Understanding Competencies Transfer During Internships in Undergraduate Industrial Engineering Students: A Case Study at the National University of Táchira, Venezuela

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Introduction

Despite engineering programs designing curriculum with the goal of preparing students for industry demands, there is still a disconnection between industry expectations of the workforce and the preparation of engineering graduates [1-3]. One way to prepare engineering students to meet industry expectations is by involving them in real world experiences where they can transfer some of the knowledge and competencies they are acquiring in their programs [4]. Transfer of knowledge can occur in a classroom setting when students are solving real world problems, however, that is not always possible. Hence, students try to find contextualized work scenarios such as internships or co-ops, where they can be involved in a real project in a company. This particular setting provides students with an understanding of the work environment and also brings benefits to industry and universities [5]. On one hand, industry demands an integral formation of individuals that are competent in technical skills in their area of discipline, but with elements that enable them socially, ethically and professionally. On the other hand, society requires answers to its complex problems as a result of the generation and application of knowledge. Furthermore, higher education institutions are expecting that their graduates are able to integrate and apply the knowledge they have learned when facing real situations in their jobs. Participation in internships help students develop skills that go beyond the technical aspect of the engineering profession and also prepares them to adapt to the fast-paced working environment.

One of the main goals of higher education is to prepare students to transfer the classroom experiences (i.e. what they learn) effectively into the professional practice. Hence, engineering programs need to develop technical and professional skills in students and provide them with the autonomy to use those skills and use what they have learned theoretically when they face their professional jobs. Furthermore, many students will be expected to become agents of change and to drive transformation in the organizations they will work for. To ensure an effective and smooth transfer of competencies from the classroom to practice, engineering educators should better understand this phenomenon. Hence, it is important to study the process of transfer of competencies in depth to identify factors associated with the success or failure of the transfer process, and finding interventions that could improve the way engineering students are aware of it.

The purpose of this study is to better understand the process of transfer of competencies in engineering students during professional internships, and identify the connection between those competencies with the industrial engineering graduates' profile of [Blinded]. Our research questions are:

RQ1: What competencies do industrial engineering students apply as compared to what the graduate profile defines?

RQ2: What factors contribute to the effective process of transfer of competencies in industrial engineering students working in professional internships?

To answer these questions, we took a qualitative approach to characterize in detail the process of transfer of competencies in professional internships and determine the factors that influence its effective development and subsequent consolidation.

Theoretical foundation

According to Wenzelburger [6] the process of transfer of knowledge occurs when the learning outcomes of a previous experience (e.g. a course taken) facilitates performance in a different situation (e.g. a project in a company). The action of facing a problem and understanding how to bring specific competencies acquired in the past to solve it, especially in a different context, is a fundamental aspect of transfer of knowledge. Hence, to understand if an engineering student is able to transfer competencies, it is important to provide an opportunity to test what they know in a different and non-familiar context. Unfortunately, for many students this exposure only happens when they graduate, leaving them with a lack of opportunities to improve it. In addition, the process of transfer is more effective when the participant is very active in the process [7], reinforcing the importance of educational interventions that allow students to be actively involved.

Transfer of Competencies

To frame this study, we are using the model of transfer of competencies developed by Wenzelburger [6]. Wenzelburger [6] proposed different levels of transfer (i) transfer from day to day (e.g. knowledge from a class that is used in a different class), (ii) internal knowledge transfer (e.g. learning more and deeper about the same topic), and (iii) broad interdisciplinary and core transfer (e.g. being able to apply knowledge from one field into another one and in multiple contexts). Each level of transfer is important to be developed in educational settings. The author explains that everything that can be learned is transferable, such as psychomotor skills, cognitive skills, affective attitudes, methods, principles, theories, facts, concepts, relationships, structures, among others[6]. Therefore, universities should prepare integral professionals that articulate global knowledge, professional knowledge and work experiences, and recognize the needs and problems of society to create sustainable and effective solutions. Competencies are the set of skills, behaviors, and abilities that allow people to reflect on an action and know how to act when situations are faced, even if the situation occurs in a new context [7]. Since they play a key role in the process we decided to focus on competencies to better understand transfer of knowledge.

In order to explore competencies as part of transfer of knowledge, we decided to use the model developed by Prelewicz [8] as it relates to engineering specifically. Prelewicz [8] model proposes 5 tiers of competencies that engineers must develop throughout their career:

1. Tier 1 - Personal effectiveness competencies: these include interpersonal skills, professionalism, integrity, initiative, adaptability and flexibility, dependability and reliability, and lifelong learning.
2. Tier 2 – Academic competencies: including reading, writing, mathematics, science and technology, communication, critical and analytical thinking, computer skills.

3. Tier 3 – Workplace competencies: although some of these are expected to be developed in the job, many of them can be promoted during school. Some of these competencies are: teamwork, client/stakeholder focus, creative thinking, planning and organizing, problem solving, decision making, seeking opportunities, working with tools and technology, scheduling and coordinating, business acumen.
4. Tier 4 – Industry-wide technical competencies: these competencies include things that highly relate to the professional practice. Similarly, to tier 3, these competencies will be developed in the workplace, however, engineering schools play a role in preparing the students for them. Some examples are professional ethics, design, operations, engineering economics, legal, sustainability and environmental impact, safety, quality control, among others.
5. Tier 5 – Industry-sector functional competencies: these competencies will vary by industry type and by companies. These refer more to specific technical competencies required by specific jobs.

For this study, we will focus on the first 4 tiers as they are the ones that relate more to the educational aspect of transfer knowledge. We will identify how different competencies happen at different levels of the internship experience and will explore the interactions of those competencies. Understanding how the combination of competencies interact in the professional setting allows for identifying the ideal graduate profile that can be promoted in engineering programs for a successful future professional [9]. Likewise, Alarcón [10] argues that providing opportunities in the curriculum for experiential learning like professional practices, can positively impact the readiness of students for the workforce. Professional practices provide an space for students to develop competencies that allow them to succeed in the work place. These practices are especially important because students' lack of exposure to real-world experiences. Therefore, professional internships represent a great opportunity to expose students experiences that allow them to use transfer of knowledge (received during the academic program so far) in a different unique context.

Professional Internships

Professional internships are considered an educational model focused on the professional practice that help undergraduate students obtain a better understanding of the working environment by being exposed to situations that are unlikely to be found in a classroom setting [11].This type of intervention enables the application of the knowledge acquired at school to concrete situations and enhances the acquisition of desired competencies. According to Perrenoud [12] internships "allow students to face unprecedented situations and evaluate their ability to think independently, assuming risks" (p.56). Although teaching practices that look for ways to develop active experimentation (e.g. active learning, problem-based learning) have been a permanent goal in engineering education (perhaps not yet fully developed), it is necessary to intensify efforts to take advantage of interventions like internships, given its effectiveness developing competencies and employability of graduates. Internships' experiences also help develop the students' individual's self-confidence and maturity, have a positive impact on students' perceptions of career development, improve future marketability, and help students develop professional relationships that are useful for them in the future [11].

According to Zopiatis and Constanti [13], internships are not easy to define since its purpose, scope, and characteristics are determined by the nature of the academic program, the curriculum, and the academic institution. In engineering, different engineering disciplines have different internship programs and it will also be influenced by the type of industry. To provide context for this paper, when we refer to internships we are focusing on the context of an internship program in the department of industrial engineering at a technical university in [blinded for review]. In this program, students in their last semester (10^{th}) have the option of doing an internship or conducting an undergraduate thesis. Students that take the internship option will be placed by a university office in charge of internship placement for every engineering major. The office of career placement has agreements with several companies around the country. The students are placed in a 16-week internship where they need to develop a project for the company. The student has an academic supervisor and an industry supervisor. The industry supervisor maintains communication with the academic supervisor (i.e. a faculty member in the industrial engineering department) to discuss the scope and expectations of the project. At the end of the placement, the student will be required to develop a technical report where they explain the project developed and the outcomes. This report is defended in a 30 minutes oral presentation to a faculty evaluation committee.

Methods

The phenomenon being researched in this study (i.e. students' perceptions of the transfer of competencies during professional internships) called for a qualitative approach. More specifically, we used a case study approach. The methodology for our data analysis was grounded theory. A case study is the study of a specific phenomenon bounded to a system that can be analyzed individually to understand the phenomenon under specific circumstances [14, 15]. The process of competencies transfer in industrial engineering students was our case of study. According to Merriam [14], some of the characteristics of a case study are:

a. Particularistic: referring to the particular situation of the process of professional internships done by industrial engineering students from the [blinded for review]
b. Descriptive: the final product of the study is a rich and dense description of the internship phenomenon
c. Heuristic: gives rise to new meanings of the process of transfer of competencies in [blinded for review]´s industrial engineering students´ internships
d. Inductive: new relationships and concepts are discovered in the particular process of transfer of competencies in [BLINDED]´s industrial engineering students´ internships.

Regarding our worldview, this research is framed in an experiential introspective epistemological approach. It is intended to address the phenomenon, through the lens and perspectives of the participants during their internship experience, trying to reflect as faithfully as possible the concepts, ideas, thoughts, perceptions, beliefs, among others, of the students and how they are potentially influenced by their personal, academic and professional formation and by the context where they unfold.

In addition, a suitable approach for data analysis was to use grounded theory. Grounded theory enables researchers to investigate complex phenomenon by using a methodology that has the

goal to develop theories[16, 17]. Grounded theory is also useful when a theory is not available to drive data collection and analysis [18], hence, this research approach allowed us to develop a rich and deep understanding of how the students experience transfer of competencies during their internships. Industrial engineering students that decided for the internship option in their last semester participated in semi-structured interviews, each lasting between 60 to 90 minutes. Interviews were audio-recorded and transcribed, and field notes were recorded to preserve the context and subtle implications of participants experiences as they were describing them.

Participants

The qualitative nature of the study did not require to have a large sample. According to Hernández Sampieri, et al. [19] in qualitative research "the size of the sample is not important from a probabilistic perspective since the researcher's interest is not to generalize the results to a wider population "(p.561). For selecting the participants for this study, we used Strauss and Corbin [17] criteria. For this study, an intentional sample was taken prioritizing the depth over the extension. We intentionally selected 5 [BLINDED]´s industrial engineering students working as professional interns. The criteria that were used to select the participants in this study was:

1) To be an industrial engineering intern of [BLINDED] for the 2016-1 period.
2) To have an interest in the study, so they can have a better disposition when participating in the interviews and observation.
3) To have a grade point average higher than 6.5 (in a scale from 1 – 9)

Each of the 5 participants were assigned to different companies in the manufacturing sector, and that were located in the municipality of [blinded for review]. Table 1 provides more information on participants and the type of companies they were assigned to. It is important to note that all participants were female, the main reason was that all of them expressed that they felt more comfortable participating since the interviewer was a female faculty member.

Table 1. Participants

Participant	Gender	Size of company	Type of company	Sector
1	Female	Small company (up to 50 employees)	Private	Manufacturing
2	Female	Medium company (between 50 – 200 employees)	Private	Manufacturing/ service
3	Female	Small company (up to 50 employees)	Public	Manufacturing
4	Female	Small company (up to 50 employees)	Public	Manufacturing
5	Female	Medium company (between 50 – 200 employees)	Private	Manufacturing

Data collection

Semi-structured individual interviews were used to collect data. Semi-structured interviews allow a close approach to reality as it is perceived by the participant, in order to understand as faithfully as possible their perceptions of their immersion in the context where it develops. This type of interview enables the interviewer explore each of interviewee responses in an unstructured way (not prepared in advance, but systematically). In addition, observations were conducted in the place where the students were doing their internship. Observations allowed the researchers to gather additional data to better inform the data analysis process and the results.

Data analysis

Aligning with the constant comparative approaches of grounded theory research [18], initial coding was conducted line-by-line for each interview transcript to identify the main emerging concepts related to our phenomenon of study. Researcher insights were captured in memos. Several researchers did the data analysis and discussed initial discrepancies in the development of codes to ensure research quality and trustworthiness of the findings. The analysis was guided by three basic types of coding: open, axial and selective coding as suggested by grounded theory procedures [17,18]. During the coding process, the researchers meet several time to continuously check for biases and make agreements on open codes and emerging concepts, ensuring trustworthiness of the findings. Following grounded theory procedures [17], the data analysis process was developed in the following stages:

Stage I: Initial and Indagatory

In this stage, the criteria of the research design was established. This stage framed the entire research project and decisions were made regarding the literature review, the research purpose, the methodological approach, the participants, the instruments for data collection, the data analysis process, and an initial contact with the participants was made to develop the interview schedule and the observation schedule.

Stage II: Media and closer approximation to data

In this stage, data of the study was collected through the following steps:

1. Design and development the interview protocol
2. Validation of data collection instruments (pilot of the interview).
3. Interview with the participants.
4. Transcription of each interview.

Stage III: Advanced and treatment of data analysis

Data were processed and analyzed using Atlas. Ti 7 version 7.5.4, a software for qualitative analysis. The processes of open, axial and selective coding were followed. Using the constant comparison method, dimensions, sub categories and categories emerged [16, 18]. This process of data analysis was not linear, on the contrary, it was cyclical and recursive (i.e. it was necessary to return to the data in repeatedly). After this phase, the axial codification, categorization, and

conceptualization were carried out, that is, the analysis and interpretation of each category in terms of their meaning [17].

Stage IV: Conclusive Closing

The last step was to obtain a natural, open, and deep understanding of the process of transfer of knowledge through competencies in professional internships from the main source -the students of industrial engineering, making an explicit effort to understand or grasp the network of meanings involved in their discourse (verbal and gestural), trying to describe the situation in detail and as vividly as possible, so that the reader can have a profound rich experience of what the participatns consider their reality.

Results

In order to determine the competencies that industrial engineering interns must apply according to the [BLINDED]´s industrial engineer graduate´s profile, the graduation profile was disaggregated in terms of the expected learning outcomes and analyzed based on the competency model of Spencer and Spencer [20]. The authors divide competencies in terms of technical (specific), and attitudinal (generic), all having a direct influence in the motivation of an individual to act and respond to different situations. When the profile based on this model, each of the elements of the profile were disaggregated and classified among seven (7) technical competencies and three (3) attitudinal ones.

The technical skills and techniques that industrial engineering interns must master and apply based on the graduation profile learning outcomes are:

1. Conceive, design, plan, execute, evaluate and improve production systems of goods and services originated by the interaction of the different factors of production.
2. Identify, analyze, design, implement and evaluate processes and projects to generate real, concrete, and creative responses to the needs of the environment taking into consideration the technological, economic, sociocultural and environmental components.
3. Investigate, collect, generate, use, and disseminate knowledge and technologies.
4. Create and implement new paradigms that ensure the sustainability of the designed systems.
5. Be aware of the necessary and permanent search for knowledge that requires the development of cognitive and affective processes as an essential part of their individual and social formation.
6. Have the ability to stay up-to-date in science and technology, which means searching for pertinent information, mastering a foreign language and taking advantage of computer tools.
7. Keep updated on the regional, national and global realities in different aspects that covers economic, social, political, geographical and professional considering their status as a border citizen.

The attitudinal competencies that must be mastered and applied by the industrial engineering intern correspond to the following:

1. Communicate effectively and participate harmoniously in work teams

2. Internalize and model values, attitudes and behaviors which include social sensitivity, authenticity, objectivity, honesty, creativity, responsibility, solidarity, tolerance, respect for nature and the human being.
3. Lead changes with social responsibility which demands leadership skills, entrepreneurial spirit, positive attitude towards risk, decision making, systemic and ecological vision.

Students reflected on the demands of companies regarding the competencies required from them. Interns expressed that they were required to be able to communicate and manage personnel. This expectation directly relates to the skills of (i) establishing an effective communication with the personnel of the company, (ii) ability to manage personnel, and (iii) to organize and direct the work of personnel under their direction. In addition, interns were expected to have an ability to solve problems, to respond to challenges the company had in the short term in areas of their competency (technical competency), and the ability to understand the production process. Companies considered fundamental that the intern could quickly understand the production process, the elements that intervene in it, how they interact, and how to improve it (technical competency).

When identifying the competencies applied by interns in the professional work from the conceptions and experiences of the students, the technical competencies were: quality control management, ability to design of plans, skills linked to understanding, channeling and improving the productive process and fulfilling assigned objectives, skills to overcome obstacles, ability to make organizational diagnosis and ability to solve problems.

Regarding attitudinal competencies, the ones that students revealed having applied are: adaptability that refers to the possibility of adapting and adjusting to the company´s culture, norms, procedures; and communication skills that is reflected in the skill to communicate effectively and achieve the approach and understanding with other workers to fulfill the tasks entrusted to them.

Based on the data, it is possible to identify some mismatches between what the students perceive as required by the companies, and what the curricular program has designed as the expected competencies for graduates. Hence, it is necessary to incorporate some qualities, values and attitudes of the intern (that emerged during interviews) that are also included as attitudinal competencies, these are: interest in long-life learning that includes the inclination and willingness to acquire new knowledge, skills, new possibilities and ways of doing work; taking initiative, referred to be always ready to manifest and execute actions to develop their work and make contributions to enrich their work to allow the intern to advance and fulfill their tasks; self-confidence, that implies what enables them to act safely, develop and take action guided, supported and confident in their convictions and knowledge; proactivity, that refers the quality of anticipating to act to perform different activities that are assigned, that is, taking charge of what needs to be done so that the objectives are met; honesty, is a value that leads them to express themselves with the truth in any situation in the company; willingness to collaborate described as their inclination to contribute or give support to the work of others; and responsibility.

Finally, regarding to the factors linked to the transfer of competencies, table 2 summarizes the emerging findings:

Table 2. Factors linked to the transfer of competencies. Summary of emerging findings.

Factors that promote the transfer of competencies	Linked to the intern	1) Interest to learn
	Linked to the evaluation process	1) Support from academic advisor 2) Support from company advisor
	Linked to the company	1) Economic support from the company 2) Support from the company 3) Mutual support between intern and co-workers 4) Company acknowledgement of intern work 5) Company receptivity of intern´s ideas 6) Company characteristics
	Linked to university	1) Quality of formation 2) Disposition of teachers in the process of students' formation 3) Mastery of technical konwledge
Factors that hinder the process of transfer of competencies	Linked to intern	1) Economic resources 2) Personal situations 3) Health
	Linked to university	1) Weak relation between theory-practice in some courses 2) Formation deficiencies 3) Procedure to locate students in industries
	Linked to companies	1) Organizational problems 2) Deficiency in defining students´projects 3) Assignment of projects not in accordance with the profile and competencies of an industrial engineering intern.
	Linked to university and companies	1) Absence or little communication between the university and the company

A finding that is clear from the data and reflects students' perception of the experience during the professional internship, is how being proficient in some attitudinal competencies help interns overcome the weaknesses they could have on technical competencies. For example, when interns had a technical limitation, self-confidence was a generic competency that helped them find the right people to talk to or the right source of information to learn the technical competency. Another significant finding is the contrast with the action theory of Argyris and Schon [21] who argue that the theory used to develop a discipline profile, should math the theoretical foundation that guides the competencies required to work on an internship project. It is true, that in the profile we analyzed there are weaknesses as in the case of the leadership competencies, where it is evident that interns have shortcomings, but there are others aspects where competencies promoted in the curriculum were highly used in the internship such as communication skills, establishing interpersonal relationships, understanding the productive process, resolution of

problems, looking for information, and taking into practice values such as honesty, responsibility and initiative.

Conclusions

When comparing "what is done" with what "should be done", the competencies students applied during their internships (what is done) and the competencies that the industrial engineering interns should apply derived from their graduation profile (what should be done), it is clear that there is some level of coincidence. Table 3 provides a clear summary of the comparison.

Although not in its entirety, our findings show that some skills derived from the profile were applied or transferred by students during their internship, such as planning, executing, evaluating and improving systems of production of goods and services originated by the interaction of the different factors of production; communicate effectively; assume the role of leader and model values of honesty and responsibility.

However, from the total competencies indicated by interns as applied in their internship, most of the attitudinal ones are not included in the profile of the industrial engineering graduate, competencies such as: initiative, self-confidence, proactivity, collaboration, and adaptability. This reflects that for them, attitudinal competencies were more important that technical. In addition, it is important to consider the emotional load that students experience when facing the challenge of applying what they learned in the classroom in the workplace. Hence, there is a need to develop research that identifies methods to incorporate these attitudinal competencies into industrial engineering curriculum.

Our results corroborate the gap between "what should be done" and "what is done." Interns describe the support of both the university and the companies' fundamental factors in this process. We identify a need to formulate university policies that promote communication between the university and industry that allow us to graduate industrial engineers that meet companies' needs.

Finally, research on the transfer of competencies is still unfinished. Future work should focus on continue to identify how to train students to adapt to the complex workforce. Moreover, we aspire to continue doing research regarding the adjustment of the competencies declared in the industrial engineering profile to match the competencies required by the work environment. In addition, we aspire to identify better ways incorporate appropriate strategies in the curriculum that guarantee a feedback loop to continuously monitoring of the competencies required by industry and find ways to incorporate them into the industrial engineering program.

Table 3. Comparison of competencies required by industry vs. the graduation profile

	Declared in the graduate profile (what should be done)	Required by companies (what is done)	Match
Technical competencies	Conceive, design, plan, execute, evaluate and improve production systems of goods and services originated by the interaction of the different factors of production.	Understand the production process, the elements that intervene in it, how they interact, and how to improve it	Yes
	Identify, analyze, design, implement and evaluate processes and projects to generate real, concrete, and creative responses to the needs of the environment taking into consideration the technological, economic, sociocultural and environmental components.	Problem solving	Partially
	Investigate, collect, generate, use, and disseminate knowledge and technologies.		No
	Create and implement new paradigms that ensure the sustainability of the designed systems.		No
	Be aware of the necessary and permanent search for knowledge that requires the development of cognitive and affective processes as an essential part of their individual and social formation.		No
	Have the ability to stay up-to-date in science and technology, which means searching for pertinent information, mastering a foreign language and taking advantage of computer tools.		No
	Keep updated on the regional, national and global realities in different aspects that covers economic, social, political, geographical and professional considering their status as a border citizen.		No
	Conceive, design, plan, execute, evaluate and improve production systems of goods and services originated by the interaction of the different factors of production.	Organization and planning skills in supervision of personnel, ability to design of plans. Ability to make organizational diagnosis and ability to solve problems.	Yes
		Quality control management, Fulfilling assigned objectives	No
Attitudinal competencies	Communicate effectively and participate harmoniously in work teams	Communicate effectively establishing an effective communication with the personnel of the company	Yes
	Internalize and model values, attitudes and behaviors which include social sensitivity, authenticity, objectivity, honesty, creativity, responsibility, solidarity, tolerance, respect for nature and the human being.	Ability to adapt and adjust to the company´s culture. Adaptability to norms, procedures	Yes
	Lead changes with social responsibility which demands leadership skills, entrepreneurial spirit, positive attitude towards risk, decision making, systemic and ecological vision.	Ability to manage personnel, Organize and direct the work of personnel under their direction, skills to overcome obstacles	Yes
		Interest in long-life learning. Ability to take initiative Self-confidence Proactivity Honesty Willingness to collaborate Responsibility	No

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