life at least since *Time* magazine celebrated it in 1983 as 'man of the year.' Furthermore the penetration of digital reading and writing into daily literate activity has increased to a level that no reasonable person can deny that it is having and will continue to have profound effects on what is considered to be mainstream reading and writing (Reinking, 1995, 1997, 1998). The incredibly rapid increase in the amount and diversity of use in e-mail and the World Wide Web are prominent, but certainly not the only, examples. Given these conditions, we believe that assimilation should now be superseded by accommodation and that such a shift is beginning to occur. But can examples be cited that clearly distinguish accommodation from an earlier

assimilation and that might give evidence of a shift from one to the other? We mention a few here.

In our work in schools we have gradually seen administrators and teachers more often adopt goals for literacy instruction that treat new digital technologies on their own terms rather than simply as extensions of print-based literacy. For example, early on, many schools recognised the need to integrate word processing into instruction in a systematic way, although this awareness was typically linked to creating conventional printed documents. Now, not only are there many more examples of teachers using word processors, there are increasingly more examples of combining word processing with multimedia presentation software such as *Power-point* to engage students in creating multimedia documents for classroom projects, which often include the World Wide Web. Educators today also clearly see that teaching students strategies for locating information is more appropriately focused on Boolean searches of electronic databases and than on how to locate a book in the library using the now almost defunct alphabetised card catalogue. However, to illustrate accommodation more clearly, we might take this latter example a step further. At the stage of accommodation, educators might even question whether alphabetising needs to be taught formally at all. Or, as some educators have begun to ask, might it be time to go beyond conventional word processing to consider developing and teaching strategies for writing hypertexts that might be either informational or narrative texts (see Murray, 1997, for a discussion of the aesthetic possibilities associated with creating hypertextual narrative). As these examples illustrate, accommodating technology in literacy instruction means thinking beyond conventional conceptions, assumptions and practices.

The movement from assimilation to accommodation in the area of classroom instruction can also be seen on a purely conceptual level. For example, the discussion of new technologies in education is increasingly focused not on how they can be assimilated into existing educational structures, but rather on how they demand a fundamental restructuring of the educational enterprise (e.g. International Society for Technology in Education, 1998; Means, 1994; Papert, 1993). New technologies are increasingly seen as a catalyst for operationalising social contructivist and other progressive views of teaching and learning and for promoting student empowerment and self-actualisation (Labbo and Reinking, 1999). Several writers have articulated such themes from the perspective of literacy (e.g. Bruce and Hogan, 1998; Tierney and Damerin, 1998). Other writers have argued that definitions of literacy need to be expanded and the consequent need to accommodate those definitions into the way schools operate, what is taught, how it is taught, and so forth (e.g. Flood and Lapp, 1995; Lemke, 1998)

On the research front, the quantitative studies comparing computer-based with conventional activities, which were consistent with an assimilation orientation in the 1980s and early 1990s, have given way to more qualitative studies examining the transformative potential of new technologies. Although this shift can be attributed to the increasing popularity of qualitative research methodologies in educational research in general, it is also partially explained, we believe, by a movement from assimilation to accommodation. That is, the perspective of assimilation tends to generate research questions comparing new technologies to more conventional approaches to accomplishing traditional curricular goals. Such comparisons lead to what Salomon (1991) has referred to as 'analytic' research methods, which typically

imply quantitative analyses. Accommodation, on the other hand, because it focuses on how the environment is or might be transformed through the integration of new technologies, generates questions that require what Salomon calls 'systemic' methods depending on qualitative and ethnographic analysis.

Several recent studies illustrate the shift toward accommodation and the qualitative approaches to research that reflect and support that shift. For example, Garner and Gillingham (1996, 1998) report six case studies of teachers in diverse classroom environments who integrated email and web access into their instructional activities. They document how these activities transformed the classroom environment, having distinct effects on the outlooks not only of the teachers about their teaching but also of the students about their learning. It is unlikely that this study would have been conceptualised and conducted from a perspective characteristic of assimilation. Instead, research guided by the perspective of assimilation might have measured quantitative gains in achievement when comparing the degree to which e-mail was used. The contrast between research conducted from the perspectives of assimilation or accommodation can also be seen in the work of Myers and his colleagues (Meyers, Hammet and McKillop, 1998). These authors studied the ways in which learners, who were engaged in creating multimedia documents, could become more critical readers who understand the socio-cultural implications of textual content. In this case, technology is studied as a planned challenge to the status quo. Likewise, Neilsen (1998) reports how introducing e-mail into a secondary school provided students with an opportunity to subvert existing lines of authority, which in turn shifted the balance of power away from teachers and administrators. We would argue that the focus of such studies and the research methods employed are developmentally different because they are derived from a view of technology that is more akin to the accommodation, rather than the assimilation, of technology.

THE CASE FOR TRANSITIONING FROM ASSIMILATION TO ACCOMMODATION

The examples cited in this article suggest that educators' and researchers' views of technology in relation to literacy are shifting away from a view that we refer to here as assimilation and more towards one of accommodation. However, we do not believe that this shift is complete, nor that it has been fully consolidated. Neither do we believe that anyone should expect it to be so. As we, and others, have argued elsewhere (e.g. Leu, in press; Labbo and Reinking, 1999; Reinking, 1995; 1998), the implications of new digital technologies for research and practice are extensive and profound. They imply that conventional theories of reading and writing, as well as pedagogical theories about the way literacy should be taught, need to be reconceptualised and, in some cases, reanalysed or reconstructed afresh.

To cite one example, consider the concept of 'difficulty' in relation to texts, which is a central concept for those interested in literacy development. In relation to conventional printed texts, it figures in assessment (e.g. determining reading level), pedagogy (e.g. in establishing students' independent, instructional, and frustration levels), and in selecting appropriate reading materials (e.g. using readability formulae). But what does 'difficulty' mean in relation to digital texts when readers

can be provided with a variety of forms of assistance if they are experiencing difficulty in decoding (e.g. the pronunciation of an unfamiliar word) or comprehending (e.g. relevant background knowledge) a text? Other theoretical constructs, such as deconstructionism (see Bolter, 1991) and 'intertextuality', become much more concrete and obvious when applied to digital texts, which are clearly constructed by the reader and which are not distinct physical and conceptual entities.

Given that digital texts raise critical questions about such fundamental issues, it is not reasonable – or even desirable – for educators and researchers to move too quickly and completely from a perspective of assimilation to one of accommodation. In any event, it may not be possible to do so because the technologies of reading and writing are moving forward at such a rapid pace. It is difficult to predict with any degree of certainty what the dominant protocols of reading and writing will be in five years let alone what they will be when elementary school students today reach adulthood. As Leu (in press) has emphasised, educators today are faced with the daunting task of preparing students to be literate for a future that is unclear and for a literacy that educators themselves have not fully attained. On the other hand, some dimensions of this challenge are clear. For example, it is clear that conventional printed materials still play a dominant role in literacy and that they are likely to do so for some time. Thus, it would be foolish to advocate complete abandonment of the long-standing conventional goals of literacy that are derived from printed materials. At the same time, it is clear that digital communication has permanently altered the literacy landscape and that students and teachers today need systematic experiences to cope with these changes and to prepare them for a future in which textual information will be overwhelmingly available in an extremely broad array of formats and contexts.

We believe that recognising and accepting that we are in a transitional stage between assimilation and accommodation provides a useful conceptual framework for considering research and practice. For example, using this perspective, a set of criteria have been proposed for integrating technology into literacy instruction for the purpose of developing 'electronic literacy' in a way that is grounded in conventional literacy (see Reinking, 1996). Our scheme is based on the realisation that it may be difficult and unwise for teachers and students to move completely away from conventional literacy and directly to the new literacies of a post-typographic world. It is also based on the assumption that it is probably too early to do so and that at least some principles of literacy pedagogy transcend the differences between print and electronic media.

To summarise, we have argued that instructional activities aimed at generating electronic literacy should ideally: (a) involve authentic meaningful reading and writing activities, (b) provide opportunities to compare and contrast printed and digital documents, (c) provide opportunities for teachers and students to discuss differences between printed and digital documents, and (d) allow students to develop strategies for reading and writing digital documents. One common example that lends itself to meeting all of these criteria is the integration of multimedia encyclopedias into instruction, perhaps by having individual or small groups of students prepare to be tour guides at a historical site to be visited on a class field trip. The field trip provides a motivating and authentic backdrop for meaningful reading and writing. The multimedia encyclopedia is a digital extension of a conventional and familiar printed reference source, providing an opportunity to compare and contrast

their respective advantages and limitations. In addition, students are provided with an opportunity to develop and use functional strategies for finding information electronically and perhaps to incorporate that information into an electronic presentation to the class prior to the field trip. In the following section we provide two further examples that also illustrate how the conception of a transitional stage can guide research focused on the integration of technology into classroom literacy instruction.

TWO ILLUSTRATIVE RESEARCH PROJECTS

We briefly describe here two projects that illustrate how a developmental perspective based on a transition from assimilation to accommodation might guide the conceptualisation, conduct, and analysis of research pertaining to technology and literacy. Both projects were conducted under the auspices of the former National Reading Research Center, funded by the Office of Educational Research and Improvement, US Office of Education, from 1992–97.

The first project examined how involving middle-grade teachers and students in creating multimedia book reviews might increase the amount and diversity of students' reading (Reinking and Watkins, 1996). This project illustrates several themes of the developmental perspective we have introduced in this article. For example, to conceptualise this project and, indeed, to introduce it to teachers and students, we framed it as an alternative to the conventional book report, which is a ubiquitous – although arguably ineffective – instructional activity aimed at encouraging independent reading. Thus, the application of technology in this case was firmly grounded in a familiar instructional activity for both teachers and students. However, the multimedia book reviews made available technologies for transforming the conventional book report into something quite different pedagogically, which invited opportunities for comparing and contrasting it with the conventional book report. For example, in contrast to the conventional book report, students worked much more collaboratively, partly out of necessity in dealing with helping each other contend with the on-line tools used to create the multimedia book reviews. In addition, the ultimate aim of the project was to create a searchable database that might be used to find books and to discover who was reading what books – in contrast to a conventional book report, which is typically read only by the teacher or given only as an oral report to the class.

Thus, from the standpoint of assimilation, this project might be viewed as using technology to extend a conventional activity (book reports) to accomplish a conventional goal (increase independent reading). Indeed, several of the teachers (in eight classrooms in three schools over two years) tended to view the project solely in terms of assimilation, and we did not press them to move beyond that orientation. For example, when asking them to consider some of the ancillary benefits of the project, they would typically cite conventional instructional goals, such as students' increased attention to the mechanics of their writing, presumably because they had a more tangible audience for their writing. However, some of our goals for the project arose from the perspective of accommodation. That is, we saw the possibility that the project would transform instruction, leading teachers and students in new pedagogical directions that also expanded their understanding of literacy in digital

environments. We saw evidence of this, too. For example, several teachers integrated aspects of the project into other subject areas, such as social studies, in which they began to use more authentic reading and writing activities.

Our research methodology was also consistent with the perspective of accommodation. We employed what has been called a 'formative experiment' (Baumann et al, 1996; Jacob, 1992; Neuman, 1990). Formative experiments establish a pedagogical goal (in our case to increase independent reading), implement an intervention designed to accomplish that goal (our multimedia book review activity), gather quantitative and qualitative data to determine what factors are enhancing or inhibiting the attainment of the goal, modify the intervention accordingly, determine what unanticipated effects are evident, and establish whether the intervention has been assimilated or accommodated.

In a second project we explored how computers might be integrated into kindergarten classrooms to support children's development of literacy (Labbo, 1996; Labbo and Kuhn, 1998). In this project we had no pre-determined application of technology to import into the classroom. Instead, we were interested in investigating how making available technology along with support and encouragement might effect appropriation of the technology. However, as before, we made no attempt to push the teachers in directions they did not wish to go.

We were able to see several instances of how the computer's role and the teachers' curricular conceptualisations and implementations progressed from assimilation to accommodation. For example, a long-standing practice in one classroom was to begin the school day by the teacher taking dictation of a daily message, which was written on the chalk board in the front of the room. After rereading and discussing the message, children were asked to identify words and letters they knew. Early in the year, the teacher assimilated the computer into this activity by using a word processor to type in the message, which was displayed on a large screen. However, later in the year in the same classroom, we found evidence of accommodation. For example, toward the middle of the year the teacher had used the computer in a learning centre for children to prepare final drafts and to publish writing that had been composed on paper and pencil, which we still saw as assimilation but which was also a step beyond simply displaying the morning message. By the end of the year, students were using exclusively a drawing and word processing program on the computer to create multimedia pieces, which the teacher recognised as having many different elements when compared with their conventional writing. Yet, this activity simultaneously and seamlessly supported children's conventional literacy development (e.g. the children heard the names of letters when they appeared on the screen) while initiating them into creating digital texts (e.g. navigating the program to employ animation and sound effects).

BEYOND ASSIMILATION AND ACCOMMODATION

The perspective presented in this article emphasises a sequential distinction between assimilation and accommodation. However, Piagetian theory postulates that assimilation and accommodation are on-going and often inseparable activities that require learners to seek equilibrium between incoming information and the cognitive structures needed to interpret that information. Sometimes equilibrium is achieved only

by moving to a distinctly different stage of cognitive development – a distinctly new world view.

Likewise, as we have argued here, literacy educators and researchers have sought equilibrium first by assimilating new technologies into conventional conceptions of literacy and traditional instructional practice. As new technologies have moved increasingly into the mainstream of what defines literacy, assimilation has increasingly given way to accommodation. However, it is also possible that reaching full maturity in our integration of new technologies into literacy and literacy instruction may require that we move to the equivalent of an entirely new developmental stage. If we are moving to a post-typographic world in which print-based reading and writing may be marginalised, as some have argued (e.g. Bolter, 1991; Lanham, 1993; Tuman, 1992), traditional conceptions of literacy will need to be replaced by an entirely new view of literacy based on digital reading and writing. While it is beyond the scope of this article to engage in exploring that speculation, the developmental view we have outlined here might be logically extended to support that conclusion. Ultimately, we believe that the value of a developmental viewpoint is to foster and to move forward such speculation from a perspective that does not denigrate any genuine desire to integrate technology into literacy research and instruction.

REFERENCES

BAUMANN, J. F., DILLON, D.R., SCHOCKLEY, B.B., ALVERMANN, D.E. and REINKING, D. (1996) Perspectives in literacy research. In L. Baker, P. P. Afflerbach and D. Reinking (Eds.) *Developing engaged readers in school and home communities*. Mahwah, NJ: Erlbaum, pp. 217–245.

BIRKERTS, S. (1995) *The Gutenberg Elegies: The fate of reading in an electronic age*. New York: Fawcett Book Group.

BOLTER, J. D. (1991) *Writing space: The computer, hypertext, and the history of writing*. Hillsdale, NJ: Erlbaum.

BRUCE, B. C. and HOGAN, M. P. (1998) The disappearance of technology: Toward an ecological model of literacy. In D. R. Reinking, L.D. Labbo, M. McKenna and R. Kieffer (Eds.) *Literacy for the 21st century: Technological transformations in a post-typographic world*. Mahwah, NJ: Erlbaum, pp. 269–281.

BRUCE, B. C. and RUBIN, A. (1993) *A situated evaluation of using computers for writing in classrooms*. Hillsdale, NJ: Lawrence Erlbaum.

CUBAN, L. (1986) *Teachers and machines: The classroom use of technology since 1920*. New York: Teachers College Press.

FLOOD, J. and LAPP, D. (1995) Broadening the lens: Toward an expanded conceptualization of literacy. In K. A. Hinchman, D. J. Leu and C. K. Kinzer (Eds.) *Perspectives on literacy research and practice: The 44th Yearbook of the National Reading Conference*. Chicago, IL: National Reading Conference, pp. 1–16.

FRIEDRICH, O. (1983) Machine of the year: The computer moves in. *Time*, 121, 3 January 1983, 14–24.

GARNER, R. and GILLINGHAM, M. (1996) *Internet connections in six classrooms: Conversations across time, space, and culture*. Mahwah, NJ: Lawrence Erlbaum.

GARNER, R. and GILLINGHAM, M. (1998) The internet in the classroom: Is it the end of transmission-oriented pedagogy? In D. R. Reinking, L.D. Labbo, M. McKenna and R. Kieffer (Eds.) *Literacy for the 21st century: Technological transformations in a post-typographic world*. Mahwah, NJ: Erlbaum, pp. 221–231.

GILSTER, P. (1997) *Digital literacy*. New York: John Wiley and Sons.

HEALY, J. M. (1998) *Failure to connect: How computers affect our children's minds – for better and worse*. New York: Simon and Schuster.

INTERNATIONAL SOCIETY FOR TECHNOLOGY IN EDUCATION (1998) *National educational technology standards for students: Essential Conditions to make it happen*. [On-line: www.http://cnets.iste.org/condition.htm]

JACOB, E. (1992) Culture, context, and cognition. In M. D. Lecompte, W. L. Millroy and J. Preissle (Eds.) *Handbook of qualitative research in education*. San Diego, CA: Academic Press, pp. 293–335.

KAMIL, M. L. and LANE, D. M. (1998) Researching the relationship between technology and literacy: An agenda for the 21st century. In D. R. Reinking, L.D. Labbo, M. McKenna and R. Kieffer (Eds.)

Literacy for the 21st century: Technological transformations in a post-typographic world. Mahwah, NJ: Lawrence Erlbaum, pp. 323–342.

LABBO, L. D. (1996) A semiotic analysis of young children's symbol making in a classroom computer center. *Reading Research Quarterly,* 31(4), 356–385.

LABBO, L. D. and KUHN, M. (1998) Computers and emergent literacy: An examination of young children's computer-generated communicative symbol making. In D. R. Reinking, L.D. Labbo, M. McKenna and R. Kieffer (Eds.) *Literacy for the 21st century: Technological transformations in a post-typographic world*. Mahwah, NJ: Erlbaum, pp. 79–91.

LABBO, L. and REINKING, D. (1999) Negotiating the multiple realities of technology in literacy research and instruction. *Reading Research Quarterly,* 34, 478–492.

LANHAM, R. A. (1993) *The electronic word: Democracy, technology, and the arts*. Chicago, IL: University of Chicago Press.

LEMKE, J. L. (1998) Metamedia literacy: Transforming meanings and media. In D. R. Reinking, L. D. Labbo, M. McKenna and R. Kieffer (Eds.) *Literacy for the 21st century: Technological transformations in a post-typographic world*. Mahwah, NJ: Erlbaum, pp. 283–301.

LEU, D. J. (in press) Literacy and technology: Deictic consequences for literacy education in an information age. In M. L. Kamil, P. Mosenthal, R. Barr and P. D.Pearson (Eds.) *Handbook of Reading Research, Volume 3*. Mahwah, NJ: Erlbaum.

LEWIN, C. (1995) *The evaluation of talking book software: A pilot study*. (Technical Report No. 220) Milton Keynes, UK: Centre for Information Technology in Education, The Open University.

McKENNA, M. C. (1998) Electronic texts and the transformation of beginning reading. In D. Reinking, M. C. McKenna, L. D. Labbo and R. D. Kieffer (Eds.) *Handbook of literacy and technology: Transformations in a post-typographic world*. Mahwah, NJ: Lawrence Erlbaum, pp. 45-5-9.

MEANS, B. (Ed.) (1994) *Technology and education reform: The reality behind the promise*. San Francisco, CA: Jossey-Bass.

MEYERS, J., HAMMET, R. and McKILLOP, A. M. (1998) Opportunities for critical literacy/pedagogy in student authored hypermedia. In D. Reinking, M. McKenna, L. D. Labbo and R. Kieffer (Eds.) *Handbook of literacy and technology: Transformations in a post-typographic world*. Mahwah, NJ: Lawrence Erlbaum, pp. 63–78.

MURRAY, J. H. (1997) *Hamlet on the holodeck: The future of narrative in cyberspace*. New York: The Free Press.

NEILSEN, L. (1998) Coding the light: Rethinking generational authority in a rural high school telecommunication project. In D. Reinking, M. McKenna, L. D. Labbo and R. Kieffer (Eds.) *Handbook of literacy and technology: Transformations in a post-typographic world*. Mahwah, NJ: Lawrence Erlbaum, pp. 129–143.

NEUMAN, D. (1990) Opportunities for research on the organizational impact of school computers. *Educational Researcher,* 19, 8–13.

PAPERT, S. (1993) *The children's machine: Rethinking school in the age of the computer*. New York: Basic Books.

REINKING, D. (1994) *Electronic literacy* (Perspective Series No.1-PS-N-07). Athens, GA and College Park, MD: The National Reading Research Center.

REINKING, D. (1995) Reading and writing with computers: Literacy research in a post-typographic world. In K. A. Hinchman, D. J. Leu and C. K. Kinzer (Eds.) *Perspectives on literacy research and practice*. Chicago: National Reading Conference, pp. 17–34.

REINKING, D. (1997) ME and my hypertext:) A multiple digression analysis of technology and literacy (sic). *Reading Teacher,* 50(8), 626–643.

REINKING, D. (1998) Synthesizing technological transformations of literacy in a post-typographic world. In D. Reinking, M. McKenna, L. D. Labbo and R. Kieffer (Eds.) *Handbook of literacy and technology: Transformations in a post-typographic world* Mahwah, NJ: Lawrence Erlbaum, pp. xi–xxx.

REINKING, D. and BRIDWELL-BOWLES, L. (1991) Computers in reading and writing. In R. Barr, M. L. Kamil, P. B. Mosenthal and P. D. Pearson (Eds.) *Handbook of Reading Research, Volume 2*. New York: Longman, pp. 310–340.

REINKING, D., McKENNA, M. C., LABBO, L. D. and KIEFFER, R. D. (Eds.) (1998) *Handbook of literacy and technology: Transformations in a post-typographic world*. Mahwah, NJ: Lawrence Erlbaum.

REINKING, D. and WATKINS, J. (1996) *A formative experiment investigating the use of multimedia book reviews to increase elementary students' independent reading* (Research Report #55) University of Georgia, Athens, GA: National Reading Research Center.

REITSMA, P. (1988) Reading practice for beginners: Effects of guided reading, reading-while-listening, and independent reading with computer-based speech feedback. *Reading Research Quarterly*, 23, 219–235.

ROTH, S. F. and BECK, I. L. (1987) Theoretical and instructional implications of assessment of two microcomputer word recognition programs. *Reading Research Quarterly*, 22, 197–218.

SALOMON, G. (1991) Transcending the qualitative-quantitative debate: The analytic and systemic approaches to educational research. *Educational Researcher*, 20(6), 10–18.

SMITH, F. (1984) *The promise and threat of microcomputers in language education*. Victoria, British Columbia: Abel Press.

STOKES, D. E. (1997) *Pasteur's quadrant: Basic science and technological innovation*. Washington, DC: Brookings Institution Press.

STOLL, C. (1995) *Silicon Snake Oil: Second Thoughts on the Information Highway*. New York : Doubleday.

TAPSCOTT, D. (1998) *Growing up digital: The rise of the net generation*. New York: McGraw Hill.

TIERNEY, R. and DAMARIN, S. (1998) Technology as enfranchisement and cultural development: Crisscrossing symbol systems, paradigm shifts, and social-cultural considerations. In D. R. Reinking, L.D. Labbo, M. McKenna and R. Kieffer (Eds.) *Literacy for the 21st century: Technological transformations in a post-typographic world*. Mahwah, NJ: Erlbaum, pp. 253–268.

TUMAN, M. (1992) *Word perfect: Literacy in the computer age*. London, UK: Falmer Press.

WARTELLA, E. and REEVES, B. (1983) Recurring issues in research on children and media. *Educational Technology*, June, 1983, 5–9.

WRIGHT, P. (1987) Reading and writing for electronic journals. In B. K. Britton and S. M. Glynn (Eds.) *Executive control processes in reading*. Hillsdale, NJ: Erlbaum, pp. 23–55.

Address for correspondence: PROFESSOR DAVID REINKING, Department of Reading Education, University of Georgia, 309 Aderhold Hall, Athens, GA 30602, USA. Email: *dreinkin@coe.uga.edu*