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Improving Learning Technology Design through the Identification of Anthropologically Invariant Learning Behaviors in the Adoption of Educational Technology

Abstract

This paper describes proposed research to identify invariants in human learning behavior through accumulation and categorization of learning activity found independent of culture and through quantitative analysis of the historical records of technological selection and rejection. The results of this research may be used to improve the design criteria for more effective development and application of learning technologies, such as deployed in on-line courses and in emerging high immersion game-based learning systems. Furthermore, with better-designed learning technology systems and devices, leading to broader diffusion and successful implementation, then criteria for technological literacy might be determined more effectively.

Objectives of the research include: 1) identifying anthropological invariants in early learning; 2) identifying invariant learning behavior in later stages of learning, including identifying vestiges or artifact behaviors from early learning; 3) documenting the adoption rates, performance, and substitution of major learning technologies in technologically advanced societies; 4) demonstrating through the historical record of education technology adoption and rejection invariant learning behaviors as cause for the selection and rejection of educational technologies; 5) identifying design criteria and potential improvements in the ongoing development and application of select learning technologies based on the research results.

The initial goal of the research is to achieve preliminary results in each of the proposed objectives, demonstrate the scholarly and practical merits of such research, and to position research teams to attract continued research funding to pursue the objectives at length.

Introduction and Research Methodology

Quantitative technology forecasting is the process of projecting in time the intersection of social needs and technological capabilities using quantitative methods. In QTF, technology is defined as any human creation that provides a compelling advantage to sustain or improve that creation, such as materials, methods, or systems that displace, support, amplify, or enable human activity. By this broad definition, technologies include not only the usual hardware and software we all recognize such as computers, automobiles, telecommunications systems, etc., but also such developments as accounting, law, learning systems, etc. It has been shown that rates of new technology adoption and rates of change in technology performance take on characteristic patterns in time. The technologies included in the broader definition also follow the common patterns of adoption and diffusion.
A technology forecast includes the study of historic data to identify one of several common technology diffusion or substitution trends. Patterns to be identified include constant percentage rates of change (so-called “Moore’s Laws”), logistic growth, logistic substitution, performance envelopes, lead/lag (precursor) relationships, anthropological invariants and other phenomena. QTF projections have proven accurate in predicting technological and social change in thousands of applications as diverse as consumer electronics and carbon-based primary fuels, on time scales covering only months to spanning centuries. The fundamental reliability and accuracy of quantitative technology forecasts are supported by new developments in systems theory and complexity modeling, such as the complex adaptive systems approach.

Invariant, i.e., narrowly- or well-bounded, human individual and social behavior, and fundamental human evolutionary drives, underlie all technological change. In essence, humans and technology co-evolve in an ecosystem that includes the local environment, our internal physiology, and technology, which can be characterized as external physiology. It has been shown that physiology, especially our biological systems critical to interaction with the external environment, act as both drives and limits on technology adoption, rates of change, and performance. The careful study of the history of technology adoption, change, and performance can reveal the anthropological invariant behavior, i.e., the expression of internal physiology, that both drives and limits technology change.

A classic example of an anthropological invariant identified through study of technological trajectories is the tendency for human beings to want to travel about an hour per day. This behavioral drive is manifest in the foraging times of aboriginal peoples, the daily commuting time of automobile drivers, and has determined the average size of farms throughout history. In the case of the commuter, the average commute time in the United States has remained at about one half hour since the automobile became the main choice of personal mobility a century ago. This identified invariant is practical and useful, for example, in the design and planning of automobiles. The advice to automobile manufacturers is that seat design need only accommodate the average drive, about 30 minutes. This example and other results from studies of transportation technology histories can provide insight into the design, adoption, and productivity of telecommuting and ‘virtual workplace’ strategies envisioned to be part of the future R&D organization and operation.

An example of invariant behavior is evident in the consistent trajectories of human exploration, whether terrestrial or extra-terrestrial (see Figure 1). The history of launches to the Moon, Venus, and Mars all show evidence of logistic growth patterns, and these trajectories mirror the trajectory of Western hemisphere explorations. Many people with intuition or vision did rightly project human space-object exploration. But QTF-identified invariant behavior, whereby humans are seen to initiate, accelerate, and cease exploration activity along logistic diffusion trajectories, is knowledge applicable to the reliable projection in time of future exploration behavior or activity. Such reliable trajectories provide opportunity for reducing uncertainty in policy and investment decisions, for example.
Objectives

1. Identify anthropological invariants in early learning.

Learning skills are an evolved set of behaviors, skills selected by survival of a species offspring most fit to learn. From generation to generation, not only are the abilities to perform survival-enhancing behaviors passed down through genetic lineage, but also passed down are abilities to learn to develop the necessary behaviors. This selective process applies to human beings. Learning is an innate response in the infant and toddler, and it devotes a significant portion of energy and concentration to learning during the time relating to its mother and other caregivers in order to survive and thrive.

Studies of early learning and education in isolated and diverse cultures have reported recurring behavior patterns of learning between mother and infant/toddler, diverse in practice but common in nature (see, for example, Olson and Torrance\textsuperscript{4}). Research under this proposal will gather and categorize from the literature the many published and accepted insights into invariants in early-age human learning. Researchers might not be aware of the consistency of their findings of learning behaviors vis a vis other research results, and so the proposed research seeks broad study of published results to identify as many behaviors as possible that appear in early learning behaviors independent of cultural manifestation.

2. Identify invariant learning behavior in later stages of learning, including identifying vestiges or artifact behaviors from early learning.

The presence of and interaction with a mentor or teacher has been observed throughout history as a pedagogically universal requirement for effective and efficient learning. Historically, all
societies have developed this model of educational system. Trends in education today are hoping to eliminate or limit the presence of a human in the learning process by way of technological substitutions, such as intelligent tutorial software or on-line distance courses. The education industry has seen mixed results, or at least mixed reviews. Many researchers suggest that insufficient data has been collected to measure effectiveness in terms of, for example, resource cost advantage or quality of outcomes as compared to the traditional intimate teacher/pupil environment. Perhaps later stage learning relies on vestiges or latency of earliest stage learning where the presence of the adult was critical for the young learner learning survival skills, and the absence of the vestige mother by technology affects negatively the learning process. This research of this objective is intended to explore this consideration, to ascertain if vestigial requirements influence later stage learning.

Researchers have identified stage-specific learning styles and behaviors and have suggested various quantified limits on these behaviors, such as attention spans. The proposed research intends also under this objective to accumulate and list the behavior norms and boundaries generally accepted as facts of the learning stages.

3. Document the adoption rates, performance, and substitution of major learning technologies in industrial societies.

Quantitative technology forecasting is the process of projecting in time the intersection of social needs and technological capabilities using quantitative methods. For the purposes of forecasting, technology is defined as any human creation that provides a compelling advantage to sustain or improve that creation, such as materials, methods, or systems that displace, support, amplify, or enable human activity. It has been shown that rates of new technology adoption and rates of change in technology performance take on similar adaptive characteristic patterns in time.

A quantitative technology forecast includes the study of historic data to identify one of several common technology diffusion or substitution models. Patterns to be identified include constant percentage rates of change (so-called “Moore’s Laws”), logistic growth (“S”-curves), logistic substitution, performance envelopes, anthropological invariants, lead/lag (precursor) relationships, and other phenomena. These quantitative projections have proven accurate in predicting technological and social change in thousands of diverse applications, on time scales covering only months to spanning centuries.

Invariant, or at least well-bounded, human individual and social behavior, and fundamental human selective adaptations of behavior, underlie technological change. Carrying out a quantitative technology forecast includes selecting a strategically important technology, gathering historic data related to change or adoption of that technology, identifying candidate “compelling advantages” that appear to be drivers of the technology change, and comparing the rate of technology change over time against the natural characteristic patterns of technology change and diffusion. After a classic pattern is identified, a reliable projection of technology change can be made and appropriate action taken to plan for or meet specific technology function or performance objectives.
This research objective intends to employ various QTF techniques to assemble the first series of studies of common adaptive characteristics in education technological change.

4. Demonstrate through the historical record of education technology adoption and invariant learning behaviors as cause for the selection and rejection of educational technologies.

Thomas Edison is reported to have said that his invention of sound recording and playback would ‘revolutionize education’. He projected that his recording devices, inexpensively produced and widely distributed, would be a popular and effective substitute for institutional learning. The revolution did not happen, though recording technology found a secure and diffuse presence in education. He later predicted the revolution in education to come from his invention of motion picture technology. Again, there was no revolution, though scholastic movies have been a staple of classroom instruction ever since his invention.

Television, too, was destined to revolutionize education, and it, too, found a place in almost every curriculum, and certainly extended teaching geographically, but has never found a large niche of substitution for the traditional learning environment of personal teacher/learner interaction. Computers and software systems have grown in application and diversity, distance-learning technology has grown as method to reach adult learners around the globe. Consensus has not been reached on the comparative quality of outcomes in learning from these teacher-substitute, exclusive systems, and controversy continues around the appropriate proportional of these technologies in select educational settings \[^{5, 6, 7, 8}\].

This objective is intended to identify heretofore-overlooked causal relationships between learning invariant behaviors and the adoption, performance, and substitution of technologies in education. This objective has the potential to bring the most new knowledge and benefit to the adoption of technology in education.

5. Identify design criteria and potential improvements in the ongoing development and application of select learning technologies based on the research results.

A classic example of an anthropological invariant (or strongly preferred, narrowly bound behavior) identified through study of technological trajectories is the tendency for human beings to want to travel about an hour per day. This behavioral drive manifests in the foraging times of aboriginal peoples, the daily commuting time of automobile drivers, and has determined the average size of farms throughout history. In the case of the commuter, the average commute in the United States has remained at about one half hour since the automobile became the main choice of personal mobility at least a century ago. As a practical matter, the advice to automobile manufacturers is that seat design need only accommodate the average drive, about 30 minutes. No matter how much a manufacturer’s investment toward seat comfort, and no matter how more intensely such accommodation is advertised, the average user is going to drive the automobile a half hour per day, out and again back, his or her translocation compulsion having been sated. This and other results from studies of transportation technological histories can provide insight into how similar research of education technological histories can help to understand and project technological change in learning.
Conclusions

This paper has described the objectives of research hypothesizing that the clear identification of behavioral invariants in learning activity can provide reliable requirements and bounds on the design of educational technologies. Published studies of the dissatisfaction of instructors and students suggest that some or some parts of technological substitutions in learning environments might be missing one or more critical components necessary for effective, efficient, and satiating learning not yet clearly identified. This proposed research intends to identify these requirements and provide direction for education technology development and application and better policymaking and investing for improved technological literacy across the populace.

Bibliography