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ORIGINAL PAPER

iWeek experience: the innovation challenges of digital transformation in industry

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Abstract
Information Technology, communication, and innovation require specific, essential competencies that employers look for in engineers. Responding to this, Tecnologico de Monterrey has been implementing the Tec21 Educational model to foster students' competencies by involving them in challenge-based learning (CBL). The iWeek is one of the first implementations of this model, where students experience immersive learning for a whole week. This study presents the iWeek Innovation Challenge to improve students' innovation and information technology and communication skills through a CBL didactic technique. During this iWeek, a group of students developed efficient solutions with Microsoft Power Apps to solve real challenges confronting a global company. The results proved that students could quickly learn and apply knowledge and develop practical, innovative solutions to real problems in Industry. It was a revelation to the stakeholders to notice how fast students can become familiar with new information technology tools to propose solutions that positively impact the company. Strong partnerships between academia and industry are crucial to developing student disciplinary and transversal competencies by challenging them to solve real-life problems in real-world environments. This work presents a roadmap for planning and designing a CBL iWeek with an educational partner from Industry. It includes the implementation details, assessment instruments, and results analysis. Finally, we also highlight the significant contributions of iWeek to explain the value of this immersive experience in the teaching–learning process.

Keywords Challenge-based learning · Educational innovation · Academia-industry partnership · Digital transformation · Higher education · STEM education

1 Introduction

Digital technologies transform the performance and mindset of manufacturing employees. The need to integrate technologies such as data analytics and artificial intelligence (AI) through operational processes makes companies demand workers to develop sets of new digital skills that complement Operational Technologies (OT) skills [1]. Nowadays, there still exists a shortage of people with skills in these emerging technologies, meaning that organizations that invest in the digital training of their employees will have a competitive advantage. Universities should consider these competencies and skills in their educational models. Tecnologico de Monterrey recognizes the importance of aligning its engineering programs with the skills required by future professionals to be competitive and prepared to face the challenges of Industry 4.0. These include the ability to innovate and use information and communication technologies (ICTs), specifically addressed in this study. The association with leading companies as educational partners is vital to offering a comprehensive educational experience to engineering students. The iWeek presented in this study offered students an introduction to a digital industrial environment. They were challenged to integrate data and systems already used by the company and automate processes by developing in-house applications that empower employees to make faster, data-driven decisions.

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1.1 Digital transformation

Digital transformation empowers employees by giving them access to relevant information in real-time to make data-driven decisions. Interconnected digital solutions boost productivity and automate manual processes. Adapting the existing processes to embrace the new technologies that come with the conversion to Industry 4.0 requires employees with new competencies to handle emerging software and hardware to exploit their benefits [2].

A digital transformation within a company needs a focus since it requires intensive investment, resources, and commitment to embrace it. A company should have clarity about why digitalization is essential, where it will take place, what enablers need to have, and a strategy among the business leaders to prioritize and select feasible initiatives that add value to the company. Moreover, the company must understand what it wants to achieve, have flexible internal processes, and be open to continuous learning [3].

Traditionally, application development has been an exclusive task for "high-code" developers within a company's IT team. This results in a bottleneck that limits the number of business ideas that, in the end, hinders the company in making business improvements. In this situation, the cost, time, and effort to develop solutions is such that only the most promising projects in terms of benefits for the company are worth the energy. The digital transformation process gets delayed.

Low-code development platforms are a game-changer in digital transformation because they enable people without a technological background to create and implement custom applications to improve specific processes. Some of the benefits of low-code application deployment are the privacy of developing in-house applications, speed (because the code is partially developed and only needs user customizations), cost reduction, complexity reduction, easy maintenance, and business integration [4]. Thus, low-code development platforms provide useful solutions to automate internal processes and accelerate the company's digital transformation. The application responds to the end user's specific needs and perspective by involving them in the design and development process, translating into rapid technology adoption. A case study demonstrates how non-expert end-users can be involved in the application development process with an approach that does not need program code to be designed and created [5]. This kind of platform empowers end-users to develop their solutions according to their specific needs.

Microsoft Power Apps is a low-code development platform that empowers non-developers to create in-house web and mobile applications to digitalize business processes. This digital tool reduces cost and time for application development. These custom applications deliver process improvements that translate into benefits such as productivity, faster data-driven decisions, reduced time-to-market, better customer service, and increased revenues [6]. The challenge is to get people involved to become familiar with the platform and start enjoying its benefits.

Students of Generation Z (GenZ) are authentic digital natives with different profiles than before. People belonging to Generation Z were born between 1995 and 2009 and are current undergraduate students. They were born with technology and are used to personalizing or customizing many things. They are ready for the digital and interconnected world. Their profile and expectations influence the way they learn. Educational institutions need to understand them and adapt their educational models to engage them in the learning journey [7]. Technologies such as Virtual and Augmented Reality, 3D Printing, Internet of Things, Artificial Intelligence, Virtual Laboratories, Wearable Devices, Blockchain, Drones and Holograms are transforming engineering education. The competencies fostered by these technologies are demanded in the workforce of the future, including innovative thinking, spatial visualization, problem-solving, creativity, and analytical and critical thinking [8]. Generation Z students can contribute to digital transformation efforts because of their ability to handle technology.

1.2 Challenge based learning

In the context of Industry 4.0 and the Internet of Things, there is a growing demand for qualified graduates to do jobs that do not yet exist. Our fast-paced, changing world has motivated universities to rethink their educational models and integrate emerging technologies to develop and improve the teaching–learning process to prepare graduates with the demanded knowledge and competencies. Future engineers should be prepared to solve problems and implement innovative solutions, to be able to adapt to change and handle Industry 4.0 technologies [9].

Tecnologico de Monterrey has recently implemented its Tec21 Educational Model, which has four main components: Challenge-Based Learning (CBL), flexibility in when and where the learning experience takes place, memorable university experience, and inspiring professors. The model focuses on the development of competencies, both disciplinary and transversal. A vital element of the model is the association and collaboration with companies and industry to expose students to a real context and real challenges [10]. By engaging students in CBL outside the classroom, immersing them in the real context, educators increase the students' commitment to the learning process and enhance the educational experience, leading to positive active learning results [11].

One of the first transitions towards this model is the iWeek, which was first implemented in 2015. The iWeek is a powerful learning experience, implemented nationwide at the different campuses of our university. The "i" in iWeek

is intended to suggest innovation, immersion, imagination, and impact. During its five days, the semester's classes and normal academic activities are suspended so that each student can be fully involved in a specific activity. The iWeek project or activity can be implemented on the campus, a given company, or even another country. Each project focuses on developing in students one or two transversal competencies that make a positive impact by having them face real challenges and propose solutions.

The iSemester is another initiative of the Tec21 Educational Model. The iSemester is an instance of Challenge Based Learning applied for 18 weeks, including modules and the main challenge defined together with an educational partner. The iSemester involves weeks of immersion at the company or the organization to understand the challenge's context and specifics. The iSemester develops both disciplinary and transversal competencies. More details about the history behind iWeek and iSemester, including implementation examples and statistics of their impact, was documented by Swain-Oropeza and Renteria-Salcedo [12].

One iWeek involved a multidisciplinary challenge named Emergency First Response, which increased student engagement in the learning experience [13]. For disciplinary competencies development, some examples are the iSemesters for Mechatronics Engineering students at different Tecnologico de Monterrey campuses [14, 15]. These studies describe the benefits of engaging engineering students with real-life challenges that encourage them to apply their design skills and knowledge to propose solutions that add value to the company. By being involved in a real context, they are motivated to adopt an active role within the learning experience to understand their work's impact. Other universities have explored engaging engineering students in active learning experiences with projects linked with the professional practice obtaining positive results in the retention rate and enhancing students' interest in engineering [16]. This approach of involving students in real projects with industry has also benefited their employability rate [17].

1.3 Industry-education partnership

Tecnologico de Monterrey recognizes the importance of aligning its engineering programs to the UN Sustainable Development Goals. Engineering education should focus on improving students' necessary skills, creativity, and innovation, inspiring them. Aligning engineering projects with strategic research, joining academia and the scientific community, and working with the industrial and government sectors can lead to implementing new teaching–learning models with projects that improve the environment [18]. The association with leading companies as training partners in education helps expose students to real-life professional problems that need to be solved. Immersing students in the real context increases the challenge complexity and uncertainty levels. Consequently, skills development is consistently higher compared to learning delivered by traditional techniques [19].

Our university is conscious of the importance of working together with industry on the educational journey. For this reason, the university has defined Educational Partners, which are companies or organizations committed to working in synergy with the university to promote the experiential learning of the students. Educational Partners provide academic projects and spaces outside the campus in which students can combine their knowledge with practice in the field to enhance their professional development. This partnership has been instrumental in the iWeek and iSemester projects and projects and challenges in the undergraduate programs' academic courses. One example is the Innovation Labs Network with Intel implemented at several universities in different states of our country. It teaches students innovation methodologies and their application in real-life challenges [20]. Collaboration among universities and private and public companies to implement new learning approaches in higher education has led to identifying key elements that add value to the learning experience and developing specific competencies demanded by industry [21].

2 Methodology

2.1 iWeek roadmap

After implementing iWeek for several years, our university defined a method to design, plan, and implement new iWeek experiences for our students. This method is described in Fig. 1, the iWeek Roadmap.

The first stage of the roadmap is Planning. At this point, the professor must find an educational partner (company, non-governmental organization, research center, etc.) willing to take part in the iWeek experience. The educational partner and the professor define the challenge proposal, objectives, and scope. They consider the educational partner's needs and the competencies the university wants to develop. The professor must ensure that the company or educational partner has signed a collaboration agreement with the university through the Life and Career Center.

The second stage is Design, which involves defining the specific details from both the university and the company perspectives. From the university side, the professor should define the iWeek description and primary objective, declare the competencies to be developed by the students, state which engineering or bachelor programs and semesters are targeted, and define the total number of students to enroll in the CBL experience. Mindful of the specific challenge to be solved and the competencies to be developed, the professor should

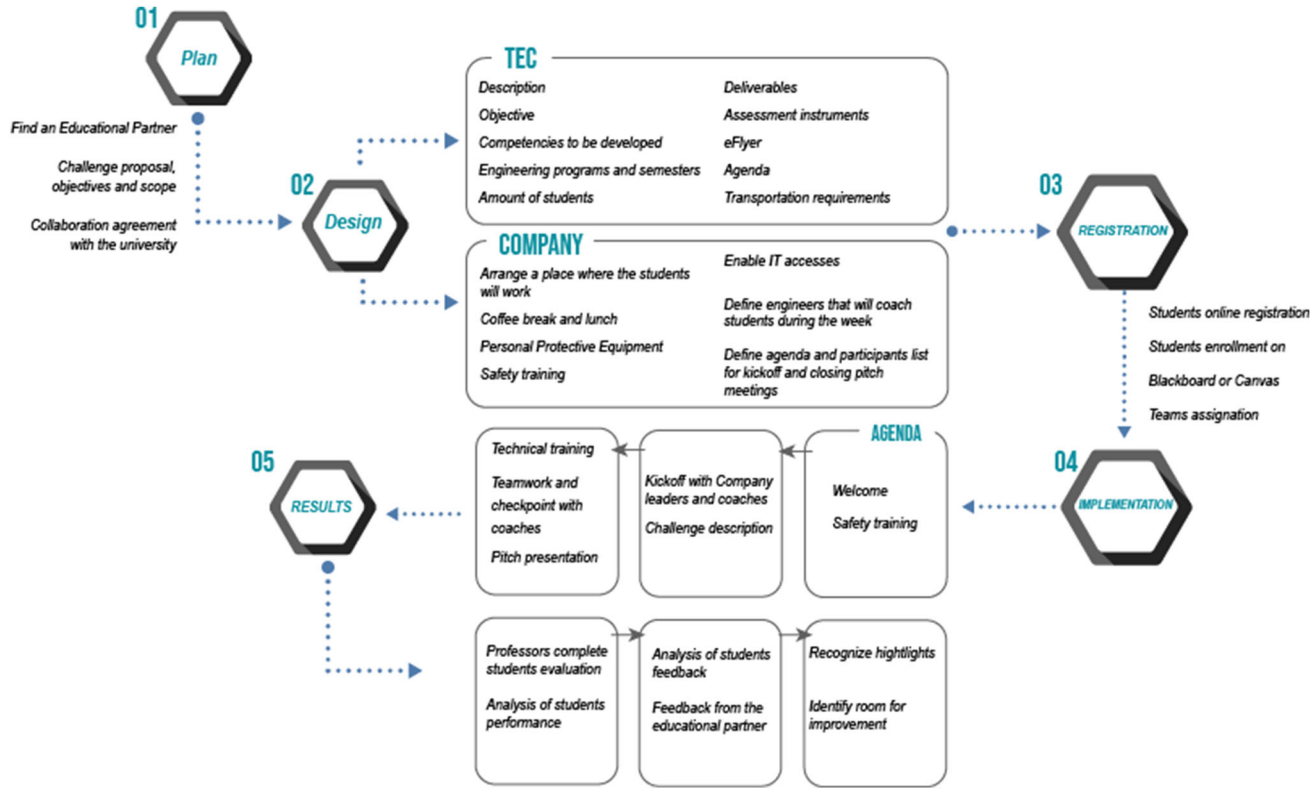

Fig. 1 The iWeek roadmap

clearly define the expected deliverables for the end of the week and design the corresponding assessment instruments. Together with the company, the professor must organize the week's agenda and design an eFlyer for the internal iWeek online registration system. In our university campus's specific case, the transportation costs and event organization are run by the university. It is recommended to arrive at the site in a group to have better control, facilitate access to the site, and follow up the agenda.

On the partner side, the company arranges the resources to prepare to receive the group of students. This includes authorizing access to the site, defining an allocated place at the company to work during the week, coffee breaks and lunches, personal protective equipment, safety training, and enabling IT access. The company must also assign a group of persons who will coach and accompany them during the week and confirm the kickoff and closing-pitch meetings' participant list.

The third step is the Students Online Registration. Students evaluate the different iWeek options and select the one they find attractive according to their expectations and career plans. Once the online registration closes, students are assigned to an iWeek space on Blackboard, Canvas, or the corresponding collaboration platform. The professor might assign the teams before the beginning of the iWeek according to the challenge needs or the first day.

Once all the planning and prework is done, the next stage is Implementation. During this step, both the professor and the company follow up on the week's defined agenda. The first day usually includes the company introduction, safety training, the challenge description, objectives and deliverables, and the university's evaluation policies. Students get to know their coaches and the shop floor where they will work on their particular process. The students and coaches interact during the week with constant feedback on their project updates. Students wrap up their work during the last day and make their pitch presentation to the relevant stakeholders, including leadership members, coaches, and the professor. Students receive feedback from the company leaders and coaches.

The final stage is Results and Analysis. The professor completes the students' assessments and analyses their performance. Students receive the professor's final feedback through the collaboration platform, including their grade for the iWeek. It is suggested to apply perception surveys on the first and the last days of the iWeek, to understand students' expectations and get feedback from their learning experience during the week. Having a closure meeting between the company and the professor is also suggested to discuss the CBL experience highlights and identify ideas for improvement for the next iWeek collaboration. Finally, the university must thank the educational partner for their time and effort in the iWeek experience.

2.2 Nemak IT innovation challenge

The iWeek experience presented in this work was named the Nemak IT Innovation Challenge. Through a CBL didactic technique, the objective of this iWeek was for students to improve their competencies in innovation and use of information and communication technology. These transversal competencies were fostered by learning a new digital tool called Power Apps and implementing it to develop a solution for the company's digitalization process in specific business areas. This iWeek experience also intended to strengthen the association with Nemak as an educational partner for the School of Engineering and Sciences at the Monterrey campus of Tecnologico de Monterrey.

Nemak is a Mexican company that provides solutions for the global automotive industry, specializing in aluminum components for powertrain and body structure applications. Nemak has 38 manufacturing plants located across 16 countries, with its headquarters in Monterrey, Mexico. Nemak's IT Business Intelligence and Innovation department collaborated with Tecnologico de Monterrey in this iWeek. Nemak's IT team serves various company business areas and is currently working on an ambitious plan to automate manual processes and connect relevant data for the decision-making process.

With efforts focused on the company's digital transformation, looking into process automation for efficiency, Nemak engineers and a Tecnologico de Monterrey professor defined five business cases to be tackled by the students. Microsoft Power Apps was the digital tool assigned for these projects. It enables users to develop in-house applications in a relatively short time compared to traditional tools that require high-code developers. This study was the company's first approach to observe how fast students learn Microsoft Power Apps and develop a functional application to improve specific processes. Nemak's IT team has been recently trying to introduce Power Apps to the company, but the adoption in the different business areas has not been as rapid as they expected. One company objective was this iWeek experience to become an eye-opener for the different areas involved to see the immediate benefits and potential of this digital tool and inspire its use. Table 1 summarizes the main elements of the iWeek presented in this study.

Table 1 Nemak IT innovation challenge iWeek

Innovative education	Tec21 teaching–learning model, iWeek
Competencies to be addressed	1. Innovation 2. Use of Information and communication technologies
Training Partner	Nemak, IT Business Intelligence and Innovation department
Challenges	1. Shipping control 2. AI classification system 3. Digital HR 4. Social events 5. Inventory control
Didactic technique	Challenge-based learning
Assessment tools	Technical report, oral presentation, video, checklist, self-assessment and peer assessment surveys

During the week of October 28th to November 1st, 2019, 20 students of the following engineering programs took part in this project: Computer Science and Technology, Business Informatics, Digital Systems and Robotics, and Mechatronics. These four engineering programs have strong programming skills development. There was a mix of students in their 3rd to eighth semesters of their curricula. Engineering programs at Tecnologico de Monterrey are nine semesters long. Teams were assigned by the professor in charge of the project and an engineer from the company, looking for a multidisciplinary balance per academic program and team members' experience, considering their semester and professional experience. Students were requested to hand in their CV (Curriculum Vitae) to consider their profiles while defining the teams and assigning the projects; the company HR team also kept these for job opportunities in the future. Figure 2 shows the students' distribution for the iWeek, and Table 2, the students' distribution per challenge according to the team selection criteria.

The five days took place at the company. During the first day, the professor explained to the students the objectives, agenda, and evaluation policies of the iWeek. Then, students were introduced to the company's history and the environment, health and safety policies. Next, students were divided into the assigned teams and learned the general objectives of their specific challenge. Students were instructed in the scrum framework for project management as a tool to be able to self-organize, adapt quickly to change, and deliver the project in a short, manageable timeline. The Nemak IT team also introduced the students to Microsoft Power Apps as a rapid application development platform to build custom applications according to the business needs. Power Apps allows connecting business data stored in different sources and is a versatile tool to transform manual processes into automated digital processes. From Tuesday to Thursday, each team had meetings with the corresponding stakeholders and visited the site to gather the project's required data. This allowed students to clarify any questions and receive continuous feedback on their progress to ensure they worked in the right direction. On Friday morning, student teams worked on their technical reports, videos, and final presentations. After Friday lunch, each team pitched its digital solution to the stakeholders and the other teams. The company and the professor evaluated each of the projects and gave feedback to the students.

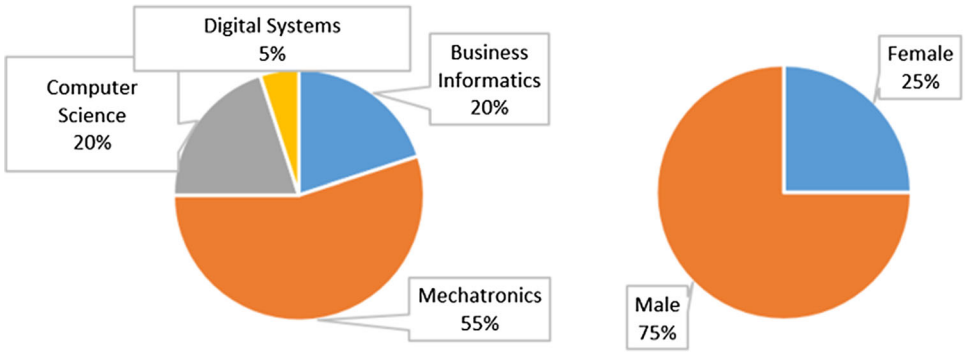

Fig. 2 Students' distribution

Table 2 Students distribution per challenge

Challenge	Engineering program	Code	Semester	Gender
1. Shipping control	Mechatronics	IMT	7	F
	Business Informatics	INT	3	M
	Digital Systems and Robotics	ISD	3	M
	Mechatronics	IMT	3	M
2. AI classification system	Computer Science and Technology	ITC	8	F
	Mechatronics	IMT	3	M
	Business Informatics	INT	3	M
	Mechatronics	IMT	3	M
3. Digital HR	Mechatronics	IMT	5	M
	Mechatronics	IMT	4	F
	Computer Science and Technology	ITC	3	M
	Business Informatics	INT	3	M
4. social events	Mechatronics	IMT	6	M
	Computer Science and Technology	ITC	3	M
	Business Informatics	INT	3	F
	Mechatronics	IMT	3	M
5. Inventory control	Digital Systems and Robotics	ISD	5	M
	Computer Science and Technology	ITC	4	F
	Mechatronics	IMT	3	M
	Mechatronics	IMT	3	M

The students were required to submit as final deliverables a technical report, the functional application in Power Apps, a video or animation showing how the application works, and the PowerPoint presentation used during their pitches. They were also required to complete self and peer assessments at the end of the week and a perception survey on the first and the last day. The professor used a checklist as an assessment tool to integrate the different elements of the week.

3 iWeek projects

This section explains the five challenges students engaged in during the iWeek: the Nemak IT Innovation Challenge.

3.1 Shipping control

The objective of this challenge was to develop a real-time monitoring application for shipping management.

3.1.1 Understanding the shipping control process

Shipping is one of the last steps of the company's operational processes and one of the most critical for the customers. Production Control and Logistics (PC&L) engineers oversee this just-in-time process. It involves constant and effective communication between the quality team (handling the final production process), the shipping team, and a third-party contractor in charge of the shipping trucks. Within this shipping process, they must check and validate plenty of information,

from the shipping order to the correct position of the product in the truck.

3.1.2 Identifying user pains and needs

The student teams interviewed the PC&L engineers and the shipping and quality team. They had an on-site visit that helped them identify the customer requirements for their solution. They noticed that many teams were involved in this process and saw that the communication between the involved parties was an improvement area. This communication problem led to the possibility of loading shipments after their scheduled times, untrustworthy reports, and notification errors.

3.1.3 Innovation process and value proposition

The Product Quality team has a key indicator called the cost of poor quality. This indicator evaluates how much the process spends on scrapping, reworking, and other reactive and preventive costs. With this indicator in mind, students presented the "cost of poor communication" approach, creating consciousness among top managers about their proposed solution's relevance. Their value proposition consisted of getting every team on the same page and a single communication platform to have a checklist of each delivery task with its current status.

3.1.4 Application development

The team developed a functional prototype of an Amazon-like platform that replaced using paper-printed Excel files and constant emails and phone calls with visual tracking of the shipping process. Each of the shipping steps was a checkpoint in the app. If a shipment was delayed, an alarm went via email to the involved employees. By connecting SQL databases and the Power Apps platform, the team developed in a few days a secure and scalable application that saves income information for further analysis, with personalized access, dashboards, and a barcode reader.

3.1.5 Shipping control results

Thanks to all these features, the application solves some of the most expensive logistics team and time-consuming problems. The digitalization of this process enables engineers to reduce their response time and to make data-driven decisions. According to *CIO Perspectives Transport and Logistics Industry Deloitte Report, 2016*, every customer and engineer has become data-enabled and look forward to being more informed through digital services throughout the shipping process [22]. As nowadays there is a massive amount of data available, engineers need to deal with just one person or system that reflects and understands the whole business process correctly and can provide feedback in real-time regarding their shipments' status. The most critical need is to clearly understand the shipment process and let the customer (in this case, PC&L engineers) see where the bottlenecks are happening. Companies related to transportation and logistics are having difficulties finding these services, especially when it comes to IT systems [22]. Many companies get on board with digital solutions that, in the end, do not meet their needs. Given the urgency of applying digital solutions, companies avoid dealing first with their traditional problems. Moreover, shipping processes are flexible, and many variables are involved. A digital solution for a shipping process must consider this flexibility.

Also, this digital solution could be a first step toward implementing an Industry 4.0 technology: Blockchain. It is defined as a digital, decentralized, distributed ledger in which transactions are logged and added in chronological order to create permanent and tamper-proof records [23]. A more straightforward definition describes it as a distributed database of records, transactions, and digital events that have been executed and shared among connected participants [24]. Blockchain perfectly fits this business case in which several roles, teams, and third-party companies are involved. Blockchain is the technology behind cryptocurrencies. Once each transaction is validated, it can also include smart contracts, which automatically detect digital events and create chargebacks or the corresponding transaction depending on the event. This event could be a checklist step in the shipping process of the application created by the students. Smart contracts are agreements between two or more contracting parties that can be automatically enforced without intermediaries [23]. For this reason, creating fast proofs-of-concept, like the one presented by the team of students, accelerates this process, bringing traditional problems to light, avoiding a whole development process for this service. During the iWeek, students succeeded in detecting and presenting their potential solutions to most of these issues. In short, the students validated the feasibility of the application, showed the value created, and gave Nemak the steps to implement it fully.

3.2 AI classification system

This challenge comprised developing an image classification system that prepares and manages datasets for AI model training to identify defective parts after the metal casting manufacturing process. Students had to understand the manufacturing process and learn about artificial intelligence and Power Apps.

3.2.1 Understanding quality factors in casting manufacturing

The manufacturing process of casting a metal alloy part involves many parameters. Most of these variables are monitored and controlled by PLCs (Programmable Logic Controllers) and control systems. Nevertheless, there are external factors that can affect product quality during the manufacturing process. Defects occur due to improper control of parameters or imprecise production equipment [25]. Hence, manufacturing companies must have an efficient quality inspection process to avoid defective products, affected by external factors, interrupting their supply chain process.

3.2.2 Understanding artificial intelligence for quality applications

The Nemak IT innovation department is continuously developing Proof of Concepts (PoCs) of emerging technologies, such as Virtual Reality, the Internet of Things, and computer vision powered by Artificial Intelligence (AI). The company has developed an in-house AI vision system that supports visual inspectors that detect defective pieces in real-time. In 2018, the fastest solution was to incorporate more inspectors in the quality process, and the most effective one was to test traditional computer vision with industrial cameras. However, this was a very high-cost solution when considering the scalability of the system. Another previous effort involved using open source technologies for artificial intelligence, detecting defects with a simple, low-cost webcam thanks to this technology's flexibility. Now, the company is looking forward to using the same technology in different products with different defects. The engineering shared best practices of deep-learning projects with the iWeek students to consider when designing their solutions.

The students learned the concept of deep learning and its application in this business case, more precisely, convolutional neural networks (CNNs). This was their first approach to artificial intelligence concepts. Students had a daily meeting with Nemak's data scientists to understand the technology and its importance within their business case. CNN is one of the most successful models of deep learning algorithms because it can directly take an image as the input and offers self-learning ability [25]. These neural networks function in computer vision applications because each layer acts as a filter and reduces the number of parameters in a simple neural network. Convolutional neural networks reduce parameters without losing the quality of the deep learning model [26]. CNNs were invented with image processing in mind. The image pixels that are close to each other usually represent the same type of information except those in edges or contours. In this method, a complete image is divided into squared sections, and the edge detector filter moves through all the sections, looking for this specific characteristic. Different filters can be included to search for specific features throughout the whole image. For the iWeek challenge, students had test files in which almost all the image was in a pixel value that represented the color of aluminum. The defect was noticed by differentiation from this color with specifics edge shapes.

3.2.3 Identifying pains and gain during CNN dataset preparation

Before training a convolutional neural network, there must exist a repository of images for training and testing. This dataset must have the label of each image file included, the initial step for a deep learning project and probably the most important. For this iWeek project, Nemak IT and the quality team had already collected this dataset. If the CNN should detect defects, the dataset should have many images, preferably, half of them with no defect issues (label 1 = Ok) and the other half with a defect (label 2 = Defect). The students, helped and guided by the data scientists, learned how an artificial intelligence model operates and understood how an intelligent system's accuracy relies on the quality and quantity of the data input. The image classification process needed to be improved since it was done manually by visual inspectors that opened each image file. Once they decided if it was defective or not, they saved it in its corresponding folder. This was an exhausting activity, and after several hours, operators classified some images incorrectly.

3.2.4 Iteration and innovation process and development

With these previous insights and after validating their proposal by creating prototypes, drawings, and mockups, the group of students developed a PoC with a functional interface that receives the dataset of unclassified images and enables inspectors to classify them with just one click (Ok or Defect). Additionally, each classified image was sent to a Nemak database in SQL, where images would later be consumed by the data science team. The next step to implement this project involved splitting the dataset to train it to detect the characteristics previously mentioned and then test the CNN with images not used for training.

3.2.5 AI classification system results

The students' application managed to save the labeled images automatically in their corresponding set folder. The digitalization of this process reduced the classification time by half, allowing engineers to focus their efforts on modeling and programming the convolutional neural networks. Students delivered a Power Apps application with a database connection and python scripts that improved image storage. Also, students designed an enterprise platform's look and feel that

empowers users to improve this AI system. Specifically, this was for the AI models' administration and analytics dashboards of the system operation per shift.

In response to the demand for Artificial Intelligence skills in industrial environments, the Engineering School at Tecnologico de Monterrey is creating close partnerships with industry and offering subjects for developing Machine Learning and computer vision skills. These courses include a final project at a company. Universities should offer courses related to AI concepts since it has potential applications in a wide variety of areas [27].

3.3 Digital HR

The objective of this challenge was the digital transformation of the HR service center.

3.3.1 Understanding HR services

The Digital Human Resources (HR) project focused on improving the Employee Service Center. This center serves more than 10,000 employees in tens of different services, from bank accounts and medical insurance to employee credentials. This center has just one contact point at the company site, a long walking distance for many employees. Moreover, this center usually has long waiting lines and much paperwork for several services.

3.3.2 Identifying customer pains

The team of students identified the top services to include in their digital solution. Students also estimated the number of visits to the center per day and the average time per visit. The analysis indicated about 1200 visits per month with an estimated time of 8 min per visit. Additionally, the team estimated 15 min to walk from the workplace to the service center and back. As a result, employees wasted much time to attend situations that could be performed remotely. On the other hand, the service center personnel also spent too much time attending to each case and processing the data because they did not have a digital management tool. All the data was manually updated on Excel files.

3.3.3 Iteration and innovation process and UX design

This business case focused on the application user experience (UX), considering end-users, administrators, and HR services managers. The digital solution required a user-friendly interface, process simplification to reduce service time, and fulfillment of IT security guidelines for handling sensitive data. To validate the UX, students created a storyboard of the application and its principal features. Students also interviewed several employees organization-wide to discover their pains when they required these services and get feedback from them to consider during the application design process.

The first proposal considered the option of end-users downloading the application to their smartphones. However, during the interviews with the stakeholders and end-user, students became aware that the application access should be through the official company email. Nevertheless, not all employees had official emails, specifically the operators who worked on the shop floor. For this reason, students decided to use the employee credential for identification purposes. Having this in mind, the team decided to install tablets at the plants' entrance and connect them with a credential sensor to link the credential ID with the application. This second approach was well received by the employees when they were asked for feedback.

3.3.4 Application development

As soon as the most demanded services were identified, and the design concept was defined, the team started building a database to receive all user inputs. It was essential to keep the same structure used in the Excel file that was manually updated during each visit. Students learned about SQL databases, Power Apps, and how to connect these tools through Google Drive or other cloud services. The IT Applications engineers mentored the students. The team developed a digital tool that automated the HR services and stored the user information directly to the new service database. Also, a report of the requested service was automatically created, which would help administrators follow up on each of these tickets.

3.3.5 Digital HR services results

The HR service center was transformed into a digital process with multiple contact points through tablets running the application across the site. The developed solution offered access to the most demanded services for the employees. The application was easy to use and, overall, more efficient compared to the face-to-face service center. More importantly, with this solution's use, employees would not waste time traveling to the service center or waiting to be attended. The employees could use the digital service and keep their HR processes up to date. The digital service was available 24/7, an excellent option for operators who work during night shifts. The HR team also had an immediate benefit by generating reports of the different processes and saving all the required data in a structured database.

The team of students defined key performance indicators to measure the efficiency of their application. The primary indicators were the service center visit reduction (since employees would still visit the service center for services

not included in the digital solution), automated processes and services, and databases consolidation. Even though the project was complete and almost ready to be fully implemented, the team could not test the ID registration through the employee credential reader. They validated the business case by explaining how the investment in tablets and ID scanners would represent significant savings by reducing the time that employees took at the current service center.

The students learned about the potential of Power Apps to create custom solutions. Serving 10,000 users was a challenge on its own. More importantly, students learned to identify areas for improvement and to listen to the end-users and stakeholders to obtain their input for the design stage to create a functional solution. Understanding the problem and being sensitive to the user requirements is a useful competency required in Industry. It avoids rework and unnecessary costs. The team managed to validate the project's important aspects, going from technology adoption to financial investment.

3.4 Social events

This challenge's goal was to replace phone calls with a digital self-service application where employees could enroll in various social activities and events.

3.4.1 Understanding Nemak social activities

The company offers a catalog of social activities to create a healthy and active employee community. These activities include marathons, 5 k races, zoo visits, and cinema nights, among others. In addition to recreational activities, Nemak continuously supports the internal and external communities and encourages employees to participate in social development activities like going to low-income schools, planting trees, and other activities. The company is interested in engaging its employees in activities that contribute to its society in terms of education, industrial innovation and infrastructure, responsible production and consumption, and global climate actions.

3.4.2 Understanding user pains and needs during events enrollments

The initial problem was having thousands of employees looking to register for the different activities and events since enrollments were only available on one specific day of the month via phone call. Consequently, the phone was overloaded by many calls at the same time, employees spent time trying to book a place, and usually, they gave up in the end and preferred not to participate. For companies, employee engagement significantly impacts productivity, profit, customer service, retention and overall performance. The company already having various activities and events made it worth the effort to improve the enrollment process so more employees could get involved.

3.4.3 Iterative innovation process and UX design

Similar to the Digital HR project, this solution involved thousands of users. The iWeek team researched different options to solve the problem. They even considered different digital platforms besides Power Apps and found Kaizala, a free Microsoft tool. The tool includes a corporative chat, message broadcast function across multiple groups, single-question polls, multi-question surveys, automatic event-feedback surveys, and results visualization. The students had daily meetings with the HR team involved in managing the events and validated Kaizala's features. This tool was suitable for this particular challenge. Students also decided to run their application on tablets with ID card readers throughout the site to overcome the personnel identification process. Not all employees had an institutional email account.

3.4.4 Integrating solution to social events managing process

All previous projects were fully prototyped on Power Apps. However, not all employees had access to this service, so the student team proposed to tackle their challenge by using Kaizala. This platform could also contact suppliers and other external collaborators through its official and secure company chat. Kaizala allows the administrators to send an event enrollment survey to all the employees through its high-level security communication media. Students created a video using Kaizala for event enrollment and documented possible applications for this tool.

3.4.5 Social event services results

Students validated this process's digitalization by presenting research done by different consulting firms on how improving this service leads to increased employee engagement, resulting in reduced staff turnover. The solution for this business case was straightforward but valuable for the company. As Human Resources is fully involved in operational processes, they sometimes have no time to evaluate new technologies. The use of Kaizala can be a game-changer for employee communication.

3.5 Inventory control

This challenge objective was to develop a digital tool for traceability of shop floor inventory movements while substi-

tuting emails, messages and Excel files with an automated database.

3.5.1 Understanding product planning and control

Inventory Control is one of the most complex challenges. In a manufacturing company, and even more in the automotive industry, it is crucial to manage resources effectively. Incorrect inventory control implementation can delay product deliveries [28]. It is the role of the Production Control and Logistics (PC&L) team to manage the materials. PC&L engineers define the production plan and capabilities considering customer demand and the company's resources to meet that demand. Inventory control involves many types of resources to be quantified and monitored. Spare parts, raw materials, and processed material are just a few examples. Production planning and control is a value-adding process of manufacturing activity. Its activities involve material requirements planning, enterprise resource planning, just-in-time manufacturing, and forecasting, among others [29].

3.5.2 Identifying customer pains and needs in the inventory control process

The complexity of these challenges starts with the number of materials to manage during a casting process. Inside each material are various categorical considerations. Additionally, material transformation during the manufacturing process must also be thought about. All inventory control must be done manually, which means that an operator has a daily routine to count resources. There are many items to monitor through the casting process. Even though students had an in-line tour of the complete manufacturing process, the PC&L engineers decided to focus on the sand core production only, before the casting process, as the first approach toward the digital transformation. Considering the short time students had, it was a very ambitious challenge to create an automated application for all materials involved in aluminum block production. The control of the sand core represented a considerable challenge on its own. Students learned about the manufacturing process to understand each sand core production phase, from the raw sand arrival to the sand processing and finished sand cores. The PC&L engineers' main problem was having to forecast production with an untrustworthy inventory report. The mentioned in-line routines were implemented to adjust any inventory system's inconsistency to increase reports' precision.

Once students understood the sand casting manufacturing process and each material's relevance, they analyzed the materials engineer's daily routine to identify the key elements necessary in the digital solution. The team of students also noticed a significant improvement opportunity in that the materials engineer repeatedly contacted each relevant player individually via email or text to know the current amount of material per process.

3.5.3 Inventory application development

An automated process was developed by the students using Power Apps to create intuitive windows and fields. The Power Apps application was connected to a SQL server to input historical data, which adds value for future forecasting through data analysis. Using Microsoft Flow, the application can send an automatic email to the PC&L team with the sand inventory's daily report.

3.5.4 Inventory control results

The students created a user-friendly app that enables each process leader to update a database with the current amount of material. This resource tracker allows the materials planners to analyze the data and improve their supply predictions. Even though the students just developed the pipeline for sand inventory management, the application was designed to include the next steps of the manufacturing process to support further implementation. The deliverables included a financial analysis of the cost avoidance for the board of directors and the PC&L leaders. It showed a high potential cost reduction by effectively controlling the sand waste and avoiding the purchase of extra sand.

The digital solution used a cloud service for inventory monitoring. This solution demonstrated the benefits of using it compared to the manual process of counting the inventory and communicating the updates among the different team players. The resources' traceability markedly improved, empowering employees to make data-driven decisions. Students developed the know-how for implementing cloud solutions. Further work on this digital tool may integrate sensors and monitoring hardware, thus advancing toward the Industry 4.0 transformation.

Table 3 summarizes the five IT challenges implemented during the iWeek, highlighting their primary objectives, key partners, leading customers, value proposition with the developed application, and critical resources needed for the digital transformation. Figure 3 shows the application designed for the shipping control challenge as an example.

4 Results and discussion

4.1 Project presentations to stakeholders

On the last day of the iWeek, each team pitched its digital solution to the stakeholders, coaches, board of directors, and the other teams. Each team prepared a PowerPoint presentation and video or animation to show the audience their

Table 3 iWeek innovation challenges

Challenge	Description	Key partners	Customers	Value proposition	Key resources
Shipping control	Create a real-time monitoring application for shipping management	Production control and logistics engineers, IT	PC&L Engineers and shipping leaders	Enables engineers to reduce shipping delays and to make data-driven decisions	PowerApps, SQL databases
AI classification system	Develop an image classification system that prepares and manages datasets for AI model training to detect product defects in the metal casting process	Data scientists, visual inspectors, and IT	Visual inspectors and data scientists	The data preparation process was reduced by half, allowing data scientists to focus on other relevant tasks	PowerApps, SQL databases, python programming
Digital HR	Digitalization of HR services offered in the registration window	HR operations, operators, and IT	All employees	Offered service 24/7 and increased HR services' efficiency	PowerApps, SQL databases, Microsoft Flow
Social events	Replace enrollment phone calls with a digital self-service application	HR social development, operators, and IT	All employees	Increased employee engagement	Kaizala
Inventory control	Create an app to track floor shop inventory movements while substituting emails, messages, and Excel sheets with database storage	Production Control and Logistics Engineers, Operations leaders, and IT	PC&L Engineers and Operations leaders	Improve PC&L supply and production forecasts	PowerApps, SQL databases, Microsoft Flow

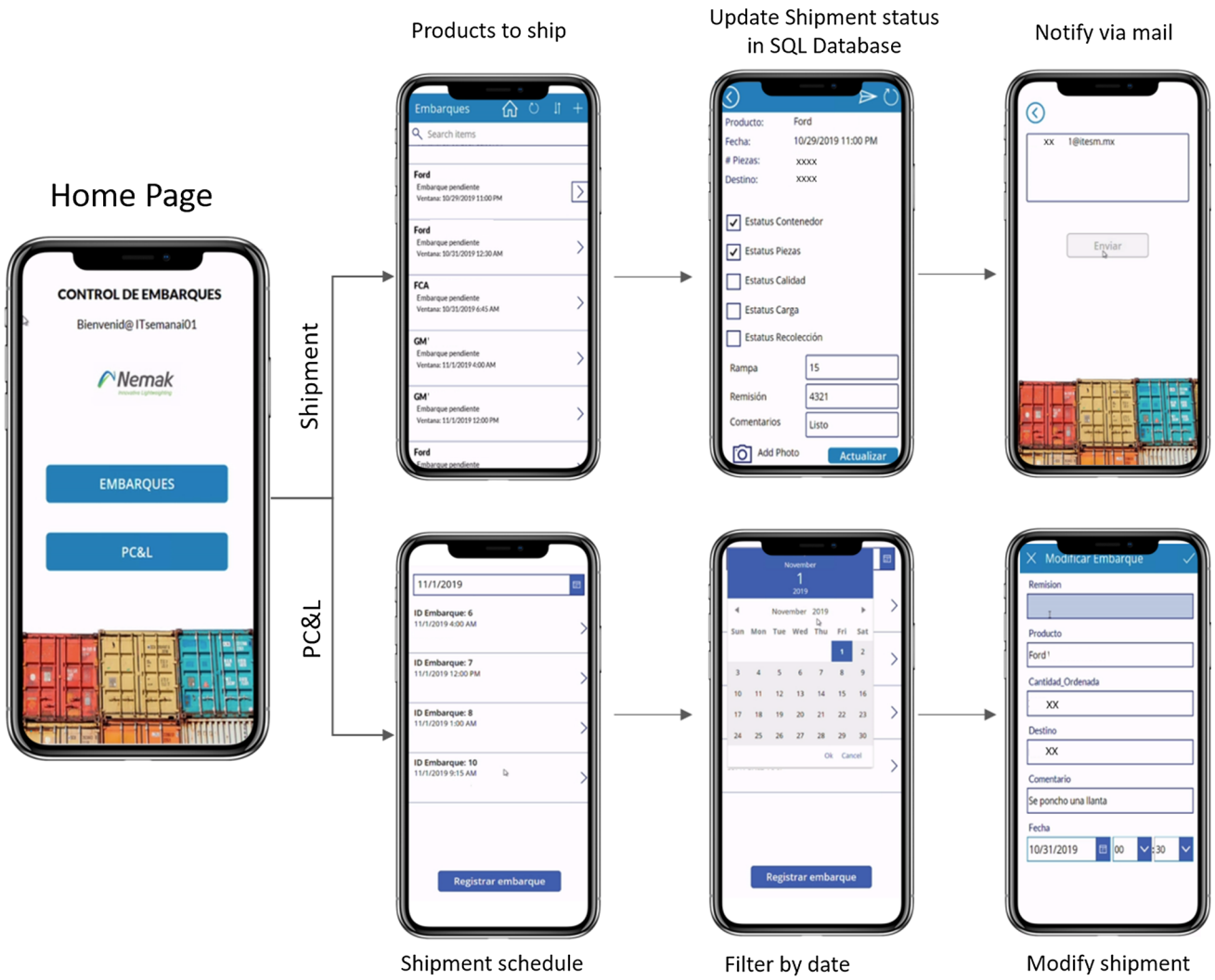

Fig. 3 Shipping control prototype application in power apps

functional application. The solutions included the different elements required by each "customer" or business area to digitalize their processes. These projects empowered both the students and employees, integrating their skills and expertise to develop useful applications utilizing the available resources. Students explained each application's potential, defined the opportunity areas clearly, and described how the applications enable the users to perform their functions more efficiently.

The proposed in-house applications integrated data and systems already in use by the company. This digital transformation allows employees to make better and faster decisions by having improved access to information. Power Apps proved to be very useful and versatile in addressing the different business cases presented in this study. Even though the students were not familiar with the platform before the iWeek experience, they made a great effort by engaging in learning the digital platform's basics, understanding the business needs, and designing and implementing a digital solution to address the problem.

The company and the professor evaluated each of the projects and gave the students feedback after their pitches. The project stakeholders were very excited and satisfied with the results, looking forward to implementing the solutions in their areas. Since there had been close communication between the team members and the project stakeholders from day one of the iWeek, each solution had the final users' input, adjusting the fine details to meet their needs and requirements. Both students and employees were satisfied with their achievements.

Overall, the feedback comments from the stakeholders and the directive board to the teams regarding their pitches was very positive. The directive board was happily surprised by the innovative applications and committed to implementing them soon. The whole experience was an eye-opener to the potential of digital transformation and the facility of low-

code tools, such as Power Apps, to empower non-developers in this transformation process.

4.2 Academic assessment

It is relevant to point out that besides the innovative learning experience, students are motivated to participate in the iWeek since it represents 5% of their final grade of every single course they are taking during the semester. This suggests that a formal academic assessment should be conducted to evaluate the transversal competencies developed during the iWeek and to define the iWeek numerical grade. This grade is determined on a scale from 1 to 5, where 5 represents outstanding performance.

Challenge-Based Learning involves a certain degree of uncertainty. The external educational partners' role is essential to mediate the complexity and uncertainty factors of the challenge. It is necessary to define an objective, transparent, and fair assessment system for the CBL experience. Professors should define the assessment instruments beforehand and share them with the students at the beginning of the week. The instruments should consider both qualitative and quantitative evaluation. Previous CBL experiences at our university have shown that checklists, rubrics and, observation guides are effective, transparent and objective assessment instruments [30, 31].

As final deliverables for the iWeek presented in this study, the students were required to submit a technical report, their functional application in Power Apps, a video or animation showing how the application works, and the PowerPoint presentation used during their pitch. Students were also required to complete a self-assessment and a peer assessment of their teammates at the end of the week and a perception survey on the first and the last days of the week. The checklist shown in Table 4 was designed and applied as an assessment tool for the iWeek. The iWeek professor analyzed the technical report, self- and peer assessments, and the surveys. The digital application in Power Apps and the final presentation were evaluated by both the educational partner and the professor.

The self-assessment and peer assessment invite students to reflect on their roles and contributions to the team during the week. It also gives the professor feedback about the team members' interaction and how committed they were to the challenge. The peer assessment helps the professor to identify any inconsistencies and have a better overview for evaluation purposes. Students assessed themselves and their fellow peers on participation, performance, attitude, commitment to the team, and punctuality. They also provided comments, including any aspects they considered relevant for the team to solve the challenge.

Perception surveys were applied to the students at the beginning and the end of the week. The survey contained both closed-ended and open-ended questions. On the initial survey, students were asked about their iWeek challenge expectations. Table 5 shows the top 5 results for this open-ended question. Their excitement about getting to know Nemak as a global company, its products and processes, working culture, and general working environment was the most common response. Students also mentioned that they were expecting to apply their knowledge acquired during their engineering program to propose innovative solutions to real-life problems in a real context. They showed interest in learning to develop digital applications and acquire professional experience. Students also considered the iWeek as an opportunity to challenge themselves to move out of their comfort zones to learn something new and develop new skills.

At the end of the week, students responded to a perception survey about the whole iWeek learning experience (Table 6). They were asked open-ended questions to share positive aspects of the iWeek challenge and opportunities to improve the learning experience. The most valued aspect of

Table 4 Checklist as an assessment tool for academic evaluation

Assessment instrument	Description	Points
Technical Report (30%)	Introduction, including the overview of Industry 4.0 and digital transformation	2
	Problem statement	3
	Application justification	2
	A detailed description of the main functions of the digital prototype (application in Power Apps)	10
	Business model	3
	Results and competitive advantages of the digital application	3
	Recommendations for use and future work	2
	Conclusions	5
Digital application in Power Apps (40%)	Working prototype in Power Apps	10
	Interface design	10
	Innovation (design and functions)	10
	Integration with other platforms	10
Final presentation (20%)	PowerPoint presentation, video or animation, and pitch	20
Self-and peer assessment (5%)	Self-assessment and peer assessment	5
Surveys (5%)	Initial and final surveys	5
	Total	100

Table 5 iWeek challenge expectations (n = 20)

Rank	iWeek challenge expectations
1	Get to know this global company, its processes and its working culture
2	Apply their knowledge to propose solutions in a real environment
3	Learn to develop digital applications
4	Acquire professional experience
5	Challenge themselves to move out of their comfort zones to learn something new

the CBL experience was the interaction with Nemak employees, including the IT team, project stakeholders and the board of directors. Students also valued having the opportunity to apply their engineering knowledge and skills to solve a real-life problem within a real environment, including time constraints, resources, uncertainty, and stress. Students considered the iWeek experience as a challenging and useful experience, where they learned engaging digital platforms and were able to add value to the company through their solutions. Among the opportunities for improvement, the most mentioned was to include a prior workshop or detailed tutorial to become familiar with Power Apps before the beginning of the iWeek, thereby reducing the learning curve and allowing more time for actual application development. Sixty percent of the students suggested this option, which is a relevant percentage for an open-ended question. Other comments were about the long commutes between the university and the Nemak site, adjusting the iWeek agenda to allocate more time for the application development, generating a Power Apps user manual to be consulted as a reference during the week, and exploring other digital platforms besides Power Apps.

Regarding the students' perception of their competencies development (Table 7), they rated their competency in Innovation on a scale of 1 to 5, with five being the highest. The group's mean was 4.05 at the beginning of the week and increased to 4.5 at the end. Similarly, students were asked to rate their competency in terms of technology and IT and communication, and the group's mean improved from 4.1 to 4.2. All the students confirmed they enjoyed the experience, and they would recommend this iWeek challenge to other students. Even though it was intense in terms of work and effort, they learned something new and were proud of what they achieved.

4.3 iWeek added value

Indeed, the iWeek CBL experience involves additional effort from students, professors and the educational partner (the company). Perhaps the main difference is in terms of time

Table 6 iWeek final perception survey (n = 20)

Rank	Positive aspects	Opportunities for improvement
1	The interaction with Nemak employees	Prior workshop or tutorial to become familiar with Power Apps beforehand to reduce the learning curve
2	Apply my knowledge and skills to solve a real-life problem in an industrial context	Long commutes
3	Challenging and useful experience	Time management for more time for the application development
4	Learned interesting digital tools and platforms	Create a user manual for Power Apps to be used during the week
5	Happy and proud to be able to add value to the company	Explore other digital platforms besides Power Apps

Table 7 Students perception of competencies development (n = 20)

	Innovation		Use of Technology and IT	
	Initial	Final	Initial	Final
Average	4.05	4.5	4.1	4.2
SD	0.826	0.607	0.718	0.523

since it is a full-time immersive experience, where students and professors focus on the specific challenge for the entire week. The rest of the courses and activities are suspended to allow everyone to focus on the iWeek. Participating in the iWeek means breaking the routine and centering all the attention, work, and effort on the particular CBL experience. This creates a shift of perspectives and provides an opportunity to try and learn new things. The educational partner also breaks the routine and allocates human resources to train and coach the students, besides the required arrangements for student visits to their site. It means a considerable effort for the university in terms of planning, logistics, and costs related to transportation and project materials.

The question behind this is if it is worth it, and the answer is yes. Figure 4 shows a comparison chart between the iWeek experience and conducting a similar challenge in a traditional classroom environment. During iWeek, students can get to know the company, walk through their processes, visualize the challenge and understand its relevance, interact with the project stakeholders, and get immediate feedback from them on their project proposals. A real challenge in industry exposes the students to the uncertainty factor and places the problem within real constraints, including economic, cultural, health and safety, and sustainability. Students have the

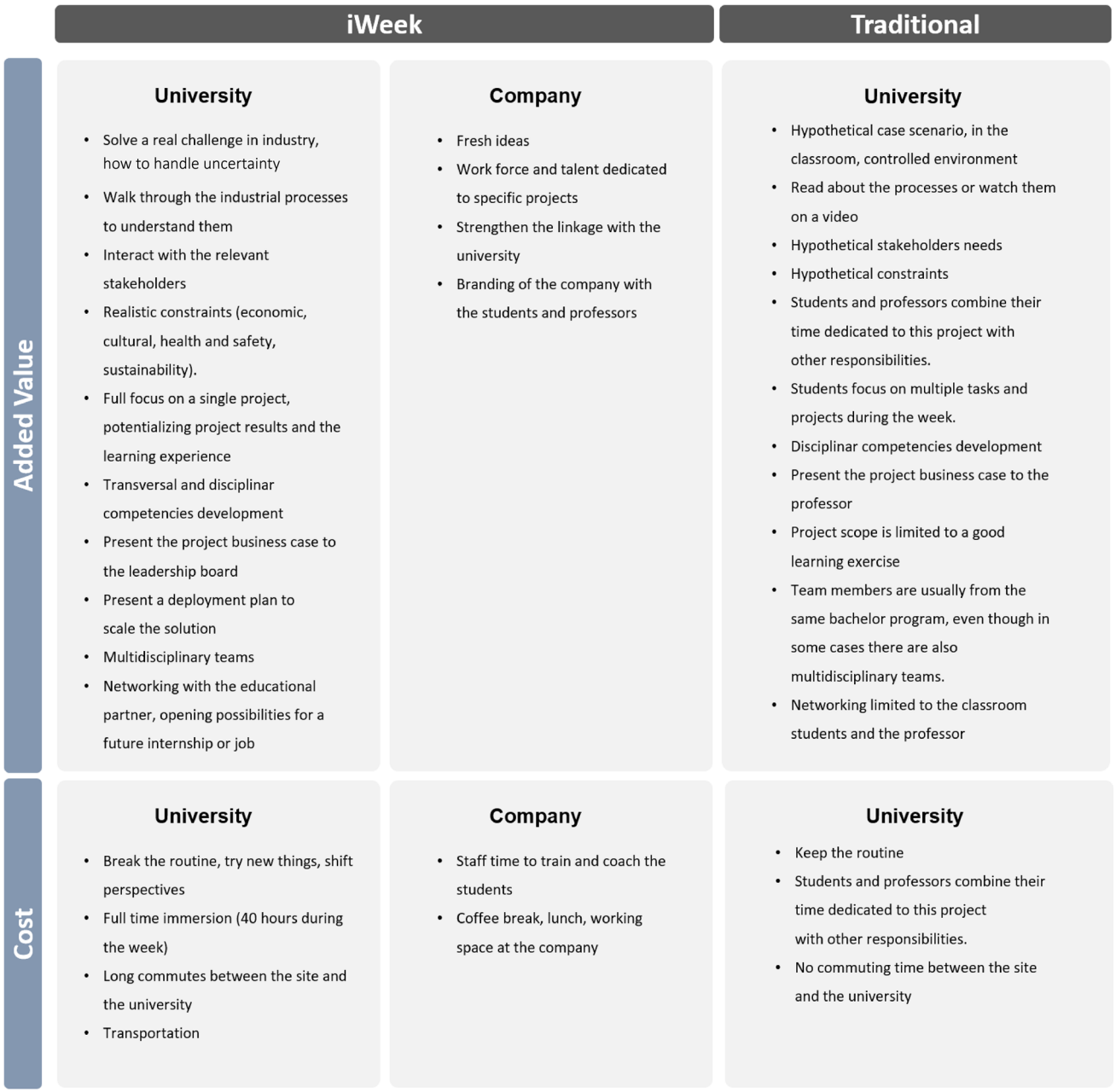

Fig. 4 Comparison chart between iWeek CBL experience and the traditional classroom environment

opportunity to work in multidisciplinary teams with members from different semesters and pitch their projects and business cases to the company leadership board. Students learn new things and develop both disciplinary and transversal competencies. Networking with the company is a noteworthy highlight. It opens possibilities for future internships or jobs. In general, iWeek is a memorable experience. From the company's perspective, several highlights include hearing fresh ideas and having a talented workforce dedicated to solving known challenges by applying new skills and technological tools to existing business processes. This experience improves the company's branding with the students and professors and strengthens the university's association for future collaboration.

5 Conclusions

The iWeek is a challenge-based learning exercise that requires a thoughtful design and planning process to be implemented successfully and be considered a memorable experience for students, professors, and educational partners.

An iWeek roadmap was described, presenting the main stages of a fruitful immersive experience: plan, design, registration, implementation, and results. The challenge objectives and scope and the competencies to be developed should be considered when designing the teaching–learning process's assessment instruments. The iWeek requires additional costs in time and resources; however, the added value justifies the experience. During iWeek, students can get to know the company, walk through their processes, visualize the challenge and understand its relevance, interact with the project stakeholders, and get immediate feedback from them on their project proposals. Taking on a real challenge in industry exposes students to the uncertainty factor and places the problem in real contexts and constraints. Students work in multidisciplinary teams, acquire new knowledge and skills, and develop disciplinary and transversal competencies. From the company's perspective, several highlights include hearing fresh ideas and having a talented workforce dedicated to solving known challenges by applying new skills and technological tools to existing business processes. This experience improves the company's branding with the students and professors and strengthens the university's association for future collaboration. CBL has been successful developing students skills and competencies aligned with the industry demands, which as a result enhances students ' employability [19]. The iWeek is an example of the potential that industry-university collaboration has on students 'development and employability. Other partnership models include challenges within entire engineering courses, internships, practical training, and competitions.

The Nemak IT Innovation Challenge is a clear example of how students can become well prepared to tackle serious challenges and grow to be real employees, even for only one week. These synergies strengthen business-university collaboration, helping to bridge the gap between academic training and business demands. Students have demonstrated developing the transversal competencies of innovation and facility with ICTs in their work during the week to produce the digital prototypes. Students managed to become familiar with Microsoft Power Apps and other technological platforms and implement them to improve the company's efficiency with process automation solutions. They provided fresh eyes to the company and new ideas of how to handle the challenges presented. Both students and the company stakeholders were delighted with the results. Students valued the interaction with the company employees and were challenged to apply their engineering knowledge to real-life problems and contexts.

This CBL experience showed students the profound complexity of implementing emerging technologies in traditional industrial contexts and the importance of engaging stakeholders and end-users to ensure the technology's long-term adoption. The company partners found the proposed solutions very innovative, creative and useful. Moreover, the experience demonstrated to employees the potential of process automation using Power Apps in the company's digital transformation journey and all the resultant benefits.

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