On the integrated professional practice in a computing course towards innovation

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***Abstract*—The integration of disciplines in higher technology courses is a significant challenge. Sometimes the student can not visualize the correlations between different knowledge in the direction of a complete formation. This paper shows an integrated professional practice that relies on an innovation discipline to discover and prospect new technological products. From this, technical disciplines can focus on developing such products, having as supporting the knowledge and capacities determined in their curricula. The results show that students were able to develop products that aligned with local and regional problems, as well as open up a possibility for the creation of startups based on the developed products.**

***Keywords*—curriculum proposal, discipline integration, technological innovation.**

I. Introduction

The way we build knowledge, in a way, defines us. In other words, if knowledge is presented in the school in a fragmented way, if the curricular components do not integrate and do not respond to an education project aimed at the full development of the students, it will not be possible to form a whole, integral person. The fragmentation of scientific knowledge to be taught manifests itself in the separation of disciplines at school and has been harmful to education. Even in the context of a given discipline, knowledge is separated into several relatively watertight contents, which are presented in a loose and disconnected manner. The result of the fragmentation of learning to be taught is the loss of meaning, which manifests itself in students as a repudiation of specific disciplines, demonstrating that they can not perceive the similarities and relations between the different areas of knowledge.

As crucial as the conception of a human being that one wishes to form is to present an understanding of relational knowledge in which the areas of knowledge - and their contents, methods, and worldviews - can be apprehended with greater integration. In the area of Education, interdisciplinary [1], multidisciplinary [2], and transdisciplinary [3] proposals are sought to overcome the curriculum fragmentation [4], which, by making the disciplines very specialized, ends up creating school dynamics in which the student, not the curricula, is responsible for bridges between knowledge. But how to integrate the curriculum without giving up the various forms of knowledge construction that the areas carry? What do you do to make learning more meaningful by connecting knowledge with life?

For curricular integration to become a reality in the school, it is necessary that the Political Pedagogical Project (PPP) announces new ways of conducting for management and collaborative work among teachers [5]. One way to do this is to adopt common practices, both concerning active teaching and learning methodologies (such as cooperative learning, project learning or research and problem-solving), as concerning formative and procedural assessment strategies [6].

Fieldwork, projects, complex problem solving, and end-of-course work are examples of integration activities that give meaning to learning, linking them together and involving students and teachers through proposals that result in meaningful knowledge of fundamental skills that permeate the whole curriculum. Group work is a great challenge for all, at any age, and in today's society. This is a relevant and fundamental capability, which aims to promote interaction and foster learning in the coordination of different roles, self-control, articulation, and management of tasks, research, planning, and construction.

This work presents the Integrated Professional Practice (IPP) as one of the practices that can directly imply the curricular integration, and indirectly contribute to the vocational affirmation of the student within the chosen area of action, besides providing the development of applications that can reinforce local and regional development.

This paper is organized as follows: In section II we present a discussion about the difficulties of integrating the curriculum and some literature proposals that try to address such difficulties; In Section III we present IPP as a viable solution to such difficulties; In Section IV we present the materials and methods used in the work; In Section V we present and discuss the products resulting from IPP; In Section VI we end with our conclusions and future work.

II. Problem Description and Related Work

Nowadays, there is no more place for purely technical training, which only prevailed for the development of specialties - based on the scientific development of knowledge. This circuit crystallized the school culture marked by the disciplinary fragmentation [7] [8], in a departmental structure that crosses the constitutive cycles of the course. However, this paradigm shift is necessary but difficult to achieve in practice.

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Interdisciplinarity emerged at the end of the last century from the need to justify the fragmentation caused by a positivist epistemology. The sciences were divided into many disciplines, and interdisciplinarity reestablished at least dialogue between them. Considered by the science of education as an internal relation of the subject discipline and applied discipline, interdisciplinarity has become an accepted term in education because it is seen as a way of thinking.

In this way, interdisciplinarity would be a way of achieving transdisciplinarity, a stage that would not be in the interaction and interchange between the sciences, but would reach a stage where there would be no more boundaries between the disciplines. Currently, interdisciplinarity has been embraced by most educators, since such a position globally guarantees the construction of knowledge, breaking with the boundaries of disciplines because only the integration of content would not be satisfactory.

The logic behind is simple: if reality is a complex and broad one, fragmented teaching does not account for understanding it in its entirety, making it as necessary as it is essential to exchange and dialogue between disciplines in the process of the meaningfulness of both content of the world in which we live. Also, interdisciplinarity develops extremely valuable skills in students, such as curiosity, interest in learning, and the ability to work in groups. This leads, at the same time, to significant results in students' performance and their development as social beings.

Faced with the progressive globalization of the economy [9], the requirements for the formation of a new professional are emphasized, with increased flexibility at the expense of specialization. From this, and safeguarding the flexibility of curricular organization, interdisciplinarity takes strength given the delineation of a new formative pathway. According to this new methodology, several proposals try to address the limitations imposed by the non-integration of the disciplines.

Perhaps the most widespread among all proposals for integration between disciplines is in the form of project development [10]. In this model, several disciplines work during the school year focusing on the development of a process or product that should be ready at the end of the disciplines. Each course contributes with some of the knowledge necessary for the development of the processes or products, which can be developed individually by the students, or uniquely throughout the class.

However, this type of integration is not something officially regulated, unless it is curricular. Integration of curricular disciplines [11] does not offer the opportunity of not occurring integration, either through projects or any other chosen methodology. This model has given rise to some higher technology courses that do not offer a single formation, but a more general basic formation, and from a certain point, the student can choose the formative path to follow, thus choosing a more specific area.

Teaching and research is also an option that has always worked well in stricto sensu programs and has also been used in secondary and higher education courses [12]. This model allows the student to be updated and in line with a specific study object, and to improve their knowledge by taking advantage of the supervision of a specialist teacher in the chosen area.

A proposal that in addition to being interdisciplinary, is transdisciplinary, consists of projects integrated by teams from different areas and courses [13] [14]. This model expands the possibilities of projects with new ideas since there are several problems of a specific area that researchers in the area alone can not solve. In general, computation has done well this role, providing support for the resolution or acceleration in solving problems of physics, biology, chemistry, among others.

From the integration of exact sciences emerges the STEM, a movement of integration between Science, Technology, Engineering and Mathematics. STEM proposals range from projects applied in early childhood education [15] to higher education [16]. The approach engages students in hands-on activities that blend different knowledge and lead to creative learning.

III. IPP

The Integrated Professional Practice (IPP) consists of a teaching methodology that aims to ensure space and time in the curriculum, thus enabling the articulation between the knowledge built in the different disciplines of the course with the real practice of the world of work. In this way, it is possible to customize the curriculum and expand the dialogue between different areas of activity.

Currently, it is a practice widely disseminated and implemented in institutions of vocational education, being a key piece for the development of practical activities related to the course [17]. In a computing course, the objective of IPP is to search for theoretical and practical knowledge to base the choice of the discipline that will be developed, and allowing the students to combine the concepts studied in the day to day with the practice, predicting their professional use.

Thus, it is evident that the IPP has as its focus the overcoming of curriculum fragmentation [18] and the search for a curriculum that makes sense and meaning to the student. It is possible to highlight in this practice the intention to operationalize the vertical integration of the curriculum, providing unity throughout the course, comprising a logical sequence and an increasing deepening of the knowledge in contact with the actual work practice, constituting as a permanent space of reflection-action involving the entire faculty of the course in its planning.

IPP is strongly influenced by the STEM learning [19] [20], where the original idea is to unite knowledge of these four areas around the construction of something that solves the proposed challenge. STEM works in the form of creative workshops so that students in groups can solve some challenge in a practical way. The main thing is that it is a practical challenge that requires knowledge from different areas.

In this work, we present an IPP that takes into account an entire innovation framework to define the fields of action of future projects to be implemented. We believe that contributions that solve local problems have a more significant potential to

Dimension	Phase	Tool	Main Objectives and Findings
Discovery	Environmental Vision	BCG Matrix	Technologies applied to agribusiness
	Strategic analysis	SWOT Analysis	Presence of computer and agriculture courses
	Innovative portfolio	Business Model Canvas	IoT applications
Design	Exploration	Benchmarking	Growing Market
	Ideation	Brainstorming	Creation of a large number of new ideas
	Prototyping	Storyboard	Choice and description of each student's best idea
Development	Implementation	Minimum Viable Product	Use of arduino, sensors, actuators and mobile systems
	Communication	Pitch	Students' presentation
	Learning	Workshop	Coffee Meeting between lecturers and students

TABLE I: Steinbeis-SIBE Innovation Framework.

become an innovation, allowing an improvement in the quality of life of such a community.

IV. Material and Methods

The IPP was proposed through the integration of three disciplines: (i) technological innovation, (ii) prototyping of hardware and software, and (iii) development of mobile applications.

The discipline of technological innovation consists of working concepts and practices focused on innovation through technological products applied to local and regional development. The students used an innovation framework proposed by Steinbeis-SIBE[1] that consists of an expansion of design thinking [21] to define the focus of the products to be developed, as well as to define all phases of the project. This framework is divided into three dimensions: discovery, design, and development. The discovery dimension includes the phases of environmental vision, strategic analysis, and innovation portfolio. The design dimension consists of the exploration, ideation, and prototyping phases. And the development dimension consists of implementation, communication, and learning phases. For each phase, a specific tool was used. Table I presents all the dimensions, their phases, tooling and the result.

The results showed in Table I demonstrated that our campus is located in a region that has a robust agricultural vocation and that our campus offers courses and counts on specialists in the farming and computing areas. This set of factors guided the work of IPP to the Internet of Things (IoT) applications [22], as it is a paradigm that can bring together all the areas addressed towards local and regional development.

The discipline of prototyping of hardware and software consists of developing hardware and software solutions that can be prototyped in a small electronics lab through inexpensive, easy-to-implement opensource platforms. Proposed projects used Arduino (or some of its variants) [23], which consists of a board with a microcontroller and some complementary components that aims to facilitate the development of projects for reading electronic sensors and actuators, besides some expansion modules.

The discipline of development of mobile applications [24] consists of learning technical knowledge about the Android Software Development Kit (SDK) architecture, library features, besides good practices for programming mobile apps. The majority of the lectures are focused on the practical aspect, developing and deploying smartphones applications. In addition, we developed a final software product for Android mobile devices that communicate with the Arduino through data communication modules (such as WiFi), and allow the reading of values coming from the sensors and manipulation of the actuators. Internally, Arduino uses a variant of the C language, but for development on Android mobile devices, we used Java programming language.

Therefore, the integration between the three disciplines occurred as follows: in the innovation class, the students defined their potential in developing new products aligned with the needs of the local productive arrangement (LPA). They participated in a creative process that resulted in one idea per student, which solves one of the limitations investigated in the LPA. Each of the solutions was prototyped and implemented in conjunction with the two technical disciplines. The products generated were presented to an interdisciplinary committee and had their potential evaluated. It was a moment of learning and socialization of knowledge, ensuring a space destined for the focus of professional training, constituting a moment of reflection, which encouraged research and promoted interdisciplinarity.

V. Results and Discussion

Agriculture, livestock, and aquaculture are a source of subsistence for a large part of the rural population who maintain small and medium-sized farms and produce agricultural products for their consumption and sale to the urban population. The outcomes of these segments consist of an essential source of income and employment for the field, usually performed by teams formed from a family unit. The data show that this economic activity is present in 85% of rural properties in Brazil, and 70% of the food consumed in the country is produced through this segment, the southern region of Brazil is the second largest producer[2]. This is the scenario that our research is established, and it was pointed out by the mechanisms of the innovation framework.

After defining each student's research theme, the prototypes to be developed were established, and are listed below:

[1] https://sibe-edu.com

[2] http://www.fao.org

- Automatic feeder for fish: the region is a major producer of fish in confined tanks. In most, the feeding is carried out manually. The proposal implemented an electro-mechanical device, which at predefined hours of the day, pour in the water of the tank an amount of fish feed.
- Automated greenhouse: several small producers keep greenhouses for the production of vegetables. Factors such as humidity and temperature should be controlled. The proposal implemented moisture and temperature sensors that drive greenhouse cooling devices when minimum and maximum limits are reached.
- A system of automation of irrigation of the soil: the region maintains a strong vocation concerning the production of grains. Grain crops, especially rice, need a layer of water to develop. The control of this layer of water is usually done manually. The proposal implemented through depth sensors dispersed in the plantation, a monitor in the opening of the siphons that allow managing the amount of water to be scattered in the plantation.
- System for detecting carbon monoxide and flammable gases: industries must control the amount of carbon monoxide in order to maintain the health of their employees. This proposal implemented through gas sensors, an alert for high levels of carbon monoxide.
- System for the control of entrance or exit of people: several institutions must control the presence of its employees. The proposal implemented radio frequency identification cards to manage entry and exit of employees on an electronic point card.
- Lighting control system for studios: home automation is an area that automates the management of electrical and mechanical devices in homes. The proposal implemented a centralized control of lights and appliances so that the owner of the residence can trigger any device through only one interface.
- Checking for spinal problems: Spinal problems such as lordosis, kyphosis, and scoliosis are quite common these days. The proposal implemented through a range of positioning sensors, a device that can generate a 3D image of a person's column, and show the type of curvature of the column and its degree.

The driver devices were developed in the discipline of prototyping of hardware and software, and the user interface was developed in the discipline of development for mobile devices. Therefore, all prototypes can be controlled or display reports to users through mobile applications developed by students. It makes all proposed solutions more dynamic and up-to-date, and attractively presented to future investors.

Such prototypes were presented to a group of researchers and evaluated regarding innovation potential. From now on, these jobs will pass through investor, and the chosen ones will become startups who can develop their products for the productive market. Therefore, what started as an IPP may have fostered the entrepreneurial spirit in students, to the point that when they graduate in the graduation course, they already have their companies selling their products.

VI. Conclusion and Future Work

The organization of scholarly knowledge by disciplines a few years ago has been the point of criticism ranging from the argument that disciplines represent more of an outcome to education than to social, cultural and political issues, underpinning the educational policies that guide the organization of academy curricula. However, the main criticism of the curricular disciplinary approach is the fragmentation of knowledge. Among the alternative proposals to the organization of academy knowledge by disciplines, those that focus on interdisciplinarity and curricular integration stand out.

This traditionally fragmented model does not lead to the rise of innovation. An environment conducive to innovation is one in which there is a clash of ideas. People of various experiences and specialties must be present in the process of creation, and these moments of creation must be structured to produce results. Another point of stimulus to diversity is the possibility that exchanges occur in any direction, be it between peers and between people from very different areas. An innovative environment was proposed and supported by IPP.

Interdisciplinarity via IPP can materialize in teaching methodologies, curriculum, and teaching practice. From the historical perspective that reveals that the process of fragmentation of knowledge is accentuated with the process of fragmentation of work, one must be aware that forms of work organization, which do not focus on completeness, can emphasize the fragmentation of school knowledge.

IPP allowed several issues to be addressed. Approaching the campus with LPA, one of the missions of higher education institutions, which consists of developing the region in which the campus is located. Students experienced a real-world innovation environment, ranging from a vision of open product development opportunities, designing solutions to prototyping. Also, they have experienced the most current development methodologies, such as design thinking, agile methods, and project management. Finally, each student has a finished product with potential patent registration, and the possibility of opening a startup aimed at marketing such a product.

Besides, IPP understands different situations of experience, learning, and work, guided by research as a pedagogical principle, whose purpose is to articulate knowledge through the integration of the disciplines in the course and to bring the training of students closer to the world of work.

As future work, the products will be presented in rounds of investors, to capture resources and boost the creation of startups. Regarding teaching, the practice of IPP will be adopted as a complementary activity to the student's education, in a continuous and absorbed by the current curriculum of the technology courses.

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