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Principles of Cybernetics for Education: How to Value the Human in Computational Systems



Rodrigo Abrantes da Silva
Modern Letters Department, University of São Paulo, São Paulo, SP, Brazil

Introduction

Learners use computer systems to process information, acquire knowledge, engage in experiments and simulations, receive constructive feedback, and obtain guidance to achieve their educational objectives. Contemporary educational solutions offer a variety of tools that cater to these requirements, such as digital platforms, automated writing assessment tools, and educational games. However, to avoid reproducing old practices in new technologies, some principles of cybernetics can be applied from a perspective of valuing the human and social aspect of learning. This can be called cybersocial learning.

The term “cyber-social” itself refers to two essential dimensions. First, it draws from the field of cybernetics, which provides a theoretical framework for understanding how learning occurs in both human and machine domains. Second, it reflects the concept of learning as a social practice, which suggests that the generation of knowledge, skills, and competencies arise from specific

contexts and relationships, situated within society and history, rather than being confined solely to an individual’s mental faculties, awaiting transfer to others.

Cybersocial learning refers to learning paradigms in societies where computers are ubiquitous and facilitate learning opportunities at any time and anywhere. Computers have become an integral part of our daily lives, leading to noticeable modifications of innate human traits, such as the integration of natural language with non-natural machine language (Cope and Kalantzis 2023). This prompts an exploration of the consequences of this transformation in the learning process.

Historical Background

Cybersocial learning represents a synthesis of cybernetic and pedagogical principles. Cybernetics, an interdisciplinary field of study, originated from the pioneering work of mathematician Norbert Wiener, who investigated machine-regulation systems employing feedback mechanisms. In 1948, his book “Cybernetics: or Control and Communication in the Animal and the Machine” was published, introducing the term “cybernetics,” derived from the Greek word “kubernētēs,” sharing its etymological root with “government,” signifying the helmsman of a ship. This metaphor vividly illustrates a basic cybernetic system, wherein a vessel and its pilot

constitute an individualized system with the encompassing sea serving as its environment. The pilot possesses a distinct purpose—to navigate the vessel in a specific direction, necessitating precise perception of environmental disturbances, and, based on this information, making the correct responses to maintain the course. Such adjustments occur through feedback loops, embodying the circular causality that mediates the dynamic interplay and adaptive relationship between the system and its surroundings.

In a cybernetic circuit, outputs feedback cyclically into the system as inputs, leading to learned behaviors that reach a preconscious level, often referred to as the “second nature” of the pilot. This state represents the pinnacle of learning, where conduct has been transformed into habit. A similar phenomenon can be observed in the act of driving a car. Experienced drivers, having amassed extensive experience, perform automatic responses such as shifting gears, steering, and signaling turns without conscious deliberation. Once learned, these actions evolve into highly reliable responses.

In his seminal work published in 1948, Wiener aimed to uncover principles that govern the operation of automatic machines and the intricate functioning of the human nervous system. His goal was to formulate a comprehensive theory that encompassed aspects of communication and control in both mechanical systems and living organisms. Fundamental principles in cybernetics suggest that learning is a transformative process in the behavior of organisms or machines over time, driven by feedback mechanisms—systems that provide responses to actions taken by people in a particular environment. Through this process, the system acquires and processes information from its specific environment, forming the basis for the adaptation and regulation of a broad range of systems, including machines, living organisms, and complex social systems.

Recovering the history of cybernetics today, as stated by Hui (2024), carries the sense of an epistemic reorientation, allowing us to envision technological approaches that transcend both the oppression stemming from platform capitalism and the ideological distopic naivety of

transhumanism, with its projections of immortality and superintelligence.

The concept of cybersocial learning underscores the significance of valuing the human perspective in a relational context and highlights the importance of recognizing the complementary relationship between humans and machines. Cope and Kalantzis (2023) have noted that this paradigm shift diverges from the common tendency to view artificial intelligence as a replication of human intelligence and emphasizes the need to consider other research models that allow us to reintegrate the human into technology.

Treating AI as a replica of humans leads to the belief that humans will be replaced by machines endowed with superior intelligence and even consciousness. However, such propositions do not align with the core tenets of cybersocial learning. In contrast, this paradigm is dedicated to fostering reflexivity within the human-machine relationship, a reflexivity that is adept at cogently conceptualizing the machine’s potential to augment human learning and enhance social capacities.

Cybernetics in Education Technology

It has not yet been realized, despite its innovative insights into learning, the immediate integration of cybernetics into formal education. Throughout the 1960s, cybernetics theorists recognized the challenges faced by educational institutions in adapting to the technological age and embarked on a significant exploration of how schools could evolve to align with the emerging realities of the machine age (Watters 2023). The application of cybernetics in education is a noteworthy transdisciplinary endeavor (Hui 2024). As a science of feedback, cybernetics can enhance education as a science of learning, and in this process, a new field of knowledge and a new approach to learning can emerge.

While educational technology tools, such as virtual tutors and adaptive resources, offer significant potential in self-learning and blended learning environments, their effectiveness is often limited by an adherence to traditional pedagogical practices, which may restrict their transformative

impact in educational settings. For example, in a popular platform such as Moodle, feedback mechanisms primarily reinforce a didactic approach, where knowledge flows unidirectionally from teacher to student, reflecting conventional classroom dynamics. For instance, test-type assessments are the classic way to evaluate if the student has learned what the teacher aimed to convey. However, Moodle tasks and even the assessment lab tool also maintain the flow of conventional discourse. In the same way, an automated data collection tool, such as the progress tracker, generates data for the teacher to monitor whether the student watched the videos or completed the tasks. Despite their advanced capabilities, these tools often fail to move beyond the conventional teacher-centric model, focusing more on retrospective judgment rather than fostering a forward-looking, student-centered learning approach.

Similarly, adaptive teaching features in tools like interactive video H5P—or its commercial counterpart, Edpuzzle—often mirror the relationship between content consumption and test-solving. The teacher inputs the content they want the student to learn using these tools, which offer editing features for highlighting information in the video and inserting questions to assess the student's comprehension. Based on the student's response, the teacher can establish an adaptive pathway, guiding the student to different lesson topics based on their answer. Once again, this approach revolves around presenting content and evaluating learning in terms of what the student has retained in his memory and can reproduce during assessments.

Cybersocial learning, integrating technology into education, allows us to reimagine pedagogy, making it more engaging and motivating in today's digital culture. We make the case for incorporating cybernetic principles in educational technology design, believing these core concepts can substantially improve pedagogical practices. Cybernetic systems are decentralized, operating on the principles of distributed knowledge networks, and flexible. This leads us to a concept known as heterarchy: an organizational structure in which elements or agents hold equally

significant positions and do not adhere to a fixed hierarchy of authority.

A practical illustration of this concept is evident in the open-source software community, such as the development of the Linux operating system. In this community, developers from around the globe contribute to a common project without a centralized control structure. For example, Linux, initiated by Linus Torvalds, has evolved through contributions from thousands of programmers. Unlike traditional software developed in a hierarchical corporate structure, Linux thrives on a collaborative and egalitarian model. Contributions are valued based on participation rather than rank, with decisions often made through community consensus or led by recognized experts based on their expertise and contribution history.

This model not only accelerates innovation but also fosters a diverse and inclusive environment. It is a dynamic ecosystem where authority is fluid and based on the quality of one's work rather than a formal position. Such an environment mirrors the cybernetic principles of distributed knowledge and flexibility, showcasing how they can be applied effectively in real-world scenarios.

A historical and noteworthy example of cybernetic principles in action can be seen in the Chile Cybersyn project of the early 1970s. Initiated under the government of Salvador Allende in Chile, the Cybersyn project aimed to create a real-time computer network for managing the national economy, combining principles of cybernetics with innovative management techniques.

The project was designed to enable efficient communication between the government and the state-run industries. It used a network of telex machines in factories across the country, connected to a central computer in Santiago. The system was intended to facilitate rapid decision-making and decentralized management, allowing factory workers to directly communicate their operational status and needs.

However, the project was never fully implemented due to the Chilean coup d'état in 1973. Despite its short-lived operation, Cybersyn was a groundbreaking attempt to apply cybernetic principles to large-scale industrial and social organization. The project embodied the concept of a

heterarchy, as it sought to distribute decision-making power and flatten traditional hierarchical structures. In this way, Cybersyn represented a bold experiment in creating a more responsive and adaptive organizational model, reflecting the potential of cybernetics to reshape societal systems.

When applying these principles to a formal education setting, cybersocial systems possess remarkable attributes that render them highly adaptable to learners' needs. They provide a wealth of resources that facilitate self-regulation within specific learning environments (Cope and Kalantzis 2022). This self-regulating ability is a significant advantage as it reduces the necessity for external support to the system itself. Each learner plays an active role, shares responsibility for the system's operation, collaborates with peers, and contributes to the distribution of diverse sources. Consequently, learners have the ability to shape and customize the system to meet their unique needs, enhancing the learning experience with increased engagement and personalization.

The Cybersocial Perspective on Formal Education

The modern world demands a shift in the way higher education programs are designed. To meet this need, cybersocial learning principles have been implemented to promote relevant, real-world-connected learning experiences. With this approach, learners are empowered to create knowledge that is applicable to their practices. In today's digital age, a cybersocial system can serve as an effective teaching tool, utilizing the capabilities of web platforms while remaining aligned with human values.

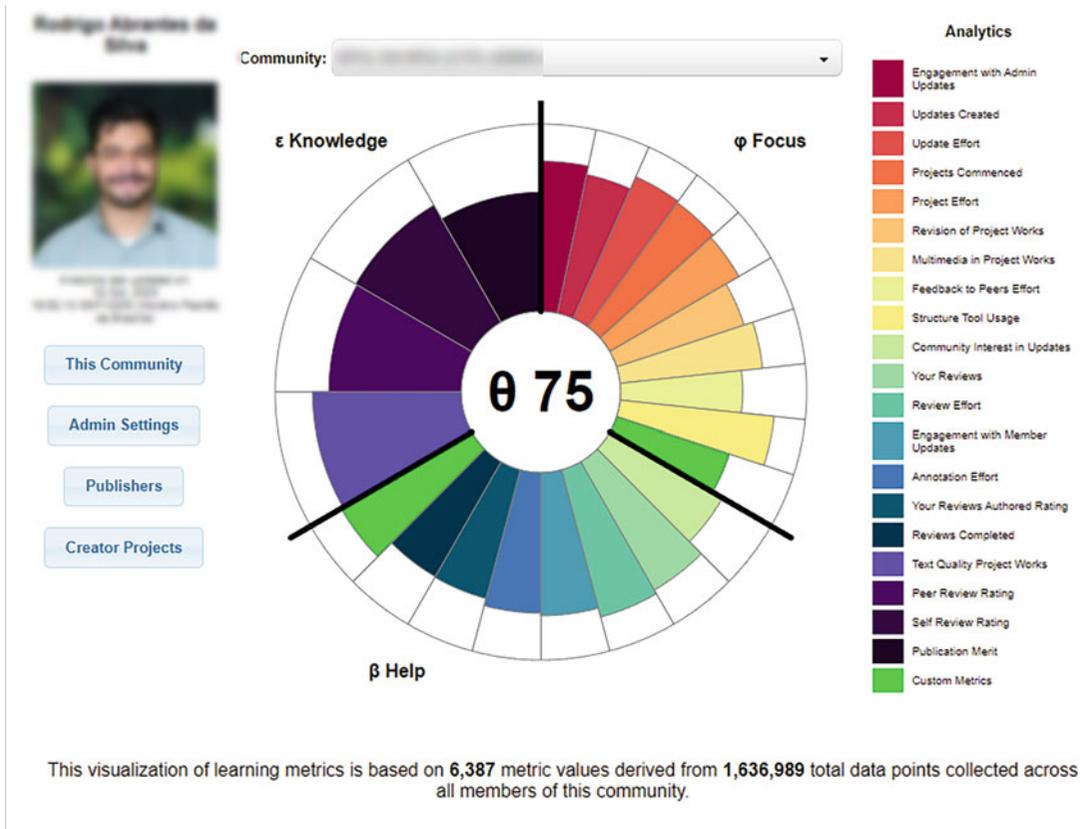
As an example, the system depicted in Fig. 1, which uses large volumes of data to provide feedback to students, is an epistemic complement to their learning. As Cope and Kalantzis (2023) state:

How then, in a cyber-social model might we recognize the synergistic relations between these two very different kinds of intelligence, human and

machine, the one that “thinks” in statistics working over traces of human meaning left in binary notation, the other that thinks in terms of models, world-views, motivations, and interests? Elsewhere, we have argued that purely statistical AI could be made all-the-more effective by bringing back to computing semantics and ontologies that capture accumulated human insights into the structures and patterns of meaning in the world. (Cope and Kalantzis 2023, p. 19, forthcoming)

The “cyber-social” concept challenges several fundamental paradigms. It suggests that causality is not linear but rather a recursive feedback loop, questions the notion of a single directing authority, and instead emphasizes the dynamic interplay between different components within a system and their environment. Additionally, it advocates for the redefinition of tools as an integral part of human experience and suggests rejecting hierarchical control systems in favor of distributed protocols. This concept also prioritizes context-driven responses over behaviorism, moving away from individualistic cognition to a conversational, meaning-distributed model among collective minds. Furthermore, it expands our understanding of artificial intelligence beyond statistical constraints. These principles have the potential to transform our understanding and interaction with the digital landscape, enabling the expansion of the reach of sociability forms that engage students in meaningful learning for their lifeworlds.

The utilization of cybernetics in formal education, coupled with recursive feedback mechanisms, enables the regulation and gradual improvement of the learning process. In such an educational setting, an artificial intelligence tool can enhance human feedback by creating visual representations that show how students understand course objectives. The Learning Analytics system of the CGScholar platform serves as an example (Fig. 1), utilized here to illustrate some cybernetic principles. (For over a decade, Scholar has been used in artificial intelligence applications for education, collaborative writing, and peer review. In 2023, it has nearly 350,000 user accounts and can be integrated with LTI-compatible learning management systems. Parts of the software suite are open for anyone to



Principles of Cybernetics for Education: How to Value the Human in Computational Systems, Fig. 1 Learning Analysis System of the CGScholar platform. (Source: Printscreen. CGScholar)

sign up and use for free; other parts have a modest licensing fee based on self-sustainability principles and are managed by Common Ground Research Networks, a nonprofit, public-benefit corporation based at the Research Park of the University of Illinois. Among others, use cases for CGScholar include literacy in elementary and high schools, higher education, including education, engineering, medicine, and veterinary medicine courses, as well as global social learning interventions by the Red Cross and the World Health Organization.)

The system analyzes and organizes data from student interactions on the platform to create a type of visualization called an Aster Plot. Each “petal” of this visualization represents a specific learning metric defined by the course instructor. These metrics are categorized into three groups: Knowledge, Focus, and Help. Fig. 1 displays an

Aster Plot; you can see the consolidated data for all students, which is also available to the instructor. Additionally, each student has an individual visualization of their progress on their personal page, and the instructor can access these visualizations at the course community level encapsulating all interactions—datapoint within the course community. This approach combines cybernetics and literacy in a vision of learning based on student performance on the platform. The feedback system’s loop in the students’ learning trajectory leads them to regulate their performance, and in this process, they develop competencies within the course learning context.

Teachers can edit these fields in the tool’s settings, as well as add new indicators. This is a way to work with automated feedback while learning is happening. In a new course or set of learning activities, the student starts from zero and

progressively moves toward 100, aligning with the teacher's learning objectives. This is a way to receive automated feedback while learning is happening.

The purpose of this feedback mechanism is to encourage students to self-regulate in the learning environment by developing engagement strategies. Every data point serves as a critical juncture in a student's academic journey, allowing them to map out their future actions. The feedback provided was not linear and was updated daily, based on the students' progress. When hovering the mouse cursor over each spoke represented in the circle, you can access a detailed description of the indicator, including the proposed goal, class average, student's position, and suggestions on what they can do to improve their performance. Teachers can edit these fields in the tool's settings, as well as add new indicators. This is a way to work with automated feedback while learning is happening. In a new course or set of learning activities, the student starts from zero and progressively moves toward 100, aligning with the teacher's learning objectives.

A Cybersocial Environment

This system shows how technology can enhance what humans can do (Cope and Kalantzis 2023). It does this by keeping track of what every student does in the learning environment. This information is then used to give feedback that helps students learn better (Luckin 2018). When properly calibrated, a system like this provides a learning dynamic that supports students on their own paths. This is a way of working on the personalization of teaching that occurs in a relationship of interdependence with the student community, which generates feedback and assists as a large collaborative intelligence. These interactions add a social aspect to the process. Such a system can be used to help students write complex texts such as academic essays, relying on extensive peer support and abundant feedback from which they can work. Furthermore, this is a way to learn how to appropriately use the capabilities of a computer system to solve complex problems.

In this system, both humans and machines observe and are observed. As the system allows a high degree of interactivity among students, everyone can be observed from various viewpoints, for example, when one of their texts is commented on by other students. Furthermore, all are also observers. Observing and being observed is a way to work with different subjectivities in the classroom. Another perceptual position comes from the machine itself, as it converts recorded interaction data into visualizations that are semantically legible to students. These various perceptual positions make the cybersocial environment much more complex than a conventional education model, in which students are observed by the teacher and observe the learning objects he makes available to them.

This dynamic challenges modern epistemology, which does not consider subjectivity in the knowledge construction process. Also, this connects with ideas that aim to rethink differences between the body and the mind, nature and culture, and matter and intelligence. These old concepts and practices need to be rethought for their roles in today's digital society.

One of the problems with the current digital media ecosystem is that it reduces human agency to an object of machine agency. This occurs when people start to reproduce a type of behavior solely to generate positive feedback in line with the design of a particular algorithm. For example, a person discovers that a certain hate speech generates more interactions than a moderate discourse. As a result, they start to dedicate themselves to hate speech and begin to monetize in a particular social media. This is an example of how a person can act according to what the algorithm expects of them, thereby feeding into a business model. A system that generates a result like this is not suitable for education. Therefore, from a cybersocial perspective, the goal is to work with human agency that is expanded and complemented by the machine, to value reflexivity. In this perspective, cybersocial systems may help restore balance to structures and behaviors disrupted by the rise of digital media, especially in education.

Conclusion

The cybersocial learning approach has the potential to significantly transform how we learn and teach. It is crucial to establish clear pedagogical principles when developing these systems to ensure a strong foundation for effective learning experiences. The ability to seamlessly integrate sociability and adapt to individual learning styles makes cybernetic education a potential game changer in the future of education.

But unlocking the potential of this proposal leads us to important questions about conventional models of education. Does it make sense to continue with 50-min classes when students can work at their own pace, anytime and anywhere? What is the relevance of teaching specialized subject content when students can obtain it from the web according to their interests and purposes? How do we create in students the disposition to become capable of creating knowledge relevant to their life contexts? These are some of the questions that invite institutions and educators to reimagine education for the digital society.

Cross-References

- ▶ [Adaptive Personalized eLearning](#)
- ▶ [Affordance Theory in Relationship to the Learning Environment](#)

- ▶ [Human-computer Interaction Visualisation in Mixed Reality](#)
- ▶ [Learning Analytics: International Perspectives, Policies, and Contributions](#)
- ▶ [Mixed Reality Multimodal Learning Analytics](#)
- ▶ [Mixing Realities: The New Partnership Between Human and Machine](#)
- ▶ [Nonlinear Pedagogy](#)

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