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A Model for Predicting an Individual's Use of a Telematics Application for a Learning-Related Purpose

BETTY COLLIS
University of Twente,
7500 AE Enschede, The Netherlands
collis@edte.utwente.nl

NICO PALS
KPN Research -ITB, The Netherlands
n.pals@research.kpn.com

Telematics, the combination of communication and information technology, offers a wide range of possibilities for education. Telematics applications include e-mail, groupware, and all the possibilities of the World Wide Web (WWW). Educational institutions and jurisdictions throughout the world are investing in Internet access and in creating the conditions so various kinds of telematics applications can be available to teachers and learners. But a major question is: Will the intended users, teachers and learners, actually make use of all these possibilities? What factors have the most impact, both positive and negative, in terms of the individual teacher or student's decision to make use of a telematics application? In a research project underway in The Netherlands, using data from a number of countries, these questions are being addressed. In this article we describe the theoretical model derived for our research. The model involves four main clusters of variables related to external context, educational effectiveness, ease of use, and personal engagement and is thus called the *4-E Model.* The paper develops this model theoretically. It also briefly describes how it is being validated and gives indications of how the model can be applied in practice.

Telematics, the combination of information and communication technologies, offers many possibilities for education. These possibilities relate to various combinations of the use of telematics tools, applications, systems, and services for publication and information dissemination, communication support, collaboration support, support for information and resource acquisition and processing, and for specialized learning-specific purposes. Table 1 shows some of the many types of telematics tools and applications now available for learning-related purposes.

Table 1

General Categories of Telematics Applications in Terms of Learning-Related Purposes, and Examples (from Collis, 1998)

The possibilities have been discovered, experimented with, and documented throughout the world, shared via many conferences (such as *ED-MEDIA*, *WebNET*, *ICCE*, and *SITE* (http://www.aace.org/conf/) and publications. Publications are not only in print, (e.g., Collis, 1996b; Harris, 1998; Khan; 1997, each of which in itself contains many further references and links), but also available via the WWW. (Particularly useful portal sites include *BlueWeb'n Learning Sites Library,* http://www.kn.pacbell.com/wired/bluewebn/, and *Evaluating Web Sites for Educational Uses: Bibliography and Checklist,* http://www.unc.edu/cit/guides/irg-49.html, Kotles, 1997).

However, despite all the possibilities, the actual voluntary use of telematics applications as a purposeful part of the instructional delivery of a course or related to a classroom lesson is still far from widespread. In Finland, for example, where network access is possibly the best in the world in terms of the proportion of the population who have access to the Internet, "teaching and learning in universities and polytechnics has not changed that much with respect to the use of telematics" (Kauppi & Vainio, 1998). In the US, "teachers have by and large not embraced new technology tools" (Inge, 1998, p. 5) and "teachers are often apathetic toward technology, often viewing its use as taking too much time for what needs to be accomplished in a day" (Inge, p. 5, citing Darling-Hammond, 1996). Such problems are not unique to education. The RETAIN Project (1998), for example, funded by the European Union, is studying the implementation of telematics in health care throughout Europe, and has come to the following conclusion: "As with other telematics sectors, there appears to be a significant mismatch between expectations of what telematics can deliver for health care in Europe and what has actually been achieved."

A simple response to the gap between the potential and the widespread use of telematics applications in educational practice is to say that there is not enough hardware or network access, or that instructors have not had enough training and support. While these reasons are valid in many cases, they do not offer a solution in themselves. This has been demonstrated through nearly three decades of efforts with respect to computers in education. For example, although the TLTP national initiative in the UK to support technology use in higher education has been carried out in an exemplary way and many high quality computer-aided learning resources are available as a result, "their successful integration into courses seems to be something of a problem" (Gunn, 1996, p. 157) and the best chance of getting used is to find "niche markets" for different highly specialized computer-related resources that address a tailored, very specific problem in a certain local setting (Draper, 1998). But such high specialization is not conducive to widespread use and often does not extend beyond the pioneer.

The gap between potential and use in practice is an implementation problem. Despite being well studied over several decades with respect to computers in education (e.g., Cuban, 1985), and during the last decade with respect to telematics applications in education (Collis, 1992a,b; Riel & Levine, 1990; for early summaries), a solution has not yet been found. Nonetheless, large investments are being made in networks, and particularly Internet, access in schools and universities. Although models have been developed to help explain implementation (e.g., Abou-Dagga & Huba, 1997; Collis & Verwijs, 1995; Newhouse, 1998; also a review of models follows later in this article), the need continues for more insight into the implementation problem. A model that is conceptually simple but powerful enough to steer predictions about an individual's likelihood of use of a telematics application in his or her learning-related acitivities can be useful to a wide variety of actors, including those in educational jurisdictions who make the decisions about network-related expenditures. For the model to be useful, it should be easily conceptualized, even to the extent of the critical relationships expressed within it being encapsulated in a single phrase, and it should be operationalized via an instrument that can be used as a predictive and practical tool.

The development and validation of such a model and instrument is the focus of a two-year research project in The Netherlands, in collaboration between KPN Research ITB (a research group related to the national telecommunications utility; http://www.kpn.com/research/en/schema/frame_itb.html) and the University of Twente (with a national and international reputation in terms of telematics research and telematics implementations in its own teaching activities; e.g., http://www.ctit.utwente.nl). The project has as its practical goal, the development of an instrument to predict an individual's likelihood of use of a telematics application for a learning-related purpose and to identify ways to improve the chance of use in practice (Collis & Pals, 1998). The project has as its theoretical goal the development and validation of a model to underlie such an instrument. In this article such a model is developed based on a literature review.

The article first presents a synthesis of relevant literature,in terms of examples of case studies, articles that in themselves have synthesized various studies and practical experiences, conceptual perspectives on implementation, and models already in the literature. From this synthesis, a new model is derived. The article concludes with a description of how the model is being empirically validated and a discussion concerning the implications of the model for the implementation of telematics applications in educational settings.

LITERATURE REVIEW

In this section, a synthesis of relevant literature is given in terms of examples of case studies, of articles that in themselves have synthesized various studies and practical experiences, of conceptual perspectives on implementation, and of models already in the literature. To be included in the synthesis, experiences relating to use in actual educational settings must have occurred or, in the case of the conceptual reviews, be the intended domain of the analysis. Actual settings are meant to be within the context of regularly scheduled courses and classes and with an instructor involved who is the person normally associated with those courses and classes. Researchers may be part of the experience of the telematics use, but the intention of the analysis is (eventual) reproducability or sustainability within normal operating conditions. From a substantial database of articles and reports meeting these criteria, only a representative sample will be cited in this review (for an earlier synthesis, see Collis, 1993). Most of the reports used for the current synthesis are from 1996 to the present; when an earlier article is cited it is the opinion of the authors that the perspectives expressed are still (in 1998) relevant. The section concludes with an identification of the variable clusters that appear most relevant for implementation.

Learning From the Individual Case

The individual case can be an important source of information with respect to the implementation of telematics applications in a learning setting. From a detailed description of their experiences and reflection on those experiences, those involved can see patterns and lessons that are useful for their own further work but also useful to share with others considering similar implementation approaches. A substantial proportion of conference papers and articles in professional journals as well as reports for limited circulation, such as those at the completion of a special project, are of this individual-case nature. In general, two main categories of cases can be identified: those involving telematics use in courses in higher education, and those involving a special project or an initiative within an educational institution.

Cases describing implementation in courses in higher-education. Case studies of course-specific applications of e-mail, computer conferencing, and more recently, WWW-based course-support environments in higher education appear consistently in the literature. Many different orientations can be found. A number of them focus on student perceptions of and reactions to telematics-mediated learning activities. Grint (1990), for example, observed that in a course on information technology offered by the Open University in the UK, only a minority of the students actually participated in discussions using computer conferencing even though they regularly used the e-mail aspects of the computer-conferencing environment. He identifies sensory overload, software problems, discomfort with having one's writing made public and "indelible," status discomfort, and gender differences as key factors relating to the relative non-use of computer-conferencing discussions. With respect to gender, Grint found through follow-up interviews that there was a perception among the students that messages relating to technical issues were perceived as objective, valid, and accurate whereas "sociologically informed information was normally perceived as biased, subjective, and irrelevant" (p. 192). Coupled with this perception was the perception that technically oriented messages were likely to come from male students while females were more likely to use the conferencing to ask for help or discuss problems.

In order to prevent such barriers to participation, many instructors and researchers have analysed the social dynamics of computer conferencing, and evolved strategies and recommendations for stimulating a positive social culture around telematics use in a course context. Sellinger (1998) for example, bases her approach to the development of a "critical community" in her courses on principles of social constructivism and Schön's theory of the reflective practitioner. Concern is not only focused on developing a sense of community; Olikowski (1992) is among those who stress the importance of a telematics application (in her case, groupware) fitting into the existing community of the classroom or workplace. In her case study of the introduction of a groupware product into a large organization with the intention of providing a base for just-in-time-learning, she concludes that "when the implementation of groupware ignores the social values of an organiszation the projects are likely to fail" (p. 368). Watson, Ho, and Raman (1994) studied the use of groupware tools in cases from the United States and Singapore, and concluded that "culture, particularly in a group setting, is a more powerful influence than technology" (p. 53) on the individual's use of the technology.

- A general conclusion of cases described with a social-psychological perspective appears to be that social and cultural aspects have an important influence on implementation.

While the studies mentioned in the preceeding paragraph are typical of many analysing psycho-social and cultural aspects affecting the likelihood of use of telematics applications, particularly computer conferencing and groupware, Posner, Danielson, and Schmidt-Posner (1992) represent a different perspective also common in the literature, a perspective focused on how effectively telematics use is integrated into an overall course or lesson. They studied the use of e-mail and bulletin-board systems within various cycles of a course in business adminstration from the perspective of the perceived benefits of the use of the application relative to course requirements. Like others (for example, Dijkstra, Collis, & Eseryrl, 1998), they found that the majority of students may not make use of the application if there is not a compelling reason for them to do so. In the course context in higher education, “compelling” means that the use becomes required for course completion, with graded assignments that require use of the applications. In itself, the bulletin-board system offered by Posner and his colleagues to their students “met a need that did not exist” (p. 18) among the students. Once the submission of reflective comments to the bulletin board became a graded part of the course requirements, the students used the telematics applications and indicated that they appreciated the experience. If not integrated into course requirements by the instructor, students typically do not have the time or motivation for optional use.

- A more-general conclusion is that the use of a telematics application is likely to increase to the extent to which such use is integrated instructionally with the rest of the course activities, and from the student’s perspective, the use is evaluated by the instructor and quantified in some way to form part of the course grade. The educational benefit of the use of the telematics application must be clear.

In contrast to an instructional-integration perspective, Hansen, Chong, Kubota, and Hubbard (1993) are typical of many who focus on management, technical, and logistic problems confronting both the instructor and student when trying to integrate a telematics application (in their case, computer conferencing) into a course situation. The main problems Hansen and his colleagues cite from their experiences with their own courses relate to difficulties in adequate access to computers and networks, time constraints, and work-pressure increase. For instructors, “when students start entering their comments into the electronic conference, the instructor immediately feels confronted with a new and overwhelming assessment task. Students have come to expect that everything they put in writing will be graded by the instructor...a conscientious instructor feels the need to provide feedback to the students’ writing” and students expect the personal feedback. For students, the extra time required to access a computer to carry out the telematics-mediated acitivities was also seen as a problem. Messing (1998) also analysed student tolerance of technical problems, in his case related to making use of an “electronic study guide” in a distance-education setting, and found that the tolerance and the perception of value were different for students with different prior experiences and different attitudes about technology. Those at the beginning of the course who were positive about technology in general perceived the benefits of the electronic study guide to be positive, were not troubled by technical difficulties in using the resource, and felt it an intellectually pleasant experience. Opinions opposite to these were expressed by those students whose prior experiences and attitudes about technology were less positive.

- In general, case studies of uses of telematics applications in learning situations agree that there are consistent problems encountered by instructors and students with regard to adequate access to the appropriate computer and network infrastructure useful for meaningful instructional use of telematics, that such use typically involves a learning process in terms of becoming familiar with the software involved, that telematics applications can add to instead of reduce the time usually spent on a learning-related task, and technology-related problems such as access to printers and needing to change one’s familiar way of carrying out learning-related activities all affect implementation.

- In addition, studies such as Messing’s indicate that individuals differ in their predispositions toward telematics use in learning-related contexts, and that these differences are related to their subsequent perceptions of what actually occurs when the telematics application is encountered in practice.

Cases describing projects or initiatives. A large number of studies have documented a special project occurring in one or several classrooms in which younger students make use of either e-mail or, more recently, e-mail and the WWW for a learning-related activity. Harris (1998) categorizes such projects according to the dominant type of learning-activity involved, interpersonal exchange, information collection and analysis, and problem solving. In addition, many such projects have the additional goals of bringing new learning possibilities into the school and classroom, raising the experience level of the school and instructors with respect to the possibilities of telematics use, and contributing to the general development of the students with regard to their technological literacy and of the school in terms of its level of technology use. Implementation reports related to projects primarily relating to e-mail have been in the literature since the 1980s. Hiltz and Turoff

(1985) for example analyse the effects of the instrumentation and the why learners use the instrumentation on the subsequent successful use of computer conferencing.

Implementation problems of a large variety are still present in classroom-to-classroom collaborative activities involving telematics. McCahill (1998) for example reports the major problems confounding her attempts to carry out collaborative activities involving schools in Canada and China. She notes that the three major problems for the teachers involved were time, financial concerns, and technological limitations. Time was related to tasks that involved the coordination of many players, requiring extensive communication as well as the time needed to create a WWW site to facilitate the communication. Technological limitations related to the selection and installation of software and hardware and the creation and maintenance of the project's WWW environment for student use. While the author (who was one of the instructors involved), describes many positive learning benefits that she believes resulted from their collaboration, she also notes that "obviously the learning described above did not flow merrily into the educational stream. Rather it often gurgled wearily to the surface after clogged hours of uphill struggle" (p. 7), with the "dreamers' visions melting into puddles of exhaustion" (p. 2). Nonetheless, the instructor perserved, believing the benefits to be worth the efforts. From many such case studies, it can be concluded that:

- Many problems face the pioneer instructor carrying out a telematics-related project, but the pioneer instructors continue, believing the benefit more than compensates for the effort involved.
- The importance of having enough time and of being able to handle the network and telematics products is a persistent concern.

While McCahill describes the efforts of two individual instructors who evolved a process of working together based on a shared vision, many project reports describe initiatives where more persons and institutions are involved and thus the vision of the leaders of the project may be one or two steps removed from the actual settings in which the project activities take place. For example, five European countries are taking part in the *FETICHE Project* whose goal is to "explore the reality of communications between teacher trainers in the university and their co-tutor partners in schools" (Watson, Blakeley, & Abbott, 1998, p. 15). The overall project involves national projects in each of the five countries involved, in which a way for teacher-education institutions and schools to work collaboratively is to be developed and carried out. In the UK national project, Watson and her colleagues note that after a period of initial discussion, in which participants focused on how to concretely set up such a collaboration (it was decided that a new course would be developed), the project was slowed down considerably because (a) schools are not able to place project work high in their agendas, (b) many levels of bureaucracy need to be involved in terms of any decision involving the schools, (c) technical connectivity among the participants in the project was time-consuming and unexpectedly complex, and (d) there was generally a low level of technical expertise. They note the importance of institutional commitment for the schools. The lack of time again was cited as a many constraint; "…although all expressed a willingness to take part in the experiment, the time and problems that it actually involved appeared to inhibit real involvement. Were it a special timetabled activity with the active support of management, then there might have been a greater chance of success" (p. 20).

- In general, institutional commitment is an important component of implementation success.

In The Netherlands, a similar project was more successful then the project described by Watson and her colleagues. This project involved a closer and more-ongoing communication between the project leaders and both teachers and school management in 39 elementary schools in a particular region. Sixteen sub-projects relating to the use of e-mail and the WWW for various subject areas were developed, and carefully supported. A project WWW site, with separate views for teachers and students, was prepared with considerable attention to the attractiveness of the user interface. Based on the evaluation results (Bruining, Pals, de Kleine, & Steen, 1998), the project was a success, with the major perceived benefit being heightened motivation on the part of the learners. However, there were substantial differences in the use of the various subprojects. The teachers' valuation of an activity was a combination of its educational usefulness, the degree to which it was pleasurable and motivating for the students, and how easy it was to use, both in terms of fitting into the busy school day and also in terms of the user interface of the WWW-based application itself. Time was again a major constraint. Many practical and technology-oriented recommendations problems needed to be solved during the project. The schools were positive about the project, but indicated that once the project's financial support was ended, the schools were not likely to be able to find funding themselves to keep such telematics-based projects in operation (Bruining, Pals, de Kleine, & Steen, 1998).

- Ease of use of the instrumentation involved, and concern about the financial implications are two major issues.

Variations of problems associated with time, unexpected time delays in getting a project operational (both technically and in terms of the persons and institutions involved), technical issues related to the instrumentation (for example, WWW-site design, development, and maintenance), and the difficulty of integrating any special project into the already-crowded curriculum and timetable of the school are found in many of the case-study reports relating to telematics applications and their use in schools. For example, Cunningham, Kent, and Muir (1998) report on the *CyberOlympics Project* involving 17 elementary schools from five different countries and note many benefits, such as building up of interpersonal links among the participants that will continue (via e-mail and the WWW after the project is over). It was agreed that the success depends on “being integrated into the pupils’ curriculum rather than being bolted on as an extra” (p. 65). Key implementation problems included: not enough time and issues related to the sending and handling of attachments and graphics as well as to the user-interface design.

- In general, school-based projects share implementation projects related to unexpected delays, unexpected technical problems (such as the time and effort it can take to send and receive attachments), lack of teacher time, and difficulties in fitting “special events” into the crowded day and curriculum.

Similar problems also confront projects involving training in large organizations. Sippel (1994) analyzed the experiences of the *Multimedia Teleschool Project* (MTS), involving the use of various telematics applications in companies where an established training programme is already in place. Sippel found that the involvement of technical staff within the institution was of critical importance, in that they will be called upon for considerable technical help. He also found that those in the established training programme need to be convinced that new approaches will not threaten or diminish their own roles. Another of his conclusions related to the importance of anticipating the time that learners will need; previously a course could be well planned for in terms of time, with a precise number of face-to-face sessions and familiar activities in-between (i.e., reading a textbook). With the use of telematics applications, and the ability to add on-going communication, access to a broad range of supplementary resources, and more flexibility in course participation, the ability for employers and learners to plan their study time becomes more problematical. Brown (1997a) also comments on the cultural change required of existing training organizations within a company when considering the use of telematics applications, in that the trainers will be expected to move from an approach and accompanying media and resources with which they have long familiarity to new sorts of approaches and technical resources with which they have no familiarity and which are often based on different underlying visions of teaching and learning.

- The importance of *fit*, a close correspondence between one's familiar (and preferred) ways of working and learning and the ways in which a telematics application is used, appears regularly in the literature as a key variable influencing user acceptability.

This is supported by experiences outside the educational field. For example, Anderson (1997) reports on physicians' usage of clinical information systems, networked environments for integration of information about the patient from many different sources within a hospital and also beyond. Even though many benefits for all parties involved could result from physicians entering their case notes into an shared information system rather than maintaining the current practice of hand-written notes maintained by the physician, Anderson found that most physicians are not making use of the database systems. Clinical information systems...”impose major limitations on how clinical data are recorded and how the medical record is organized. They interfere with the way that physicians organize their thought processes in caring for patients. This loss of individualism in constructing a medical record causes resistance by clinicians...When clinical information systems interfere with traditional practice routines, they are not likely to be accepted by physicians” (p. 87). Anderson's observation is equally relevant for educational professionals, substituting comparable terms, such as learner instead of patient.

- Thus, “fit with existing practice” is a major variable affecting implementation.

Underlying the majority of the case studies relating to telematics implementation in their particular settings is the conviction that society as a whole is moving into the information age, and “that information technology will transform our lives and our world in the new century” (Gates, cited in Dertouzos, 1997, p. vii). A similar sort of technology-push that confronted educational decision makers in the early 1980s is reoccurring with respect to the Internet (Collis, 1996a). Educational decision makers feel compelled to support access to the Internet; there is a feeling that if one does not, then students are disadvantged and the institution in itself will fall behind. Schools must reflect the rapidly increasing use of the Internet in society as a whole. These sorts of messages are implicit in many reports.

- Developments in technology, particularly Internet technology, and the publicity and support given them in the media, create a technology push that can cause an institution to continue experimenting with new technologies, with the predictable implementation problems ensuing.

Synthesizing From a Variety of Cases

In addition to many individual-case studies, there are also many reviews and syntheses appearing in the literature in which a number of cases involving the implementation of telematics applications into learning settings are examined, and their results combined so that a set of guidelines emerges. Each set of guidelines tends to have its own perspective, and thus will have its own emphasis. For example, Brown (1997b) summarizes a variety of case studies from industry and also higher education involving the implementation of computer-related techologies (including telematics) into their educational delivery. Ten guidelines were derived, based on his analysis of the different cases. These include:

- Have a clear vision of change that relates to the needs of the organization and communicate this effectively.
- Ensure you have at least one influential champion on board who can ensure the support of key power groups and where necessary, impose conditions such as compulsory staff development.
- Motivate people to want to change by building in rewards.
- Allay concerns about impact on teaching methods, workloads, and job security. (pp. 194-195)

These differ in tone and emphasis but also in more fundamental ways from many of the other sets of guidelines, for example, as a comparison, those of Erwin (1990). Erwin based his guidelines on a number of years of experience with approximately 200 schools participating in the *Computer Pals* network in the 1980s. Erwin extracted guidelines such as the following as most important for the success of e-mail projects in schools:

- Establish a strong relationship among the teachers involved, a solid understanding of each other's expectations and timelines; and
- make a commitment among participating teachers that they should be in contact with each other at least once per week and that they can rely on a certain day during each week when messages can be checked (p. 15).

Erwin's guidelines assume the individual teacher must be responsible for the success of a telematics project, whereas Anderson's guidelines see the leadership and strategic aspects of the organization as the major components.

Many such sets of guidelines, based on the synthesis of a number of separate cases, can be found in the literature, the diversity among them represented by Anderson's and Erwin's conclusions. Table 2 extracts some typical guidelines from a series of such syntheses.

In summary, there are many different orientations and sets of guidelines possible for predicting and improving the likelihood of telematics use in learning settings. In this section, only a sample of such sets of guidelines has been offered, in each based on the synthesis of some number of experiences. Main categories of variables that emerge from this analysis include:

- Variables related to the organization in which one works and studies;
- variables related to the social and cultural setting in which implementation is to occur;
- variables relating to technological developments and *technology-push* factors;
- variables related to the perceived educational value of the telematics application;
- variables related to facilitating conditions, such as time, fit with familiar way of working or studying, support, technical infrastructure, software characteristics, and access to network technology; and
- variables relating to personal background and reaction to events involving telematics applications

In the examples so far, the researcher has focused on what has taken place in a realistic learning setting when someone decides to make use of a telematics application. There are at least two other approaches that appear in the literature: approaches that are conceptual in nature, to focus on hypothetical individual users and looking for patterns of response to telematics applications for learning-related purposes that predict behavior; and approaches that attempt to model the system of variables that together have the most effect on eventual use in practice. Conceptual models for the change process in terms of the individual confronting technology use for learning-related purposes are discussed in the next section.

Table 2

Guidelines for the Implementation of Telematics Applications in Educational Settings: A Sampling

Conceptual Perspectives on Implementation

For almost 30 years, the implementation problem relating to technology-related resources in educational settings as been a subject of concern for researchers studying the teacher's or learner's response to innovation involving technology. There are a number of conceptual models based on the ideas that individuals will move through predictable phases in terms of their response to a technical innovation, and that in a given population a distribution of individuals over categories of response can be expected. Several of these will be summarized here.

In the 1970s, researchers at the University of North Texas developed a model (the Concerns-Based Adoption Model, (CBAM); Hall, George, & Rutherford, 1979) to predict and explain the relatively slow uptake of teachers to the use of a technological innovation in their instructional practice. In their model, an individual goes through a series of seven predictable "stages of concern" about the innovation, starting with the concern of not having enough information and moving through several levels of concern relating to his or her own personal competency in adapting the innovation before concerns related to more than routine use of the technology can be expected. The CBAM Model has been extensively used to help understand the differential response of teachers to the possibility of being able to make use of a technological innovation in their instructional practice (e.g., Wells & Anderson, 1997; Manley, 1998). Somewhat parallel to the CBAM approach, McGonigle and Eggers (1998) talk about "stages of virtuality" in terms of instructors' and students' transition into making use of the Internet. They define seven stages (as did the CBAM researchers) but different in their aspects. For instructors, McGonigle and Eggers suggest that the following seven stages will be experienced: an excited stage ("Guess what, I can make use of the Internet!"); an apprehensive stage; a questioning stage; a determined stage ("Now I am actually going to try to make this happen...")'; an overstimulated stage ("Managing the communicative dilemmas brought on by the energized Internet can be overwhelming..." (p. 24); the questioning stage revisited, and the exhausted stage. McGonigle and Eggers also identify stages of virtuality for students: the confused stage, the shock stage, the timid stage, the frustrated stage, and the Eureka stage ("It's over...! and I have successfully handled it").

- As a conclusion, individuals can be expected to react differently to the use of telematics in the instructional context, but can also be expected to move through a series of somewhat predictable reactions.

Another well known conceptual model with respect to innovation was developed by Rogers in 1983 and still routinely cited (e.g., Northrup, 1997; Siegel, 1998). Roger’s *Innovation-Decision Model* suggests that an innovation is likely to be accepted by an individual if it has the aspects (among others): relative advantage compared to the current practices; compatibility or fit to the previous experiences, values, and needs of the individual; trialability, the degree to which the innovation can be tried out in non-threatening and experimental circumstances; and observability, the degree to which the efforts made will be observed and valued by others. A negative influence is complexity, the degree to which the innovation is perceived to be difficult to use. Rogers also emphasizes the impact of the individual’s social network and its norm on the decision to make use of an innovation. He claims that “the heart of the diffusion process is the modeling and imitation by potential adopters of the near-peers’ experiences who have previously adopted a new idea” (1995, p. 304). In a recent study in The Netherlands, the importance of peer influence on the teacher’s implementation decisions was also reaffirmed (Moonen, 1995). Rogers also suggests that “adopter categories” can be predicted in the implementation timeline, distributed normally as Innovators (2.5%), Early Adopters (13.5), Early Majority (34%), Late Majority (34%), Laggards (16%) (p. 262).

- The fit of the telematics applications to the social norms of the community to which the instructor belongs will have a major influence on implementation.

Another researcher who has been long active with implementation research is Fullan (1982, 1991). Fullan tends to focus on change as a process, with phases relating to the events leading up to the decision to proceed with change in an organization, the events occurring in the initial period of the change process, and the events leading to routine use. Fullan’s work emphasizes the view that many different factors have an influence on the change process. In his 1982 book he lists various factors and discusses them at length, but the visualization of the factors into a causal model does not occur.

- In summary, there is a conceptual foundation for predicting how individuals will respond to telematics innovations in their learning-related activities. We can expect that individuals will respond differently, and that some series of types of responses may be likely to occur.

The conceptual models developed by Hall and his CBAM colleagues, Rogers, and Fullan have been in use for many years and yet the need to understand implementation problems and act upon this understanding still is present. Models that integrate more aspects of the overall problem domain, especially in terms of the technological and cultural contexts of the late 1990s, but do this with as few variables as possible, can still serve a purpose.

Models for the Prediction of Implementation Success

A model is a visualized representation of key variables in a complex system, including the relationship of those variables to each other. A causal model attempts to explain the impact of the variables in the system to the outcome variable. In implementation research, an important outcome variable is related to the likelihood of an individual making voluntary use of an innovation in his or her own practice. Causal models are typically built on the basis of a synthesis of previous experience, in terms of a logically argued relationship. Causal models can be tested against sets of data to support their validity although in general they cannot be proved, only supported. The support can be expressed in terms of statistical indicators of goodness of fit. It can also be expressed in terms of the perceived value of the model by those for whom its use is intended. Several current models relevant to the prediction of telematics applications in learning settings are described below.

Newhouse (1998) constructed a model using measures related to the CBAM concepts, but also positioning those concepts as variables under the influence of other clusters of variables, in particular external entities (parents, school, teacher peers,etc.); (a) variables related to the classroom learning environment; (b) variables relating to teacher beliefs, attitudes and perceptions; (c) to student attitudes and skills; and (d) to obstacles such as features of the physical classroom, computer systems, and curriculum. He used his model to interpret the uptake of computer and network use over a three-year period in a school. The model was not tested statistically; from its application to a single case it seemed a helpful interpretive framework.

Not coming from a basis of educational research, but from research in organizational theory, Fulk, Schmitz, and Steinfield (1990) developed a social-influence model of technology use. In this model, variable clusters representing media features, social influence, task features, media experience and skill, and task experience, and skill together influence the variable clusters media evaluations and task evaluations. Taken together these variables, along with situational factors relating to individual different, facilitating factors such as accessibility of media, and constraints such as geography, all influence the outcome variable, media use. They do not indicate an empirical test of their model.

- Social influence is a major factor affecting implementation success.

Some models have been tested empirically. Golden, Beauclair, and Sussman (1992) developed a simple three-factor model, with media (in this case, e-mail use in an educational institution) expressed as being influenced by perceptions of the media, managerial roles used, and organizational and social pressures. A factor analysis of the responses to their questionnaire yielded a four-factor structure: task orientation, usability, direction of communication, and openness of communication. Factor scores based on these factors were combined in a regression equation that also included formal and informal pressure from within one's organization. The overall model had an F=4.99 (p< .001) with an $R^2 =$ .3625. From this, the researchers concluded that "the general thesis that qualities of the media, managerial roles, and critical mass and social pressure affect electronic mail use was accepted" (p. 305). Abou-Dagga and Huba (1997) constructed a model with six variable clusters influencing the outcome cluster relating to likelihood of use of two-way full-motion videoconferencing via fiber optics telecommunications, if and when such a network becomes available to the instructor. The factors hypothesized to influence this outcome were the individual's past experiences and inclination toward using any form of innovative technology, the individual's attitudes toward two-way full-motion videoconferencing in general and towards educational use in particular, the rewards or punishments that were expected to result from using the videoconferencing, the approval of significant others, and the degree of affirmation of self-confidence that were expected to occur from using the videoconferencing. The model was tested empirically with the result that a major source of variance in the system could be related to the variable relating to the teacher's previous habits with respect to using technical innovations in instruction. The researchers concluded that "teachers' likelihood of using (videoconferencing) increases when teachers perceive that the use of technology enhances their professional role as an educator" (p. 412).

- Past experiences and personal attitudes are critical to implementation.

As a final example, Mende and Curtis (1997) emphasized the need for a comprehensive and concise model of success criteria for instructional systems, and hypothesized that a set of four variables could serve this purpose.

These four variables are defined as technical efficiency, whether waste could be eliminated from existing practices; economic efficiency, whether cost could be decreased by altering the mix of inputs; user effectiveness, whether value could be increased by altering the mix of inputs; and marginal effectiveness, whether small increases in cost yield large increases in value. They further hypothesis that overall system success depends on the algebraic product of the four criteria. They note that their four criteria are similar to the "3-Es" (economy, efficiency, and effectiveness) recommended by Adams (1991; see also Moonen, 1997, who spoke of the 3-Es with respect to effectiveness, effort, and enjoyment). Mende and Curtis develop their model computationally but do not appear to have tested it with data from an empirical study.

Each of these models has its own contribution, but each omits some features deemed important in the literature. Newhouse's model relates the CBAM theoretical concepts about change to factors influencing that change. Fulk, Schmitz, and Steinfield stress the importance of perceived social norms and pressures, and also of characteristics of the instrumentation itself. Golden, Beauclair, and Sussman also stress social impacts and media characteristics, but add a focus on the individual's own sense of self-confidence and personal reward. Mende and Curtis, following Adams, emphasize the 3-Es of economy, efficiency, and effectiveness. Mende and Curtis also indicate the value of a simple-to-use model with which likelihood of success can be expressed numerically, based on a simple computation.

In summary, there is not yet consensus on how to model the factors the best predict likelihood of use of a telematics application in a learning-related setting. What is clear is that many factors are involved; a balance needs to be found between completeness of modeling, and usability of the model in practice.

Conclusion: Critical Variables for Implementation

Given the literature synthesized above, a model to predict the likelihood of use of a telematics application in a learning context should include attention to the clusters of variables and other aspects summarized in Table 3.

With regard to the outcome variable, likelihood of telematics use in a particular learning context, Rogers' (1995) emphasis on the impact of peer behavior on personal behavior and attitude formation implies that likelihood of use should not only be predicted or indicated by the individual about his or her own behavior but also a measure should be taken of the individual's perception of the extent to which significant peers and others in his or her social network are likely to make use of a telematics application in their own learning-related activities.

Table 3

Clusters of Variables for a Model to Predict Telematics Use in Learning-Related Practice

Table 3
Clusters of Variables for a Model to Predict Telematics Use in Learning-Related Practice (Continued)

With regard to the model itself, following Mendes and Curtis (1997):

- It should be as concise as possible, and yet represent a powerful combination of variables.

Also, again following Mendes and Curtis, attention should be given to facilitating the application of the model to practice; it should be:

- Quantifiable, expressible in a simple idea (i.e., Adams' 3-Es and Moonen's 3-E Model), and it should be capable of giving an numerical indication, based on a computational formula to reflecting the relationship among the variables, of the predictive and dynamic aspects of the model.
- It should be a model, stressing an interrelated system of variables, rather than only a set of guidelines. Guidelines can be derived from the model after it is validated. Finally, the model should be empirically validated.

And, with so much work already done in the area of implementation of technological innovations in education, there must be a distinct added value to the model and its subsequent uses compared to the previous work in the area. In the next section, a model that is hypothesized to meet these requirements is presented.

THE 4-E MODEL

In this section, a model to predict an individual's likelihood of use of a telematics application in a learning-related context, which in previous forms has been in use in The Netherlands for several years is described and its newest version introduced. The model reflects each of the clusters of variables indicated in Table 3, and also can be argued to meet the requirements noted at the conclusion of the last section for such a predictive model. The original model has been called the 3-G Model.

The 3-G Model

In the mid-1980s, Kappetijn, a Dutch telematics specialist, introduced the idea of expressing the individual's likelihood of use of a telematics application in terms of three aspects, which are called in Dutch, *gewin, gemak,* and *genot*. Gewin is Dutch for payoff or benefit, gemak is Dutch for ease of use, and genot is Dutch for pleasure of use (Kappetijn, 1989). Kappetijn's notion was the a person would be prepared to change his or her behavior (which occurs when starting to use a telematics application) if it is clear that the results will be better than they are with previous approaches, for example, a savings of time or money (gewin). Use may also occur just because the application is so easy to use (gemak), or so attractive to use (genot).

In 1991, the 3-G Model was elaborated through expressing the entities gewin, gemak, and genot as vectors with a common metric, and by the hypothesis that an individual's likelihood of using a telematics application in his or her teaching or learning (assuming a voluntary choice is involved) can be expressed as the vector sum of the three vectors (Collis & De Vries, 1991). Various terms in English to express the three vectors and still maintain an easy-to-remember alliteration (such as payoff, problems, pleasure; effectiveness, efficiency, enjoyment; advantage, accessibility, attractiveness) have been tried, but none seem to be fully appropriate translations for *gewin, gemak, and genot.* Since 1991, in a series of studies, the three vectors have been further elaborated (e.g., Collis, Veen, & De Vries, 1994). *Gewin* has come to relate to utility, but also to other payoffs that can accrue from using products that are not related to its functionalities, for example, enhanced status in an institution or increased chance of funding. *Gemak* relates to usability, not only at the instrumentation level but also at the situational and social levels, including the ease or difficulty with which a potential user can access an appropriate computer, connected to an appropriately functioning network. *Gemak* also takes in other factors external to the functionalities of the product, such as its cost, and in the educational context, its instructional and pedagogical fit. It relates also to Spohrer's *social fit*, (Spohrer, 1998) relating to the ease the user feels in trying out a new technology in the social environment of the workplace. *Genot* relates more to Spohrer's *cognitive fit*, the individual's own personal response to an innovation, and to the telematics innovation in particular. For some people, such as those who pioneer teleware in their teaching, we hypothesise that *genot* is high. According to the model, when the vector sum of these three vectors approaches a certain positive amount, use-in-practice is likely to occur; otherwise not.

Figure 1 shows the hypothesised 3-G relationship, as expressed by Collis and De Vries (1991), with an example where the vector sum approaches, but does not quite reach, the hypothetical "Likelihood of Use" threshold.

Figure 1. The 3-G relationship, expressed as a vector sum (Collis & De Vries, 1991)

Adding a Dynamic Threshold

The 3-G Model as shown in Figure 1 has served as a useful interpretive heuristic, but it has become clear that more variables are involved than could be encapsulated in just the three gewin-gemak-genot constructs. In this framework, Messing (1998) added another dynamic to the 3-G Model. He introduced the idea of variable threshold levels for the same individual vector values. Figure 2 shows how in Threshold Level A, the likelihood of use is lower than for Threshold B, while for Threshold C, the likelihood of use is now very high.

Figure 2. Variable threshold levels (adapted from Messing, 1998)

The 4-E Model

Collis and Pals (1998), in the context of the current research, have extended Messing's variable-threshold concept by suggesting that the height of the threshold line varies according to the influence of a variety of forces external to the individual. They call this combined set of exogenous variables a "4th G" and hypothesise that the Likelihood-of-Use prediction is not only a sum of the original 3-Gs but also critically affected by the 4th G, in that the latter determines the meaningfulness of of the vector sum (or, in figurative terms, the height of the "acceptance baseline." Because no alliterative Dutch-language term starting with the letter "g" can succinctly define a variable cluster relating to external aspects, the vectors are now re-defined in terms of the letter “e” and in English. The original gewin is defined as educational effectiveness, the original gemak as ease of use, the original genot as individual engagement, and the new fourth component as forces external to the individual. Three clusters of forces have been included in the fourth component relating to external influences. These clusters, relating to variables in the organizational setting in which the individual works or studies, to variables relating to the individual’s perception of the social and cultural values and norms related to telematics use in education, and to the individual’s perception of the impact of technological developments associated with telematics, are also the variable clusters appearing in the first three rows of Table 3. The educational effectiveness, ease of use, and personal engagement clusters relate to the fourth through six rows of the Table 3, respectively. Figure 3 shows the current “4 E Model.”

Figure 3. The 4-E Model (Collis & Pals, 1998)

The expanded model shown in Figure 3 indicates the influence of the “4th E,” the combined effect of three clusters of exogenous variables related to the external organizational, and social and cultural influences on the individual, and also to the technological developments occurring generally in the individual’s living and working environments. It is hypothesised that the sum of these vectors has an influence on the threshold level needed for likelihood of use to occur. This influence can be positive in terms of eventual implementation success, if the threshold line is “pushed” lower to the baseline and thus the vector sum needed for likelihood of use is lowered. But the influence can be negative if it serves to heighten the threshold, and thus make the likelihood-of-use level more difficult to achieve. In preparation for model testing, the cells have been regrouped as shown in Figure 4.

Figure 4. The 4-E Model, re-visualized for model testing

VALIDATING THE MODEL

Empirical validation of the model is currently underway, via the WWW, at http://projects.edte.utwente.nl/4emodel/. For the empirical validation each of the clusters in the model needs to be expressed in terms of a set of variables based on the literature. A questionnaire has been constructed, with one item per variable. In this section, the variables are defined, and the procedure has gotten underway for the empirical validation are described.

Variable Definitions

Row 1 of Table 3 indicated variables related to the influence of the educational organization in which an individual works or studies on the individual's subsequent likelihood of making use of a telematics application in a learning related context. Table 4 expands the definition of the variables related to this organizational cluster. References are given to literature cited in the earlier sections of this paper, as well as to other references pertinent to the variable.

Table 4

Variables Relating to the 4th E: Organizational Aspects

(continued)

Table 4 (Continued)
Variables Relating to the 4th E: Organizational Aspects

Row 2 of Table 3 indicated variables relating to the individual's perception of the social and cultural attitudes relating to telematics use in education. Table 5 expands the cluster into four variables.

Table 5
Variables Relating to the Fourth E: Social and Cultural Aspects

Row 3 of Table 3 indicated variables relating to the individual's perception of the impact that technological developments are having on him or herself. Five variables are defined, as shown in Table 6.

Table 6
Variables Relating to the Fourth E: Technology-Push Aspects

Row 4 of Table 3 indicated variables relating to the individual's perception of the educational value of telematics use. Table 7 gives the ten variables relating to educational effectiveness.

Table 7
Variables Relating to Educational Effectiveness

Row 5 of Table 3 indicated variables relating to the ease or difficulty of making use of a telematics application, or ease of use. Table 8 gives the 10 variables relating to ease of use.

Table 8
Variables Relating to Ease of Use

(continued)

Table 8 (Continued)
Variables Relating to Ease of Use

Row 6 of Table 3 indicated variables related to the individual's own personal reaction to telematics use, based on his or her background and aspects of personality and interests that have a bearing on the level of enjoyment felt. Table 9 gives seven variables relating to the personal-engagement construct.

Finally, the outcome measure to be predicted by the model needs to be operationalised in terms of the individual's opinion of his or her current and likely future use of a telematics application for a learning-related purpose. The specific telematics applications that are most likely to be named as those related to e-mail, those related to the use of WWW environments, and those related to videoconferencing. It is recognised that these functionalities can occur in the same environment. Also, following Rogers (1995), as a component of the outcome measure, the influence of one's peers is represented, through two variables asking the individual to predict the likelihood of his or her peers to be users of telematics for learning-related purposes.

Table 9

Variables Relating to Personal Engagement

Based on these variables, a questionnaire has been developed to measure these variables and subsequently to test the fit of the model. Data were collected during the period November-December 1998, with data analysis, model testing using LISREL, and an discrimination-function analysis followed in early 1999. As a result of the model testing, a WWW-based decision-support tool called *Tele-Meter*, was built and will lead the user through questions related to each variable cluster in the model, generating a user profile in terms of the 4-Es after the submission of the user's responses. (For more information, see http://projects.edte.utwente.nl/4EModel/4EM.html)

IMPLICATIONS OF THE 4-E MODEL

The 4-E Model and its resulting Tele-Meter instrument can be useful to at least four groups of persons involved with telematics applications for education. First, for decision makers, persons who must plan for the future, the model is easy to remember, to visualize, and to apply. Decisions about costly network provision are being made daily in educational jurisdictions, often based on only a partial analysis of what might eventually be used in practice. The simplicity of the model and the use of the instrument can help sharpen awareness of what is likely to be used by individuals in the system. More is not always better. Second, designers and developers of resources to be used in a networked environment need support in identifying in the future the sorts of products that learners and instructors will want to use. Third, persons involved in implementation projects can gain new insights into the factors that most influence the decisions of persons to make use of new technologies, and can try to see which of the variables can be manipulated to improve the chance of success. The dynamic nature of the 4-E Model, where changes in the external environment of the user can lower the threshold and thus reduce the distance needed for the vector sum of educational effectiveness, ease of use, and personal engagement to have to reach in order to increase the likelihood of a decision to use. Last, the research can be interesting to all those who are interested as researchers in the reasons why people act the way they do when confronted with the opportunity to make use of a technology innovation, and in particular, a telematics-based innovation, for their learning-related activities.

References

Aalst, J.W., Mast, C. van der, & Witkam, T. (1997, 21 November). *Spraakverwarring regeert multimediaprojecten* [Language confusion dominates multimedia projects]. Automisering Gids, nr 47, p. 15.

Abou-Dagga, S.I., & Huba, M.E. (1997). Factors related to teachers' adoption of a two-way interactive distance education technology. *International Journal of Educational Telecommunications, 3*(4), 401-414.

Adams, M. (1991). Evaluation and educational performance: Making sense of performance indicators in a managerial context. *Journal of Further and Higher Education, 15*(1), 3-16.

Anderson, J.G. (1997). Clearing the way for physicians' use of clinical information systems. *Communications of the ACM, 40*(8), 83-90.

Applegate, L.M. (1991). Technology support for cooperative work: A framework for studying introduction and assimilation in organizations. *Journal of Organizational Computing, 1,* 11-39.

Boh, B. (1994). *Interactive educational technologies in higher education*. ESP Discussion Paper Series, Education and Social Policy Department, The World Bank, Washington, DC.

Brown, S.C. (1997a). Corporate context and cultural change: Distance learing in BT [British Telecom]. In S. C. Brown (Ed.), *Open and distance learning: Case studies from industry and education* (pp. 37-54). London: Kogan Page.

Brown, S.C. (1997b). Curriculum or culture change? In S. C. Brown (Ed.), *Open and distance learning: Case studies from industry and education* (pp. 183-195). London: Kogan Page.

Bruining, J., Pals, N., De Kleine, E.A.J., & Steen, M.G.D. (1998). *Het schoolplein: Evaluatierapport pilot basisscholen Zwolle* [The Schoolgrounds: Evaluation report of the pilot study of elementary schools in Zwolle]. Groningen: KPN Research ITB.

Chiero, R.T. (1997). Teachers' perspectives on factors that affect computer use. *Journal of Research on Computing in Education, 30*(2), 133-145.

Clark, C. (1988). Two projects that worked: Using telecommunications as a resource in the classroom. *The Computing Teacher, 16*(4), 17-91.

Collis, B. (1992a). Supporting educational uses of telecommunications in the secondary school. Part I. An overview of experiences. *International Journal of Instructional Media, 19*(10), 23-44.

Collis, B. (1992a). Supporting educational uses of telecommunications in the secondary school. Part II. Strategies for improved implementation. *International Journal of Instructional Media, 19*(12), 97-109.

Collis, B. (1993). Telecommunications applications in education: A research taxonomy. *Australian Educational Computing Journal, 8*(2), 1-11.

Collis, B. (1996a). The Internet as educational innovation: Lessons from experience with computer implementation. *Educational Technology, 36*(7), 21-30.

Collis, B. (1996b). *Tele-learning in a digital world: The future of distance learning*. London: International Thomson Publications.

Collis, B. (1998). Teleware: Instrumentation for tele-learning. *Education and Information Technologies,* (in press).

Collis, B., & Pals, N. (1998, 15 May). *Validating the 3-G Model*. Paper presented at the national conference, Onderwijs Research Dagen (Educational Research Days), Faculty of Educational Science and Technology, University of Twente, The Netherlands.

Collis, B., Veen, W., & De Vries, P. (1994). *Final report of the CISO Project: Recommendations for an online service for Dutch education*. The Hague: PTT Telecom.

Collis, B., & Verwijs, (1995). Evaluating electronic performance support systems: A methodology focused on use-in-practice. *Innnovations in Education and Training International, 32*(1), 23-30.

Collis, B., & De Vries, P. (1991). *Vooronderzoek telematica in het voortgezet onderwijs* [Preliminary research: Telematics in secondary education]. Hoevelaken: PRINT-VO .

Cox, F., & Huisman, T. (1995). *De telerenscore 1995* [The tele-learning score, 1995]. Amersfoort, NL: SVE.

Cuban, L. (1985). *Teachers and machines: The classroom use of technology since 1920.* New York: Teachers College.

Cunningham, M.F., Kent, F.H., & Muir, D. (1998). The CyberOlympics: Schools, sports and the superhighway. *Computers & Education, 30*(1/2), 61-65.

Darling-Hammond, L. (1996). The right to learn and the advancement of teaching: Research, policy, and practices for democratic education. *Educational Researcher, 25*(6), 5-16.

Davie, L. (1990). Facilitation techniques for the on-line tutor. In R. Mason & A. Kaye (Eds.), *Mindweave: Communication, computers and distance education* (pp. 74-85). Oxford: Pergamon.

Dertouzos, M. (1997). *What will be: How the world of information will change our lives*. San Francisco: Harper Edge.

Devine, J., (1994). Integrating hypermedia in flexibleand distance learning: Findings and issues from one pilot implementation. In G. Davies & G. Tinsley (Eds.), *Open and distance learning critical success factors* (pp. 92-94). Erlangen, Germany: FIM.

Dijkstra, S., Collis, B., & Eseryrl, D. (1998). Instructional design for tele-learning. *Journal for Computing in Higher Education* (in press).

Draper, S. (1998). Niche-based success in CAL. *Computers & Education, 30* (1/2), 5-8.

Erwin, J. (1990). Computer Pals code of ethics. *Computer Pals Newsletter, 3*(1), 15.

Francik, E., Rudman, S.E., Cooper, D., & Levine, S. (1991). Putting innovation to work: Adoption strategies for multimedia communication systems. *Communications of the ACM, 34*(12), 53-63.

Fulk, J., Schmitz, J., & Steinfield, C.W. (1990). A social influence model of technology use. In J. Fulk & C. Steinfield (Eds.), *Organizational and communication technology* (pp. 117-140). Newbury Park, CA: Sage.

Fullan, M. (1982). *The meaning of educational change*. Toronto, ON: OISE Press, the Ontario Institute for Studies in Education.

Fullan, M. (1991). *The new meaning of educational change*. London: Cassell Education.
Gaines, B.R., Shaw, M.L.G., & Chen, L J. (1996). Utility, usability, and likeability: Dimensions of the Net and Web. In G. Marks (Ed.), *Proceedings of ED-MEDIA '96, Vol. 1* (pp. 167-173). Charlottesville, VA: AACE.
Golden, P. A., Beauclair, R., & Sussman, L. (1992). Factors affecting electronic mail use. *Computers in Human Behavior, 8*, 297-311.
Grint, K. (1990). Accounting for failure: Participation and non-participation in CMC. In R. Mason & A. Kaye (Eds.), *Mindweave: Communication, computers and distance education* (pp. 189-192). Oxford: Pergamon.
Gunn, C. (1996). CAL response: What questions are being answered? A response to the article "Integrative Evaluation." *In Computers & Education, 27*(3/4), pp. 157-160.
Gurchon, M.V., & Rijssen, E.H.V. (1995). Analyse van kriteke succes- en faalfactoren [Analysis of critical success and failure factors]. In W.B. Teeuw, D.D. Velthaus, & H. Bakker (Eds.), *Multimedia: van 'buzz' naar 'business'* [Multimedia: From buzzword to business] (pp. 83-132). Enschede, NL: Telematics Research Centre.
Hall, G.E., George, A., & Rutherford, W.L. (1979). *Measuring stages of concern about the innovation: A manual for the use of the SoC questionnnaire.* Washington, DC: US Government Printing Office. (ERIC Document Reproduction Series No. ED 147 342)
Hansen, E., Chong, S.M., Kubota, K., & Hubbard, L. (1993). Computer conferencing for collaborative learning in large college classes. *DEOSNEWS, 3*(4). [Electronic journal] Available via ACSDE@PSUVM.PSU.EDU
Harris, J. (1989). Tailoring telecommunications innovations to fit educational environments. *Educational Technology, 29*(11), 7-11.
Harris, J. (1998). *Virtual architecture: Designing and directing curriculum-based telecomputing.* Eugene, OR: ISTE.
Hiltz, S.R., & Turoff, M. (1985). Structuring computer-mediated communication systems to avoid information overload. *Communications of the ACM, 28*(7), 680-689.
Inge, C. (1998). *Staff development and training policy: Directions for the new millennium*. Project report, US WEST Foundation, Denver,CO. [WWW document] URL http://www.uswest.com
Kappetiijn, F.K. (1989). Diensten: Recente ontwikkelingen. In H. Bouwman & N. Jonkowski (Eds.), *Interactieve media op komst* [Upcoming developments in interactive media] (pp. 116-124). Amsterdam: Cramwinkel.
Kauppi, A., & Vainio, L. (1998, 23 September). *The state of the art of learning technology in universities and polytechnics: Findings of the assessment project of the Finnish National Fund for Research & Development (SITRA).* Paper presented at the conference Networks of Skills & Competencies, Joensuu, Finland.
Khan, B. (1997). *Web-based instruction*. Englewood Cliffs, NJ: Educational Technology.

Kotlas, C. (1998). *Evaluating Web sites for educational uses: Bibliography and checklist.* Center for Instructional Technology, University of North Carolina at chapel Hill. [WWW document] URL http://www.unc.edu/cit/guides/irg-49.html

Kraut, R.E., Rice, R.E., Cool, C., & Fish, R.S. (1994). Life and death of new technology: Task, utility and social influences on the use of a communication medium. In In T. Koschman (Ed.), *Proceedings of CSCL '95, the Conference on Computer Supported Cooperative Work* (pp. 13-21). Chapel Hill, NC: ACM.

Leggett, W. P., & Persichitte, K.A. (1998). Blood, sweat, and TEARS: 50 years of technology implementation obstacles. *Techtrends, 43*(3), 33-36.

Mahoney, M.J. (1994). Beyond pedagogy and technology: Critical factors in the policy environment for distance and open education. In G. Davies & G. Tinsley (Eds.), *Open and distance learning critical success factors* (pp. 139-142). Erlangen, Germany: FIM.

Manley, K.; & Brooks, D.M. (1998, March 10). *Using the Stages of Concern questionnaire as an ancillary tool to evaluate the effectiveness of the TEAM Approach.* Paper presented at SITE '98. Washington, DC.

Massey, W.F., & Zemsky, R. (1998). *Using information technology to enhance academic productivity.* [WWW document] URL http://www.cba.bgsu.edu/amis/facstaff/masman/taskfrc/MASSY.HTML

McCahill, P. (1998, 12 October). *Learning through cross-cultural collaboration: The joys and woes of our Web site classroom.* Paper presented at the ICCE '98 (Sixth International Conference on Computing in Education), Beijing, China.

McGonigle, D., & Eggers, R.M. (1998). Stages of virtuality: Instructor and student. *Techtrends, 43*(3), 23-26.

Mende, J., & Curtis, D. (1997). Four major success criteria of instructional systems. *Innovations in Education and Training International, 34*(4), 307-314.

Messing, J. (1998). Are we really doing students a favour? A study of the use of an electronic study guide in distance education. In I. Tomak (Ed.), *Proceedings of ED-MEDIA '98* (pp. 960-965. Charlottesville, VA: AACE.

Mitra, A. (1998). The notion of functionality in the faculty use of e-mail for instruction. In I. Tomaz (Ed.), *Proceedings of ED-MEDIA '98, Vol. 2* (pp. 972-976). Charlottesville, VA: AACE.

Moonen, B.H. (1995). *Een onderzoek naar de factoren die het gebruik van informatietechnologie in de klas veroorzaken.* Masters thesis, Faculty of Educational Science and Technology, University of Twente, Enchede.

Moonen, J. (1997). Analogue paths next to digital highways. In. R. Pavlova (Ed.), *Multimedia systems for higher education*: Workshop proceedings (pp. 43-52). Sofia, Bulgaria: MMG Laboratory, Technical University of Sofia.

Mutton, R. (1994). *Technologically mediated instruction*. Ontario University Media Directors, Toronto. [WWW document] URL http://www.nib.unicamp.br/recursos/distance_education/techno-instruction.html

Newhouse, P. (1998). *Teachers' responses and classroom learning environments associated with student access to portable computers.* Unpublished doctoral dissertation, Curtin University, West Australia.

Northrup, P.T. (1997). Faculty perceptions of distance education: Factors influencing utilization. *International Journal of Educational Telecommunications, 3*(4), 323-358.

Orlikowski, W.J. (1992). Learning from NOTES: Organizational issues in groupware implementation. In J. Turner & R. Kraut (Eds.), *CSCW '92: Sharing perspectives* (362-368). New York: ACM.

Posner, B.Z., Danielson, R.L., & Schmidt-Posner, J. (1992). Factors in the adoption and use of an electronic communication system for MBA students. *Journal of Educational Technology Systmes, 21*(1), 5-19.

Riel, M., & Levine, J.A. (1990). Building electronic communities: Success and failure in computer networking. *Instructional Science, 19*(2), 145-169.

RETAIN Project (1998). *RETAIN-Radiological Examination Transwer on ATM Integrated Networks: Current status of implementation of telematics in health*. [WWW document]. URL http://offis.offis.uni-oldenburg.de/projekte/retain/retain3_e.html

Rogers, E.M. (1983, 1995). *Diffusion of innovations* (3rd ed.). New York: Free Press.

Salvador, T. (1998). Changing how people work: The time-to-end-user value. *Interactions, 5*(3), 9-12.

Schakel, B. (1990). Usability-context, framework, definition, design and evaluation. In B. Schakel & S. Richardson (Eds.), *Human factors for information usability* (pp. 21-37). Cambridge: Cambridge University Press.

Sellinger, M. (1998). Forming a critical community through telematics. *Computers & Education, 30*(1/2), 23-30.

Siegel, M.E. (1998). *Instructional instrastructure planning: Innovation theory, systems theories, and computer modeling*. [WWW document] http://sunsite.unc.edu/horizon/mono/CD/Change-Innovations/siegel.html

Sippel, F. (1994). *The art of marketing and implementing teletraining. Final evaluation report of the Multimedia Teleschool Project.* Report submitted to the European Union, DG XIII, by the Research Group Technology Assessment at WIK, Dortmund, Germany.

Smith, C., & Mayes, T. (1998). *BT's 'Tomorrow's Customer Project': Evaluation report.* Glasgow: Usermatics Limited.

Spohrer, J. (1998). ATG education research: The authoring tools thread. *SIGCHI Bulletin, 30*(2), 124-133.

Teague, M., Teague, J., & Marchionini, G. (1986). The high tech road to research. *The Computing Teacher, 14*(3), 8-10.

Teng, J.T.C., Jeong, S.R., & Grover, V. (1998). Profiling successful reengineering projects. *Communications of the ACM, 41*(6), 96-102.

Watson, D., Blakeley, B., & Abbott, C. (1998). Researching the use of communication technologies in teacher education. *Computers & Education, 30*(1/2), 15-21.

Watson, R.T., Ho, T.H., & Raman, K.S. (1994). Culture: A fourth dimension of group support systems. *Communications of the ACM, 37*(10), 45-55.
Wells, J.G., & Anderson, D.K. (1997). Learners in a telecommunications course: Adoption, diffusion, and stages of concern. *Journal of Research on Computing in Education, 30*(1), 83-105.