Design Thinking: a didactic-methodological proposal for the training of computer science lecturers

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***Abstract*—Design Thinking arises from applying techniques and phases of the design process adapted to marketing, commercial, business and industrial processes, and in recent years it has been contextualised in training processes. This research shows how this approach can constitute a way of working in the context of training computer science lecturers. Our proposal is based on identifying techniques for the transit through the different stages from the didactics of the teaching media to the educational research. We developed a concrete set of actions to develop and research academic/productive skills and competencies in the context of solutions to problems of pedagogical practice. It goes through the identification of academic training objectives, problem analysis, strategy design, the conceptualisation of digital didactic media and constant verification of satisfaction levels, all under a multidisciplinary, collaborative and creative approach in tune with the current times.**

***Index Terms*—Design Thinking, computer science lecturers training, digital teaching media production**

I. Introduction

The training of education professionals currently has a determining role in the present and future generations. Education professionals must be prepared to lead and participate in innovative research projects that involve dealing with a collaborative environment and obtain short-term results that contribute to raising the quality of processes with the intervention of information and communication technologies (ICT). In the case of education professionals in Computer Science, Computer Systems, and Information Technology careers, they should acquire skills for Computer Didactics and create digital didactic media that support the process of virtualization of education.

Design Thinking is a collaborative, multidisciplinary work approach focused on the needs of end-users of projects that has been studied for its flexibility in different contexts: business, marketing, industry, innovation, education, project development, among others.

This paper presents a Design Thinking methodology applied to the training of lecturers in the Computer Science degree of the Universidad de Oriente (Cuba) as a work methodology when evaluating professional practice projects. This training implies the integration of knowledge to solve problems of academy practice with the intervention of technology. The final recipients of the projects are students and lecturers. The learning approach is multidimensional and multidisciplinary. Such an approach requires collaborative, interactive, multidisciplinary, integrative methods, where the needs of students and lecturers determine decision-making in the project, with Design Thinking being the approach that is capable of meeting the abovementioned requirements. Moreover, in order to demonstrate how the approach of Design Thinking can contribute to the comprehensive preparation of lecturers in training for the Computer Science degree at the Universidad de Oriente, we state the following hypothesis: Will the Design Thinking approach raise the quality of the training of computer science lectures when applied in the elaboration of digital didactic means?

II. The Design Thinking approach

A. Characteristics of the Design Thinking method

Tim Brown [1] assumes Design Thinking as a discipline based on the methodological elements of design to adapt them to clients' needs and market opportunities applied in industry and marketing; Cooper et al. [2] identify the approach as a human-centred innovation process applying it to business strategies. On the other hand, Plattner et al. [3] value its application in solving everyday problems with technological innovation.

Within the educational field, Leinonen et al. [4] analyze the process from the research-based Design Thinking (DBI); Gonzalez [5] analyzes it as a strategy to work creativity in higher education combining its techniques with project-based and game-based learning; meanwhile, Peña and Torres [6] analyze it as a Teaching Strategy for Methodological Innovation.

Other authors are closer to its application in software development, such as the case of Espinoza and Espinoza [7] that focus on software development with agile methodologies; Llerena and Terrones [8] applied such methodology to the

development of information systems and user satisfaction in the context of industrial processes.

As abovementioned, Design Thinking is understood as a discipline, strategy, or methodology. Design is present in all spheres of life, products are designed, but strategies, processes, services, and intervention models are also designed; everything is the result of a previous design process. Under this conception, we can affirm that Design Thinking is a method that applies in all personal and professional contexts. To make a fair analysis of the subject, one must start from the characteristics that distinguish Design Thinking and how they are applied in the formative process of the Computer Science lecturers:

- **It is people-centred**. Part of the foundation of the design, which assumes the subject as the centre of the process, to the consideration of this researcher is the key to the success of its application in business, technological and educational processes, where it is necessary to understand for whom it is aimed, what they need, and what the recipients of the product or service expect, which gives it a humanistic, personalized, contextualized and scientific character. Such facts, applied to educational environments, has a critical connotation since, in this context, it implies having the student at the centre of the process, not as an object of study but as a subject that intervenes in it. This aspect has great significance since, as a biological entity, psychosocial is not limited to the analysis of the subject itself, but its relationships with the environment surrounding it and other subjects.
- **It takes place in a collaborative environment**. The design is a process that requires constant interaction with the public and the members of the work team; it is the form of feedback to define the understanding of the messages that are transmitted, the functionality of the products, the effectiveness of the solutions, the synergy with other processes with which it interacts to achieve the expected result more effectively. For this, it is essential to use participatory and teamwork techniques, the evaluation and constant feedback of the guidelines or requirements established by clients, users, colleagues, and supervisors at an individual and group level, under working conditions in collaborative environments in favourable communication climates. In training professionals in the education sector, teamwork skills are essential. The lecturer needs constant feedback from other specialists such as psychopedagogues, doctors, teachers of other subjects, parents, supervisors, and the students, so this is pertinent in their training.
- **Conceptualization and Planning of the design process**. The conceptualization in the design is the simplified, analyzed and ordered information embodied in an object. It is the basis for the creation of any designed element. *"[. . .] As the first phase of any project, it collects information about the product, user, and context. The conceptualized design allows us to generate the shape and attributes of a designed solution, satisfying a specific need successfully, fulfilling all the requirements, which we call the functional design"*[9]. This is assumed as a significant element in the procedural order since the search for information prior to conceptualization determines the structural organization of the visual language to be used to transmit visual messages. In the conceptualization in the educational context, the diagnosis has the role of inquiring about those questions that in the order of didactics affect the learning of students and in what conditions they exist, to later trace the actions that since the creation of a digital didactic medium they can minimize the current learning situation in a scientific-methodological way. In this sense, the diagnosis intends to collect data that allow the coding of visual messages to promote visual communication of educational software with potential users. Conceptualization constitutes the stage before planning; after knowing the essential elements that distinguish the process being designed, the subjects involved, and their relationships, one is in a position to plan. Planning implies projecting, defining objectives, tasks, times, the techniques to carry them out and thus theoretically anticipating the final result.
- **Ideas representation and exploration techniques application**. The search for user and/or customer needs is frequent in design processes; such needs determine the product, the objectives, the visual language to be used. Same as the first characteristic abovementioned, it considers the subject as the centre of the process. There are numerous techniques used to obtain information; such techniques are selected depending on the designed process. Later on, a set of techniques is proposed for each stage of the Design Thinking method.
  In educational processes, obtaining information is done via multiple techniques, among which the following stand out: document review, observation, tests or exams, interviews, surveys, tests, and others. In any context where this method is applied, it is highly recommended to search for the details that determine the knowledge of the needs to be solved, based on questions (what, how, where, when, why, why, with what, to what extent, since when, in which other way).
  On the other hand, one of its most distinctive characteristics is using visual resources to represent information related to the process, product, or service that is designed, intervening subjects and their relationships. The resources to represent information graphically today used are: mind maps, timelapse, timelines, graphs, tables, maps, infographics, matrices. Such resources facilitate the illustration of data, break language barriers, make it easier for the audiences to understand the information, and expand the communication capacity. For this, it is essential to have notions of the basic elements of design to create hierarchies, correct visualization, contrasts and readability.
- **Testing and validation.** It is a stage of the design process

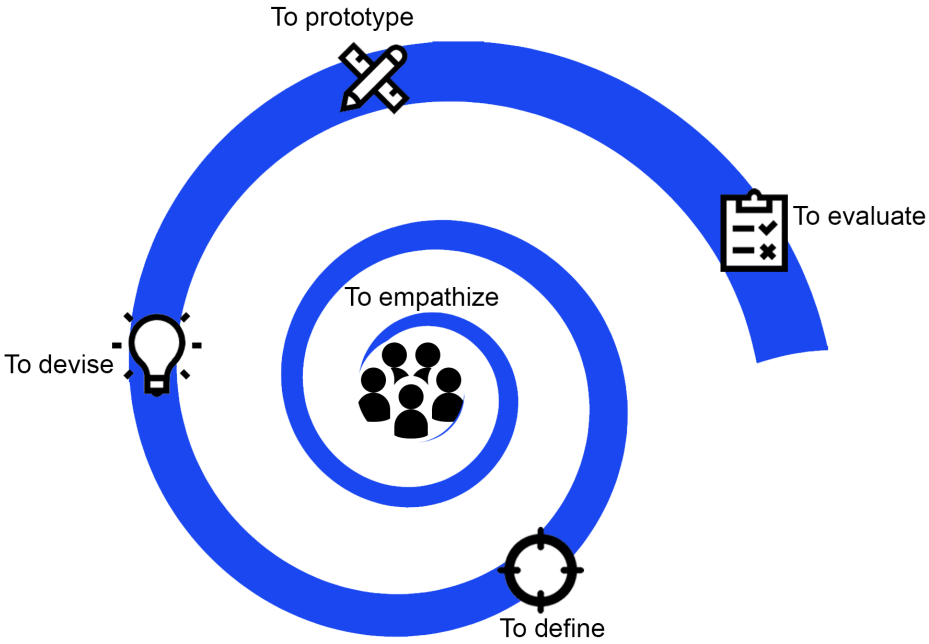

Fig. 1: Phases of the Design Thinking method

that confirms or refutes what was projected and designed. The tests allow us to define to what extent the solution selected and produced satisfies the needs that motivated the design process. This stage applies to any context, in the case of educational processes, it has particular importance in decision-making, the design of intervention strategies, the development of teaching methods so that the feedback that occurs in the validation processes allows confirming a hypothesis raised in the conceptualization and planning of what is designed.

As aforementioned, the characteristics of the Design Thinking method shows that it is not only relevant in the context of business, the marketing processes for which it was devised, but that it is possible to extrapolate it to the educational context.

B. Phases of the Design Thinking method

The Design Thinking method requires going through a succession of phases in which the method evolves towards obtaining the desired results. It constitutes an iterative and incremental process in such a way that the result of each phase constitutes the basis of the subsequent phase; from the above, we can affirm that it is systemic since it maintains synergy between the components of the process, service or product being designed.

The following phases are presented and a brief explanation of each one of them in Figure 1

- **Empathize:** It is the ability to imagine the world from different perspectives to understand people's habits. It consists of creating an empathic feeling and understanding of the problem we are willing to solve. For this, it is essential to delve into the details of the problem to understand all the analysis edges that it has. It allows us to know the subjects involved and their needs, in what context they operate, what activities they carry out, how they do them, what it depends on and what other process it is related to.
- **Define:** One has to define the problem through creativity clearly. Define the solution so that one can get to it. At this stage, different ways of solving the problem should have been explored from a deep analysis of the background of the problem. It cannot be done without a collaborative and participatory environment.
- **Devise:** The defined solution is executed, conceptualizing the proposal and planning the resources to be used for its execution. The basis of creativity is imagination; a specific context is not limited but interacts with others influencing their improvement, evidencing the synergy between them.
- **Prototype:** It represents how the final result will be in a previous stage. It favours identifying non-functional elements and validating the solution depending on the results and thus redesigning the solution if required.
- **Test:** It is the phase that closes the process cycle in which the solution's effectiveness is determined, and the end-users' satisfaction is evaluated, and to what extent the established needs or requirements are satisfied.

To develop each of the phases of the Design Thinking method, different techniques are suggested that facilitate the fulfilment of its objectives; Figure 2 shows the characteristics that typify the process.

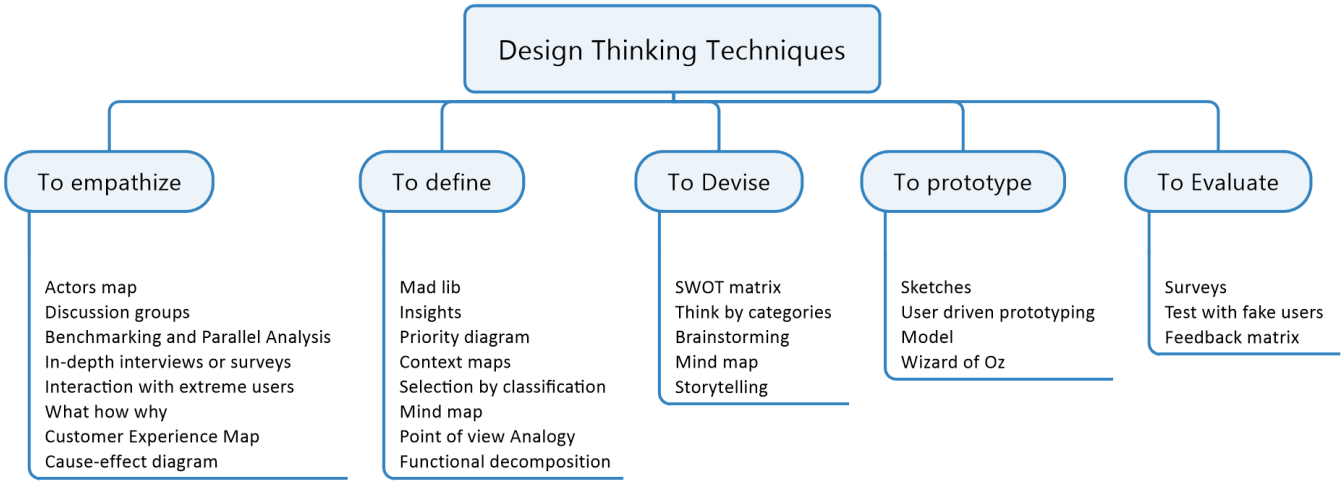

Fig. 2: Phases of the Design Thinking method

C. The approach of Design Thinking in the creation of integrative projects for the training of Computer Science teachers in the elaboration of digital didactic means

The discipline, Investigative Labor Training (FLI) is presented in the curriculum E of the Bachelor's Degree in Computer Education with a new conception, which in addition to the investigative labour practice, occupies a significant role in the study of the contents of the Methodology of the Educational Research, the particular didactics of Computer Science and the preparation for the exercise of the culmination of studies.

This discipline enables the integration of the content acquired in basic training, specialized basic training and basic training of the profession, through the realization of the professional situations of the pedagogical process in general and the teaching-learning process of the Computer Science subject in education, as well as, the solution to problems of the profession through the scientific method. This concretion must be achieved in the pedagogical group of the year by integrating the academic, labour, research and university extension components as substantive processes of Higher Education. Despite the work carried out, difficulties are evident in the presentation of integrative projects by students such as:

- Limitations in the interdisciplinary conception of the integrative exercises focused on fulfilling the objectives of the year.
- Insufficiencies in the design of activities related to work practice lead to pedagogical, scientific and research training.
- Limitations for oral, written and visual communication to explain the results obtained.
- Establishment of logical expressions for problem-solving.
- Insufficient capacity to integrate knowledge to solve problems in the educational practice.
- The training has a technical approach towards mastering computer tools.
- Difficulty developing teamwork.

The integrative exercise is a formative commitment, which has the explicit purpose of developing a research culture with a professional approach. It seeks the integration of the theoretical contents of each training course around a problematic academic nucleus and/or the real context [10].

The integrative exercise is assumed to be a problem situation structured from an integrating axis (the scientific problem) composed of interdisciplinary problems and tasks. Its main objective is to learn to relate the appropriate specialized knowledge from the interdisciplinarity through the conjugation of scientific research methods and the articulation of the forms of organization of the activity. This allows achieving integrated knowledge, expressed in a new synthesis and in increasingly whole ideas of objects, phenomena, and work practice processes.

In the Bachelor's degree in Computer Education, the student prepares himself/herself not only to teach the contents, but also to teach the design and evaluation of digital didactic means used in the training process. To do this, the student faces research processes where he/she must apply the contents received during the degree of the different modules of the Theory of Education track that allow him/her to evidence the need, the content addressed, the design, the application, and the effectiveness of the didactic means worked within a group of students, in correspondence with their psycho-pedagogical features with a project approach in which the evolution of the project is presented at different moments of the training process.

For the above reasons, the Design Thinking method proposes a procedure for its application in the research process adapted to the stages of educational research. application in the research process adapted to the stages of educational research, please refer to Fig. 3.

For the methodological treatment of this process in the training context, the following teaching methods, forms of organisation, evaluations, and means are proposed to enable for the Design Thinking method in the classrooms 4.

D. Benefits of the application of the Design Thinking method in the training of the Bachelor of Computer Science Education

As already mentioned, design thinking is an innovative method that enhances analytical, logical, visual thinking, the development of creativity and collaborative work in those who use it. That benefit in the training of teachers the development of capacities and abilities based on their performance from the didactic, investigative and technological point of view. The advantages of this in the training of the Computer Science teacher are listed below.

- To develop of innovative thinking through the use of research methods and techniques to explore the context of the problem to be solved and the needs of the users.
- To develop of productive thinking for the development of a relevant digital didactic medium, adapted to the needs of students and teachers, functional and aesthetically correct.
- To use a universal visual language that can be understood by the widest possible audience.
- To adapt to new contexts, experiences and users, focusing on meeting the needs.
- To develop visual thinking on the principle that ”less is more”, being able to convey a message with the minimum of visual resources necessary.
- To apply best practices based on design patterns of authoritative institutions in the field, ISO standards, style and interaction standards, etc.
- To develop the ability to anticipate the effects of design on users.
- To map the functionalities from the needs and conditions of the users and managers of the application, acting as an interface between the demands of both actors in the process.

III. Evaluation

Given the characteristics and advantages of the Design Thinking method for product development processes, it was necessary to test and to verify its effectiveness in training processes. To do this, we chose the Bachelor's degree in Computer Education, which through the application of evaluations with a project approach, allowed all the disciplines of the curriculum to be used in educational research and the creation of a digital didactic medium.

To carry out the validation of the results, we created work teams that brought together lecturers from all the subjects of the year, in which activities or tasks had to be created, that contributed to the development of the integrated project that responds to the research of an object of study from the didactic and investigative standpoint, and to the production of a digital didactic medium to contribute to the transformation of the investigated object.

In each year of the degree, integrative projects were created that were relevant to the objectives of each year, the subjects and the technological mastery of computer tools, depending on the year of study, for the development of digital lecturing aids.

Starting from the creation of the activities of the integrative projects, the students carried out their research by applying the phases of the Design Thinking method to respond to the different tasks covering the academic and research aspects in the production of the digital didactic medium.

Among the aspects that we evaluated to measure the effectiveness of the proposed methodology are:

- Use of various techniques to obtain information from the context in which the research is carried out.
- Use of visual language for the representation of information.
- Ability to analyze the problem to be solved from various perspectives.
- Creativity in solving the problem.
- Interaction with other classmates, teachers, specialists, searching and/or validating solutions.
- Relevance of the digital teaching medium with the defined objectives, the characteristics of the users and the context of the research.
- Means used for the validation of results.

A. Materials and methods

The research has a qualitative approach that allows us to measure the integration capacity and the performance of the students in relation to the evaluative projects in the development of digital didactic media. Theoretical methods were used for this purpose: Analysis-Synthesis, Systemic and empirical approach, Hermeneutic-Dialectic and empirical methods Observation guide, Heuristic evaluation guide and Surveys.

From a population of 161 students, we selected an intentional sample of 74 students of the last years of the career (11 from 4th in the Day Course and 63 from 5th Course)

For the lecturers: methodological activities were carried out to adjust the evaluations according to the objectives of the year and the integrative work developed; adjustments were made to the syllabuses of the different subjects according to the curricular integration; seminars were given to lectures to apply the design thinking approach combining didactic, semiotic-visual and technological elements to evaluate the research reports, teaching aids and teaching materials were developed for students and teachers.

For the students: the level of preparation in the elements that justify the need for research and the argumentation of the evaluative projects of the professional practice, higher quality in the research reports and mastery of the different dimensions

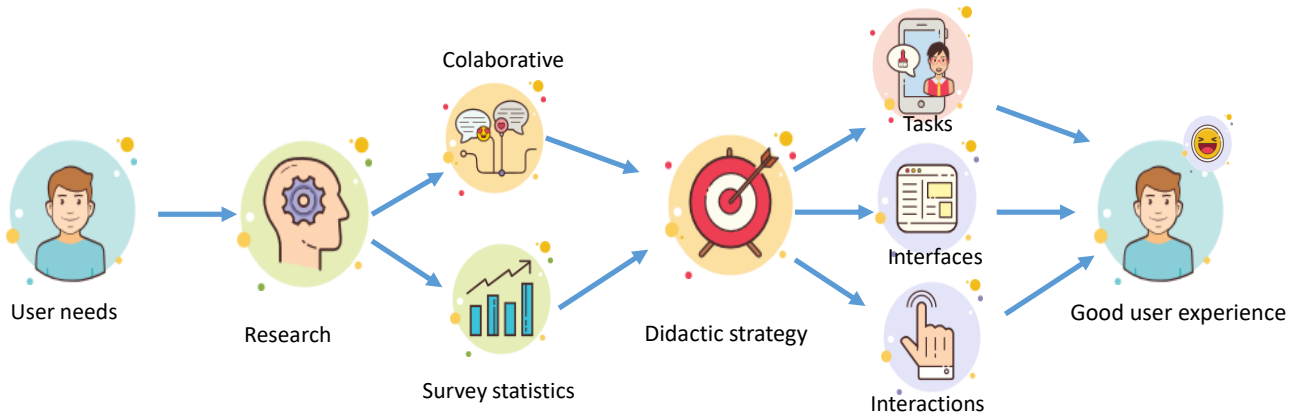

Fig. 3: Stages of the Design Thinking method in integrative exercises for the elaboration of digital didactic media in the Bachelor's degree in Computer Science education.

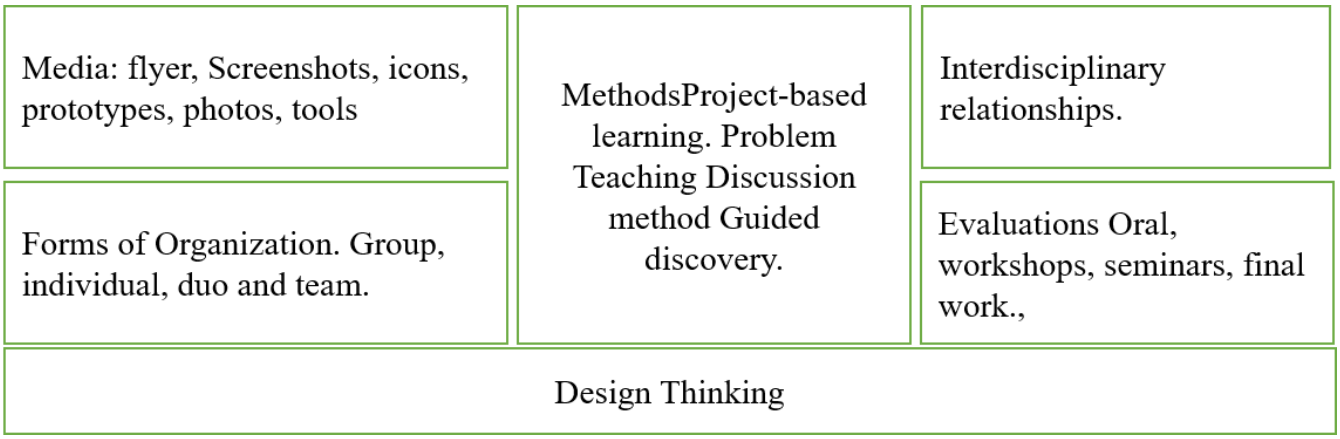

Fig. 4: Representation of the didactic components.

of the process of elaboration of digital didactic media was raised.

B. Results

An observation guide was applied as a result of the participation in the integration project tribunals and the presentation of the research work. Of the 74 students, 44 (59.4%) were evaluated. The quality of compliance with each indicator was evaluated on a scale of 1-5, Table I is a summary of the results of the guide applied.

We analysed the obtained results, despite the fact that in all the indicators, the evaluation of 4 and 5 predominates, unfortunately, stand out that creativity in the solution of the problem, ability to analyse the problem to be solved from diverse perspectives and interaction with other classmates, lecturers and specialists in the inquiry for and/or validation of solutions. In this respect, the search for simple solutions, the abuse of pre-designed templates to create digital teaching aids, the lack of capacity for innovation and the search for new tools to solve the problems have significantly impacted the skills and competencies of the participants to solve the problems arising in their projects. Moreover, difficulties persist in teamwork and assigning and fulfilling roles and/or tasks in

TABLE I: Results obtained

Indicators ↓ ——— Scale →	**1**	**2**	**3**	**4**	**5**
Use of various techniques to obtain information from the context in which the research is carried out.			6	8	86
Background study				4	96
Use of visual language for the representation of information.				9	91
Ability to analyze the problem to be solved from various perspectives.		2	8	12	78
Creativity in solving the problem.	3	3	12	10	72
Interaction with other classmates, teachers, specialists, searching and / or validating solutions.		4	12	60	24
Relevance of the digital teaching medium with the defined objectives, the characteristics of the users and the context of the research.				85	15
Means used for the validation of the results			10	68	22

terms of a common goal within their collaborative project.

Finally, the analysis of the problem to be solved in their projects is limited to the field of pedagogy and educational technology, with little exploration of other areas of knowledge and disciplines that can contribute a great deal to the analysis of the problems identified in the teaching-learning process. Unfortunately, there is a lack of a cross-multidisciplinary approach.

In our current society where the dynamics of educational processes demand the development of the necessary skills, particularly technical and professional, to access employment, decent work and entrepreneurship; in which technology is advancing at an accelerated pace and is made available to education to optimise processes and raise their quality through new training scenarios; students and lecturers must continue preparing themselves in these working methods in order to favour multidisciplinary, teamwork, collaborative environments, development of projects based on real problems that favour their analysis from different dimensions; and the mastery of technology that serve as tools for achieving objectives more efficiently.

IV. Conclusion

Design Thinking has a project approach, is flexible, systemic, collaborative, focused on human needs and contributes to the integral training of Computer Science lecturers.

The application of this approach made it possible to integrate didactic, semiotic-visual and technological elements in terms of the development of digital teaching aids to solve problems of educational practice and the virtualisation of processes.

As a result, it was possible to improve the working habits of students and lecturers in terms of curricular integration in the evaluation of learning through the use of the Design Thinking method in the training of Computer Science lecturers.

Work must continue on the capacitation of lecturers to consolidate the application of these methods in order to prepare future education-related professionals to solve professional problems in line with the current times with collaborative, multidisciplinary and creative approaches.

V. Acknowledgement

This paper has emerged from the collaboration between Belgium and Cuba in the VLIR IUC 2019 Phase 2 UO, specifically its sub- project dedicated to the safeguarding of the cultural heritage in Santiago de Cuba and the eastern region of the country.

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