Foreword

TECHNOLOGY AND EDUCATION

Karl Benz's invention of an automobile with a built-in internal combustion engine in 1885 caused a worldwide revolution, not only in the technological field but also in all segments of human life, such as economics, culture, family structure, urbanization, women and youth emancipation, and climate change. A car, however, seems more suited to solve mobility problems than to serve educational goals. The rise of personal computers and network facilities in the second half of the 20th century eventually converged in a digital World Wide Web (WWW) that revolutionized information development and exchange. Increasing miniaturization, integrated functionalities, and wireless use now comprise a communication hyperspace in a global world. In contrast to the gas-fueled engine, information and communication technologies suggest sensitivity toward lifelong human learning issues. This is what the *Handbook of Research on Educational Communications and Technology* is all about.

Because education is a critical topic in all societies and cultures, it is a common social impulse to (try to) use available technology for schooling purposes. Though linking technology and education seems at first glance to be a rather natural endeavor, it is by no means a smooth and progressive enterprise. Indeed, the history of educational technology documents a long and often difficult process of mutual adaptation, hesitation, and integration. Closer scrutiny of this history reveals some cracks or fissures in a less than smooth process of progressive development; these breaks are successively stimulated by promises of producers of new media and technologies. From their backgrounds in business or technology, these self-proclaimed educational reformers make a linear forecast of efficient and effective output for learning and instruction but neglect the complexity of multidimensional and multilevel educational settings. Moreover, these overly optimistic promises are formulated before any valid empirical evidence for success has been found. Entire lists of sayings about that promised *techno-land* are abundantly available on the Internet. Teachers, parents, and school directors, either genuine innovators themselves or pressed by policymakers, hold strong beliefs about the positive impact of new devices. They are sensible to the societal need for implementing technology in modern schools and using new technologies as external means for serving an internal need for innovation (the Trojan horse phenomenon). In most cases, however, experience with technologies brings more difficulties and less productivity than expected at the beginning, an observation that often causes frustration even in the research community. One waits, then, until the next, more powerful tool is available. This resembles the myth of Sisyphus, a king of Corinth who was condemned forever to roll a boulder up a hill in Hades only to have it roll down again as he neared the top.

Indeed, media and technologies were invented and developed for out-of-school purposes, which means that they are initially not natural but foreign organs in the education organism; therefore, we are in dire need of transplantation knowledge to cope with the school's immune system. Building this transplantation knowledge to stick with our metaphor is not a mere technological issue; it also has to receive an empirical grounding in a multidisciplinary, broad-spectrum, and multi-vocal research approach. In this way, research on learning and instruction, philosophy, curriculum, methods, school organization, technology, and user characteristics could converge in educational innovation strategies that take into account increasing complexity.

EVOLUTION IN MEDIA AND TECHNOLOGY

Depending on the attributes of the different media or technologies and the educational contexts in which they are embedded, different answers are given or need to be given to build up a fruitful interaction between technology and education. Some speak in this context of a marriage. A quick scan of evolutions in media and technology reveals various stages of development; however, rather than suggesting a definite break between each developmental step, which leads inevitably to isolation or compartmentalization, it seems more apt to use the concept of a wave. Educational technology is a cumulative endeavor in which knowledge from earlier phases can be absorbed smoothly in more recent waves. To mention only a few examples, former research on the effects of media attributes or symbol systems can easily be integrated into a complementary view on different symbol systems in multimedia systems; early investigations on hypercard and

hypertext continue to yield insight into the characteristics of hypermedia; research on mental effort can be integrated into the so-called cognitive load theory; and research on peer learning with personal computers can shed light on key aspects of learning communities in an Internet environment.

Evolutions in technology can be summarized in three successive developments. After World War II, information representation media were expected to support traditional teaching and learning, mostly in classrooms. Such media were supposed to bring the real world into the stuffy classroom with the use of radio, television, slideshows, film, and video. This kind of technology was conceived of as an extension of verbal and textual symbol systems contained in teacher lectures and books; however, the traditional school format hindered the exible adaptation of these new media due to locked time slots, predefined curricula, teachers' resistance toward change, and limited organizational exibility, infrastructure, and finances. If used, media were a mere add-on that brought about no fundamental change in teaching and learning approaches.

From 1970 on, the increasing use of computers in society created a dual argument for integrating computers into educational settings. On the one hand, society claimed that youths had to be prepared to live in an information society, equipped with the computer skills necessary for driving on the information highway (though nowadays youths seem to outperform their teachers and parents in their use of digital technology). On the other hand, the attributes of computers allowed for interactive data processing, symbol transformation, and information storage, which seemed compatible with human information processing and knowledge construction. The personal computer was loaded with software, ranging from drill-and-practice programs to simulations and open tools. In terms of innovation strategy, most governments assumed that filling schools with computers would automatically enhance learning processes and higher-order skill acquisition. Research has shown, however, that computers only create learning output if sufficient support is available and computer use is an integral part of the curriculum or learning environment.

Since the last decade of the 20th century, the closed position of personal computers has been opened by the communication facilities of networked computers. Computers are no longer personal or even computing machines that manipulate digits. They are tools that activate human communication. On the one hand, these tools complement, correct, or fine-tune information embedded in educational software or available on the Internet; on the other hand, they can be used to develop new information and shared knowledge through computer interaction. This human shield allows for many interactions among experts, coaches, teachers, peers, parents, and learners. Computers are communication tools in an information-rich environment and are used by myriad technology-enhanced communities of learners and communities of practice.

INNOVATIVE RESEARCH ON EDUCATIONAL TECHNOLOGY

The shared feeling that recent communication and information technologies are much closer to education than their nondigital predecessors could lead to a smoother educational use. This opinion can be sustained, at least from a logical perspective; however, innovations in instruction and learning are dependent not only on logical perspectives but also on *psychological* motives. Surveys on computer use indicate that only a fraction of the time spent with computers is used for educational or learning purposes. Contrary to the simple procedure of finding useful information on the Internet, learning and knowledge building are developmental processes that integrate new knowledge into already existing prior knowledge and lead to increasing abstraction, comprehension, and conceptual change. Learning is cumulative and an object of mental effort, motivation, and cognitive skilfulness. Learning is not so much defined by the quantity of information available but by the gradual transformation of relevant information into knowledge. This is not a matter of mere information delivery in an information society. It is essentially the way novices are supported in building their own knowledge out of available information in a long-lasting effort and a long-term perspective, as well. Learning is essentially a developmental activity.

Although research on educational technology is often tuned toward evolution in the field, it started with many studies at a microlevel of complexity: assessment of the effectiveness and efficiency of computer software, detection of minimal conditions for implementation of technology in schools, insight into the main characteristics of learners confronted with technology, and so on. Later on, when not only technological tools but also human interactions with tools and peers became dominant, research was more complex and situated at the mesolevel of complexity. Integral school innovation, integration of computers in curricula, and interaction between of ine and online learning or between face-to-face and distant learning are topics that require intensive research. The rise of both the complexity and the range of technology use in education calls for adapted research approaches. If the entire

educational system is to become the object of research, the only answer is a systemic approach. *Systemic* means that both the conceptual coherence and the empirical method contribute to a better understanding of the complexity, leading toward better designs. Instead of a proliferation of terminology, approaches, methods, and variables, research should aim at accumulation. The centrifugal trend needs to be transformed into a centripetal one: bringing researchers together through strong research programs.

Complexity cannot be solved by simple or monodisciplinary approaches. Because the system consists of many subcomponents that refer to different backgrounds and interpretation frameworks, the solution lies in an interdisciplinary research endeavor. Indeed, technology, curriculum development, courseware development, distance teaching, innovation strategies, philosophy, social psychology, anthropology, learning paradigms, organizational issues, and ethics all define the value of modern technology use. This is simply due to the fact that at the macrolevel of complexity highly organized blended learning includes and integrates technology and human interactions among the individual, group, and community levels of organization.

The research question is no longer how individual studies contribute to evidence-based uses of technology but how these studies can be brought together in multidisciplinary and multilevel research programs. This includes an emphasis on interactions between variables and levels rather than on individual, at studies; for example, because open technological environments call for learner control, self-regulation, and group learning, the nature of technology support has to be defined in the complex relationship between learner control and environmental (technological) support. In this way, research programs can take into account long-term goals and exible adaptation toward changes in the environment.

Most technology research is focused on a limited sample (mostly college students) with a restricted set of one-shot research questions. We know little about evolutions in technology use or about developmental characteristics in the transition from novice to expert. There is a need for more longitudinal studies that can shed light on this evolutionary perspective.

Since the early times of design and development of learning software, emphasis has been placed on the designer and on his or her expertise. If, however, learners are to codesign their learning environment as partners in a learning community, it will be necessary to conduct research on the users: the complex mindset of policymakers, school directors, coaches, teachers, and students, as well as their competencies in cobuilding environments. This includes the required instructional knowledge for contributing to optimal learning environments.

The information made available in this *Handbook* by acknowledged scholars depicts many contributions to the foundation, strategies, technologies, models, design and development, and methodology of educational communications and technology. One of the expected outcomes of this immense knowledge base is the creation of a new generation of research and development, in which conceptual alignment, empirical richness, and synergy are spearheads of educational innovation.

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