Transversal System of Teaching-Learning and Virtual Learning Environment to Teach Artificial Intelligence

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***Abstract*—This Research-to-Practice Work in Progress (WIP) presents initial result on pedagogical implications by using the Transversal System of Teaching-Learning (TSTL) and Virtual Learning Environment (VLE). Both were used in the module "Artificial Intelligence (AI) in the Technology in Digital Games" course available at a specific University Center. This investigation is qualitative and adopts action research methodology. This study adopted some specific steps. Data collection was composed by field diaries, focus groups, group work delivered by the VLE, tests with open questions, and evaluation form of module and material support. The analysis of the collected data is based on the theory of Structural Cognitive Modifiability (SCM) from Reuven Feuerstein. In addition to the data analysis, a script of episodes was proposed, in which the relationship with the content to be studied was established. Results revealed that the TSTL can also be used in lessons to teach complex topics in Computing as AI. The TSTL was instrumental in assisting in the planning of a transversal module such as AI and the cooperation between teachers from other modules as well.**

***Index Terms*—Artificial Intelligence, learning, Virtual Learning Environment, Transversal System of Teaching-Learning**

I. Introduction

Brazilian education has faced many challenges such as inadequate infrastructure, untrained teaching staff, and socioeconomic problems [1]–[3]. As a result, undergraduate students have presented many problems in learning and understanding the content in Higher Education as, in fact, they do not have the basic requirements of literacy and numeracy. In Information Technology and Computing Undergraduate courses it is demanded a solid previous knowledge of Mathematics. Critical thinking and logic are essential skills for learning programming and other complex topics mandatory for this area.

The importance of learning Artificial Intelligence is crucial for any course related to Computing, for example Computer Sciences and Technology in Digital Games. Its content is transdisciplinary because it involves many different areas, such as Biology, Maths, Sociology, Psychology, Linguistics, Philosophy, Computing, Neurophysiology, and Programming Logic. This module aims to discuss the contemporary overview of scientific and commercial application of the use of techniques of Artificial Intelligence (AI) with practical examples [4]–[6].

Teaching AI might be considered challenging because it requires previous knowledge and because it is transdisciplinary. Some of these challenges are: defining a clear didactic sequence with many topics to be addressed; knowledge of advanced Mathematics; and mastery of Programming Logic, which can also lead to frustration and affect the learning process.

Given these challenges, it is necessary to investigate the needs and aspirations of teachers and students to develop new ways of teaching and learning. With this in mind, the present research aims to contribute to the discussion of better ways of teaching and learning, by trying to understand the barriers in AI education. Because of this, our research question is "How can the Transversal System of Teaching-Learning (TSTL) help AI teaching and learning?". The hypothesis pursued is that the use of TSTL increases the possibilities of interaction, favors the dialogue and critical thinking, motivating the interaction in the classroom, if there is an adequate pedagogical strategy.

The Transversal System of Teaching-Learning (TSTL) developed by Professor Stela Piconez at the Faculty of Education of the University of São Paulo (FE-USP) supported by Virtual Learning Environment (VLE) [7]–[9].

II. Teaching Artificial Intelligence in Higher Education

Some experts and researchers define artificial intelligence that differ in categories as shown in Table 1 [10]. This is because these categories vary according to research and application line, being difficult to categorize it's boundaries.

Problems in this area are not restricted to it's definition. It extends to the processes of teaching learning as well. A literature review was made about academic papers that investigated challenges and contributions to the teaching of AI in Higher Education since 2008. The majority of studies found were restricted to developing and presenting media resources support as frameworks, but not mention the application and teaching methodologies to support the use of these frameworks as: Athena [11]; ANNeF [5]; FuzzF [6]; Sistema Hipermídia [12].

TABLE I
DEFINITIONS OF ARTIFICIAL INTELLIGENCE. TAKEN FROM [10]

Thinking Humanly	Thinking Rationally
"The exciting new effort ... to make computers think machines with minds, in the full and literal sense." "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning ..."	"The study of mental faculties through the use of computational models." "The study of the computations that make it possible to perceive, reason, and act."
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." "The study of how to make computers do things at which, at the moment, people are better."	"Computational Intelligence is the study of the design of intelligent agents." "AI . . . is concerned with intelligent behavior in artifacts."

Given the computer education issues presented so far this paper contributes by rethinking and reshaping the module of artificial intelligence using the TSTL.

III. THEORETICAL-INTERPRETATIVE VIEW

The present qualitative research treats education as a social phenomenon and, for this reason, adopts action research as its methodology. This methodology deeply considers several aspects of the research object, not only the question of learning, but also social, economic, and cultural issues [13]. Data were collected through field journals, written tests, focus groups, and open questionnaires. The purpose of using different sources of data was triangulation.

This WIP wants to understand teaching and learning AI phenomena, for that it is mandatory to adopt qualitative research, quantitative research not fit to this propose [14]. It is very important to be aware of students' social, cultural, and economic aspects and how it can affect their learning processes. To achieve that it is essential to use a strong theoretical framework for education research.

Data collected were analyzed by using the theory of Structural Cognitive Modifiability (SCM) and Mediated Learning Experience (MLE) of Feuerstein et al., [15]. For Feuerstein, the student is seen as open, adaptable and changeable. These changes that take place in the structure of thought create conditions so that one can increase the repertoire of words to be used in the process of thinking about new things that previously did not make sense. It is assumed that the student can autonomously acquire, not only different skills or knowledge, but also new cognitive structures, through which new areas previously not included in the set of skills and knowledge provided by the school curriculum [15], [16].

The Transversal System of Teaching-Learning (TSTL) was used to plan the AI lessons. This is because it included explicit pedagogical bases in all educational processes from planning, design, implementation, and evaluation, to the training and continuous updating of teachers. It also covers the production of didactic material. The TSTL have more than three decades of maturity through research and application with proven effectiveness [8].

In order to create a successful learning experience, Feuerstein developed the Mediated Learning Experience (MLE). This approach is centered on modifying the student, emphasizing autonomous and self-regulating transformations. It is not just about stimulus exposures, it is necessary to have a mediator (teacher/professor) to provoke cognitive changes aligned with significant cultural elements, and events experienced by the students.

According to Feuerstein theory, the TSTL can be turned into a MLE if it contains the three following essential characteristics: Intentionality and Reciprocity; Transcendence; The Mediation of Meaning. Other important parameters of mediated learning experience (MLE) that contribute to the diversity of human learning and development are: feelings of competence; regulation and control of behavior; sharing behavior; individualization and psychological differentiation; goal seeking, goal setting, and goal achieving; search for challenge, novelty, and complexity; awareness of being a modifiable entity; optimistic alternatives; sense of belonging. These parameters of MLE derive from specific situations in the particular cultures that the mediator and the mediatee belong to [15].

IV. METHODOLOGICAL TRAJECTORY

This study adopted some specific steps. First there was a diagnostic analysis from teacher interviews and literature review to identify the common challenges in teaching AI in Higher Education. A small amount of material was found in Brazilian literature on challenges in the teaching of AI. Then, the research key words became challenges in Higher Education in Computer Sciences and Information Technology courses.

Having identified the problems, research was made to identify different possibilities to face these issues. It was established that the TSTL fits the proposal of the module of artificial intelligence due to it's transversality. Moreover, a curriculum analysis and syllabus of the module taught at the University Center was done.

In addition to the analysis, a script of episodes was proposed, in which the relationship with the content to be studied was established. For each episode a pedagogical support material was elaborated based on the TSTL handouts [8]. In parallel, an application script was also created for each episode. This episode planning varies in application time, where some episodes fit into a 4-hour lesson, and other episodes require 8-hour lessons or up to 10-hour lessons.

After elaborating this planning and supporting material, the AI teacher, responsible for the module in the course of the Digital Games Technology applied the planning and support material. The group was composed of 27 students with varied age groups, including 17.6% of students aged 15 to 18, 64.7% of students aged 16-19 years, 5.9% of students between 26-30 and 11.8% aged 31 or over. During this period the teacher recorded in the field diary the relevant events and all

impressions on each class. In addition to the field diary, each episode included group activities of a maximum of 3 students that were assessed by focus groups Due to the limited time available, the teacher always randomly selected 3 to 4 groups to share the results of the activities. The group of students discussed with other groups and with the teacher about the results of their activities.

The planning and implementation of the activities was supported by a Virtual Learning Environment (VLE), where some of the activities were delivered and support material was available. In addition to the content of the lessons, the teacher opened a discussion forum on topics related to the module.

Data collection was composed by field diaries, focus groups, group work delivered by the VLE, tests with open questions, and evaluation form of module and material support. After data collection, they were triangulated to cross the information and perform the analyzes according to theorists Feuerstein and SCM.

V. Presentation of the proposed Classroom Plan

Planning the semester consisted of creating episodes of lessons in which each episode encompassed cross-cutting topics relating artificial intelligence and many other topics. For example, when the episode of genetic algorithms was planned the topics of generic operations and their related issues, genetic calculations, algorithms and data structures as Darwinian theory were analyzed to create a lesson script, a handout study, slides of lectures and other supporting materials.

Each episode followed the same structure. It started with the presentation of the supporting handout that served as a guide for the lessons. Based on it, the teacher instigates the students with a focal question that involves transversality as much as possible. After that, there is a group activity to evaluate students 'prior knowledge to help direct the lecture, using students' own examples as well as adapting the language they bring. After this activity, there was an explanation using slides with images and didactic videos. Then the students were challenged with more complex activity that could involve coding a new function to test the example algorithms. Finally, the teacher requests a reflection of all these activities in relation to their importance in the development of software and it's possibilities.

VI. Results

The results collected via field diaries helped to illustrate that the focal question was a factor to develop attention, curiosity and engagement of the students. It also acted as an icebreaker and as a quick assessment to find out the student's prior knowledge of what will be discussed in the classroom. The teacher may realize that several of these questions favored a deep and complex reflection by having students use critical thinking to try to answer such questions. This activity was important in helping students to separate important concepts and to understand that, in order to discuss something, it is important to clearly define certain concepts that are discussed, as to enable everyone's understanding and capacity to discuss in a sensible way.

After the discussion of the focal question, students had to make a formal activity, in which they would need to reflect, discuss, research and describe concepts of the studied topic. This other activity was fundamental to students to become autonomous and spontaneous when dealing with contents and diverse topics of their interest. That validates the mediation of meaning and intentionality, reciprocity, regulation and control of behavior. The process of discovery and discussion in pairs about a new topic not discussed by the teacher made them excited and motivated. After the stipulated time (15 – 30 minutes), 3 to 4 groups were randomly chosen. These groups presented and discussed with the class and teacher the material produced. The teacher always asked stimulating questions for students to organize their ideas and to discuss their points of view using coherent and concise arguments.

The next step consisted of a lecture by topic of the episodes to explain it. The discussion was coordinated by the teacher, but the students were protagonists. After the lecture, another group activity was proposed, this time with greater complexity and involving formal technical terms from the lecture. In some classes, the activity involved coding whole codes, or part of codes ready in relation to some artificial intelligence technique. At the end of the stipulated time for this activity, some groups were randomly selected to share and discuss how they managed to solve the problem and thhe challenges faced. In order to finish the class, the teacher asked the students to answer the focal question again, but now the students were able to respond more properly and taking into account what was developed in class. Then. he teacher asked another question to promote the reflection of the theme of the lesson and how it might relate to the area of the course. All the activities done by the students were submitted to the VLE.

During the activities, the teacher may notice that the students used the TSTL handouts to discuss and ask questions while they were doing the activities described above. The teacher can perceive contentment by reading about some curiosities and facts contained in the handouts. It was also perceived by the teacher that the activities were essential to reveal students' doubts and misunderstandings of the lectures. Because students often claimed that they had understood all the lectures.

The integration between the module of Artificial Intelligence with the Programming Object Oriented, Integrative Project and Data Structure in order to work in an integrated manner made students realize the engagement of teachers and, because of this, students started to feel more involved in the module with greater collaboration. The application of AI constructed knowledge in another module was important to mediate the student's transcendence. As a group activity, it helped the mediation of sharing behavior.

Results suggested that students showed greater engagement and interest when activities developed in class were related to the students' background, for example the "Lord of the rings" trilogy [17]. This is because the tasks started to have more

sense and meaning, regardless of the technical questions of programming, philosophy, logic and mathematics they were asked to solve. Most students were able to solve these activities. Some of the students delivered their activities incomplete, but in a satisfactory way. The teams provided documents describing the analysis of the application of programming codes in addition to their theoretical explanation of various artificial intelligence applications. This favored the mediation of sense of belonging, optimistic alternatives, goal seeking, goal setting, and goal achieving, search for challenge, novelty, and complexity.

In parallel two written tests carried out involving the content of the lessons with a maximum score of 10. The mean of the students was of 6.46 with a standard deviation of 2.60 and an avarege deviation of 2.05. The minimum grade was 1.5 and the maximum grade was 10.

The Integrative Project module used the learning of the module researched where the students developed a game and applied at least one AI technique, and this was fundamental to validate the students' learning. All groups of students were able to demonstrate a minimal application of what was learned in the AI module. By minimal application, it meant students were asked to implement a search algorithm using heuristics.

Before the last test, the teacher had an open questionnaire to students regarding their contribution, the material used and the challenges they faced. The students mentioned as challenges: the theoretical load seen in class; the scientific formalization; language and technical terms; problems in relating theory and practice to applications in digital games; categorizing the AI scenarios; formulating logic; understanding new programming syntaxes that were not presented in advance.

As for the strategy and TSTL handouts, the students considered that: "the teacher's help is less necessary, since the lesson script is available for the student to remember what to do and think about it, which makes the class more productive"; improves understanding of the subject and complementary contents; "it helps in tracking the lesson, enabling us to reread the material after class and it works as a way to research about the subject again through its sources"; "there is a concise summary of the lesson with easy access to key subjects"; "material of study, relevant references, activities that contribute to the absorption of the subject of the class"; "the exercises in the handout help with learning, there are fun facts, as well as some examples for exercising"; "contributes to the understanding of AI and its behavior; helps in understanding how an AI can be useful in practical solutions and how it will do this".

When asked about the contributions of the dynamics used by the teacher in the classroom, the students listed: "Agility when presenting the proposed content. Clarity in explaining what will be done in class "; "they help understanding the subject and getting more in touch with what is being studied"; "interaction with students, questioning of previous and subsequent knowledge about the subject"; "The ability to ask the teacher questions via the internet (quiz tools from google presentations) was a great resource as some students can ask without embarrassment."

The triangulation of these results allows more accurate evaluation. It can be noticed that there was variation of the students' engagement throughout the semester by several factors. One of them was the student's prioritization of solving problems outside the context of the module, whereas detected by the field diary, caused student dispersal, and the teacher sometimes had to interrupt the lesson to alert the importance of his module and negotiate with the students a possible solution to this problem. Despite the group work being satisfactory and often rich in detail and important reflections, the written test has shown that students have greater ease of building knowledge in groups than in individual tests without consultation.

Another factor detected is that the teacher of the module can work on more complex content such as the development of new functionalities in code and their theoretical analysis in group work. However, in an individual test without consultation this is not possible due to time, space and adequate environment. With open questionnaire it was also possible to detect that some students do not present questions due to shyness, and that technology can help overcome this barrier.

VII. Final Considerations

This paper proposed to align the Transversal System of Teaching-Learning strategy originally created for Adults and Young Adults Education (EJA) to be applied in the module of AI in the Technology in Digital Games course available at an University Center. The importance of analyzing a lesson about different perspectives and using different evaluation methodologies enabled us to reveal something closer to the reality of the student and their struggles because it provided a greater approximation of the student.

Results revealed that the TSTL can also be used in lessons to teach complex topics in Computing as AI. The TSTL was instrumental in assisting in the planning of a transversal module such as AI as well as cooperation between teachers from other modules. Their help in the creation of support material was fundamental for the success of the class and engagement of the students of the proposed challenges. Finally, the appreciation of students' prior knowledge and their use in the teaching and learning dynamics as well as the discussions in groups fomented in the classroom were also of great importance. Every theoretical and practical guide to the application of classroom activities was made possible by the TSTL.

It is concluded that the TSTL, in addition to facilitating the activities and tasks of the teachers, significantly helps students, because in addition to the development of critical thinking and student engagement, the teacher has a support material to guide the classes and evaluate students in various aspects.

Although the results indicate the confirmation of our initial hypothesis, it is still necessary to continue the research, collect more data and further deepen the analyzes and reflections. As future work, a deeper analysis in relation to all the competencies contained in Feuerstein's theory. In addition, it is intended to extend the TSTL to other disciplines related to computing.

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