Cybertraining – A Development by Using a Holonic Control Structure

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Abstract. School reform is a process that develops from within, but under the pressure of external influences. Externally, social demands and the increasing pressure of technologies and research that find a field of application in education are acting. From within can act the desire for modernization, the accumulated competence. The article combines the two forms of pressure in the form of solutions already implemented in the CyberTrainer™ service (www.cybertrainer.online), a professional service to assist learning processes. It is justified, for the beginning, the need to integrate information technology in the school concept. Subsequently, the set of requirements of the specification is built and the details of developing and implementation of the solution are provided. The chosen path is to treat the school as a second-order cyber system and to build a holonic control system. In this system, students and instructor are holons. The main features provided by the control system are the student’s autonomy and the high degree of cooperation during the learning process. The effects of applying the solution indicate a sketch of the change of school idea: the teacher becomes an instructor, the student becomes more responsible and involved in his work, and the school activity more and more efficient and adaptable.

Keywords: Cybertraining · Second order cybernetics · Holonic system · Training group · Educational technology

1 Introduction

The COVID 19 pandemic has once again, clearly, shown that the use of e-learning is far from a real alternative of school. The main goal of e-learning services consists, in fact, in ensuring the preserving of the traditional role of the teacher through technical solutions that use computer applications and electronic communication resources. The pandemic also showed that the technical solutions covered by the use of teleconferencing computer applications mean both a depletion of resources and a decrease in the emphasis for student-centered learning.

The pandemic acted as an examination that confirmed what some researchers have reported earlier, more or less explicitly: in reality, at this time, learning is
not done by integrating the technique but by simply joining the technique to a traditional and outdated school.

In the described situation, there are, entirely, appreciations from the works of some researchers [6].

... technology is providing tools that provide radical new opportunities for education, but simply adding technology to the existing mix is not enough. We need to use technology to develop better pedagogies, and most importantly, to redesign educational organization at all levels, from the course to the national system, to allow potential benefits to be realized ...

The consequences are immediate: the performance of assisted learning methods, whatever they may be, is comparable to the personal performance of the teacher.

The following are excluded from the assisted learning applications: a) the real and personalized involvement of all the students of the study group; b) the way of generating the authentic problems, specifically for the students of the study group; c) an objective, systematic, personalized assessment of the students.

A synthesis of Murray [10] captures at least three essential aspects of current education: a) the static character of knowledge, b) the dynamic character of training; c) the importance of communication and training through communication.

... learning is constructed in communication in the relationships we build and the connections we make with our environment, which includes other living systems. In this view, knowledge is not formed by the senses taking information in, but as a whole body changing in dynamic reciprocal interaction in an environment. In fact, learning may be more accurately described as engendering knowing rather than some kind of static, stored knowledge. In this cybernetic view of the world it appears that learning happens to us as we communicate in an environment. It enables us to go on living ...

Thorough research give a good synthesis, in a salutary way, as requirements for the transition from conventional to student-oriented education [12]. There are some special ideas to remember, including the need to reconsider the balance of power, the need to place the responsibility for learning on the student and the need for an objective assessment. The shift of emphasis to this paper is to emphasize that there are strategies in parallel with point research [2,7].

Before approaching the reported research, we note a new suggestive passage from [6] that once again summarizes the artisanal way of doing school:

... this structure constrains the educational options available to learners, who have to be fitted into its structure. They typically need to choose from lists of available courses, and have to be assessed for their suitability to study these. This usually results in so-called ability groupings, and
typically, teaching proceeds as if all students in a cohort were identical, separated only by final examination results. But people do not easily fit these categories. They have different personal histories, aptitudes, interests, desires and preferred ways of learning. Fortunately, the efforts of teachers and the willingness of learners to forgo their uniquely individual requirements allow the system to continue . . .

Here are all the evidences that the school can be described better as lack of school and purely bureaucratic arguments are put forward for what an entire system is unable and unwilling to do. And again, the system one thanks the individual who does what the institution cannot: improvise.

This paper proposes the framework of an alternative of a new school. It is a framework already implemented and verified through the CyberTrainer service. The essential element of the framework is the action of framing and integrating a dedicated IT service in the school structure. Two elements are highlighted with priority: a) the fact that the purpose of the school, i.e. the learning of each student simultaneously with the learning of the group of students, must be functionally ensured; b) the fact that the school, as a social system, can be approached only through the means of second order cybernetics. The modeling of the school is done by introducing the holons associated with the students. Holons are the ones who ensure the learning activity at the individual level and at the level of the training group.

The holonic approach requires the construction of the virtual instructor. The virtual instructor is specified and his attributions in the matter of the organization of the learning activity and in the matter of ensuring the relations of autonomy and cooperation of the holons are retained. The organization of the learning activity has as its backbone the binomial built-problem - a solution of a built problem in which the student is directly involved and to which are added activities of analysis and direct assessment of problems and solutions. In this activity, the instructor is involved in the level of obligations of the students. Ensuring the relations of autonomy and cooperation of the holons is done by adjusting the position of the teacher who is functionally divided into virtual student, head instructor and authority. Subsequently, a complete reticular structure is built that includes the students of the training group together with the virtual student. The virtual instructor ensures the publication of all student contributions, their anonymization as well as the operations required by the analysis and evaluation process. The training session or lesson ends by communicating the results determined automatically regarding the activity of each student.

In the first chapter are given reference points from which it results that the current education contains a series of irreconcilable functional contradictions in the conditions in which the school avoids to integrate, in a real way, the information technologies. In the second chapter, a connection is made between the functioning of the school and the need to attach a goal in order to find cybernetic control solutions of the social institution. The third chapter details the group of students as an essential operative element that becomes the object of a holonic structure. In the fourth chapter we proceed to the specification of
the holonic control structure and the first implementation details are given. A fifth chapter examines the effects of introducing the new vision and building the virtual instructor for school reform. The chapter of conclusions emphasizes the importance of introducing the concepts of second-order cybernetics and the holonic mechanisms for the redesign of the education system.

2 Functional Integration of Information Technology in School

A correct treatment of the conventional school in the face of the technical revolution requires a paradigm shifting. For this it is necessary to resume and update an image of the conventional school. As principle, it consists, generically, of a teacher, a group of students, an institution, a material base. If the teacher, the students and the institution are regarded as a social ensemble, together with its components, then the material basis is always an auxiliary reality without initiative.

The emergence of computer applications dedicated to school use has created a new segment of the material base. We will conventionally call this new segment “school technique” by its similarity, for example, to medical technique.

The evolution of the school technique followed the general evolution of the technique and became more and more, from a useful annex, a component part of the school.

2.1 A Motivation of Cybernetic Treatment of the School

In the evolution of technology, it is not the first time that machines have come to be assimilated, at least in part, as human partners.

By having a goal or direction, the new situation of the school, as institution and technology, makes it even more eligible for treatment through cybernetics-specific means [3].

The existence of a purpose, of a direction raises the problem of keeping them. The action of keeping a certain purpose in the face of the action of disturbances corresponds to a controlling or monitoring activity [13]. Wiener introduces the concept of system and its description through mathematical variables. In this way, the reduction of the effect of disturbances on the purpose of the system is done by introducing the feedback as a negative reaction. The feedback can be summarized as the action of reducing the effect of the disturbance when it causes a departure from the intended purpose. The feedback involves both the mechanism for determining the effect of the disturbance and the mechanism for correcting the evolution of the observed system. The technical mechanism solving these tasks is called controller.

A brief analysis shows that we are not in the specific situation of first-order cybernetics, specific to the observed systems, even if the presence of control to achieve the goal is also a necessity here. If we were in such a situation, the control problem could be solved by algorithmic design and by using mathematical models
associated with the observed systems. These models are usually dynamic models described by the methods of differential equations. The main quality sought is that of dynamic stability, i.e., keeping the purpose of the system in time in the face of all disturbances that may occur.

In this situation, however, we are in a social system, made up generically of a man and a machine or exclusively of people. In this ensemble, the man is a part but also an agent who knows his role as a part and who thinks about the status, respectively about his model in the system. The new system corresponds to the situation that can be treated only through second-order cybernetics in which man, agent and observer try to build a model of another cybernetic system.

In this new context, the individual’s initiative, his interests and feelings, his ability to control himself no longer allow the construction of a simple and comfortable mathematical model.

It is much more convenient to work with entities for which it is only noted that they have the ability to have a certain behavior and that they can act based on a set of rules.

### 2.2 A Holonic Model of School

The current school can be functionally described, in the new context, as a set of holons, an informational structure that represents a more adequate description of the social reality [8], including at the level of this institution. We check here Koestler’s definition [4] according to which by holon is meant any entity that is socially or biologically stable and displays a behavior governed by rules.

In this way, the holon becomes the constitutive functional element of all activities in which control can manifest itself and which refers to behaviors in which the human being is involved. Each holon is seen both as an individual and as part of a whole of which he is a part. It should be noted that each holon belongs simultaneously to two different levels so that, in one level, he is a member, and for a lower level he has the position of chief.

In a synthesis of Mella [9] it is stated that by generalization of the Koestler definitions:

\[
\ldots \text{the term } \text{holon} \text{ indicates any object or concept observable on three levels: (1) as an autonomous and independent unit that acts according to its own behavioral } \text{canons}; (2) as a superordinate unit, possessing emerging properties, with respect to the component parts that it transcends; and (3) as a subordinate unit in that it is part of a vaster whole that conditions it } \ldots
\]

In this way, the holon becomes the basic element in the materialization of second-order cybernetics.

In the case of the school, both the education system and the students and the instructor are found as holons. Together with their mode of association, holons make up what is called a holarchic structure or holarchy. In the holarchy, holons are considered along with all their control attributes. In this way, control becomes
an attribute of a social reality. Holarchy is, by the specificity of its elements, that is, holons, a structure devoid of conventional hierarchy, with ascending control paths and descending control paths. Such a control structure will also be called heterarchy to distinguish it from the well known path of hierarchy.

The reason for this analysis is to find a way to integrate the machine and the social environment. We must not forget that along with people and the social system, like holons, there is the school technique.

Compliance with the objectives of the school as a second-order cybernetics system can be ensured only through a control system. Due to the special nature of the description made by means of holons, any action that refers to the organization of holons in order to ensure a purpose becomes an alternative of holonic control.

### 3 Training Group as a Holonic System

As a holonic system, the training group must be open, modular and standardized. The structure of the group is one open by the common nature of the participants in the form of training. In this situation, by the nature of individual interest and common knowledge, students prove to be interchangeable. The modular nature is intrinsically ensured by the identity of the people involved. Finally, standardization consists mainly in providing an interface, through which interchangeable holons must be harmonized so that they can be integrated through communication possibilities in the considered framework [1].

For the general case of a school based on learning groups, each student can be regarded as a holon.

Holons all have the same ability to ensure the success of training activity. This capacity is a form of manifestation of interest in acquiring competence, as a group, but also as an individual, regardless of the form of its manifestation. For a good understanding it will be admitted that, mainly, the competence will be found by ensuring the good understanding of a given lesson or a good acquisition of the required skills.

The integration of the holon activity is done through an integration and control holon and this is the instructor. Its role is regarded through the quality and performance requirements imposed on training and not through hierarchical attributes.

As a holon, each student represents an autonomous entity that is set to cooperate with other similar entities to achieve the overall goal. Each holon has its own goals that sometimes, conflict with the goals of other related holons. These conflicts must be negotiated. The effectiveness of negotiation will have a significant effect on the efficiency of the whole system [1].

A closer analysis of the conflicts that occur in the activity of holon students highlights that they are specific to any human group activity. Moreover, here the conflicts are oriented towards those aspects that lead to competition, thus to the increase of the efficiency of the group’s activity. Beneficial conflicts between
members of a holarchy occur, either due to natural causes or are stimulated by the activity of the holon-instructor.

A natural conflict occurs when there are differences in individual traits such as pride, desire to win, desire for superiority in action.

A stimulated conflict can be the correct classification of objectives in such a way that their approach leads to different awards. It is enough for a problem to solve to be declared a priority and the desire to win makes the students of the group enter a direct competition.

Another situation of conflict stimulated by the activity of the holon-instructor is the scattering of the value of the awards in a sufficiently wide range, simultaneously with the limitation of the number of prizes. In this case, it is found that holon-students end up building real strategies to approach the activity towards alternatives with high chances of success.

On the contrary, a moderation of conflict states is obtained when risky situations are defined. The simple elimination of the name, the anonymization, which should be associated with the results of the work of the holons and their exposure to the interested competent vote of the members of the holarchy leads to an increase of the degree of responsibility. At the same time, there is an increase in the objectivity and quality of training activities.

4 School – Structure of Holonic Control System

In the first phase, the technical conditions for performing the holonic control will be analyzed. In this control structure, stability and accuracy are no longer priorities. Instead, it is necessary that the performance of the control system be achieved by ensuring the autonomy of the holons, i.e. their ability to act autonomously in the face of unpredictable circumstances and the ability to cooperate with other holons [5].

Obviously, the holonic control structure aims at associating holons in holarchies that contradict traditional hierarchies and appears to be without defined ascending or descending control pathways.

Through the interventions imposed by the design of the holonic control, the observance of the characteristics of the holonic systems derived from the observance of the behavior of the systems and human societies will be followed. A human holon simultaneously exhibits two basic, rather opposite, behaviors: a self-affirmative tendency and an integrative tendency. The self-affirmative tendency is the dynamic expression of the holon as a whole, while the integrative tendency is the expression of its part condition [11].

The achievement of the holonic control system supposes the building of a virtual instructor, technical component realized as computer service. Its role is that, during a lesson, to bring together students-holons with the instructor-holon in such a way that the performances of autonomy and cooperation are achieved in conditions of efficiency of the training process.
The specification of the virtual instructor is based on the requirements:

(a) A structure of the holon set is created without any conventional hierarchy. For this, we opt for a heterarchy based on the regular reticular structure, i.e., a structure that includes sides between each two participating holons.

(b) Any detail by which he can intervene through actions of excessive authority is removed from the *functionality* of the instructor. Functionally, this is achieved by separating the possible actions of the holon instructor into three categories: a) actions specific to the interaction with students and included in a character or actor with the role of virtual student; b) specific actions of monitor and coach character included in a character or actor with the role of head instructor; c) actions specific to the investiture of a representative of the authority for decisions regarding the confirmation of the impact analyzes of the students, actions associated to a character or actor with the role of authority.

(c) Learning activity is limited to student actions and interactions between students completed through contributions i.e. built problems, solutions to built problems and analysis reports on peer contributions.

(d) The entire control of the quality of the contributions is transferred to the students’ vote, which manifests itself in front of some public contributions, problems or solutions of problems, without revealing the names of the authors.

(e) A unitary assessment module of the students’ results is built based on the actually submitted activity and on the quality of this activity appreciated in the group.

Through holonic control, developed and implemented inside of CyberTraner service, an unnecessary hierarchy was removed from the school structure and in this way all control decisions are made at the local level. In the new situation, without the possibility of a global optimization of the school’s functioning, an increased flexibility of the learning system is reached. It is also noted that, in the new framework, all school technology systems are integrated with the reason of the school as a social system.

![Fig. 1. A sketch of the holonic control of the learning activity.](image)

In Fig. 1, a group of three students, $S1$, $S2$, and $S3$, respectively, form a holonic structure under the action of an *HSMU* coordination unit. The holonic
control structure is under the influence of the virtual instructor \( ViTr \) and the results of the activity from the \( AssM \) assessment unit are evaluated and communicated later to each student.

A peculiarity of the proposed solution is the exploitation of the heterarchy characteristic of the holarchic structure [3]. For this, another solution was exploited that meets Weimer’s recommendation [12] on changing the balance of power in student-centered systems. Specifically, the person of the instructor was decomposed into three characters with different roles that intervene in the learning process in different places. The three hypostases of the instructor are: as a virtual student (\( VS \)), as a head instructor (\( H.Tr \)) and as a representative of the authority or instructor-decision maker (\( A.Tr \)). In this way, Fig. 1 is completed by including the virtual student in the holistic learning structure. Specific to the holonic structure is that it is by way of construction a heterarchy, i.e. in the learning process there is no pre-established hierarchy.

The schematic diagram in Fig. 1 is the basis for the operation of the Cyber-Trainer service implemented and installed at www.cybertrainer.online.

Figure 2 a) describes the idea of separating the three actors to take over the functional responsibilities of the conventional teacher. Along with the separation, there is a resettlement of these roles/actors in the reticular network associated with the holonic control of the learning system.

![Fig. 2. Reconsideration of the instructor role by separating the teacher’s attributions: a) separating the instructor’s roles in the Cybertrainer service and repositioning him in the group of students; b) the vision of the conventional school where functionally, the teacher is located in the center of the activity.](image)

It is assumed that the training group is composed of students \( S1, S2, \) respectively \( S3 \) who cooperate with a trainer \( Tr \). Following the functional separation, the teacher \( Tcr \) becomes a group of actors: \( VS \) - virtual student; \( H.Tr \) - the main instructor and \( A.Tr \) the representative of the authority. Unlike the case of the conventional school as in Fig. 2 b) following the change, the teacher \( Tcr \) functionally changes his central place in the relationship with the students. Students \( S1, S2, S3 \) and the virtual student \( VS \) form a complete reticular structure, where a predefined hierarchy is lacking.
5 Outcomes and Interpretations

By implementing the holonic control system, the new school, the cybernetic school is composed of students, virtual students, instructors and a virtual instructor service. The virtual instructor is the technical component meant to implement the rules that ensure holonic control for students considered holons in a specific holarchy. Holistic control is built to allow through uniform and systematic rules the autonomous action of students and their permanent cooperation.

The same virtual instructor service is the one that manages the duration of the training session or lesson. This duration is divided into four active stages designed to build problems, solve built problems and analyze and assess the quality of problems, respectively of solutions. All student contributions are public and available to all participants in the session. The authors of the contributions are permanently anonymous to the participants in the session. The analysis of the contributions is finalized by the quantitative vote of the students.

The instructor can intervene, in the training activity, only from a position equal to that of a student, as a virtual student. Thus he can indefinitely introduce problems, contradictory or correct solutions, without his name being known among the other participants to learning session. Technically, in this way the effect of heterarchy specific to the holarchic structure is obtained.

Cybertraining is compatible with all other forms of training and learning currently practiced. Cybertraining and the virtual instructor service recognize all other computer products and services for learning. The advantages of using the virtual service appear when it turns out that cybertraining shifts the responsibility of learning to students and to explicitly covering their individual needs.

The cybertraining method, together with the virtual instructor, becomes the basis of an integrated educational technology.

The development of a second-order cybernetic system associated with the school represents a technical approach in which the pedagogical and psychological aspects do not appear in the foreground. The specific details of a certain discipline do not appear in the foreground either. It does not appear in the foreground, nor does the working language matter. In this way, one can speak of the fact that the cybernetic school is an “abstract machine” intended for the “learning industry”.

But what appears permanently in the cybernetic school is first of all the individual, it is the student and then the training group. The personal interest of each student through the way of reporting to the subject to be learned and the cross-interaction in the training group are the driving elements of the cybernetic school.

The instructor’s effort is reduced to the achievement of the best selection of knowledge that can be associated and that can guide the acquisition of an imposed theme. This selection of knowledge, called support of the training session, is only a necessary reason to initiate the “search movement” of the target of learning, understanding, learning skills, but also innovation, design.

Although no form of appeal to the instructor is excluded, such an approach is no longer considered the school’s endurance piece, just as teaching is no longer
infallible, which is considered a completely obsolete and unnecessary form of didactical activity. One highlights the individual activity, driven by their own needs, influenced and peer supervised.

6 Concluding Remarks

Cybertraining, together with the virtual instructor, determines a new educational technology. The operation of the ensemble respects the principles of second-order cybernetics in which the parties involved have, at the same time, the role of observed part and observer part. Modeling students as holons and the training group as a holarchy allows the construction of the appropriate controller that can address individuals and the learning process as a goal pursued and ensured. The purpose of learning is thus pursued flexibly and specifically for each individual and the group as a whole.

The cybernetic school, i.e. the school that operates through the extended application of the educational technology of cybernetic training, possesses a significant synergistic resource resulting from the distributed character of the holonic control. To this is added the active and always fresh action between the initiative of one’s own interest and the pressure of the integrated interest of the group.

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