Data Analytics and Cloud Computing vs Breast Cancer: Learning That Helps

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***Abstract*—This article presents the deployment of the Semester i (i-Sem) "Data Analytics and Cloud Computing vs Breast Cancer: learning that helps" (*DA&CCvsBC*).**

i-Sem is one of the elements of the Tec21 educational model of The Monterrey Tech. *DA&CCvsBC* is a learning environment where engineering students developed competences, by resolving an inspiring challenge designed from a problem posed by a training partner (*TP*). The challenge consisted in designing and implementing computer applications to support the follow-up of patients with breast cancer before and during their treatment.

The project started with the selection of a list of competences to be developed in the students. From that list and based on a real problem situation posed by two training partners (*TPs*), a challenge was designed. The challenge was presented to students interested in participating and 11 students were selected. So, in 18 weeks, the students, accompanied by professors, built solution proposals for the challenge. During the construction process, the students developed the established competences. The project had a vision: "learning that helps".

The intended outcomes were: A report that evidenced the development of students' competences, and two computer applications for monitoring the treatment of patients with breast cancer.

***Index Terms*—Educational innovation and higher education, competency-based learning, computer sciences, learning environment, computer applications, breast cancer, data analytics, cloud computing.**

I. Introduction

THE Monterrey Tech [1] (The Tec) is a private university in Mexico, founded in 1943 and currently with a presence in more than 20 cities in the country. Being congruence with its vision ("*Leadership, innovation and entrepreneurship for human flourishing")* and its purpose *("life-transforming training")*, the institution made the decision to transform its educational model to adapt it to the new world trends, taking into account the new student profiles, the new demands of the labor market and the rise of information technologies at global level. The transformation of its academic model began in 2012 with consultations with graduates, professors, students and employers, and the process resulted in the so-called Tec21 Model [2]; the official launch to the academic community occurred in 2015.

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The Tec21 Model proposes the formation of solid and integral egress competences by placing a challenge as a trigger for the learning process, where the student, when solving it, develops his potential to transform his present environment and trains himself for his professional future. The essence of the model [3] is shown in Fig. 1.

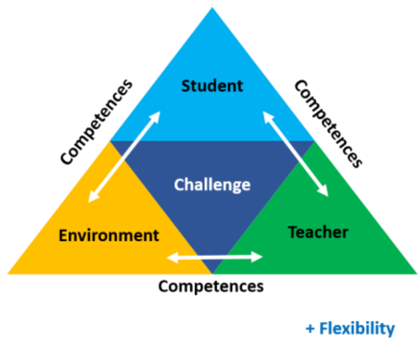

Fig. 1. The essence of the Tec21 model [3].

The i-Sem is one of the core initiatives of the Tec21 and incorporates, by design, all the model elements [3]. A challenge appears in the center and it is the detonator of competency-based learning. The student is the protagonist and has an active role. Professors act as Mentors and Advisors and the environment links the classroom with the outside world.

In this article, we present the project "Data Analytics and Cloud Computing vs Breast Cancer: Learning that Helps", *DA&CCvsBC* as a learning environment [4] for development of competences in computer sciences.

The structure of the article is as follows: Section II describes the origins of the project. Section III describes the four stages (*4-S*) of *DA&CCvsBC* design. Section IV details the Competency-based Learning Model used in *DA&CCvsBC*. Section V presents the Architecture and outcomes of the deployment of *DA&CCvsBC*; and finally, Section VI includes Conclusions, Findings and Future Work.

II. The Origin of the *DA&CCvsBC* Project

With the aim of bringing the Tec21 Model to the classrooms of The Tec in Campus Cuernavaca, and as a result of the research and bonding work of a group of teachers (called *DT*, Design Team), at the end of 2017, raised the idea to design an i-Sem with the vision: "learning that helps".

The project design concluded in January 2018, and it was accepted by the Academic Authorities of The Tec on February 2018 under the title of "Data Analytics and Cloud Computing vs Breast Cancer: Learning that Helps" to be implemented on the Cuernavaca Campus in the academic

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period of August-December 2018.

A. *The Dream Became a Challenge*

The first activity of the *DT* consisted in selecting a list of competences to be developed. Then, we looked for training partners (*TPs*) interested in offering our students the opportunity of learning through to solve a problematic situation existing in their organizations (see e.g. [5]).

The *TPs* are fundamental members of the Tec21 Model. They are called training partners because they participate in the process of developing competences of students. They are the link between school and real life. They are not simple spectators who benefit from the products generated in the i-Sem, on the contrary, they are active members of the team that are involved in the whole process: they participate in the design phase of the challenge by presenting real problems that need to be solved, then, they become expert Advisors that feed the solution proposals in the deployment phase; and finally, they participate in the implementation of the solutions proposed by the students in their organizations.

Fortunately, two extraordinary training partners joined the project. The first *TP* was Indra, a multinational consulting firm at its Mexico headquarters [6], [7]. A team of consultants promoted the integration of the required elements to initiate the i-Sem and linked the *DT* with what would be the second and strategic *TP*.

The second *TP* was the National Cancer Institute, INCan [8], a public health institution of the federal government that offers medical and hospital care to cancer patients throughout Mexico, many of them, patients without access to social security.

We were very interested in working with INCan because in Mexico, cancer presents itself as one of the major challenges in public health [9]. Malignant tumors have been positioned as one of the leading causes of mortality for several decades. The mortality projections for 2020 show that of the ten leading causes of cancer death, breast, prostate and liver cancer are constantly increasing every year, reaching rates of more than 5 deaths per 100 thousand people; and specifically, as mentioned in [10], breast cancer is predicted to exceed 11 cases per 100 thousand.

Against this background, the challenges that INCan currently faces are many, mostly due to the high demand for medical and hospital care. For this reason, the institution selected its Department of Mammary Tumors as the place to identify a problem situation that was the basis for designing a challenge that could be solved using information technologies [11].

Finally, using [12]-[15], and based on the selected competences, the DT and the INCan defined the challenge as "design and implement computer applications to support the follow-up of patients with breast cancer before and during their treatment". Because of the technology that we planned to use, the i-Sem was registered under the title of "Data Analytic and Cloud Computing vs Breast Cancer: Learning that Helps". Due to the environment and theme, the designed challenge would follow the original established vision "learning" (development of skills in students) "that helps" (using the profession to help others).

III. The Stages of *DA&CCvsBC*

The *DA&CCvsBC* project had a 4-Stages Model that occurred in a timeline. The model is shown in Fig. 2. The four stages constituted the lifetime of the project: Start, Design, Selection and Deployment. The project was designed as a Learning Environment built from an inspiring problem situation and focused on the development of skills.

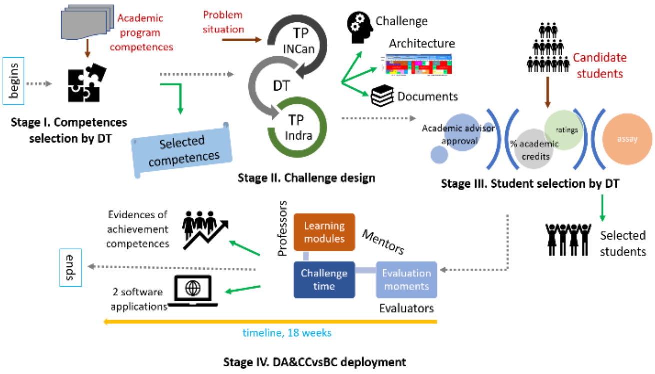

Fig. 2. The DA&CCvsBC 4-stages model.

A. *The Teacher's Roles*

The teachers' roles proposed in the Tec21 Model are: Mentors, Professors and Evaluators [16] and for *DA&CCvsBC*; one of the main tasks of the *DT* was the selection of the teachers who would participate in each of the project stages.

Two teachers were selected to participate as Mentors. Their main role was to provide personalized support and continuous formative feedback to the students [17], [18]. Also, Mentors participated in evaluation moments and were observers throughout the deployment stage.

For the role of Professor, six teachers were selected. All of them, experts in different Computer Science areas, with an extensive teaching experience and wide recognition within the institution. Their main activities were to develop and evaluate discipline skills. As the Mentors, some of the Professors were observers in great part of the deployment phase. Two teams of Advisors joined the group of Professors. One team advised and fed our students on computer science issues (three experts from Minsait by Indra), and the other team advised our students in medical matters (tree Oncologists from INCan). The Advisors also participated in the final Evaluation Moment.

Finally, the Evaluators role [19], [20] was to assess the progress of competences in each of the eleven students. Therefore, eight Evaluators were appointed for *DA&CCvsBC*.

B. *From the Design Stage to the Deployment Stage*

As shown in Fig. 2, in Stage I the *DT* selected the target competences. The product of this stage was the list of competences that would be developed by the students through the deployment of our project.

During Stage II, the problem situation was selected, and the challenge was designed. This stage was led by the *DT*, but both *TPs* also participated. Three products were the output of this stage: The statement of the challenge, the academic deployment model (the architecture) and the documentation required by the Tec21 Model regulations.

During Stage III, the *DT* selected the students who would participate in the project. The profile of the candidate students was established as being a student of the Tec, being enrolled in the BS Computer Science and Technology, having at least 60% of the program credits approved and having their Academic Advisor approval. In addition, each candidate who met the basic requirements should submit an essay describing their motivation to participate in the i-Sem. The outcome of this stage was a team of eleven students capable and eager to participate.

The duration of the last stage (Stage IV) was 18 weeks and consisted of the deployment of the *DA&CCvsBC* academic model. The products of this stage were: A report with the level of competence development observed in students and the software applications developed by students to solve the proposed challenge.

IV. The Development of Competences in Students Through Deployment of *DA&CCvsBC*

According to [21] and [22], the learning process of the competency-based model begins with the selection of the specific competences to be developed, and from them, design an inspiring challenge whose solution process leads the students to develop each of the chosen skills. Supported by Professors and Mentors, the students can reach the domain of the competences at their own pace, developing the skills they "feel" is necessary to achieve the solution of the challenge.

A. The Competences of DA&CCvsBC

The selection of which and how many competences would be included in the project, was made based on the extensive academic and discipline experience of the *DT*.

DT selected Area (discipline) Competences from the graduation profile of the academic program BS Computer Science and Technology of the Tec. In addition, in accordance to [23], Transversal Competences were included in *DA&CCvsBC*. This set of competences is not exclusive to any of the academic programs and are considered important allies for the good performance of professionals in a globalized and multidisciplinary world [24]-[26].

On the other hand, in [27] is stated that for any competency-based learning model, the expected domain level to be achieved for each one of the competences must be determined. For our project, we selected a three levels of domain scheme: *A* (basic), *B* (intermediate) and *C* (advanced). Due to the profile of the selected students, the expected levels of proficiency would be only B or C.

Table 1 shows the domain levels for the *DA&CCvsBC* competences. Two computer science competences were selected, each one with two sub-competences. In all cases, the expected domain levels would be *B* or *C*. In turn, three Transversal Competences were selected, one with two sub-competences and two with one sub-competence. Also, for the Transversal sub-Competences the expected domain level would be B or C.

B. Evaluation of the Training Process

Competency-based learning requires an evaluation process for students [28]-[30] to check the progress of the development of their competences. At *DA&CCvsBC*, each student built an evidence's e-Portfolio [31], [32] to demonstrate such progress. The e-Portfolio was very useful because it also allowed to observe, at an early stage, the knowledge and skills they still needed to reinforce.

Fig. 3 shows the Evaluation Moments of *DA&CCvsBC* in which each student placed evidence to be evaluated. In most cases, evidences were evaluated in a collegial way by the group of Evaluators.

TABLE I: The *DA&CCvsBC* Discipline and Transverse Competences, Sub-competences and the Expected Domain Level[A]

Competences	Sub-competences	Domain level	Discipline	Transversal
D1	D11	B	✓	
	D12	C	✓	
D2	D21	C	✓	
	D22	B	✓	
T1	T11	C		✓
T2	T21	C		✓
	T22	B		✓
T3	T31	B		✓

[a] The Tec Academic Programs have 7 Transversal Competences defined in [16].

Because formative feedback is the element that gives the students the control of their learning [33], during the entire deployment of the project, students were exposed to oral and written feedback, with the aim of aligning efforts and actions in the development of their goal competences. That's why teachers, *TPs*, and students participated in formative feedback processes. An example of written formative feedback used in the project is presented in Fig. 4.

In summary, Fig. 5 shows the different moments in which each member of the evaluation team participated in the evaluation and feedback processes.

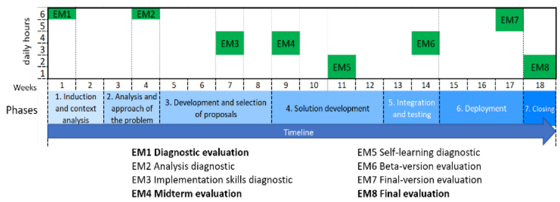

Fig. 3. The evaluation moments in *DA&CCvsBC*.

Fig. 4. Formative feedback formats used in *DA&CCvsBC*.

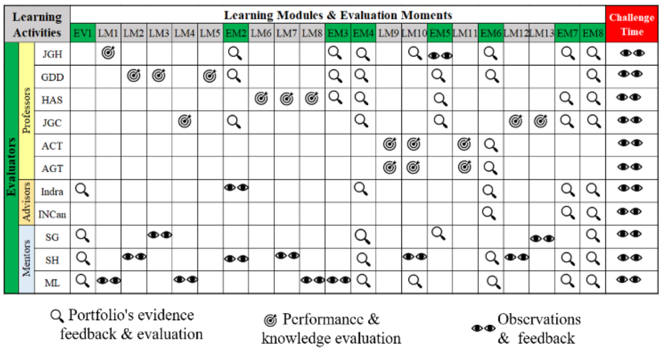

Fig. 5. The evaluation process during the *DA&CCvsBC* deployment.

V. An Architecture for the Academic Deployment of *DA&CCvsBC*

The architecture for the academic deployment of *DA&CCvsBC* included all the elements indicated in the Tec21 Model for an i-Sem. Our design was built from a set of flexible learning moments [4] that occurred over a period of eighteen weeks. The architecture combines different teaching techniques and didactic activities, as well as learning support tools for each moment (see e.g. [14], [34]).

A. The Architecture

The architecture for the deployment of *DA&CCvsBC* is shown in Fig. 6. The design was a specific one to develop Transversal and Discipline Competences in computer sciences students by solving the challenge posed.

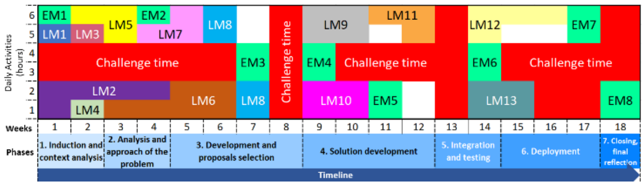

Fig. 6. *DA&CCvsBC* deployment architecture.

Our model included: thirteen Learning Modules (*LMs*), Challenge Time (*CT*) and eight Evaluation Moments (*EMs*) distributed over time through seven implementation phases (*IPs*).

The *IPs* were consistent with the software development methodologies and gave the project a sequence in time in which the solution of the challenge was built.

During the *LMs* (numbered from 1 to 13) students worked on computer science topics. The modules integrated different learning activities to develop the target competences and were led by the Professors. The sequence in time for each *LM* was determined by the implementation phase to which it belonged. The sequence considered the opportune moment in which each topic had to be treated to provide knowledge and skills to the solution of the challenge.

On the other hand, the *CT* consisted of a set of moments in which the students, through individual reflections and collaborative experiences, built the solution to the challenge.

Finally, the evaluation activities were distributed at strategic moments of the project deployment: The Evaluation Moments. The evaluation activities and tools applied were different, and they adapted to the topic and time in which they were presented.

B. Model Focused on Learning

Looking to preserve the motivation of the students and due to the modular architecture of our model, different teaching-and-learning activities and various tools [35] were selectively incorporated during the deployment of the project. In addition, the *DT* decided to incorporate the use of technological tools (e.g. GitHub, Trello, Zoom, Blackboard, Google Drive, Google Calendar, Hangout, WhatsApp) to strengthen learning activities [13]. Most of these tools also contributed to improving communication among all participants throughout the project.

For *LMs*, the main teaching strategy chosen was the flipped classroom [36]-[39]. This strategy was used to transform students into partners in their learning process, in addition, to allow teachers to provide a more personalized and close attention to students.

The *CT* was a set of moments in which the students put into practice what they learned, that's why for *CT* we included the active learning strategy [40]-[42]. Working individually and collaboratively [43], [44], during *CT*, students designed and built the proposals to solve the challenge. They worked on their own and at their own pace. We observed that these moments were highly formative and those that most contributed to the training of discipline and transversal skills. In addition, because self-learning [45], [46] guide students to develop lifelong autonomous learning skills, we included in *CT* some activities using Massive Open Online Courses (*MOOCs*) [47]. Selected MOOCs allowed students to learn specific topics on their own.

As mentioned before, depending on the topic and time, for EMs we used different activities and evaluation instruments [48]:

- Oral presentations and observations (*EM4*, *EM8*). Evaluated with observation guides.
- Technical reports (*EM4*, *EM7*, *EM8*). Evaluated with checklists.
- Interviews (*EM1*, *EM6*). Evaluated through questionnaires.
- Co-assessment activities (*EM2*, *EM4*, *EM6*, *EM7*). Attitude scales were used.
- Performance (*EM2*, *EM3*, *EM5*, *EM6*, *EM7*). Evaluated through written practical exams.

C. Results of the Project Deployment

The *DA&CCvsBC* deployment outputs were of two types:

- A document that included the final report with the level of proficiency achieved by each student in each of the declared competences.
- Two software products, developed by the students, that solved the challenge.

TABLE II: The Proficiency Level Achieved by the Students

Evaluation Moment	Diagnostic Evaluation								Midterm Evaluation								Final Evaluation							
Expected Domain Level	B	C	C	B	C	C	B	B	B	C	C	B	C	C	B	B	B	C	C	B	C	C	B	B
Sub competence	D11	D12	D21	D22	T11	T21	T22	T31	D11	D12	D21	D22	T11	T21	T22	T31	D11	D12	D21	D22	T11	T21	T22	T31
Student 1	B	A	A	A	B	A	B	C	B	B	B	A	B	B	B	C	B	B	B	A	B	B	B	C
Student 2	A	A	A	A	B	A	A	A	B	B	B	A	B	B	B	B	C	B	C	B	C	C	B	B
Student 3	B	A	A	A	A	A	A	A	B	B	B	A	B	B	B	B	B	C	C	C	C	C	B	B
Student 4	B	A	A	A	B	A	B	B	C	B	B	A	C	B	C	C	C	C	C	C	C	C	C	C
Student 5	B	A	A	A	A	A	B	A	B	B	B	A	C	B	C	B	B	C	C	C	C	C	C	B
Student 6	B	A	A	A	B	A	B	B	C	B	B	A	C	B	C	C	C	C	C	C	C	C	C	C
Student 7	B	A	A	A	B	A	B	A	C	B	B	A	C	B	B	B	C	C	C	C	C	C	C	B
Student 8	B	A	A	A	A	A	A	A	B	B	B	A	B	B	B	B	B	C	C	B	B	C	B	B
Student 9	B	A	A	A	B	A	C	C	C	B	B	B	C	B	C	C	C	C	C	C	C	C	C	C
Student 10	A	A	A	A	B	A	A	A	A	B	B	A	B	B	B	B	C	C	C	B	B	C	B	B
Student 11	B	A	A	A	B	A	A	A	C	B	B	A	C	B	B	B	C	C	C	C	C	C	C	C

The final report is presented in Fig. 7. It shows the comparison of the domain level of students' competences in three moments: diagnostic, midterm and final. In some cases, it was observed that some students reached the expected domain level in the early stage of the project.

Based on the data shown in Table II, two condensed reports of quantitative results from de project are presented in Fig. 7 and 8.

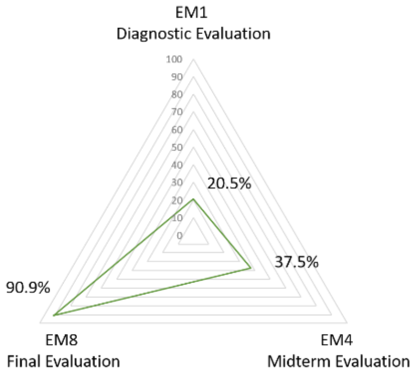

Fig. 7. Frequency occurrence of domain levels.

The Fig. 7 shows the effectiveness of the performance levels achieved for each sub-competence by the group of students at the time of diagnostic, midterm, and final evaluation, and it also shows the increase in the distribution of the expected domain level at each evaluation moment from 20.5 % in the diagnostic evaluation to 90.8 % in the final evaluation.

Using this information, we could conclude that the 90.8 % of the students who participated in the project, developed the level of proficiency established for each of the 8 sub-competencies defined.

The Fig. 8 shows the percentage of students that reach the performance levels at the time of diagnostic, midterm, and final evaluation. It can be concluded that 98.9% of students developed level of proficiency *B* or *C* of the established sub-competences.

On the other hand, to solve the challenge posed in *DA&CCvsBC*, two software applications were designed and implemented:

- *SAPI*, for the management and follow-up of treatment of patients with breast cancer and,
- *SAVA*, a tool for doctors to select treatment for patients.

Both applications were delivered to INCan authorities in December 2018. Due to the sensitive issue of confidential information handled in software applications, the applications are managed by the Technological Information Department of INCan. Both products are in testing period during 2019.

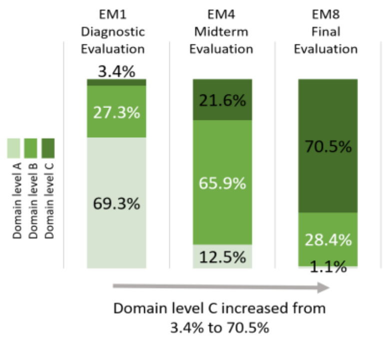

Fig. 8. Achievement of domain levels for established competences.

VI. Conclusions And Future Work

The characteristics and experience of the participating teachers, as well as the multidisciplinary team of 2 training partners, were key for building the learning environment.

The selection of the quantity and type of learning activities of the *DA&CCvsBC* enriched the design and achieved in the students of the Tec in Cuernavaca an experience with lasting learning. Through a survey, students evaluated their experience with a rating of 9.8 out of 10.

It was observed that the choice of an inspiring problem situation as the basis for the challenge design, strengthened the students' commitment to build a solution to the challenge, while achieving that, the students reached the established domain levels for the defined competences.

The software products developed as a solution to the challenge were well received by the INCan and during 2019 the tools are in the testing period.

Currently, the second generation of students is starting to participate in the next stage of *DA&CCvsBC* in the academic period August – December 2019. This new team will continue with the improvement of *SAPI* and *SAVA* and will add new functionalities that will solve complementary challenges for INCan. It is intended to move forward with the vision of this project: “learning that helps”.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Mónica Larre wrote the paper and managed communication with the training partners; Sergio Hernández evaluated and analyzed the competence development; Pedro Nájera build the architecture of the research, Ramona Fuentes worked in the data analysis and proficiency levels; all authors had approved the final version.

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