Faculty as Machine Monitors in Higher Education?

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Predictions concerning postindustrial society include that of workers serving as machine monitors. That concept is explored in this article in respect to faculty in higher education serving as monitors of computers that are executing instructional programs. Questions concerning changes in faculty roles and the control of educational quality are addressed. Alfred Bork's vision of asynchronous learning systems is elaborated, and that alternative is compared to the concept of machine monitoring. It is concluded that monitoring in higher education is not likely unless student demand for distance learning is great, but in that case, monitoring would be superior to proposals for automated asynchronous learning systems.

When profiles of the postindustrial society began to emerge more than two decades ago, the changing role of the modern worker was of key interest. A common prediction was that work would evolve in step with the growth of information technology and that worker roles would change as a consequence. Workers had functioned as skilled artisans during the crafts era and as machine operators supporting mechanized production in the industrial age. It was expected that production would become increasingly automated in the postindustrial era and that the role of the worker would become that of machine monitor. Work that was previously done by humans would be carried out by machines, but humans would oversee the functioning of these machines. (Gendron, 1977, provides a readable overview of predictions concerning the postindustrial era.)

Examples of machine monitoring already exist in various industries, but the aim here is to explore the relevance of this prediction to an area in which it seems foreign, that of higher education in America. I believe that recent developments in distance education and asynchronous learning systems have made the educational relevance of the conception of faculty serving as machine monitors much less doubtful than it once was and that the relative worth of such a role for higher education faculty is still undetermined. In any event, three basic inquiries will be pursued here: (a) What would the concept of workers as machine monitors look like when applied to higher education? (b) how would the implementation of monitoring change faculty roles? and (c) how would monitoring affect the control of educational quality?

The Nature of Monitoring

To articulate the concept of faculty serving as machine monitors, designs for educational uses of information technology will be examined both as projections for the future and as they currently exist. One set of explicit projections for the future development of distance education and asynchronous learning is provided by Alfred Bork (1999). Bork, a renowned, early advocate of the use of microcomputers in teaching physics, emphasizes the importance of focusing on learning, not teaching, in the design of instructional systems.

> New approaches to learning can resemble the interaction between a student, or a small group of students, and a skilled tutor. Such learning is highly active for both the student and the tutor. It does not offer the same approach to each student, as a lecture does, but is individualized to the needs of each student. Future learning should look continually for individual learning problems and offer help for these problems. Students should have adequate time to learn the material well. (p. 25)

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In addition to being adaptive and individualized, Bork sees learning as connected to Socratic-style dialogues. Such dialogues for teaching physics have existed for years (Arons, 1984), and Bork has been involved in the development of many computerized instructional dialogues. Bork expects these interactive dialogues to soon be integrated with multimedia components and delivered globally, not over the too narrow bandwidth of the Internet, but via compact and digital video disks.

The concept of machine monitors in higher education can be further articulated by delineating various forms of distance education and asynchronous learning that already exist. One useful framework for understanding these technologies is to characterize instruction in terms of space-time dimensions (Jones & Paolucci, 1999). Traditional instruction, for example, is based on a "same time, same place" format. Instructor and students meet together at the same location during a shared time period. "Different time, same place" activities emerge when traditional instruction is supplemented by the use of various technologies, such as computer labs. Much like language instruction, which spans both classroom and language lab, some computer labs provide opportunities for students to practice or supplement what was learned during class. A "same time, different place" approach is taken by some forms of distance education, particularly those that involve simultaneous broadcasts to remote classrooms. Finally, asynchronous learning systems provide "different time, different place" instruction. These systems allow students to work on course materials on CDs or across computer networks from their homes or other locations at times of their own choosing.

Technologies that support forms of nontraditional instruction involve e-mail, online chat systems, teleconferencing, Internet newsgroups, and various forms of tutoring and computer-assisted instruction. These technologies and those envisioned by Bork have clear points of relevance to the concept of faculty serving as machine monitors. First, such an enterprise would certainly be a form of asynchronous learning. That is, students would interact with computers without simultaneous interaction with faculty. Second, these computers would run instructional programs, either locally or via some network, that would provide instruction by means of appropriate techniques. These techniques may well be discipline specific. For some subjects, the programs might present a good deal of text, with links to related resources, frequent quizzes with appropriate feedback, and opportunities to participate in student discussions or Socratic-style dialogues. Other subjects would involve intelligent tutoring built around student models that guide problem selection and individualized feedback. Other subjects might require the use of simulations, graphic illustrations, or multimedia components. Probably a common strand would be some form of mastery learning in which students move at their own pace through an ordered sequence of topics, progressing only after mastering a component. Finally, the automated process of instruction would be monitored by humans.

Questions immediately arise as to what form this monitoring would take and who would serve as monitors. The answers to these questions depend on the exact nature of monitoring and the scope and reliability of automated asynchronous learning systems. There are at least three types of monitoring possible. One would focus on hardware and software functioning. This form of monitoring would detect system failures and would not require faculty for its execution. Another form of monitoring derives from incrementalist theories of technology development. In this view, every technological system, regardless of quality control efforts, should be assumed to be flawed and hence continuously scrutinized for any sign of error (Collingridge, 1980). This produces a kind of ongoing evaluation of whether the technology is accomplishing its basic aims. This approach can be applied to a wide range of technologies, including education (Croy, 1996, 1997). Faculty could certainly be involved, along with system analysts, in this endeavor, but their inclusion does not seem necessary.

A third form of monitoring is related to student performance. Detailed records of student performance would be kept for remote inspection by faculty. In cases where students are performing poorly, faculty could intervene to determine the extent and nature of the difficulties and to provide remedial aid or motivational support. In cases where students are excelling, faculty could suggest additional readings and/or activities, guide students in exploring their own interests in the subject, or refer them to related career resources. In cases where students have disengaged from the course, faculty might inquire as to the nature of the circumstances and endeavor to reconnect students with the subject matter. As the nature of these activities suggest, faculty would play a primary role in their execution. Bork illustrates a pedagogical role related to this concept. He once followed a procedure

in which his students interacted with computers in learning physics but met with him whenever performance fell below a certain level. Bork (1985) referred to himself as the "court of last resort, the teaching-learning device that students could appeal to when all else failed" (p. 171). Although Bork does not currently advocate such a system, faculty monitors could play a similar, though expanded, role. In sum, the concept of faculty serving as machine monitors involves asynchronous learning, detailed records of student performance, and faculty oversight, intervention, and guidance based on those records.

Changing Faculty Roles

Interesting questions arise concerning the evolution of faculty roles, given the advent of asynchronous learning. The above description of faculty intervention assumes, of course, that this role is not itself automated. In articulating the monitoring concept in this context, some assumptions must be made about the intelligence and capability of automated asynchronous learning systems. The more intelligent and capable these systems are, the less need there is for highly educated content experts to serve as monitors. It may be that student assistants or learning experts could fulfill the monitoring function. It would seem, however, that subject matter expertise and teaching experience put faculty in the best position to carry out the monitoring function.

Like many others, Bork believes that faculty roles must change. Universities will not survive competition with certificate- and degree-granting companies and corporate continuing education programs unless faculty construct high-quality interactive courses of the kind he promotes. So, faculty will have to reallocate their resources and redirect their efforts to concentrate on these pedagogical tasks. Bork realizes that this may distract faculty from their research and that this may be a serious problem, but there is no alternative. Universities cannot abandon their teaching tasks and support themselves as pure research entities. The only hope for salvation is through increasing the quality of learning by means of technology.

> Teaching faculty, in the sense that we know them today, may cease to exist, except for in smaller, advanced courses. But their skills and experiences will be important in the design of learning modules. This raises many issues about the structure of universities, such as the need to maintain research. If learning units are very profitable, they may support research! (Bork, 1999, p. 49)

Other views of the impact on faculty roles have been put forward. Davis and Kick (1996), for example, have reviewed the Utah Higher Education Technology Initiative. In response to growing enrollments and budgetary shortfalls, Utah has made a commitment to distance education and multimedia-enhanced forms of instruction. The development of such technology-enriched courseware will be costly, but such costs may be a minor problem in comparison to unexpected consequences for faculty.

> The impact on faculty of the career shifts necessitated by the initiative may be far more pernicious. What is called for, it seems, is a fundamental retooling that will distract some faculty, primarily at research institutions, from one of the fundamental aspects of their profession and life. Our suspicion is that there will be an exodus of research faculty from the state's flagship institution, as well as other public universities (e.g., Utah State) where research has heretofore been a vital component of the faculty workload and psyche. (p. 179)

Alternatively, Garson (1999) does not expect that an exodus of research faculty would occur. He predicts that "electronic courses will for the most part be prepared and delivered by campus educational technology units, but with faculty providing nominal content guidance and lending their names to the resulting product" (p. 10). If this view is correct, then the implementation of asynchronous learning courses may have much less impact than either Bork or Davis and Kick expect. However, the economics of introducing asynchronous learning into existing institutional frameworks may also weigh in favor of greater change in faculty roles. Hawkins (1999), for instance, emphasizes the need for understanding the economics of colleges and universities when assessing the potential impact of asynchronous learning. For example, different academic departments generate different net revenues based on the cost of their programs (faculty salaries, library resources, computing equipment, space, laboratories, etc.) and their revenues from enrollments and external grants. Some departments actually subsidize others, and educational institutions work out their own budgetary balancing of these conditions. This balance

can easily destabilize, Hawkins believes, when asynchronous learning courses begin to compete with existing courses in various departments. Moreover, a similar destabilization can occur when academic departments themselves begin to alter the economic balance by offering their own asynchronous learning courses. Hawkins believes that it makes more sense to pursue this development in a different direction.

> If an extra-institutional structure existed, could these development costs, these support people, these programmers, plus some of the involved faculty, be housed in a separate entity? Maybe these faculty wouldn't have a research obligation but would instead shift their full energy into the development of course materials. Maybe they could share in the resources, that is, in the profits that might emanate from a successful distributed learning program. It is unlikely that such an entity or strategy could be accomplished with the current faculty model. Thinking extra-institutionally seems appropriate. (p. 43)

These remarks and others above reveal a disagreement over the predicted extent and form of change in faculty roles in response to the evolution of asynchronous learning courses. Many, however, agree that developing these courses will demand more pedagogical effort from faculty. Just how much more may be critical, and this issue is among those considered next.

Whether Asynchronous Learning Systems Require Artificial Intelligence

The extent to which faculty roles will be changed by asynchronous learning depends on a number of factors. One factor involves the resources needed to construct and maintain learning programs and the level of sophistication such programs must attain. Bork foresees the role of faculty changing, not in the direction of serving as machine monitors, but rather in the direction of serving as designers of interactive, individualized, learning systems. These systems surpass what Bork considers to be the generally low quality of current distance education courses. These courses do not make extensive use of multimedia, nor do they involve interactive dialogues. As for the prospect of asynchronous learning evolving toward machine monitoring, Bork sees no need for such monitoring. Bork's asynchronous learning system would automatically detect and provide any needed direction or encouragement. This capability is implemented by such components as interactive dialogues. The feasibility of automating individualization thus becomes a key issue. Bork is convinced not only that it can be achieved but that its achievement does not depend on further advancements in artificial intelligence research. This is crucial because artificial intelligence research has made few worthwhile contributions to education in general. Projects focused on intelligent tutoring systems (Sleeman & Brown, 1982) and instructional expert systems (Anderson, 1988; Pollack & Grabinger, 1989) were once widely heralded, but serious study of the requirements for such systems are sobering (Fox, 1993). Research reports on useful educational applications of artificial intelligence research are scarce. (In fact, the *Journal of Artificial Intelligence and Education* has been transformed to the *Journal of Interactive Learning Research*.) So, there is little wonder that Bork divorces asynchronous learning systems from dependence on artificial intelligence research. Nevertheless, a good case can be made that progress in artificial intelligence research is required for the types of individualized dialogues proposed.

Consider individualization itself. Psychologists admit that individualization in education is far from being achieved, and some even doubt the possibility of finding specific techniques fitted to what amounts to idiosyncratic, individual needs. The problem is compounded by targeting geographically separated, culturally diverse students of all ranges of ability. At the very least, highly sophisticated techniques are required for genuine individualization that surpasses self-pacing and conditional branching. Student modeling (Self, 1974), once a hot research topic, has turned out to be much more difficult than ever imagined. When discussing the construction of learner profiles that serve to individualize instructional objectives, Seels and Glaskow (1998) recommend the inclusion of such information as educational level, aptitude, ability, previous experience, cognitive style, level of accomplishment with the subject matter, age, gender, motivation, and attitude. Filling in these variables for each individual poses something of a challenge, but this is a minor technical obstacle relative to determining how such information should be used. Discovering what a particular profile means for selecting particular learner objectives can only be accomplished through extensive empirical research. Individualization does not emerge from the mere application of any technology. Such technology only implements knowledge concerning the pedagogically relevant ways in which indi-

viduals differ. That knowledge is based on empirical research that is logically prior to its technological use.

A survey conducted by Jones and Paolucci (1997) estimates that since 1993 only 5% of published claims about the value of educational innovation include the requisite empirical evidence. This does little to inspire confidence in recent attempts at educational innovation. Moreover, the question as to whether monitoring could be automated requires empirical research. Rather than forging ahead, disclaiming artificial intelligence or assuming its success, a better development strategy would be to first implement monitoring. This approach capitalizes on human flexibility and faculty expertise. Faculty serving as monitors would attempt to identify patterns of student mistakes and to document successful responses. They would continuously endeavor to codify the rules of their diagnoses and interventions. It is an interesting empirical question how far this rule codification could go. How much human variability could be captured by general, pedagogically useful categories? Arguments have been given as to the limitations of representing expertise by rules (Dreyfus & Dreyfus, 1986), but the question in a particular context is a quantitative and empirical one. It could be, for example, that for a particular subject, 80% of student difficulties could be handled in a rule-governed manner, while the remaining 20% involve unanticipated, possibly idiosyncratic combinations of student and subject matter characteristics. Even if rules can be written for unanticipated situations as they occur, it is an open question as to whether there is ever an end to this process.

System Design and Control of Educational Quality

The introduction of new technologies can change lines of authority and shift powers of decision making. Moreover, technological innovations create new opportunities, and different groups can be better positioned than others to take advantage of these opportunities. These points raise questions concerning faculty and student interests in respect to new educational technologies. For example, faculty interests are at stake in respect to the ownership and control of the courses they teach. The degree of faculty control over pedagogical decisions may vary greatly given courses based on traditional methods, asynchronous learning, or monitoring. Traditionally, faculty have decided issues concerning curriculum, course content and pedagogical method, number and nature of student assignments, course readings, supplementary instructional materials, means of evaluating students, grading standards, and even enrollment limits. Many of these decisions fix the time and effort required for both teaching and completing the course, and it is by power of these decisions that faculty have served as the main guarantors of educational quality. When contributing to the design of an asynchronous learning course, faculty exercise control over many of these decisions as traditionally done, but much depends on what becomes of courses once implemented. Will courses function independently of faculty who designed them, or will faculty be continuously involved in course updates and maintenance? The issue of course ownership is easily recognized as having political dimensions, but the strategic plan for long-term course maintenance also has consequences for control and authority, especially as related to course quality. Some faculty fear that if this control over quality is lost then monetary values may predominate pedagogical values. For example, course updates or improvements might be omitted due to cost constraints, or increased student diversity may go unaddressed as new markets are targeted. In any event, the move toward increased automation may diminish faculty control over course quality, a domain over which they have traditionally ruled. With monitoring, faculty have the opportunity to stay much closer to both the courses and their students. By scrutinizing student performance and intervening when appropriate, course improvement becomes a natural part of the process as opportunities for increasing individualization or redesigning course components constantly arise. As with traditional instructional materials, there is a natural process of continuous refinement. Moreover, faculty constitute an integral part of the instructional process and the life of the course in the long run. Hence, monitoring promises to maintain faculty control over courses and course quality.

In respect to interests served, faculty often see corporate interests at the heart of the controversy over distance education (Nobel, 1997). Corporate support of distance education frequently becomes a factor, given the high development costs of multimedia, Socratic dialogues, and so on. Consequently, large numbers of students are required to recover those costs. Corporate interests are thus served when cost-effectiveness is the highest value. Garson (1999) argues that student interests are best served by a hybrid course design that com-

bines traditional instruction with distance technology. But this means increased development costs, and there is a danger of the

> emergence of a two-tier educational system—a more expensive upper tier with sound traditional education supplemented with the benefits of full online access, and a cheaper inferior tier dispensing programmed training which meets objectives far narrower that the traditional goals of liberal education. (p. 13)

Lower income students would have fewer alternatives available, and they may not be in a position to take advantage of the full range of opportunities offered by new educational technology. Minority groups should well be concerned about these issues. In her study of student motives for taking Internet-based courses, Roblyer (1999) cites data showing that African Americans and other minorities have fewer home computers, less access to information technology, and make less use of the Internet. White students are more apt to develop positive attitudes and skills that promote success with distance learning course formats. It is already clear that certain students cope better with distance learning than do other students. The dropout rate for distance learning courses is notoriously higher than that for traditionally taught courses, and students may be affected differently by distance technologies.

> Based on results of related DL [distance learning] studies, it is possible that certain kinds or groups of students may be affected more than others (e.g., students from cultures who prefer face-to-face interaction or disadvantaged students who lack access to home computers). It seems likely that students who already have difficulties structuring their time and coping with the demands of schoolwork may drop out more, achieve less, and find their learning experiences less enjoyable with DL. (p. 169)

This prospect reemphasizes the importance of individualization and the potential of automated systems to provide this for students.

In sum, faculty, students, administrators, and corporate partners all have an interest in quality education that is accessible and inexpensive. There is disagreement over how best to attain educational quality and, in particular, over who should be in a position to define and control quality. Different educational designs place the authority for making crucial pedagogical decisions in the hands of different groups. Traditional modes of instruction distribute the control of quality across faculty, whereas technology-based systems tend to concentrate that authority in the hands of fewer faculty or in the hands of nonfaculty. The development of asynchronous learning may shift power away from faculty over the long run. Nevertheless, long-run educational quality itself is more important than who wins the struggle to control it. Student demand may itself contribute to defining quality, and the extent of that demand will next be considered when comparing alternative instructional designs.

Assessing Alternative Designs

The usefulness of alternative instructional designs depends, in part, on the conditions affecting higher education. For example, the degree of student demand for asynchronous learning and how that demand affects institutionalized patterns will be important. The degree of student demand is not yet reliably predictable, and its impact depends on how flexible and responsive various forms of instruction within higher education are to those pressures. The extent to which faculty have already integrated various forms of information technology into their courses is important in this respect. Both student demand and its impact will vary within different segments of higher education. Demand will probably be greater for continuing education and certain forms of professional graduate education than for undergraduate distance degrees. (This is fortunate because good reasons can be given for not providing undergraduate degrees by distance learning [Croy, 1998]). Phillips and Yager (1998) describe nearly 200 accredited distance graduate degrees, and many postsecondary institutions see continuing education as a growing market. Any impact of distance learning in these areas will be crucial. Student demand for alternatives to traditional instruction plus the rise of competition will put some pressure on higher education institutions to produce asynchronous learning courses. If this pressure is low, then modes of traditional, same place, same time instruction will survive with few changes.

On the other hand, if the pressure is great, then traditional modes will be inadequate, and more radical changes will be called for. There is no shortage of professional educators' predicting the need for radical

change and the demise of higher education should it prove unable to effect this change (Denning, 1996; Drucker in Lenzner & Johnson, 1997; Massey & Zemsky, 1995; Noam, 1995). Given these predictions, four alternatives to traditional instruction will next be assessed. This assessment will assume that demand for radical change will be great. The question is, If radical change is dictated by the need to educate more students, reduce costs, and increase quality through effective use of information technology, which direction should development take?

The first alternative is the hybrid approach proposed by Garson. This alternative suggests that Internet resources, multimedia presentations, and perhaps even Socratic dialogues would be used to supplement traditional classroom-based instruction. This means that some element of same time, same place instruction would remain unchanged and probably central. In consequence, many of the strengths of traditional instruction would be preserved. There would also be relatively little diversion of faculty from their disciplinary research. However, if pressures for change are great (high student demand plus severe competition with less-costly alternatives), this alternative will not be satisfactory. Although it responds to pressures toward increased quality via information technology, it does not appear to address issues of increasing the number of students served, geographic separation of students from places of learning, or cost reduction. In fact, it is clear that this alternative will increase costs. Garson recognizes this, but believes that increased quality is worth the increased cost.

A second alternative is an enhanced version of Garson's hybrid approach. A different way of mixing traditional instruction and information technology would be to construct courses out of sequenced modules that could be completed either by traditional or asynchronous methods. Students could engage in a form of mastery learning in one of two ways. They could either attend class, participate in learning activities, complete assignments, and then face module mastery tests before proceeding, or they could complete assignments, activities, and tests over a computer network. Having two alternatives for each module would afford a high degree of flexibility. At one end of the continuum, some students could take the entire class in a traditional manner, while at the other end, some students could complete the entire class asynchronously. Between these extremes and within the limits of the course timetable, some students could choose a middle road of mixed modes. This approach fares well in respect to increased course availability and quality. However, it is obviously more costly than Garson's hybrid model and would require a greater shift away from research, at least while instructional modules are under construction. It also says nothing about the increased teaching burden on the instructor (which would result from increased enrollment).

Next, consider Bork's proposal for asynchronous learning. The emphasis on multimedia and dialogues is heavy due to the aim of automating individualization. Achieving this aim raises costs significantly, but the asynchronous nature of instruction provides service to a large number of students, large enough to offset development costs. A number of points have already been made about asynchronous learning systems, but the tension among their multiple goals should be understood. To begin, the level of sophistication required to automate individualization through dialogues and multimedia dramatically increases development costs. Large numbers of students must be served to recover these costs. But, large numbers of students mean increased diversity in cultural background, learning styles, previous educational experience, aptitude, and so on. Coping with increased individual differences requires increased sophistication, probably in the form of artificial intelligence but certainly in the form of extensive empirical research. This increased sophistication further drives up the cost of development. Increased costs, again, are offset by targeting larger groups of students, and so on. The upshot is a vicious circle of increasing aims and costs. Pragmatically, the circling may be ended by imposing an arbitrary cap on expenditures that limits the sophistication and capability of the resulting system. So, for a certain price, a certain range of student diversity can be accommodated. Nevertheless, Bork's ambition for asynchronous learning overlooks this difficulty and grossly underestimates both the challenge and the cost of achieving individualization.

Finally, consider monitoring as elaborated above. This alternative is a kind of hybrid approach in which traditional faculty involvement is combined with information technology and asynchronous instruction. Individualization is provided by faculty monitors, although it may progressively be automated as faculty intervention strategies are evaluated and codified. This means that start-up costs would be lower than those required for Bork's system. Unlike that design, monitoring could be operational with a short lead time and a relatively unsophisticated technological base. A system designed to initially depend on humans for its

intelligence while slowly automating that intelligence would spread development costs over a greater period, and this incremental build up of sophistication would run fewer risks of costly mistakes and delays (Collingridge, 1992). This approach also builds on what is perhaps the chief source of quality in teaching: the accumulation over time of small, incremental improvements to courses repeatedly taught. There is, of course, some question concerning the extent to which automation can proceed in this context, but the monitoring model can cope with resistance to automation much better than Bork's system can. Monitoring can function even if resistance is high, and it does not fall victim to the vicious circle of increasing sophistication and costs. However, if resistance is high, then more faculty would have to be involved in the monitoring effort. This could increase the degree to which faculty are distracted from research. However, it should be noted that many faculty will recognize the research potential of monitoring. Discovering salient indicators of the need for intervention and documenting successful intervention techniques for diverse student populations is a form of empirical research into the ultimate feasibility of individualization. Most faculty recognize the worth of individualization and its tie to higher education. Nevertheless, at least some faculty would have to shift their focus from disciplinary research to research into teaching. Finally, monitoring does replace face-to-face interaction with some form of electronic interaction, but it places faculty closer to students than is the case with Bork's model. It should be remembered that computers are rule-governed machines, and programs consist of rules devised by humans and executed at a distance. Much depends on who devises the rules, how great this distance is in respect to serving student needs, and what alternatives are available when rules do not suffice.

Summing Up the Prospects for Monitoring

The majority of faculty in higher education favor traditional forms of instruction, and there is currently no widespread rush to asynchronous learning, either monitored or unmonitored. This should not be surprising because student demand for distance learning is proportionally small, and faculty seek to maintain control over their courses, educational quality, and their professional futures. Faculty are not prone to change until the pressures to do so are compelling. Some believe that this attitude will prove disastrous, but that remains to be seen. Two questions, one empirical and one normative, emerge about faculty serving as machine monitors. The first is, will it come to be, and the second is, should it come to be. On the empirical side, the best current prediction is that neither monitoring nor Bork's form of asynchronous learning will become prominent unless student demand is high. High student demand is not likely in the area of undergraduate degrees. Nevertheless, as more courses are developed for undergraduates for summer sessions and as supplements to regular academic year schedules, the impact even here may begin to accumulate. Student demand is much more likely in areas of continuing education and professional graduate degrees. If high demand in these areas materializes, it will affect some institutions much more than others, and faculty at affected institutions would do well to consider the relative advantages and disadvantages of monitoring. The concept of machine monitoring may raise images of dull, routine, slavish work, but in comparison to standard asynchronous learning system designs, monitoring offers several benefits. It maintains faculty control over course quality, allows continuous course refinement, keeps faculty closer to students, and provides opportunities for productive, pedagogical research in pursuit of individualization. The conclusion drawn here is that, assuming great pressure for radical change, monitoring would be superior to current proposals for asynchronous learning systems.

References

Anderson, J. (1988). The expert module. In M. Polson & J. Richardson (Eds.), *Foundations of intelligent tutoring systems* (pp. 21-53). Hillsdale, NJ: Lawrence Erlbaum.

Arons, A. (1984). Computer-based instructional dialogs in science courses. *Science*, *224*, 1051-1056.

Bork, A. (1985). *Personal computers and education*. New York: Harper and Row.

Bork, A. (1999). The future of learning: An interview with Alfred Bork. *EDUCOM Review*, *34*(4), 24-27, 48-50.

Collingridge, D. (1980). *The social control of technology*. New York: St. Martin's.

Collingridge, D. (1992). *The management of scale: Big organizations, big decisions, big mistakes*. New York: Routledge.

Croy, M. (1996). Collingridge and the control of educational computer technology. *Techné: The Electronic Journal of the Society for Philosophy and Technology*, *1*(4), 1-15. Available: http://scholar.lib.vt.edu/ejournals/SPT/spt.html

Croy, M. (1997). An incrementalist view of proposed uses of information technology in higher education. *Philosophy in the Contemporary World*, *4*, 1-9.

Croy, M. (1998). Distance education, individualization, and the demise of the university. *Technology in Society*, *20*, 317-326.

Davis, B., & Kick, E. (1996). Human capital issues in the use of information technology in education. *Social Science Computer Review, 14*(2), 169-181.

Denning, P. (1996). The university's next challenges. *Communications of the ACM, 39*(5), 27-31.

Dreyfus, H., & Dreyfus, S. (1986). *Mind over machine: The power of human intuition and expertise in the era of the computer.* New York: Free Press.

Fox, B. (1993). *The human tutorial dialog project: Issues in the design of instructional systems*. Hillsdale, NJ: Lawrence Erlbaum.

Garson, D. (1999). *The role of technology in quality education* [Online]. Available: http://hcl.chass.ncsu.edu/sscore/garson2.htm

Gendron, B. (1977). *Technology and the human condition*. New York: St. Martin's.

Hawkins, B. (1999). Distributed learning and institutional restructuring. *EDUCOM Review, 34*(4), 12-15, 42-44.

Jones, T., & Paolucci, R. (1997). Putting educational technology in perspective: The question of learning effectiveness. In J. Willis, J. Price, S. McNeil, B. Robin, & D. Willis (Eds.), *Technology and teacher education annual, 1997* (pp. 881-884). Charlottesville, VA: Association for the Advancement of Computing in Education.

Jones, T., & Paolucci, R. (1999). Research framework and dimensions for evaluating the effectiveness of educational technology systems on learning outcomes. *Journal of Research on Computing in Education, 32*(1), 17-27.

Lenzner, R., & Johnson, S. (1997, March 10). Seeing things as they really are: An interview with Peter Drucker. *Forbes*, pp. 122-128.

Massey, W., & Zemsky. R. (1995). *Using academic technology to enhance academic productivity.* Washington, DC: EDUCOM. Available: http://www.educom.edu/

Noam, E. (1995). Electronics and the dim future of the university. *Science, 270,* 247-249.

Nobel, D. (1997). *Digital diploma mills* [Online]. Available: http://www.firstmonday.dk/issues/issue3_1/noble.

Phillips, V., & Yager, C. (1998). *The best distance learning graduate schools: Earning your degree without leaving home.* New York: Princeton Review.

Pollack, J., & Grabinger, S. (1989, April). Expert systems: instructional design potential. *Educational Technology,* pp. 35-39.

Roblyer, M. (1999). Is choice important in distance learning? A study of student motives for taking Internet-based courses at the high school and community college levels. *Journal of Research on Computing in Education, 32*(1), 157-171.

Seels, B., & Glasgow, Z. (1998). *Making instructional design decisions*. Englewood Cliffs, NJ: Educational Technology.

Self, J. (1974). Student models in computer-aided instruction. *International Journal of Man-Machine Studies, 6,* 261-276.

Sleeman, D., & Brown, J. (Eds.). (1982). *Intelligent tutoring systems*. Orlando, FL: Academic Press.

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