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Cultivating Engineering Professional Competence and Employabilities Through Internships Program

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ABSTRACT

Internships are a common approach for cultivating higher education talent in industry–academic partnerships. The work context of an internship influences an intern's professional competence. Therefore, this study deconstructed the learning context in which interns develop professional competence through the application of the internship human resource development model. A total of 59 students from eight universities in Taiwan and two universities in China participated in an internship program from July to August 2019. Notes on 48 internship presentations given at the end of the internship, the presentation slideshows, and individual interviews and a focus group with 14 and 11 of the interns were analysed. I determined that students not only gain professional knowledge and skills but also learn that communication skills are essential for working with others. This is consistent with the content that internship programs aim to deliver to students. Moreover, awareness of practical experiences during an internship was found to have considerable educational significance; it enables interns to acquire the professional competence required for completing tasks, achieving work goals, and improving work quality. The findings serve as a reference for universities and businesses.

Keywords: engineering professional competence; internship; internship human resource development model; professional competence.

1. INTRODUCTION

How can engineering department students who have never worked in a work setting build professional competence in their occupational field?

Numerous studies have argued that internships and corporate collaborations can enable students to integrate theoretical concepts with their practical applications (Huang & Lin, 2010; Kapareliotis, Voutsina & Patsiotis, 2019), to understand their own work, and to transition smoothly from school to work settings (Coco, 2000). These work-integrated programs connecting schools and businesses (Lester, Bravenboer & Webb, 2016) build student professional competence and improve the quality of the corporate work force, increasing industry value (Boud, 2001a, 2001b; Garnett, Comerford & Webb, 2001; Onyx, 2001; Willmott, 2003). Thus, the goal of the internship system is to cultivate intern employability.

Internships are a major method for universities to cultivate student industry competency. However, little research has investigated what students learn during these internships. This study expanded on a 2020 study involving the same internship company (Lan, 2021) to investigate the context of building university intern professional competence through internship presentations, slideshows, and interviews.

In 2020, an internship human resource development model was constructed (Lan, 2021), as depicted in Figure 1. The model addresses the cultivation of task capabilities and long-term human resource development (HRD) for interns (Chang & Lin, 2018; Lan, 2021) and therefore can be applied to businesses of different natures. The model references Werner and DeSimone's (2006, 167) training and HRD process model and Lester, Bravenboer, and Webb 's (2016) work-integrated degrees model.

To understand the context in which interns develop professional competence, the internship presentations from Phase IV of the internship HRD model (Lan, 2021) were the basis for a retrospective analysis of intern experiences in Phases II and III. The analysis facilitates a reflective transfer of research outcomes on the learning context of professional competence (Schon & Rein, 1994) for university internship courses and business practices.

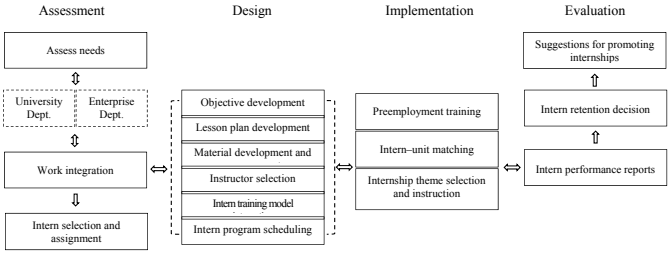

Fig. 1 Internship human resource development model

2. LITERATURE REVIEW

2.1 Defining professional competence in industries and education

In 1999, 29 European countries signed the Bologna declaration to advance the international competitiveness of higher education in Europe and the employability of graduates (Sebkova,

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2002; European Commission, 2021a, 2021b). The United Nations Educational, Scientific and Cultural Organization (UNESCO) also stated that globalization in higher education has resulted in higher valuations of higher education in Europe and North America (UNESCO, 2021).

Developing professional competence has been becoming a focus of higher education (Dahlgren et al., 2008). Schein (1972) defined a profession to be full-time work or employment in which the employee possesses strong motivation, specific knowledge or skills, theories of coexistence, and service attributes; the employee can determine specific customer needs and has autonomy to display expertise in a professional organization or group in a specific field. Taiwanese pedagogue Lin (1972) and Wu (2012) echoed this perspective in his descriptions of professionals.

Stout and Smith (1986) considered competence to be specific behaviors or performances of an individual, the command of knowledge and skills, the demonstration of sufficient capabilities, and the quality of person or state of being. By contrast, Jarvis (2004) argued that professional competence consists of three domains—professional knowledge, professional skills, and professional attitudes—and that the standard for professional competence in each field should be adjusted over time. Hence, in specific professional fields, competence is not instantaneous performance, but a continuous accumulation of learning and experience (Brewer, 2004) that conforms to contemporary professional and ethical attitudes.

Chen et al. (2014) reported that cultivation of university talent should include industry issues, system integrations, talent development, courses, and research (Akomaning, Voogt & Pieters, 2001). Internships are institutionalized and systemized guidance for student learning in a work setting; students can put theory into practice through practical experience and gain a better understanding of their own ability to work. Students can also use the experience to explore career paths and transition smoothly from school to the workplace (Coco, 2000; Lattuca & Stark, 2009; Lin, 2017; Lung, 2017; Chang & Lin, 2018; Kapareliotis, Voutsina & Patsiotis, 2019).

The United Kingdom's Quality Assurance Agency for Higher Education (QAA) replaced work-based learning with work-integrated approaches in 2010, paving the way for degree apprenticeships in higher education and resulting in more efficient professional development in the workplace. The best effects are achieved through the integration of industry and academia, such as by providing students entering high-level jobs and professions with path planning; investments by and partnerships with business owners, structures, and organizations through work-integrated solutions; and teaching methods, assessments, and quality assurance mechanisms in work-integrated solutions (QAA, 2010; Jackson, 2015; Lester, Bravenboer & Webb, 2016; Nyanjom, Goh & Yang, 2020). Therefore, in terms of school education, internships are far more significant for learning than for hiring (Weible, 2009).

2.2 Industry trends and internship fields

This study was a case study of an upstream components manufacturer in the automotive industry. In response global automotive industry trends such as vehicle electrification, unmanned vehicles, Car2Car, and Car2X (Ministry of Economic Affairs, 2020), the company has adjusted its business strategies involving materials, R&D, design, production, manufacturing, and sale of car wheels (Siao, 2019; Jhu, 2020). These are issues faced by all automotive component vendors and represent key areas of industry expertise that interns must understand. To teach the job fundamentals to the interns, the company first administered 28 hours of orientation training (Table 1). The purpose was to provide the interns with a comprehensive understanding of the product processes.

Furthermore, with the advent of automated technologies and the digital era, production and manufacturing is also facing issues of digital transformation. In Taiwan's manufacturing industry, digital transformation of mechanical equipment involves four levels: level one is the digitization of tools, level two is the integration and application of digital information, level three is continued innovation based on digitized products and services, and level four is the innovation of organizational functions and commercial models (Syong, 2020). Considering the key orientation training points in Table 1, the studied company was in levels one and two of its digital transformation.

Table 1 Key points of expertise in the orientation training

Training	Key points	Hours
Management rules and core values	Understanding the company's regulations and core values	1
Production processes and quality systems	Understanding existing techniques, small batch control methods, production quality control, and customer requirements in the production process	10.5
Mold construction and fabrication	Understanding the mold fabrication process; the founding, machining, and coating processes; and the process controls	7
Design R&D and criteria	The product designs and R&D based on customer requirements, including quality control in trial production, sampling, and performance and coating tests and verifications	9.5
Integrated test	Basic knowledge after the training courses	2.5
Total hours		**30.5**

3. RESEARCH DESIGN- A CASE STUDY

3.1 Introducing the case company

This case study involved one of the world's top five manufacturers of aluminum wheels; the company is a Tier 1 supplier of major European, US, and Japanese automotive manufacturers. Founded in Taiwan in 1971, the company is now headquartered in Taiwan and has 18 plants across 9 provinces in China (Table 2). Recently, in response to the global development of electric and unmanned cars, they have collaborated with universities in Taiwan and China since 2017 to cultivate interns for potential future employment at the company.

The HRD model for interns was integrated with data from interviews with internship advisors at the company (Lan 2021). For research continuity, the topics discussed were within a specific timeframe and location (Stake 1995). After constructing the HRD model for interns, the internship presentations of 59 interns who interned at the company from July to August of 2019 were the research subjects to investigate the intern development of professional competence.

Table 2 Distribution of interns

University	Number of interns and field of study	Total
National Yunlin University of Science and Technology	Electrical engineering- 2 Mechanical engineering- 8 Chemical and materials engineering- 2 International management- 1 Accounting- 5 Business administration- 1	19
National Taipei University of Technology	Mechanical engineering- 4 Materials engineering- 5 Industrial engineering- 10	19
National Tsing Hua University	Power mechanics- 3 Materials engineering- 1 Industrial engineering- 4	8
Fu Jen Catholic University	Electrical engineering- 1 Opto-Electric physics- 3 German- 1 Spanish- 1	6
Tamkang University	Mechanical engineering- 1	1
Feng Chia University	Material engineering- 1	1
Providence University	English- 1	1
Cheng Kung University	Foreign languages- 1	1
Shanxi University (China)	Automation- 1 Mechanical engineering- 1	2
Central South University (China)	Material engineering- 1	1
Total		59

3.2 Research design

The 59 interns were from eight universities in Taiwan and two universities in China. Interns' fields are electrical engineering, mechanical engineering, material engineering, management et al. The interns were distributed among five plants in three Chinese provinces. Most of the students interned at the parent factory. Most of the 59 interns presented their presentations singly, whereas some presented in groups of two to four people; there were 48 total slideshows.

To ensure that the research context was orderly and coherent, the research procedure was to observe the interns' internship presentations, analyse the contents of the internship slideshows, and interview the interns, as illustrated in Figure 2. Information relevant to the case study were obtained through observations, literature review, and interviews (Yin, 2009), Observation records of 48 internship presentations, 48 slideshows, transcripts from 14 individual interviews, and a transcript of an interview with a focus group of 11 students were also obtained.

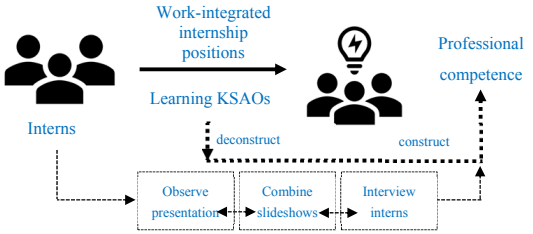

Fig. 2 Research process and concept schema

3.3 Reliability and validity

Denzin and Lincoln's (1994) triangulation was used to review the reliability and validity of this study from three dimensions: data source, research method, and researcher. The data came from on-site observations of intern presentations, intern slideshows, and intern interviews and were relevant to this study; as such, the research data is reliable. The research method involved the researcher observing and analyzing the interns' presentations and slideshows and interviewing the interns, then, based on the research data, refining, summarizing, analyzing, and conceptualizing the data to ensure the results could be used to discuss the research topic; therefore, the research method has validity. Finally, the researcher objectively performed deconstructive and constructive analyses of the internship data. Theorems and articles were also referenced for an analysis of intern context for developing professional competence to achieve practical reference value.

4. RESEARCH RESULTS

4.1 Observations of the internship presentations

Observation data was from the achievement presentations given by the interns on August 26 to 27, 2019 just before the end of the internship; 48 presentations, each 10 minutes, were given over two days. The company president and management team participated in the event by reviewing the presentations and giving suggestions. Advisors were also in attendance while their intern teams were presenting. The researcher observed all 48 intern presentations and recorded the main points, which, in addition to the presentation itself, also included intern attitudes while presenting and intern dynamics with the company managers in response to questions and feedback. After the event, the researcher completed her notes and combined them with the intern company's assessments on professionalism, innovation, future applications, and expression to form a comprehensive record of student performances (Table 3).

4.2 Slideshow content analysis

To understand the professional learning context of the interns, the analysis of the slideshow contents was performed in three steps. First, based on the interns' department, the slideshows were sorted and conceptualized into five concepts of professional learning: electromechanical integration, mechanical structures, material properties, production management, and operations management. Next, after considering the 48 slideshows—including the topics, tasks, issues, solutions, task results, and suggestions—the contents of each slideshow were refined and summarized according to the five professional learning concepts to create slideshow overviews (Table 4 is an example). Overall, most interns received professional learning that was highly consistent with their field of study; the few interns from language-related departments were an exception. The key points of professional learning demonstrated in the intern slideshows are described as follows, according to the five professional concepts (4.2.1~4.2.5).

Table 3 Observations of the internship presentations.

Assessment item	Key points of observation
Professionalism	1. Most interns had research topics assigned by their advisor; a minority of interns researched topics before discussing their research topic with their advisor. 2. The interns typically engaged in ongoing department projects such as product function designs, testing, analysis, comparisons, audits, programming, system improvements, and market surveys. 3. Most intern tasks were related to improving work efficiency or reducing costs. 4. Few interns performed experiments to develop concrete solutions with the assistance of their advisors.
Innovation	1. Interns typically proposed solutions based on existing methods; few ideas were independent and innovative. 2. Innovative ideas might not be actually implemented on-site, possibly due to inadequate equipment or department managers advocating for the status quo.
Future applications	1. Managers are more likely to inquire regarding research topics that benefit the company's future development, leading to ideas that the company may adopt in the future. 2. Presentations on intern topics that could be developed in partnership with school advisors were more likely to receive attention from company managers, who then inquired about advisor expertise and teaching methods and asked the intern to discuss the possibility of collaboration after returning to school.
Expression	1. Interns concretely expressed their tasks and implementation processes in their internship position through slideshows or oral presentations. 2. The interns were typically able to answer manager questions and exchange opinions.

Table 4 Overview of intern slideshows based on professional concepts-Examples.

Professional concept	Task	Issue	Solution	Results
Electromechanical integration	Automating processing logistic lines, and production lines	1. Lateral promotion in collaboration with processing automations 2. Reduce defects in car wheels from human factors	Reduce handling and staffing	1. Automation reduced staffing by 18 persons and 50% of the heat processing shifts. 2. Automation reduced human negligence
Mechanical structures	Bend testing spoke cross-sections	Reduce bending strain on wheel spokes	Use changes to the geometric dimensions and analysis software to determine stress changes	1. Confirmed relationships affecting the wheel spoke designs 2. New spoke design increased stress response by 2.2 times and cut down on materials
Material properties	Assessing the current state of semisolid casting	Determine strengths and weaknesses of semisolid casting and low-pressure casting	Analyze the metallography of these two types of casting	1. Low-pressure casting is less expensive than semisolid casting 2. Semisolid casting has greater precision and strength than low-pressure casting
Production management	Planning client shipments and confirming cargo delivery	Reduce errors from conventional human planning	1. Deploy an ERP and smart warehousing to improve materials management 2. Add object scanning mechanisms	1. Expected to reduce inventory of finished goods by 20%–30%. 2. Expected to increase inventory of materials by 12.5%. 3. Data is relayed to the ERP system through scanning, reducing update delays
Operations management	Activity-based costing (ABC) – inventory and looking up acceptance forms	Reduce related manufacturing costs	Deploy ABC to manage the company's manufacturing costs	Reduced unnecessary waste

4.2.1 Electromechanical integration

The interns were from electrical engineering or power machinery fields. These internships were primarily focused on automation and optimization of electromechanical equipment and on equipment maintenance and repairs. Examples include (1) com-

bining different systems and software to improve machine operations and data analyses; (2) comparing and analysing equipment operations to propose solutions for reducing equipment failure rates, energy consumption, and man-made defects; and (3) improving the optimization configurations and automation processes of production lines to reduce manpower and product defect rates to improve efficiency in collaboration with automation processing.

4.2.2 Mechanical structures

These interns mostly majored in mechanical engineering. These internships were primarily focused on testing product structures, inspecting and maintaining manufacturing equipment, and optimizing equipment. Examples include (1) product tests based on different structures and combinations to observe changes of the product structure and propose solutions, (2) analysis of correlations between manufacturing methods and equipment operations to optimize manufacturing processes and reduce defects, and (3) the deployment of database computing to improvement the operational efficiency of manufacturing equipment.

4.2.3 Material properties

These interns majored in materials and chemical engineering. The internships focused on the production, performance, and physical condition of product materials. Examples include (1) performance tests and physical analyses of product materials to determine differences in material compositions and proportions and to propose improvements to the formulas, (2) comparisons of the compatibility of different formula ratios and manufacturing processes to reduce defects and improve product quality; and (3) detections of influences from external conditions and material properties to design better processes and optimize the manufacturing process.

4.2.4 Production management

These interns majored in industrial engineering and management. Their internships focused on production lines and product quality management. Examples include (1) managing equipment operations based on modularized parameters to improve equipment utilization; (2) Using an enterprise resource plan (ERP) and smart warehousing to schedule and manage procurement and production of materials and to optimize systems to improve efficiency; and (3) implement material quality management procedures from the supplier to the customer to increase the product quality management standards.

4.2.5 Operations management

The interns majored in business administration and foreign languages. Their internships focused on the management of finances, human resources, and marketing. Examples include (1) accounting department interns implementing activity-based costing (ABC) in account write-offs and inventory cost, inquiry, and acceptances; (2) operations management interns planning training solutions; and (3) foreign language interns learning issues related to internal management and marketing. In this last example, because expanding into the international market is a company objective, the interns used their foreign language skills to engage in marketing, assisting in the company's international development and enabling the intern to develop practical expertise beyond language skills and increase future employability.

4.3 Interviews

Interviews were conducted one semester after the interns returned to their schools to determine what students had learned during their internships and to evaluate their professional development. These interviews enable this study to be particularistic, descriptive, and heuristic (Merriam, 1998). A total of 19 students from National Yunlin University of Science and Technology (YunTech) were asked to interview; 14 students agreed to individual interviews; 11 of the 14 students also agreed to participate in the focus group.

For the individual interviews, the 14 interview respondents were asked to complete a structured questionnaire before interacting with the researcher to ensure that respondent information matched the research content. The individual interviews were held from February 20 to March 20, 2020 and covered eight topics: internship motivation, reasons for choosing the internship company, how the student found out about the internship, the internship position and internship information, the internship topic and achievements, professional competence gained, and professional competencies they would like to improve. The respondents were asked to rate their internship motivation and the internship company on a scale of 1, lowest, to 10, highest, as a reference for comparisons.

The focus group was held for 3 hours on March 28, 2020. The main focus was on three topics—corresponding professional competences, internship benefits, and internship suggestions—but was open to free discussion. Through the interns' exchanges and recollections of their internships, the researcher summarized the information shared into a collective consensus, then incorporated this consensus into the discourse analysis.

4.3.1 Internship motivations

The internship motivations among the 14 respondents were self-exploration, workplace experience, course requirement, experience of local Chinese culture, and peer influence. Of these motivations, self-exploration was an exceedingly strong motivation, with a mean score of 9.3. As Intern #44 stated, "I wanted to try different things to understand what kind of work that I'm best suited for." Workplace experience was the motivation that resonated with the most people and was also strongly rated (mean 9.2). Inter #3 expressed, "I wanted to understand what value I had in the professional world." Moreover, for motivations due to graduation credit requirements, students enrolled in requisite courses demonstrated a mean score of 7.5, while students in elective courses demonstrated a mean value of 4.8. However, course requirement was still an internship motivation for the students, just not as strong as autonomous motivations.

4.3.2 Reasons for choosing the internship company

Among the reasons expressed by the 14 respondents for selecting the internship company, the highest-rated reason was interning abroad (mean score of 8.9). Intern #12 stated, "The internship let me experience different cultures, companies, and customs." The second highest-rated reason was better compensation and benefits, which had a mean score of 8.4. As stated by Intern #2, "The company helped us pay for the airfare, accommodations, and all three meals." The third reason was gaining industry expertise and knowledge. Intern #44, who majored in finance, stated, "I wanted to understand the difference between a financial department job in a company and in an accounting firm." Intern #14, who majored in engineering, stated, "I wanted to understand how the car wheel industry operates." Moreover, recommendations from their senior

classmates and the size of the company were also factors in the students' choice.

4.3.3 Professional competences gained from the internship

The 14 respondents were asked about the professional competences they had learned during their internship based on "professional abilities, work behaviours, and work attitudes." The interview responses regarding professional abilities matched the slideshow contents and therefore will not be reiterated here.

A summary of the interview responses revealed that most advisors began by explaining the work content and led the interns in an on-site tour of the work conditions and equipment operating procedures. Some of the advisors were in the intern's work division; others belonged to affiliated divisions. Furthermore, in the work process, the internship advisors used operations, demonstrations, and feedback to guide the interns. Two interns in different fields described the advisor instruction styles as follows.

Intern #12: First, we started from getting to know the wheels. Then, step by step, we were taught the process from molten aluminium to the aluminium wheels. Finally, we began our design attempts. (Specialized in mechanical structures)

Intern #43-2: Take write-offs for example; the advisor first demonstrated the process for us once, then we took turns running through the process to practice. Through practical execution, we had a better understanding of how to handle this transaction. (Specialized in operations management)

For work behaviours and attitude, the original semantics of the 14 respondents were distilled into condensed semantics, which were then sorted based on similarity and given appropriate concept names. The concept names conveyed the significance of the category.

Work behaviours were sorted in four concepts: communication skills, work skills, autonomy and problem-solving skills, and work relationships and ethics. Based on intern responses, 14 people learned communication skills, 8 people learned work skills, 7 people learned autonomy and problem-solving skills, and 3 people learned work relationships and ethics (Table 5).

Work attitudes were also sorted into four concepts: value of work safety, efficient time management, diligence, and team spirit. Based on intern responses, ten students learned to value work safety, nine students learned efficient time management, seven students learned diligence, and five students learned to have team spirit (Table 6).

Table 5 Work behaviours gained during the internship among the 14 interview respondents

Language used by the respondents (Similar instances were omitted)	Work behavior types	Corresponding respondents (Same identifying numbers as in Appendix I)
1. Improving verbal communication skills 2. Improving communication skills 3. Onstage communication skills 4. How to communicate with other people more clearly 5. Improving group collaboration and communication skills 6. Learning how to interact and communicate in interpersonal relationship 7. Improving interdepartmental and intercompany communication skills	Communication skills	14 people: 2, 3, 11, 12, 14, 15, 17, 20, 21, 27, 42, 43-1, 43-2, 44
1. Learning operations progress planning 2. Data selection abilities 3. Presentation creation abilities 4. Improving practical abilities to combine expertise 5. Multitasking abilities 6. Carrying a small notebook for notetaking	Work techniques	8 people: 2, 3, 14, 20, 27, 42, 43-1, 43-2
1. Independent thinking skills 2. Autonomous learning skills 3. Learning to manage one's own time 4. Problem-discovery and problem-solving skills 5. Do what is right, do not do what is not right 6. Improving adaptability to environment 7. Having a certain sensitivity to and observing peripheral events	Independence and problem-solving skills	7 people: 3, 14, 15, 27, 43-1, 43-2, 44
1. Understanding the correlations between departments 2. Do not go above one's paygrade 3. Report progress for all matters	Work relationships and ethics	3 people: 17, 21, 42

Table 6 Work attitudes gained during the internship among the 14 interview respondents

Language used by the respondents (Similar instances were omitted)	**Work attitudes**	**Corresponding respondents (Same identifying numbers as in Appendix I)**
1. Be more careful in work safety precautions 2. Importance of work safety 3. Safety above all; repeat checks 4. Safety first 5. Attention to personal safety	Emphasis on work safety	10 people 2, 12, 15, 17, 20, 21, 27, 42, 43-1, 43-2
1. Experiencing the importance of work efficiency 2. Importance of punctuality 3. Working more efficiently and proactively	Efficient time management	9 people 3, 15, 17, 20, 21, 27, 43-1, 43-2, 44

1. Constant awareness of one's own behavior 2. Diligences in each task 3. Adherence to the SOP of any operation 4. More observations, more questions, less talking 5. Prudence and patience 6. Manners and humility to ask for help 7. Organize questions before asking	Prudent work attitudes	7 people 11, 12, 14, 21, 27, 42, 43-2
1. Understanding how to divide work and work together 2. Learning about work ethics 3. Experiencing the challenges facing frontline workers 4. Being considerate of others 5. Transitioning from self-serving thinking to altruistic thinking 6. Completing tasks assigned by supervisors 7. Establishing friendly work attitudes	Team spirit	5 people 2, 17, 20, 21, 44

4.3.4 Professional competence following the internship

Based on knowledge, skills, abilities, and other characteristics (KSAOs) (Noe 2008), the respondents were asked to give feedback on which of the four abilities—expertise, practical skills, personal abilities, and work attitudes—they needed to improve. Overall, the students perceived that their expertise and practical skills were insufficient during the internship, and thus the abilities that they needed to improve were knowledge and skills relating to internship tasks such as electromechanical integrations and system programs. Furthermore, communication skills, work efficiency, and independent responses were the main personal work abilities that the interns wanted to improve.

As for work attitudes, stimulation from the internship prompted the students to understand survival in work settings and that each person must have a proactive attitude and hard-working spirit. Such as, be more careful in work safety precautions, importance of punctuality, more observations, more questions, less talking and being considerate of others.

5. CONCLUSION

5.1 Discussion on internships build professional competence

Countries share a consensus that higher education cultivates industrial talent with professional competence European Commission (European Commission, 2021a, 2021b; UNESCO, 2021). Planning the education of professional competence is a focus of higher education in each country (Dahlgren et al., 2008). However, enabling university students that have never experienced actual industrial scenarios to develop professional competence is challenging. An internship is the approach recognized by most pedagogues. Not only do internships combine theoretical understanding with practical applications (Huang and Lin, 2010; Kapareliotis, Voutsina, and Patsiotis, 2019), they also allow students to understand their own work abilities (Coco 2000). This type of work-integrated program connecting schools and businesses (Lester, Bravenboer, and Webb, 2016) is effective for building student professional competence in industry (Boud, 2001a, 2001b; Onyx, 2001; Willmott, 2003).

On the foundation of this consensus, the context in which university students learned professional competence during their internship was analyzed. To ensure the discourse on this learning context was consistent with common academic and industry usage, professional competence was defined in this study as, "The worker exercising knowledge and skills of the profession that they already possess to execute specific work tasks on the job, for the purpose of not only successfully achieving their work targets, but only to ensure the outcomes meet the quality requirements; the worker's professional competence is continually accumulated through learning and experience" (Lin, 1972; Schein, 1972; Stout and Smith, 1986; Brewer, 2004; Jarvis, 2004; Wu, 2012). Based on this definition and the study data, two propositions were raised in this study to discuss the contexts for building professional competence.

5.1.1 Proposition 1: Internships can be used as learning plans for building professional competences required by students to execute specific jobs.

The analysis of the three forms of data on actual internships confirmed that "internships can be used as learning plans for building professional competences required by students to execute specific jobs." However, for this proposition to hold, businesses must arrange for the internship to have corresponding professional duties (Lattuca and Stark, 2009; Chen et al., 2014) to implement the internship human resource develop model; that is, (1) the internship assessment, selecting the appropriate intern; (2) design and planning, plan out the intern program based on the department needs; (3) the internship, assign an internship advisor to guide the interns; and (4) internship review, the internship presentations (Lan, 2021). The company in this study demonstrated the spirit of internship for HRD, and thus the interns gained practical learning in their field of expertise.

For example, based on the characteristics of the university departments in which the 59 interns were enrolled, we categorized the professional knowledge learned by the interns in five major dimensions: electromechanical integration, mechanical structures, material properties, production management, and operations management. Each professional dimension had corresponding university departments; for instance, electromechanical integration has electric engineering and power mechanics. Except for a small number of interns who did not precisely meet their departmental standard for professional learning, most of the interns had professional learning arrangements that met the requirements of the internship assessment and design and planning phases of the internship HRD model (Fig. 1). That is, students from the appropriate university departments were chosen for internships based on job expertise requirements.

Second, the analysis of the internship slideshows revealed that for most interns, the learning in their internship position was highly consistent with their major. The exceptions were the language major interns, who had internship positions in market surveys and marketing. Although their duties did not match their field of study, they aided in the company's future overseas development. This was also reflected in their presentation: Intern #48 stat-

ed, "The internship was very difficult, but I am willing to face this type of challenge." In terms of talent cultivation, the added value of this expertise is a positive for the company and for the interns.

A combined analysis of all three types of information revealed that the interns understood the contents of their professional learning but lacked innovative suggestions and perspectives; the lateral connections with future applications were also underdeveloped. This effect may be due to the brevity of the internship; intern unfamiliarity with the company, or a lack of acceptance of intern suggestions by the internship departments. Notably, during the presentations, the company president expressed more interest in innovative topics and possibilities for university collaboration. Therefore, the balance in internship strategies between business leaders and internship departments may be a topic for further discussion by both industry and academia.

Finally, to understand whether the intern professional learning was in line with the digital transformation layers in Taiwan's manufacturing industry (to apply the students' postgraduate professional industry abilities in the workplace) the internship fields and key tasks were compared against the digital transformation levels (Syong, 2020). Interns performed tasks such as applying system software or digital systems to execute work tasks, using data results to improve efficiency, or suggesting optimizations of production equipment and environment configurations match digital transformations levels I (tool digitization) and II (integration and application of digital information). However, level III (continued innovation based on digitized products and services) was only demonstrated by partnerships with customers to develop products and in product maintenance. Level IV (innovations in organizational function and business models) involved the company's overall strategy and therefore was not demonstrated in the internship slideshows.

At present, most companies in Taiwan are still at Level I and II in their digital transformations (Syong, 2020). With internships as a starting point for building university student professional competence in work settings, in addition to gaining professional knowledge and skills required in their internships through executing their internship duties and the guidance of their internship advisors, students can increase their employability by simultaneously developing professional competencies that can be applied to other industries and businesses in specific job roles.

5.1.2 Proposition 2: Internships allow students to develop workplace employability through professional learning.

Intern employability is typically assessed according to criteria set by the school's internship guidance department and involves an assessment by the internship supervisor and a self-assessment by the student after the internship. At YunTech, the supervisor's assessment of the intern student includes professional knowledge and skill, problem-solving and independent thinking skills, learning spirit, proactiveness, expression and communication skills, interpersonal relationships, team spirit, and attendance (YunTech, 2021a). Similar assessment items by other universities included quantity of work, quality of work, job knowledge, personal qualities, cooperation, dependability, and initiative (West Liberty University, 2021).

The internship self-assessments were sorted into two main categories based on student fields of study. The first category was skills and abilities, including analysis and problem solving, rapid response to environmental changes, independent work, work improvement, contingency responses, interpersonal exchanges, language, computer information, organizational presentations, task completion, and work efficiency. The other category was attitude and ethics, which covered responsibility, compliance with company and departmental regulations, willingness to ask for help, proactive engagement in work, proactive feedback on progress, manners, cheerfulness, liveliness, passion, creativity, and diligence (YunTech, 2021b). The University of Washington's Intern Performance Evaluation includes similar items, such as critical thinking, problem solving, communication, leadership, teamwork, collaboration, intercultural fluency, professionalism, work ethic, technology, and career management (University of Washington, 2021).

Conceptualizing the 14 interview respondents' learning of work abilities yielded four major abilities: communication skills, work techniques, autonomy and problem-solving abilities, and work relationships and ethics. Except for attendance, which was not mentioned, these four major abilities correspond with the items expected to be assessed by the university (YunTech, 2021a). Furthermore, for learning of work attitudes, the respondent interns learned to prioritize work safety, efficient time management, diligence, and team spirit in the workplace; most students reported that prioritizing work safety was a key point that they experienced first-hand in their internship and which will have positive influences on their future workplace attitudes. Although work safety was not listed by the university in the internship self-assessment (YunTech, 2021b), these responses highlight the educational significance of linking internships and practical experiences—student self-awareness.

Regardless of the internship supervisor's assessment or the intern's self-assessment, professional competence is a key item for the measurement of the internship effectiveness, as discussed in Proposition I which held that interns simultaneously learn how to achieve work goals and to improve the quality of their work. That is, based on Phase IV of the internship HRD model, internship review, which involves the internship reports and suggestions (Lan, 2021), internships allow students to develop workplace employability through professional learning.

5.2 Practical implications

Higher education is key for the cultivation of industry experts, and is not limited to university professors giving lectures on industry knowledge; a connection with industry practices is also required. Specifically, a systematic transmission of dynamic industry expertise to campus to firmly establish industry-based education within universities and create a repository of professional human resources for industry is necessary. Within this integration, internship courses borrow dynamic industry resources from specific companies to enable students to learn professional knowledge, skills, and abilities required for industry practices. Students gain practical experience from internships and can extend their industry knowledge into actual work settings. Internships maximize the influence of a professional competence education, incorporating industry knowledge into university courses and allowing students to smoothly integrate into work settings after graduation.

For interns, the work context of the internship is a critical component influencing the creation of intern professional competence. In this study, by integrating professional work content, work abilities, and work attitudes, the students not only gained professional knowledge and skills but also learned the value of communication and cooperation to perform tasks. The students also realized the necessity of ensuring personal work safety and of completing work logs and tasks assigned by supervisors, demon-

strating improved time management and planning to improve efficiency. These lessons provide students with intrinsic and extrinsic motivation to improve their future professional development and inspire students to consider future workplaces and competences. During internships, student experiences of the importance of these professional competencies was in accordance with the internship goals.

Moreover, the transformation of Taiwan's industries requires middle and upper management personnel who equally value theory and practice to implement smart manufacturing and smart services throughout industries. With the commencement of Industry 4.0, companies have introduced smart manufacturing and smart service approaches to integrate the company, its key techniques, and staffing. This study on the cultivation of professional competence in higher education also contends that talent is cultivated through industry, and academic collaborations increase the value of staffing in key technologies, resulting in innovative operation of companies and increased competitiveness through smart manufacturing.

5.3 Research limitations

The data analysed in this study were captured from observations of the interns, their presentations, and interviews. The researcher also engaged in objective discussions involving related theories and literature. However, because the 59 interns came from 10 different universities—eight in Taiwan and two in China—the researcher was only able to observe and record intern reports, spontaneous questions and responses, and other interactions occurring during the two-day internship presentations. The researcher was unable to obtain firsthand data through in-depth individual interviews with each set of interns, limiting the study.

The second limitation is that the context for learning professional competence for each set of interns was deconstructed, reviewed, summarized, sorted, and conceptualized by the researcher based on sorting principles determined by the researcher. The interns did not participate in the process of determining professional competencies. Finally, in-depth interviews and the focus group interview only involved interns from YunTech; as such, more information about intern workplace employability could not be obtained, and the discussions only involved internship assessments from the YunTech interns.

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Appendix I. Professional concepts and the corresponding bases of expertise (fields of study)

Professional concepts	Order	Bases of expertise (Department)	Internship topic	Note
Electromechanical integration	1	Electrical engineering	Maintenance and wiring of energy and wastewater equipment	
	2	Electrical engineering	Basic repair and upkeep of electrical equipment	V/1
	3	Electrical engineering	Optimization of automated production lines on the processing end in new plants	V/1
	4	Photoelectric physics	Maintenance and management of air compression equipment in wheel manufacturing	
	5	Photoelectric physics	Measuring workpieces of coordinate measuring machines in LMT metric chambers	
	6	Automation	Research into hollow wheel boss technologies	
	7	Power mechanics	Parametric designs for steering knuckles	
	8	Power mechanics	Wheel finish and surface treatments	
	9	Power mechanics Mechanical engineering Photoelectric physics	Automaton of machining logistics lines and production lines	
Mechanical structures	10	Mechanical engineering	Surface pretreatments and process performance	
	11	Mechanical engineering	Bend testing spoke cross-sections	V/1
	12	Mechanical engineering	Research and improvement of wheel spokes	V/1
	13	Mechanical engineering	Repair and maintenance of processing machines – maintenance equipment for cleaning benches	
	14	Mechanical engineering	Remelting and pressing of aluminum cakes	V/1
	15	Mechanical engineering	Exploration of casting defects	V/1
	16	Mechanical engineering	Optimization of automatic brush head machines	
	17	Mechanical engineering	Analysis and improvements of T07 cracks	V/1
	18	Mechanical engineering	Improvements to drying devices of automatic washing machines	
	19	Mechanical engineering	Improving retention in the LMT Processing Section	
	20	Mechanical engineering	Investigation into operational problems in mold flow analysis	V/1
	21	Mechanical engineering Material engineering	Improvements to development processes and process improvements	V/1
Material properties	22	Material engineering	Wheel mechanical performance tests—stretching, metallography, and hardness	
	23	Material engineering	Mg content of material machines—stretching and hardness tests	
	24	Material engineering	Cast steering knuckle defects, improvements, and reasons	
	25	Material engineering	Casting improvements, investigation of production processes and equipment	
	26	Material engineering	Semisolid casting, current conditions and assessments	
	27	Chemical and material engineering	Effect of transparent paint molds on coating	V/1
	28	Chemical and material engineering	Surface coatings: coating pretreatments, parts baking, and quality control inspections	
	29	Material engineering	Optimization of production lines	
	30	Material engineering	Research on effects of cooling speeds on A356 castings and performances	

Professional concepts	Order	Bases of expertise (Department)	Internship topic	Note
Production management	31	Industrial engineering	Investigation into errors of bending fatigue test machines – mechanical impact tests	
	32	Industrial engineering	Production purchase orders, dispatch of production capacities and inventories – standards for accepting customizations	
	33	Industrial engineering	Quality management of supplier products – shipment quality control	
	34	Industrial engineering	Application of seven major quality control methods	
	35	Industrial engineering	Materials management: customer shipment planning and delivery confirmation	
	36	Industrial engineering	New company profile	
	37	Industrial engineering	Deployment of equipment management systems	
	38	Industrial engineering	Optimization of A-line unloading inspection zones and digitization of quality-related data	
	39	Industrial engineering	Intelligent production scheduling	
	40	Industrial engineering	Profile and optimization of coating laboratories	
	41	Industrial engineering	Comparative analysis of the heat consumption of LMT heat treatment furnaces	
	42	Industrial engineering International management	Management of maintenance and procurements of equipment spare parts: spare parts management, procurement, and quotation sourcing	V/1
Operations management	43	Accounting	Processing of account write-offs – collation of vouchers/shipment orders, end-of-month plant inventories, account balance sheets	V/2
	44	Accounting	ABC methods: inventory, acceptance form queries	V/1
	45	Business administration	Employee training planning	
	46	German, English	Optimization of factory signs – adding and revising English signage	
	47	English	Analysis of Nissan, Renault, and Mitsubishi business developments	
	48	Spanish	Domestic market analysis for Homark Wheels	

Note: V signifies interns who were interviewed in this study, and the following number indicates the number of respondents.