A Teaching Guideline for Work-Integrated E-Learning: Design Challenges of Online Courses in Production Technology

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Abstract

Due to the increasing requirements for continuous competence development in the manufacturing industry, workplace training and e-learning combined builds a new education platform. Such initiatives and educational models have increasingly been studied as work-integrated e-learning focusing on how organizations are trying to increasingly incorporate higher education at the work place, and how higher education can benefit from close cooperation with organizations.

This thesis work investigate challenges among experienced higher education teachers who are going to design and implement course modules as a work-integrated e-learning initiative based on demands from several manufacturing industries in West Sweden. During the project, the required 20-40 course credits (ECTS) will be divided into smaller course modules, consisting of about 2-5 credits in order to meet demands of flexibility and time sensitiveness from participating manufacturing companies. As it is a cooperative project, the course modules could be tailored according to different requirements from the companies. The course modules are focusing on industrial automation, flexible and virtual automation, robotics, simulation based manufacturing, production systems and precision engineering among other fields within production technology. The research method is abduction with qualitative research, and the empirical data is collected through interviews.

Through an abductive approach teachers subjective experiences were analyzed in accordance to how they expressed their challenges in relation to how to design courses with flexible pedagogical set ups, incorporating course content and what digital technology best matched these aspects. Based on these analyses, the design guideline was constructed in relation to the analysis and to previous research of collaborative learning and engineering education. The guideline for engineering teaching in production technology suggests a new pedagogical approach of work-integrated e-learning. The guideline is expected to help teachers to design and implement work-integrated e-learning course modules in the production technology field. As a result, the outcome of the guideline could contribute to the development of work-integrated e-learning as a more effective learning approach for competence development for engineering teachers.
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Yours sincerely,

Du Ruijuan

Trollhättan, May 2014
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1. INTRODUCTION

With the prosperity of economy and the development of science and technology, the competition among industries is becoming increasingly fierce. In the manufacturing industry, apart from the traditional requirement for employees’ engineering work ability, there is more demand for communication and management competence. Thus, even experienced engineers are required to learn new ways of communication and collaboration, and expanding their competence for improved work skills as engineers. In contrast, the new employees, who are expected to be educated with new pedagogical approaches and advanced technology brings communicative knowledge to the current work environment. However, the new employees lack engineering workplace knowledge which is hard to learn from the traditional classroom education. These various competences, broadly described as belonging to two different categories of engineers, highlight a need to meet these various competences and design competence development initiatives with various needs in mind. Therefore, we must clarify the target groups among the manufacturing industries that take part in training programs within the knowledge field of production technology. The requirements from these target groups are challenges that teachers are facing when they are designing and conducting courses.

As engineering work is precise and intensive, it is hard for a company to arrange long-term training programs with many employees. Nevertheless, with the popularity of information technology, e-learning could be a feasible choice for training program in manufacturing. E-learning has advantages of being accessible, flexible, low cost, etc. Moreover, tailor made e-learning courses restricted in time duration could be a better learning choice suitable for the manufacturing companies. In this thesis I therefore investigate how e-learning courses can be designed from a teacher perspective applied to the knowledge needs that engineers in the manufacturing industry currently are facing.

This master thesis is based on an interview study and an instructional design initiative that I conducted within a research project called MERIT (Manufacturing Education and Research with Information Technology). This project is part of the reference organization 1 – Production Technology West (PTW) at University West, Trollhättan, Sweden, where I have been collaborating with engineering teachers and researchers during the master program in Informatics with specialization in work-integrated learning.

My research work is about developing e-learning courses within production technology in work-integrated learning for the target group consisting of experienced engineers that need to deepen and broadening their theoretical knowledge from a teacher perspective. From the previous research within the MERIT project (described at section 2.1.1), it has been shown that there is a need for tailor made course modules among the companies taking part in the project. The modules are on University level of approximately 2 ECTS and can be arranged in different orders. They contain a variety of knowledge content within the wide area of production technology. The tailored courses are supposed to suit the current workplace learning through a combination of theory and practice. As the knowledge is required to be more pertinent to the workplace, it leads the trends towards work-integrated e-learning.

This thesis is researching the challenges in work-integrated e-learning from a teacher perspective aiming for developing tailor-made e-learning courses adjusted to engineers at post-graduate level.

1 Reference organization refers to the partner organization from which the student can collect data and get their own working experience during the master program. An essential part of the exchange consists of the students co-working in the field of Informatics with specialization of work integrated learning.
The following chapter includes a description of the study background and the aim of the study. The methodology used in this thesis work is presented in chapter3. Relevant research literature is outlined in chapter4. Through the previous literature research and interviews with the engineering teachers, chapter5 lists the collected interview data. Chapter6 presents an analysis of the interview information in relation to the theoretical framework, which focus on the challenges of work-integrated e-learning implementation from the course teacher perspective. After that, a result of a suggested teaching guideline and general advices for work in this field is provided in chapter7. Then a discussion of the general study, challenges and other considerations are shown in chapter8. In the end, a conclusion of the thesis work and the future work about technology and program implementation are discussed in chapter9.

2. THE STUDY

2.1 Background

As everything is developing in the new century, the boundary between work and learning has become increasingly obscured. Work-integrated learning (WIL) is a new concept in education which has already affected the traditional way of working and learning. Work-integrated learning can be defined as an umbrella term for a range of approaches and strategies that integrate theory with the practice of work within a purposefully designed curriculum (Patrik, et al. 2008). Following the footsteps of social development, technology is widely used in education, especially the Information Communication Technology (ICT). E-learning can be briefly described as the use of telecommunication technology to deliver, support and enhance teaching and learning (Violante & Vezzetti, 2012).

With accelerating globalization, the competition among companies is more and more fierce. At the same time, rapid development in technology is changing people’s daily life, with dramatic changes taking place in the workplace (Binninger, 2000). In such process of development, maintaining and strengthening employees’ enterprise and technical skills are important factors to ensure the development of a company and in-service training becomes increasingly interesting as competence developments initiatives calling for a range of models to meet these demands. At the beginning of the new century, the use of new technology, such as computers and the internet, to provide instruction began the “e-learning” revolution (Binninger, 2000). However, technology is developing rapidly and various part of industrial actors struggle differently with how to become effective in in-service learning at work. Many Swedish manufacturing companies lack learning opportunities that can help engineers in a flexible and in-service way. When the manufacturing industry for example aims to work with new technologies for automated manufacturing, the employer must invest heavily in training programs, as advanced practical operation is resource demanding. Years ago, the Swedish production agenda clarified that research results should be translated into industry related innovations (Engineering Industries, 2011). This means that universities should work closely with companies in order to incorporate new knowledge into the industry more effectively at the same time as companies should influence research to be more relevant for industrial development. Therefore, how to develop such a technology platform according to the customer demand, and how to make the in-service learning more convenient and effective has become a big issue for both universities and companies.

Nowadays, the manufacturing industry faces opportunities and challenges from both internal and external demand. As industry work is of high effectiveness and close collaboration, there is strict requirement for the employees. The nature of engineering demands of the employee is to have rich operational experience and advanced technical knowledge at the same time. This competitive and demanding situation triggers the need of comprehensive competences for engineers, and they have to continuously improve their ability in the working process. As Downey (2009) showed in his
research, there are three ongoing challenges for the engineers. The first concerns suitable curriculum for the engineer adapted to the industry development. The second concerns professional skills and practices beyond the core of technical problem solving are urgently needed. The third concerns the efficiency of transforming research findings into new initiatives needs to be increased (Downey, 2009). Considering these conditions, work-integrated e-learning course modules organized as collaboration between universities and manufacturing companies can be one feasible solution to meet identified challenges.

The ideal e-learning course for manufacturing industries is given as short period course modules tailored according to company’s requirements of knowledge content, as the employee can learn on their own time and work at their own pace, that will not negatively impact production, scheduling or shipping (ProProfs, 2013). This request seems contradictory. However, the tailor made course modules are more effective and flexible, thus suitable for the manufacturing industry.

2.1.1 Research content

The research team that I worked with is part of the research group - Production Technology West (PTW). They work with development of production processes in collaboration with the manufacturing industry and belong to the engineering department at University West in Trollhättan, Sweden. The researchers in PTW have a multitude of specialties and backgrounds. They are divided into four work arenas: Automation, Machining, Thermal spraying and Welding. During the project work, researchers from different arenas work together with experts, technicians outside and the PhD students in University West as a project team. As PTW is my reference organization during the whole master study, I worked closely with the research team on problems in my courses and in this thesis work.

This thesis study is part of the MERIT project – Manufacturing Education and Research with Information Technology. The goal of MERIT is to design and implement technology mediated course modules on advanced level to support work-integrated learning for employees in the manufacturing industry. The MERIT project runs from 2013 to 2015. As the industry is facing continuously global competition and increasing customer needs, they face challenges like high quality deliveries and technological performances with less cost, which calls for advanced knowledge and learning to manage necessary changes. From the University point of view, production technology is one prioritized field with doctoral education and research programs at University West, and work-integrated learning is the major direction for future development. Therefore, this cooperation can also benefit the development of work-integrated learning to a large extent. The development of the MERIT project will last for two years, and this thesis work was conducted during fall 2013 and spring 2014. According to the previous research of the requirements from manufacturing industry, the first objective of the course modules will be to implement high quality personalized content with flexible and interactive way of teaching. The next is to further develop employees’ knowledge in the use of software and digital systems for computation, simulation, optimization and automation. For the course teachers in this project who are working in PTW, they also have different roles in other work, e.g. lecturer, researcher, project manager. During the work in MERIT project, they face challenges of competence management and time limitation as well. The result of this thesis is a teaching guideline. It is

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2 During the master program, all students have their individual reference organization that they collaborate with during the full program. This organization is a vital part of the educational design since it stresses that the student have contact with the same organization throughout the whole program in order to deepen the understanding of both the organization as well as how theoretical concepts and perspectives at the master program courses can further deepening the understanding of organizations issues such as learning its organizational culture, norms etc. Additionally, the reference organizational also provides the student with empirical data that are elaborated within the university setting.
expected to help the teachers developing and design learning material, and the way to teach online.

As this research field is new with many issues that need to be further studied, this work will be a promising and meaningful study. This study is relevant due to a lack of deep insight into how engineering teachers plan and conduct online learning integrated in the workplace.

2.2 Aim of the study

The aim of the thesis is to investigate challenges that engineering teachers experience when designing and conducting work-integrated e-learning course modules. Therefore, the outcome is expected to provide a teaching guideline for teachers in higher education regarding preparations before courses start. The overall problem formulation in this thesis is what challenges are teachers experiencing when they teach in-service engineers and how can these experiences be analyzed and systematized to serve as instructional design guideline for e-learning initiatives integrated in the workplace?

RQ1: What are the challenges for teachers to design and implement course modules as support for e-learning at work place?

RQ2: How can these experiences inform design guideline for developing a teaching model for e-learning integrated in the workplace?

3. METHODOLOGY

The research in this thesis work is carried out within the MERIT project. The main focus of the study was to capture engineering teachers’ subjective experiences when developing courses for employed engineers in various manufacturing companies. Therefore, a qualitative approach was decided upon to capture these unique individual experiences. In this chapter I expand on the arguments how and why the study was conducted as a qualitative study and how the theoretical framework was expanding due to the abductive approach this thesis work was designed upon and continuously guided by. The literature research in the following chapter focuses on the aspects of work-integrated learning, e-learning, collaborative learning and engineering knowledge content. The result and analysis section give descriptions and discussions of the collected information combined with relevant theory research. As this is a new research area, the relevant study emphasis on recent articles and journals.

3.1 Research design

Bryman (2012) describe research design as a framework for the collection and analysis of data. A choice of research design reflects decisions about the priority being given to a range of dimensions of the research process. It include the importance attached to: expressing causal connections between variables; generalizing to larger groups of individuals than those actually forming part of the investigation; understanding behavior and the meaning of that behavior in its specifics social context; having a temporal appreciation of social phenomena and their interconnections.

The research subject is settled namely, – the challenges for engineering teachers participating in work-integrated e-learning courses. The process of data collection is interviews in order to capture the teachers’ individual experiences regarding challenges of course design and implement. Through analysis with relevant theories, a teaching guideline is generated with an abdicative approach – systematic combining. As described by Dubois and Gadde (2002), systematic combining is a process where theoretical framework, empirical fieldwork, and case analysis evolve
simultaneously. The first process is matching theory and reality, while the second deals with direction and redirection. These processes affect, and are affected, by four factors: what is going on in reality – the competition in workplace environment, available theories – work-integrated e-learning (presents in chapter4), the case – MERIT project, and the analytical framework – TPACK (presents in chapter4). The following figure1 illustrates the basic ingredients in systematic combining.

Figure1. Systematic combining (Dubois & Gadde, 2002)

Dubois and Gadde (2002) describe the process of systematic combining as: the preliminary analytical framework consists of articulated ‘preconceptions’. Over time, it is developed according to what is discovered through the empirical fieldwork, as well as through analysis and interpretation. This stems from the fact that theory cannot be understood without empirical observation and vice versa. The evolving framework directs the search for empirical data. Empirical observations might result in identification of unanticipated yet related issues that may be further explored in interviews or by other means of data collection. This might bring about a further need to redirect the current theoretical framework through expansion or change of the theoretical model.

For this thesis work, the research background is settled within the MERIT project. After my studies about the research background information, I studied literatures that focused on work-integrated e-learning with manufacturing education (presented in chapter4). However, that literature was insufficient for my purpose. Therefore, I conducted interviews to collect the empirical data for further developing the teaching model. After the initial work with the empirical data (i.e. transcribing the interviews), I went back to study the TPACK (presented in chapter4), and use it as a framework to present the analysis since I identified a need for an analytical model that incorporated pedagogical issues with content and use of technology in the learning situation. Through the result presentation and analysis, the previous research is corroborated and new findings are discussed. Afterwards, the teaching guideline as the thesis outcome is presented. The abductive research work process is shown in figure2.
3.2 Qualitative research

Qualitative research is a strategy that emphasizes descriptive information rather than quantification in the collection and analysis of data. First, it predominantly emphasizes an inductive approach to the relationship between theory and research, in which the emphasis is placed on the generation of theories. Second, it has rejected the practices and norms of the natural scientific model and of positivism in particular in preference for an emphasis on the ways in which individuals interpret their social world. Third, the qualitative research embodies a view of social reality as a constantly shifting emergent property of individual’s creation (Bryman, 2012). Miles and Huberman (1994) emphasize that the qualitative study is in its all types of reduction, essential data are separated from non-essential data. The purified data can then be presented as tables, maps, trees, matrices and other structures to extract the most essential relationships and themes (Järvinen, 2012). In my work I use the experienced higher education teachers’ subjective experiences as fundamental insights of how to address challenges as design guideline in combinations with previous research regarding e-learning challenges as pedagogical challenges and in particularly so in e-learning situations taking place at the work place. Since that approach is not entirely inductive, nor deductive. The abductive approach is more close to how the research process was planned and conducted (see figure 2).

The strength of qualitative research is its ability to provide complex textual descriptions of how people experience a given research issue. In this research work, I interviews five teachers from the MERIT project. Through the talking, I could get the teachers’ subjective experience, deep understanding of current statues and the prospect for future ambitions. An opinion from the social aspect, the qualitative research provides information about the “human” side of an issue – that is, the often contradictory behaviors, beliefs, opinions, emotions, and relationships of individuals (Mack, et al., 2005). In the result and analysis section, the interview data are categorized and analyzed with relevant theories and quotations from the respondents exemplifies how interview was interpreted. Instead of large numbers of digital data sampling, a descriptive analysis of deep understanding the thoughts and actions are more effective to draw the direction
and redirection of a research. After the analysis of information and related theories, the teaching guideline is put forward.

3.3 Data collection

The data collection method in this thesis work is interviews. In order to receive more useful data, the qualitative interview tends to be flexible, responding to the direction in which respondents take the interview and perhaps adjusting the emphases in the research as a result of significant issues (Bryman, 2012). The qualitative interview is a kind of general interview guide approach, and it can ensure that the same general areas of information are collected from each respondent. It provides more focus than the conversational approach, but still allows a degree of freedom and adaptability in getting information from the respondent (Turner, 2010).

The interview guideline is designed following the thesis aim. It is semi-structured with six themes and listed sub questions. As the delimitation of the target group in this research is experienced engineering teachers, the interview guidance design should focus on their teaching experience and opinions around work-integrated e-learning. At the beginning of the design process, through looking up articles about managing online courses, I found that the teachers’ previous experiences, the skills of operating online technology and the way of examination are highlighted. Then I made the interview questions and discussed with the MERIT project leader. She suggested me to categorize the question list into a semi-structured guideline. After that, my thesis supervisor reminded me to ask questions about their individual perspectives of work-integrated learning. She also suggested me to follow defined principles for receiving more useful information. The interview principles raised by Turner (2010) are: a) wording should be open-ended; b) questions should be as neutral as possible; c) questions should be worded clearly d) be careful asking “why” questions. The interview question guidance is designed from the aspects of background teaching experience, difficulties with technology use in pedagogy, communication, assessment and work-integrated learning. The interview question design is pertinent to the research background, the form of interview is casual and new questions are coming with the progress of the conversation. The interview guide with pre-prepared questions is presented in Appendix. I argue that the way I proceed during the construction of the interview guide (having close contact with the project leader in my reference organization, my supervisor and the consultation of previous research) also secured the validity of the questions, i.e. that I was investigating what I had aimed to investigate (see section3.4 below).

As the research is done within the MERIT project, the 5 respondents were teachers who are project members as well. The interview question guide was sent to the respondents before the interview took place. Then, each interview was done face-to-face among three people, the individual respondent, the author and the project leader. The interviews were held in the following order and I also present short reflections from each interview in order to briefly show that each interview drove the research process forward. A more elaborated presentation is presented in chapter5. Each interview lasted typically for 1 or 1.5 hour, and the interview was audio recorded for later transcripts.

The interviews were carried out at the work place of the teachers in order to create a comfortable and accessible interview situation for the involved teachers. First, we interviewed a teacher major in logistic and received a lot of information about online education from the teacher perspective. Then we interviewed a teacher major in automation and received the serious considerations about communication and assessment. On the next day, we interviewed a teacher major in automation and received some information about the experience of workplace learning. After that, we interviewed a teacher major in machining and received many suggestions for the current situation of production technology education and expectations for the future development. The
last person we interviewed was a teacher who is a new comer in online education. We received considerably information for design the teaching guideline for new comers in work-integrated e-learning. The five interviews are done within one week. Soon after each interview, the full transcription was done.

The information from the transcriptions was then categorized for further analysis. In order to systematize the empirical material, the initial categories followed the interview guideline. After I studied the theory of TPACK, new categories were constructed during the process of reading though the transcripts. The categories of information from the transcriptions are: technology (online education, software), pedagogy (work-integrated learning, collaboration, teachers’ experience), and content (manufacturing education, lecture and seminar, assessment).

In the section5.1, the respondents’ background information is first described. Then the detailed interview information is analyzed following the content of the interview guide and put in relation to the framework presented in chapter4 and in particular in relation to the TPACK model, described in section4.4.

3.4 Validity

The validity is concerned with the integrity of the conclusions that are generated from a piece of research (Bryman, 2012). Also Joppe (2000) defines validity as: “Validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are. In other words, does the research instrument allow you to hit “the bull’s eye” of your research object? Researchers generally determine validity by asking a series of questions, and will often look for the answers in the research of others.” In a qualitative research, as there is no large amounts of numbers or information to verify the correctness in a quantitative manner. Rather the data collection of interviews aiming for deep understanding and transparent analysis with relevant theory is a method to guarantee the research validity.

During my master program, before start the thesis interview, I have already worked a half year with the MERIT project. In this thesis work, each interview is carried out among three people, and the project leader also raised her questions during the interviews. The project leader is familiar with the interviewed teachers and the production technology education. During the interviews, her questions always grasp the new points and lead the respondent talk more deeply from their perspectives. As the teachers come from different background, the collected information is linked to each individual experience and since they all have doctoral degrees they also are experts in their respective knowledge area. After the interview, the data from the transcriptions are categorized and analyzed follow the framework presented in the relevant literature research. As this study is collaborated closely with the reference organization, and the MERIT project leader also act as supervisor in the work process, hence the research validity is thoroughly addressed.

4. RELEVANT RESEARCH

As described in the previous chapter, this research is going to investigate the challenges for teachers when managing the modules as work-oriented courses. The target group for the courses is employed engineers in the manufacturing industry. The course modules will be carried out in flexible forms and mainly online. The course could be tailored according to different requirements from the customer. Within this research background, the literatures will be studied around the knowledge within manufacturing education, workplace learning, online education, and collaboration.
4.1 State of manufacturing education

The education in manufacturing field is growing substantially. With the increasing proportion of manufacturing industry in national economic system, the enterprise has higher demands of in-service training and workplace education for the employees. Moreover, as stated by Swedish production agenda in 2025 that research results should be translate into industry relevant innovations (Engineering Industries, 2011). It is obvious that high education institution should cooperate closely with manufacturing industry to improve the development of production. However, engineering education is a science and mathematics based subject, it emphasizes much on laboratories and equation manipulation (Bourne, et al., 2005). Furthermore, the engineering education also requires highly on specialized research and high investment for the organization which conduct this kind of courses.

The traditional manufacturing courses have long depended on curricula based engineering methodologies covering product and process designs, functional design development, concept selection for product design, materials and process selection, process planning including assembly analysis, etc. (Jawahir, et al., 2013). As presented by Godfrey and Parker (2010), the engineering education has the culture of using mathematics as a means of communication and an equation. With the prevalent of visual communication, the “engineering way of thinking” was focused around problem solving and design. In this kind of problem- and project-based learning, the open-ended problem solving is an important component (Godfrey & Parker, 2010). However, the advanced manufacturing courses emphasis more than merely on training students’ capabilities of flexibility, interaction, professional realities, etc. (Walther, et al. 2011). Such changes have driven a fundamental shift from transmitting technical content knowledge to the urgent need for educating for broader competencies which concern students’ attitudes and values (ASCE, 2004).

Furthermore, the team building and collaborative problem-based learning have been added into engineering education recently (Bourne, et al., 2005).

The professional skills a current qualified engineer should be equipped with are: 1) good communication ability; 2) functioning on multidisciplinary teams; 3) understanding professional and ethical responsibilities; 4) broad education to understand the impact of engineering solutions in a global and societal context and knowledge of contemporary issues, and 5) a recognition of the need for and the ability to engage in lifelong learning (Shuman, et al., 2005). In response to calls for change in manufacturing industry, the decisions in curriculum design should be made on how to best to arrange the sequence of learning experiences so that the students are encouraged to make linkages and connections across courses to build rich, interconnected knowledge (Litzinger, et al., 2011). Another important decision in curriculum design given by Sheppard, et al. (2009) is selecting the optimal balance of learning experiences aimed at developing knowledge and skills, including professional skills, with learning experiences that require integrated application of the knowledge and skills. In addition, they described that the ideal learning trajectory is a spiral, with all components revisited at increasing levels of sophistication and interconnection. In this model the traditional analysis, laboratory, and design components would be deeply interrelated (Sheppard, et al., 2009).

However, Johri and Olds (2011) described the critical aspects of the development in the manufacturing education as knowledge production in the field of engineering education is vibrant, highly distributed and fragmented. As engineering and engineering learning is closely associated with professional practice, it is a limiting factor for manufacturing education development. Same as mathematics and science learning, design is a unique element of engineering learning, this instability aggravate the difficulties for further development (Johri & Olds, 2011). Moreover, for creating continuing engineer courses, to attract and retain students in engineering are also challenges for the current manufacturing education. As stated by Edward Goldberg, “a significant
proportion of physical face to face education will be replaced by Web delivered, electronic learning opportunities” (Todd, et al. 2001). The online engineering education will be widely implemented with the trend of technology development. For this consideration, more issues about workplace learning, online education pedagogy, etc. will all be highlighted in the future researches. To improve the current online engineering education, Bourne, et al. (2005) suggest that: 1) the quality of online courses must be comparable to or better than the traditional classroom, 2) courses should be available when needed and accessible from anywhere by any number of learners, and 3) topics across the broad spectrum of engineering disciplines should be available. In the engineering work environment, learning is fundamental in the engineering workplace, where products and processes are constantly changing due to technology, innovation, economic factors and the encompassing influences of society and culture. The engineering workplace provides an extraordinarily rich environment for exploring learning. It has diverse modes of organization ranging from highly structured courses to informal conversations between co-workers. This requires the continuous creation of both formal and informal learning activities (Lawton, et al., 2012). Therefore, as complement to the traditional classroom learning, new ways of workplace learning is required in the current manufacturing education. From this point of view, the cooperation program between companies and university is highly demanded by workplace education in manufacturing industry for competence development.

A traditional perspective regarding the dominant qualities and attributes for an engineer is: numerate, practical, tough and self-reliant, not emotionally demonstrative, conservative, and pragmatic (Godfrey & Parker, 2010). However, today’s engineer is expected to be more flexible and sociable. For the online education participants, the working engineers are motivated adults who can provide detailed perspectives based on their understanding of their own learning. Newly acquired knowledge is usually immediately applied to project, enabling the direct study of knowledge transfer from learning activities. The learning is often inherently social and collaborative, with working engineers often fulfilling the roles of teachers and mentors. Learning in the engineering workplace must enable learners to respond to a variety of circumstances as business processes evolves, and to develop agility and flexibility (Lawton, et al., 2012). Meanwhile, except the engineers, more and more employments are related to manufacturing industry, e.g. marketing, operations management. This situation enlarged the range of participants (employees from different department), the teaching content (e.g. practical, management oriented) and the pedagogy approach (e.g. work-integrated learning, collaborative learning) in production technology field, which calling for flexible education.

4.2 Work-Integrated e-Learning

The term “work-integrated learning” broadly refers to courses that incorporate a workplace-based component but are also connected to classroom learning or an individual’s program of study (Kramer & Usher, 2011). Work-integrated learning is widely known as a combination of education with workplace practice. It is a learning activity with not just sources of learning and knowing, instead, they constitute environments in which knowing and learning are co-constructed through ongoing and reciprocal processes (Billet, 2001). Work-integrated learning has the potential to provide direct and significant benefits for students, workplaces, universities, and in turn, the wider community. For students, Work-integrated learning courses can provide the opportunity to enrich or learn both generic and discipline specific skills, relevant to professional practice. Also the workplace experience can serve to build confidence and maturity, and increase motivation to learn (Gibson, et al., 2004).

Learning is perhaps the most indispensable activity in the current knowledge-based new economy, which is characterized by industrial change, globalization, increased intensive competition, knowledge sharing and transfer, and information technology revolution (Zhang & Nunamaker,
For the individuals, the migration of skilled worker and the increasing demand from social life intensified the competition in workplace. Therefore learning is gradually been regarded as a continuous process that last life-long. However, the contradictory problem is the limitation of time and location. With the development of technology, the e-learning is gradually carried out with workplace education. Workplace learning is built on practical tasks and work situations with the aim to serve organizational goals. Recently, attention to workplace learning has greatly increased due to the significant role of professional skills and expertise in organization development. Moreover, with the development of technology, workplace e-learning or web-based training is being studied by a significant number of groups (Wang, et al., 2010). By leveraging workplace technologies, e-learning is bridging the gap between learning and work. Both employers and employees recognize that e-learning will diminish the narrowing gap between work and home, and between work and learning (Oye, et al., 2012).

E-Learning is based on distance learning, implemented with advanced information technology. It has been described as the use of telecommunication technology to deliver, support and enhance teaching and learning (Violante & Vezzetti, 2012). As presented by Violante and Vezzetti (2012) workers that have to acquire new knowledge or improve the knowledge they already possess is one of the major student type which the e-learning is mainly focused on, the Work-integrated e-learning is a new developing trend. The target group of work-integrated e-learning is employees which work in organizations and have an urgent demand of education but limited by time and location. Furthermore, another key factor is that they should have a high motivation to participate this kind of learning. To support this viewpoint, Biggs (1999) described that: what each student gains from a learning encounter “depends on their motives and intentions, on what they know already and on how they use their prior knowledge. Meaning is therefore personal … education is about conceptual change” (Erin, et al., 2004).

Today’s online education has significant progression in comparison to earlier generation of distance learning. Online learning is a new social process that is beginning to act as a complete substitute for both distance learning and the traditional face-to-face class. It is in the process of moving from traditional course to online and hybrid courses using digital technologies to support constructivist, collaborative, student-centered pedagogy, offered by a few hundred “mega-universities” that operate on a global scale (Hiltz & Turoff, 2005). To judge a good online learning system, five factors should be taken into consideration: learning effectiveness, student satisfaction, faculty satisfaction, cost effectiveness, and access (Lorenzo & Moore, 2002). With the application of scientific technology into advanced pedagogical approach, the irrelevance of the location where the course takes place and the inexistence of the restrictions associated with a traditional timetable are the most important advantages. The flexibility of time, place and programs offered via web training is appealing to students who are trying to balance school with work and home responsibilities. Workers who seek flexible working hours and telecommuting work arrangements are being drawn to companies that offer opportunities for them to upgrade their skills (Violante & Vezzetti, 2012).

The three complementary components of e-learning are: technology, learning content and learning design (Naaji, et al., 2013). As Zhu J. (2010) described in her research, online learning can be enhanced by giving learners control of their interactions with media and prompting learner reflection. The technology is undisputedly an important element to promote the online education. Educational multimedia uses a variety of different media such as text, graphics, animation, video, and sound, to present information. Multimedia software can be a powerful tool in enhancing learning by helping learners to construct their own knowledge (Kaufman, et al., 2009). Different technology applications are deployed to support different models of online learning. Synchronous technologies, such as, live webcasting and chat rooms, are used as live face-to-face teaching strategies such as delivering lectures; while asynchronous communication tools (e.g., threaded discussion boards, newsgroups), allowing users to contribute at their convenience, provide a
flexible approach for users (Zhu, 2010). For another component, the learning content and design, several principles should be followed as: 1) the texts should be interesting and useful with examples, case studies, short exercises; 2) the technical and expert content should be clear, with sufficient explanation of the less familiar and new notions; 3) the complex content should be presented by using graphs, diagrams, models; 4) the content should be divided into sections that are more suitable for the computer medium; 5) interactivity, animations, simulations, sound and video, as well as video records of the lectures should be part of the learning materials; 6) the contents and the interrelations of the content elements should be clearly distributed and organized (Violante & Vezzetti, 2012). Nevertheless, to ensure the teaching quality, it is important to consider the perspectives of the online learners. Tomei (2010) presented the characteristics of an online learner as 1) ability to work independently and in groups, 2) responsibility in completing assignments and readings, 3) ability to learn using content in various formats, 4) time management and personal organization skills, and 5) the knowledge and skills to use technology. Other aspects to consider in developing online courses refer to the structure and the components of a course, the multimedia resources, the teacher-learner and the learner-learner interaction, the presentation/delivery mode, and the role and selection of assessment methodologies (Naaji, et al., 2013).

The work-integrated e-learning is to implement workplace learning with online technology. With its advantages of time flexible, location freedom and workplace oriented knowledge content, this new pedagogy approach could help the employees having the in-service learning during their works. In the current situation, work-integrated e-learning is carried out with the technique support of texts, graphics, videos, and synchronous communication.

4.3 Collaborative Learning

In this section, the literature research of collaborative learning is from the aspects of collaboration between learner-learner, learner and instructor – community of practice, and learning with environment – the situated learning. Also the major target is the engineering education subject.

The definition of community of practice given by Wenger is: groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis (Wenger, et al., 2002). Community of practice is an important component in work-integrated e-learning. Svensson (2004) described in his research that there is an inseparable relationship between human learning and the cultural and institutional context in which learning occurs – learning should be understood as something we do in communities of practice (Lave, Wenger, 1991). Three central processes or activities that are characteristic for communities of practice concluded to Wenger (1998) are: mutual engagement, where members in various manners pays attention and give interest to whatever is in common in the community; the negotiation of joint enterprise stresses the fact that available resources and boundaries must not be perceived as static, but rather as objects of constantly ongoing debates, interpretations, and change; finally, a community is characterized by its shared repertoire, where the mutual history constitutes the foundation for knowledge of shared norms, tools, language genres etc. that distinguishes the insider from someone outside or in the periphery of the community (Svensson, 2004). In combining these three elements, the activities do not occur in isolation within a community but instead are based on a multiplicity of relations. Therefore, learning becomes embedded within a social context, and social membership, identity, and knowledge are mutually dependent (Mills, 2011).

Situated learning is one important component to support community of practice. Mills (2011) described situated learning theory similarly suggests that learning is experienced and mediated through relationships with community members or within a “community of practice”. One significant change in research on learning over the past couple of decades is a move towards examining learning as a situated activity. A central aim of the situated perspective is to understand
learning as situated in a complex web of social organization rather than as a shift in mental structures of a learner (Johri & Olds, 2011). The three aspects of situative learning are: social and material context, activities and interactions, participation and identity. First, learning is an activity inevitably involved with social and material context. A conclusion draws by Johri and Olds (2011) observation shows that different forms of knowledge emerged when different materials were involved. As engineering education is probably one of the most material-saturated disciplines, the situated learning is precisely conforming to engineering education. Second, to explain the activity and interaction according to the situated perspective, Johri and Olds (2011) described that learning is doing and it is through situated engagement in motivated action, using tools, and in interaction with others, that we learn some of our most essential skills. Mediation by tools and engagement in activities are essential for learning and require paying attention to the micro-foundation of interaction. They also highlighted two core issues of Lev Vygotsky (1997), any higher-order cognitive function is the result of social interactions; speaking and thinking are two separate but mutually influencing processes that themselves are always developing. Third, the meaningful participation in practices is a central concept within the situated perspective. As we learn to participate we undergo an identity transformation. The identities we develop or reflect play a significant role in our learning trajectory.

For the engineering education, Johri and Olds (2011) also described three distinguishing characteristics of engineering learning according to situated perspective: use of representations, alignment with professional practices, and the emphasis on design. However, the learning contexts should be interrogated to discover the ways in which these contexts allow participants to develop positive engineering-related identities. Despite this, except the work-based component in engineering education, there is also a need to provide realistically complex experiences in which students can integrate the various cognitive and social aspects of their learning in as authentic a context as is possible in the academic environment. Project work tackling real world problems is more engaging and motivating, and helps to build graduate attributes such as the ability to engage with the ethical and social dimensions of engineering (Russell & Posada, 2011).

The community of practice provides an opportunity for students in work-integrated learning course to identify themselves in the practice of collaborative learning. Consequently, identification is a key factor in community of practice. According to Nedić and Nafalski (2011), in community of practice, identity is defined as the understanding of self. An existential definition of self-identity has been described as “to know what one is doing and why one is doing it” (Giddens, 1991). As many actions are non-conscious and, or emotional, and they are difficult to make conscious, Eraut (2000) argues that non-conscious learning and tacit knowledge needs to be made explicit through collective reflective dialogues in order to share practice knowledge and develop expertise (Trede, 2012). Hung, et al. (2004) described that identities are shaped through local interactions in which individuals confirm or disconfirm each other’s state of identity. In this sense, identity is always mutually constitutive, and re-constituted through local interactions within the community. As knowledge cannot be detached from the knower, it has no independent existence. It is an important of the identity of the individual.

To consider identification in the engineering area, an observation done by Anderson, et al. (2010) shows engineers often emphasized the big picture of learning, collaboration, and coordination, instead of the individual, technical work that they did. Therefore, to continue learning, to participate in community of practice, to enhance their self-identification and coordinating ability is essential in the engineering industry.

For community of practice developing in online environment, some additional findings which classified under the three main components of community of practice are: mutual engagement
include IT skills, confidence in IT uses, access to computer hardware and software, VLE (Virtual Learning Environment) access and technical support; joint enterprise sees the development of trust and support of identity presentation as an added facet of online community working; with shared repertoire suggesting longevity of the community is required (Moule, 2006).

The theory of collaboration in work-integrated e-learning is collected from the dimensions of situated learning and community of practice. Situated learning mainly emphasizes the individual’s cognition and identification. The community of practice focuses on the mutual engagement, joint enterprise and shared repertoire. The collaborative learning is an important component in work-integrated learning.

4.4 TPACK (Technological Pedagogical and Content Knowledge)

As described above, the new pedagogy approach – situated learning and collaborative learning, the technique applied education – e-learning are the major aspects that the teacher should emphasis during the work-integrated e-learning courses. Especially in the production technology education, the new pedagogy is different from the tradition to a large extent. To implement online technology in the engineering course is a heavy work, as it emphasizes on problem solving and practical operation. Therefore, there comes a higher requirement for engineering teachers’ competences to design and hold courses. Based on this condition, a well-structured teaching model is needed as to guide their work when facing challenges.

TPACK is shorted for technological, pedagogical, and content knowledge. It is a framework builds on Lee Shulman’s construct of pedagogical content knowledge (PCK) to include technology knowledge. The PCK represents the blending of content and pedagogy into an understanding of how particular aspects of subject matter are organized, adapted, and represented for instruction (Mishra & Koehler, 2006). As Shulman (1986) argued that having knowledge of subject matter and general pedagogical strategies, though necessary, was not sufficient for capturing the knowledge of good teachers. For teachers to be successful, they would have to confront both issues (content and pedagogy) simultaneously by embodying “the aspects of content most germane to its teach-ability” (Shulman, 1986). However, in the new century, the PCK model is not sufficient due to the development of technology and its use in learning situations. Koehler and Mishra (2009) described that, the technique today presents new challenges to teachers who are struggling to use more technology in their teaching. Consequently, a framework needed to be created and designed to support their teaching. Compare to PCK, TPACK additionally emphasizes the complex interplay of these three bodies of knowledge. In practical terms, this means that apart from looking at each of these components in isolation, we also need to look at them in pairs: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and all three taken together as technological pedagogical content knowledge (TPCK) (Mishra & Koehler, 2006).

TPACK is a form of knowledge that expert teachers bring to play anytime they teach. As newer technologies often disrupt the status quo, it requires teachers to reconfigure not just their understanding of technology but of all three components (Mishra & Koehler, 2006). Moreover, Shulman (1987) argued that the goal of teacher education is to educate teachers to reason soundly about their teaching as well as to perform skillfully (Shulman, 1987). For this reason, TPACK is widely researched and developed for improve educators’ competence. The TPACK framework can guide further research and curriculum development work in the area of teacher education and teacher professional development around technology (Mishra & Koehler, 2006).
For the TPACK model, there are seven elements involved as showing in figure 3. Koehler and Mishra (2006) defined the seven elements as:

- **Content knowledge (CK)** is knowledge about the actual subject matter that is to be learned or taught.

- **Pedagogical knowledge (PK)** is deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values, and aims.

- **Technology knowledge (TK)** is knowledge about standard technologies, such as books, chalk and blackboard, and more advanced technologies, such as the Internet and digital video.

- **Pedagogical content knowledge (PCK)** includes knowing what teaching approaches fit the content. It is concerned with the representation and formulation of concepts, pedagogical techniques, knowledge of what makes concepts difficult or easy to learn, knowledge of students’ prior knowledge, and theories of epistemology.

- **Technological content knowledge (TCK)** is knowledge about the manner in which technology and content are reciprocally related.

- **Technological pedagogical knowledge (TPK)** is knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies.

- **Technological pedagogical content knowledge (TPCK)** is an emergent form of knowledge that goes beyond all three components (content, pedagogy, and technology).

![Figure 3. The TPACK framework and its knowledge components (Koehler & Mishra 2009).](image)
TPACK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students’ prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones (Koehler & Mishra 2006).

As the online education is becoming increasingly mature, the focus of researches has changed from technology-focused model to pedagogy-focused model. To measure TPACK development from the teachers’ perspective, Kabakci Yurdakul and Coklar raised the TPACK-deep scale. It concludes four factors: design, exertion, ethics and proficiency (Kabakci Yurdakul & Coklar, 2013).

- The design factor refers to competency in designing the instructional process from planning to assessment to teach the content by applying technology and pedagogy.

- The exertion factor refers to competency in putting technology into effect for the execution of the instructional process designed regarding the subject area as well as for the measurement and evaluation of the effectiveness of the process.

- The ethics factor refers to competency in conducting the instructional process as appropriate to the ethical rules considering the ethics of the teaching profession in the environments where technology is used.

- The last factor, proficiency factor, refers to competency in acting as a leader regarding the integration of technology into content and pedagogy by getting specialized in the field of teaching.

The above four factors are the major criterion to judge a teacher’s competency in the TPACK model.

With the technology development, the number of online courses is increasing. It has gradually changed the role of teachers and the traditional pedagogical approaches. Teachers, who are at the center of this increasing demand and pressure to teach online, are being challenged to rethink their underlying assumptions about teaching and learning, and the roles they take as educators (Wiesenberg & Stacey, 2008). The early instructor’s role model defined teachers’ functions under four different categories: pedagogical, social, managerial, and technical (Berge, 1995). However, Berge (2009) called for a change in the roles that would focus more on ‘informal, collaborative, reflective learning, with user-generated content’. The competencies of online teachers collected by Baran, et al. (2011) are technology-related competencies, communication competencies, and assessment-related competencies can be considered more important than others depending on the context and culture within the online teaching environments. And the common roles of online teachers are identified comprised pedagogical, facilitator, instructional designer, social, managerial, and technical roles (Baran, et al., 2011). Nevertheless, there also rises a high demand for the online course participants. As the online students are expected to take greater control of their learning process and be more active in stimulating their peers’ learning, facilitation of online learning emerges as an important role in guiding these student-centered approaches (Baran, et al., 2011). Moreover, in online courses, the teacher moves from being at the center of the interaction or the source of information to the ‘guide on the side,’ which implies that teachers design, organize, and schedule the activities and learners assume greater responsibility for their learning by coordinating and regulating their learning activities (Anderson, et al., 2001; Berge, 2009). Regarding to the online community of practice from the engineering educator perspective, the main features are:
understanding the landscape of practice, recognizing the challenges, creating curricular resources and constructing new knowledge (Capobianco, et al., 2006).

To sum up, the thesis work aim to develop design guideline for a teaching model for the engineering teachers who work with online courses. The education target group is employees in the manufacturing industry. Therefore, this is a kind of work-integrated e-learning education. Based on this situation, the relevant literature researches are focused on production technology education, work-integrated learning (WIL), online education (e-learning), collaborative learning (CL) and Technological Pedagogical and Content Knowledge (TPACK).

As this research is devoted to find out what challenges there are for the teachers work in work-integrated e-learning courses, so the literature researches are concentrated on the teaching perspective. In addition, the delimitation of the participants is they are current employees in companies which have limited time for fulltime study. The participants also should have a level of engineering knowledge, operational experience and high motivation to participate in the study.

5. EMPIRICAL RESULT

In this section, result from the analyzed data of the five interviews is presented. This outline contains the teachers' background description, and the detailed data description with quotations.

5.1 Information from the respondents

The teachers which I interviewed are mainly within the broad subject of production technology. They teach and do research in different fields and have different expert specialties within this area. The following presentation is a description of the respondents’ background.

a. Teacher A

<table>
<thead>
<tr>
<th>Subject (course):</th>
<th>Courses related to automation systems, robotics, Programmable Logic Controller (PLC), and virtual manufacturing.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position:</td>
<td>Senior Lecturer</td>
</tr>
<tr>
<td>Detailed information:</td>
<td>Teacher A is major in automation field. He is the leader of automation section in the research team. He has rich teaching experience, mainly teaching on master level. Teacher A has some experience in operating online education software (e.g. video making, online meeting), and he has had a PhD student tutoring online. Teacher A and B are close work partners.</td>
</tr>
</tbody>
</table>

b. Teacher B

<table>
<thead>
<tr>
<th>Subject (course):</th>
<th>Courses related to automation systems, electronics, control system, robotics, and virtual manufacturing.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position:</td>
<td>Senior Lecturer</td>
</tr>
<tr>
<td>Detailed information:</td>
<td>Teacher B is major in automation field. He has rich teaching experience, and has workplace experience before. He also emphasis on collaboration in high-level courses. Teacher B has been involved in online teaching course before, and he has experience of tutoring PhD students online. Teacher B works closely with teacher A.</td>
</tr>
</tbody>
</table>

17
c. Teacher C

<table>
<thead>
<tr>
<th>Subject (course):</th>
<th>Courses related to manufacturing technology and operations management.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position:</td>
<td>Senior lecturer</td>
</tr>
<tr>
<td>Detailed information:</td>
<td>Teacher C is major in machining. He is the leader of machining section in the research team. He has a good cooperation with manufacturing companies (have more activity in industry). Teacher C has rich teaching experience, and has experience of follow online courses. He is creative in online laboratory and work-integrated learning development.</td>
</tr>
</tbody>
</table>

d. Teacher D

<table>
<thead>
<tr>
<th>Subject (course):</th>
<th>Courses related to logistics, operations management.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position:</td>
<td>Senior lecturer</td>
</tr>
<tr>
<td>Detailed information:</td>
<td>Teacher D is teaching multiple subjects, e.g. Logistics, Quality and Design relevant courses in Machining. She also supervises students for thesis work. She has basic level of online teaching and familiar with work-integrated learning. In her teaching, she emphasis on communication and collaboration. She is excited and optimistic about online education.</td>
</tr>
</tbody>
</table>

e. Teacher E

<table>
<thead>
<tr>
<th>Subject (course):</th>
<th>Courses related to manufacturing technology and electrical engineering.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position:</td>
<td>Senior lecturer.</td>
</tr>
<tr>
<td>Detailed information:</td>
<td>Teacher E is major in manufacturing and production technology. He gives electrical engineering courses for industry economic and production technology students. Teacher E has the computer science background (familiar with digital tools), but he is a new comer of online education. He has the basic knowledge of operating labs and high-level courses.</td>
</tr>
</tbody>
</table>

5.2 Description of collected data

The detailed information collection is described from seven aspects: experience, pedagogical approach (online), course content (design), technology, collaboration, assessment, and other difficulties. These categories are following the information from the interview transcriptions and the study of relevant literature that also served as background for the creation of the questions to the experienced teachers (Appendix). The teachers’ experience is what we want to know for further analysis. In the following section, I present what the teachers expressed in relation to the categories of experiences that we asked for. Below I present each category as short summaries regarding teachers’ experiences and exemplify these experiences and views with teachers’ quotes.
5.2.1 Experience

Through the interviews, the teachers’ experiences can be concluded into three aspects: traditional teaching approaches, online education experience, and the other work experience. The followed descriptions are concluded of what the teachers was talking about during the interview and this comment is valid for the chapter5.

Traditional teaching

From the interview, according to the teachers’ perspective, the traditional teaching content in manufacturing education can be separated as emphasis on technique practice and management ability. The technique practice course includes exercise; lab; project work; writing exam (beyond the book); provide different solution for problem solving (programming course). The management oriented course includes: lecture; seminar; group discussion; presentation; white/black board education (regression). In general, the course in bachelor level is exactly following the basic pedagogy approach and the course in master level is more flexible.

“For campus course, we have lectures, weekly exercises, I can hands on exercises in lab. When we have project works, thesis works, then it’s based on seminars mainly.” – Teacher A

“Last year we did a huge effort on update our PowerPoint presentations, since my thought was the students just sitting there and have some entertainment, they were not focus since they know they will have the pack. Compare if you write down on the board all the time, then the students will write what’s on the board, and they will take more participation in the lecture.” – Teacher C

Online teaching and learning experience

The online teaching and learning experience of the respondents can be conclude as: 1) participate in video conference which is popular years ago; 2) supervise PhD student use online communication tools; 3) take online exam with complex questions; 4) follow several online courses but not satisfied enough; 5) have long film teaching content which is terrible for the students; 6) find rarely good and suitable teaching material online. From the above description, it can be concluded that most course content and examine are unsatisfactory, not even related to work-integrated learning.

“When I first taught here, we use video conference. We have studio groups in many smaller cities, and the teacher will be presented here in the video conferencing equipment. It was with the learning centers, we broadcast those things. So that is different form of doing online teaching.” – Teacher D

“Online education, it depends on what you counting, I would say, none. I did it in 1989, and it is completely different techniques. And the last year I have done it on PhD level, so I have supervised a PhD student with online tools.” – Teacher A

“I have tried to follow lots of regular courses in that way, but I have use part of that educate myself if I want to learn something new, so I’m familiar with these kinds of tools. But I’m not following any regular course, I can pick piece of one more that the things I need. For the materials, it’s rather easy to find, but to find good materials is rather hard.” – Teacher A

Other work experience

However, except the above experiences, the course teachers also own real workplace experience; have good connection and active participation in companies; even have the computer system
development education background. These experiences are advantages for them to design and implement the work-integrated e-learning courses.

“I have worked at engineering company years ago, so I am familiar with their works.” – Teacher B

“I have many cooperation projects with companies, so I can tell stories to the students that might be good for their studies.” – Teacher C

“Before I entered the engineering field, I actually got 80 credits in computer science. I can create a system by myself” – Teacher E

5.2.2 Online pedagogy approach

The pedagogy approach in online education contains the preparation work and the challenges in online environment.

Preparation work

From the teachers’ experiences, the preparation works for teachers to do are well plan and clarify the course content and schedule; make clear deadlines for hand-in assignments and exam; select appropriate technique (material making and online communication); take more time to further study and learn to make the teaching material.

“It is hard to follow a distance course on you own, how do you motive yourself? That’s why I would like them to work on specific assignments and even it is small, keep giving them assignment or meeting each week. It is the range of the course. You need to have deadlines, and they have to be very clear.” – Teacher D

These preparation works are supposed to guarantee the pedagogy quality and reduce the risk of losing students. In addition, if the time is limited or the resource is difficult to get directly, ask for support from the other department or have a technique assistant (e.g. creative center, graphic designer) is a good way to improve the work efficiency.

Challenges in online environment

According to the information received from the interview, the challenges for manage pedagogy approach in online environment are from the perspectives of theoretical course content design and information technology. The theoretical aspect includes: long time is needed to do preparation for the course content; reuse and repackage previous teaching materials; translate material from traditional to online; study on how to keep the participants’ interesting and make them catch up with the course modules; define assessment in online education (e.g. to exam the tacit knowledge); keep the interactivity in teaching.

“I think it takes more time than the regular course. For the university, it will cost a little bit, but maybe we can save it later on, because next time it won’t cost that much.” – Teacher A

While the technical aspect includes: study the difficulties to do real-time communication (group/large number of participants); course content might change/limited with different scale of participants; hard to realize online lab (high quality image and interaction); and the position and time might not be flexible for exam (project check/discuss).

“For the communication part, when you have online communication in real-time, that’s really hard. If you have 50 students, you really need to plan this. My learning so far is with at least 50% of these students, the
system will fail the first or even during the course, the technique will fail. The real-time communication is really not that good.” – Teacher A

5.2.3 Didactics within production technology courses in classroom teaching

Here the interviewed teachers express and describe how and what kinds of issues they face during classroom courses. The courses that we are aiming to develop in MERIT are: operations management, automation, and machining. At present, these courses are traditional courses at the University but will be modified to better suit the e-learning initiative and modular set up of small course modules that companies can selected in accordance to their individual needs.

“The automation course will start at this spring semester, and you are welcome to look at that.” – Teacher A

“We are trying to contact with companies, hopefully we will have the operations management and the machining course at the autumn semester.” – Teacher C

The course content of operations management is project based and more focus on theory and management ability development (e.g. negotiation). It is to learn new knowledge besides professional field (technology) for the engineer. The courses mainly focus on project work and the project work need to be related with their company. The teachers usually act interactive with the class. For this kind of course, it is easy to adjust the teaching content to online course compare to the technology practical course.

“At the master course e.g. operations management, there I have different teaching style. I try to have the Harvard cases, then we have more interaction will the class, then I need to prepare the cases, and try to ask question to discuss through the case from different perspectives.” – Teacher C

The automation course is more strict, emphasis on exercise and individual laboratory. It normally has lectures, weekly exercises, labs, FAQ, seminars, and project work. The student’s project work should follow the framework made by the teacher. For the programming courses, the teachers usually check the solutions individually. The study process is an individual work, not necessary to discuss with anyone. However, the communication is more active between teacher and student in high level courses.

“My course a mixture of lectures, hands-on exercises, and I also tries something I called frequently ask question (FAQ) or small seminar when we discuss topics.” – Teacher A

“I propose different topics, and saying with these specific topics, you can follow four things, and the students can pick up one of those.” – Teacher A

“I would like to say it depending on what kind of course. If it is a basic course for a high number of students, I teach go through things, and one way communication. If it is more advanced course, then we have more freedom to put our time as we want. It is fewer lectures, and more guidance, more to read, and they have more time to do discussions.” – Teacher B

The machining course is lectures based and emphasis on interaction. It usually has lectures and PowerPoint presentation. For the teachers in my research, they have gone back to white board education and get good feedback from course evaluation. For the online teaching, a mixture of PowerPoints presentation and video illustration would be good for the interaction. Also this kind of course needs amounts of practical exercises.
“During my PhD, I do a lot of PowerPoint, but I have left them a lot. I went back to a more traditional style with a lot of drawings on the white board, and I had better feedback from my students. Because I think much of the knowledge is in the “arm wrist” when you move your body, and mind, also it gives more time to ask questions, the information is not something that just flowing in the classroom. And it’s easy for me to do calculations on the white board. But some subjects, if it is a lot of illustration, I use to show some more advanced pictures in the PowerPoints. It’s more flexible with PowerPoint.” – Teacher E

5.2.4 Technology

From the interviews, we received much information about the teachers’ previous experiences of using technology, and their expectation for technology in the MERIT project. The collected information about technology can be concluded from the aspects of Learning Management System (LMS), video making, communication and virtual labs.

The technology of Learning Management System should be easy for the customer to use and suitable for course management. Certainly the technology is difficult for both teacher and student initially, and some technology or functions need to have license. The platform for work-integrated e-learning should have more interactive functions. It should be intuitive for user to operate with.

“When I started to do the online course, I was warned to use too many techniques. It is because the student might get frustrated, and the study could be worse. Then I decided to do it simple.” –Teacher D

“I think it’s good to have a board to express and discuss some subjects. But it could be extremely easy to use, it’s all about user-friendly. If the web page is not so intuitive, they don’t use it. It takes a lot of time every time to figure out how to do things.” – Teacher C

The video making will take long time to learn and to do. The process to learn new software will also cost a lot of time and money. Some teachers in my research would prefer to use film only for the course information introduction. While some of them would prefer support from IT department as to keep the work efficiency. From their work experience, to work is pair or group is better.

For the video online “it should be lively, like the calculate process. The content can be presented in a nice way. I would like to do it synchronously, and in an interactive way.” – Teacher E

According to the teachers’ experience, they have tried much communication software in tutor the PhD student before. The possible real-time/synchronous software has Adobe connect, TeamViewer, WebEx, Skype, and a phone, as it is the most common tool. The teacher should choose specific communication software according to image, voice, share screen and files, limited number of people.

“If I go outside university, and I need to talk to a company or a person, first I need to know do we need to show something, like desktop, or do I need to see the other person’s desktop. Then I pick certain model or tools and its video involved or just the voice. Sometime it’s opposite, it’s only video then we call each other, because the voice is not good, so totally depends on who I speak to. Eternally, I would prefer Lync, because it is convenient.” – Teacher A

“Yes, only to have the same equipment, the same microphone and so on, so the sound level is equal. I have been involved in lots of online meetings, where I can’t hear two or three guys discuss something.” – Teacher A

“I have been using synchronous, connections like sharing screen, some present things and other. When you have online communication in real-time, that’s really hard. If you have 50 students, you really need to plan this. The system will fail the first or even during the course, the technique will fail.” – Teacher A
The schedule need to be well planned and the content need to be well arranged. “When we discuss in the seminar, we looked at each other, which are nature for me to speak, and so on, and it’s really hesitated when you have online meeting, if it has some delay in the communication. You start to speak, and you realized someone has started the same time. I think it happened quite often when we have free discussion online. So you need to have another discipline.” – Teacher A

However, there might be some restrictions with the technology. “If the student work at his company, there are a lot of technique problems to get in, because they have their firewalls and safety department, we are not allowed to go into their systems. Then it’s hard to have the synchronous communication.” – Teacher B

Also the network should be kept in high quality. “Sometimes when we have these online meetings, it’s very important that you have very good bandwidth. There is no delay, and you have a good quality of the picture, and particular the sound.” – Teacher C

The virtual lab is hard to achieve in current situation, it requires high budget, high quality graphics (3D), high quality bandwidth (technology). And some courses don’t need labs.

“It requires a very high level graphic quality, and the way how to interact with. We are not close to that yet. But I have one just total crazy idea, as I want to show as much the phenomenon in manufacturing with cooking, you might have most of the manufacturing processes similar as activities in your kitchen. I just want to open their eyes to see it’s the same physics, that’s how the concept interacted. But it needs to keep good quality graphic and high budget.” – Teacher C

5.2.5 Collaboration

From the traditional perspective, the collaboration in work-integrated e-learning is among teacher and students. In the teacher-student oriented collaboration, teacher should consider about the students’ background and lead the collaboration with lively atmosphere. For the synchronous communication, clear rule (speaking sequence) of online seminar might be useful and efficient, as the quality of technique/network will affect the teaching/learning efficiency. This kind of collaboration is also an opportunity for the teacher to learn from students about their work experience at company. However, for the teachers, new schedule of the collaboration should be included in their work plan.

“As they are working in manufacturing industry, we can receive many new things from them. If they come with questions, we can then discuss it.” – Teacher B

“Because we will get close to those company and employees, we can learn more about collaborations, and network as well.” – Teacher D

5.2.6 Assessment

The assessment contain written exam, seminar, problem with technology and some other way of exam. According to the interviews, it can be concluded that, the demand of these kinds of assessment comes from the pedagogy of the course that the teachers already designed, and what they want to implement in their future work.

The written exam could be carried online with the support of technology. Some teachers want it to verify what the students have learned, to ensure the teaching effectiveness. Whereas some teachers believe that a written exam is not needed as this kind of work-integrated learning is to study with high learning motivation. The seminars, some need to be face-to-face, some can be carried online. It is required as to bring out the students’ tacit knowledge. The phased assignments and final report are same as the traditional way of assessment.
For the technology, when it comes to the online environment with the work-integrated learning course, to assess the learning outcome is quite difficult. The way of communication should be tailored to the current situation. For the online exam, questionnaires or checkbox questions are too simple. Whereas the roll-back questions\(^3\) are too complicated and easy to make the examinee lose patience. The multiple choice question might be accepted for some courses. And a summary or reflection of case study after online discussion will also be a good way for assessment.

“I need to give feedbacks on hands-on exercises and I think it needs to be real-time. You will not get engineer student to write a lot of thing and then I comments back, and it will take forever. For the questions in the written exam, it could be four solutions in one question. You don’t need to be an expert in that programming language, but you should have the knowledge of how to solve the problem.” – Teacher A

The other ways of exam have the hand-on exercises; one by one check the problem solution (in programming course); hand-in assignment and report; write report related to own company; fixed limited time of report exam by email; write reflection as assessment. For the engineering education, assessment is actually an important section of learning for the students. For the work-integrated learning, the exam should be more based on the students’ requirement (credits or diploma), and the exam could be carried out in different way. It is important for the teacher to know that how the student learned can affect their company. In addition, to count the students’ login in times might be a good way to evaluate their learning motivation.

“I would more prefer the students assign in on the course. Then we have the e-mail, and we can say you have a home exam. The mail will be sent out at 8 o’clock morning, and I would like to have reply at 4 o’clock in the afternoon. So then the students have 8 hours to conduct their exam.” – Teacher C

“Sometimes it’s hard to have word to express it. Just like bicycles, you know how to do it, but you can’t describe it. When they try bicycle, they show they can bicycle, and then I said, ok, let’s stand aside and discuss what you did. This tacit knowledge examine is a challenge in online environment.” – Teacher A

“You can see how many times the students were logged in, and that could be a measure of the interest of the student. How much time and effort the student has put in by himself to the course. One needs to find a way where you can actually subtract the uninterested students from the interested, then you can evaluate.” – Teacher C

5.2.7 Other difficulties

The other difficulties for the teachers to have a course in work-integrated e-learning are: hard to do online lab; hard to catch/evaluate work-integrated learning in course content design; whether to define the title/signature of the films or not; how to carry the collaboration among teachers (enhance the work efficiency); technical assistant is needed.

From the above description, we can sum up that the teachers in MERIT project all have a general idea of online education and work-integrated learning. The online pedagogy approach should be designed according to different course content. The course content design should follow the aim of each individual course. The technology is an important factor affect the online education, the biggest challenges today is the communication. The collaboration is emphasized in work-integrated learning. The assessment is more complex as the course is carried online. It can be concluded that the major challenges for teachers are from the aspects of teaching content design, pedagogy approach and technology.

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\(^3\) Roll-back question, e.g. it requires to answer the question in limited minutes, if not answer in time, punish by send back to previous level. If fail, have it repeat. If fail twice, roll two level backs.
6. ANALYSIS

In this section, the empirical result is analyzed with relevant literature study. According to the previous description, the challenges that the teachers faced in design and implement work-integrated e-learning course can be concluded as from three dimensions: Content, Pedagogy and Technology, which are the key factors in the TPACK model. The content knowledge analysis focuses on the practical and management oriented courses. The pedagogy knowledge mainly consists of work-integrated learning and collaborative learning. The technology knowledge is analyzed from the aspects of online education and the information communication technology. In addition, the information from the interview is also cited to enhance the description.

6.1 Technological Pedagogical and Content Knowledge (TPACK)

The Technological Pedagogical and Content Knowledge (TPACK) model is raised by Mishra and Koehler (2006). This model is emphasizes on the complex interplay of the technology, pedagogy and content knowledge. In this section, the main division of analysis is based on the TPACK model. Additionally, as the research is focuses on the teachers’ perspective, the requirement of teacher’s competence is more emphasized in the analysis. The relationship between TPACK and other theories are categorized at Table1.

<table>
<thead>
<tr>
<th>TPACK</th>
<th>Theory research</th>
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<tbody>
<tr>
<td>Content knowledge (CK)</td>
<td>Production technology education</td>
</tr>
<tr>
<td>Pedagogy knowledge (PK)</td>
<td>Traditional teaching; workplace knowledge; community of practice</td>
</tr>
<tr>
<td>Technology knowledge (TK)</td>
<td>Software, ICT tools</td>
</tr>
<tr>
<td>Technological content knowledge (TCK)</td>
<td>Online education</td>
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<tr>
<td>Pedagogical content knowledge (PCK)</td>
<td>Work-integrated learning (WIL)</td>
</tr>
<tr>
<td>Technological pedagogy knowledge (TPK)</td>
<td>Collaborative learning/communication</td>
</tr>
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</table>

Figure4 shows the TPACK framework, the relevant theories are categorized into the three components: TCK, PCK and TPK. The online education can be regarded as a combination of teaching with technology (TCK). The work-integrated learning is teaching with new pedagogy approach (PCK). The communication and collaboration with information technology is teaching in new pedagogy approach with technology (TPK).
Besides the listed six components (table.1), the research issue – work-integrated e-learning can be seen as an example of TPACK. It is a combination of three elements: content, pedagogy and technology. TPACK is at the core of the above framework. Therefore, it takes all the features of the other six components. Through the complex interaction, TPACK is on the most advanced level, and it has the highest requirement for teachers. In similarity to the competencies of online teachers collected by Baran, et al. (2011), the roles of teachers who work with TPACK are identified comprised pedagogical, facilitator, instructional designer, social, managerial, and technical roles. Moreover, the teachers’ competences are evaluated by four factors: design, exertion, ethics and proficiency (Kabakci Yurdakul & Coklar, 2013). Firstly, the teacher should be able to design suitable course content for work-integrated e-learning. Secondly, they should be proficient at operating online education. Thirdly, they should conduct the work-integrated learning appropriate to the ethical rules and consider the ethics of the teaching profession in the workplace environments. Finally, they should exert the collaboration to improve the effectiveness of work-integrated e-learning.

The following analysis is in accordance with the manufacturing education (CK), online education (TCK), work-integrated learning (PCK), and collaboration (TPK). Nevertheless, the followed suggestion is from a more comprehensive consideration of TPACK.

### 6.2 Production technology education (CK)

Content knowledge (CK) is knowledge about the actual subject matter that is to be learned or taught (Koehler & Mishra, 2006). In the current production technology education, both practice and social management are important content knowledge for engineering student to learn well. In MERIT project, according to the customer need, the theory study module, practice module and the social management module could be ordered and tailored in different courses.

For the practical course, the content knowledge is more related to the traditional engineering knowledge. Similarly with the opinion of “engineering way of thinking” described by Jawahir, et al. (2013), the product and process designs, functional design development, materials and process selection are the major content in engineering teaching (Godfrey & Parker, 2010). From the empirical result showed in section 5.2, we can see that the courses are formed by exercise, lab, project work, solution for problem solving in programming, etc. They are tradition and common in
manufacturing education. Resemble with the research from Bourne, et al. (2005), the mathematical science and hands-on practice is the core and the most important content of engineering teaching. However, in the practical course, “one way to solve the problem is not good for the next student, if you force two students to work together, you will kill one of them.” (Teacher A) From this perspective, we could conclude that the learning process in practical course needs to be individual and rigorous to a large extent. It will raise a high demand for technology and assessment approach in work-integrated e-learning.

While for the social management oriented course, it is emphasis on training capabilities of flexibility, interaction, professional realities, etc. (Walther, et al. 2011). Same as the research of Bourne, et al. (2005), my interview data in section 5.2 also shows that this type of courses need more group discussion, seminar, and more interaction among teacher and students. For the social management courses, project work with case study might be an effective approach to operate with. In the work-integrated e-learning course, most of the participants should have a background of engineering theory study and practice experience. As Shuman, et al. (2005) discussed that what they actually need more are knowledge and skills related to social and management, e.g. good communication ability, functioning on multidisciplinary teams, understanding professional and ethical responsibilities, and a recognition of the need for and the ability to engage in lifelong learning. According to Litzinger, et al. (2011), in order to make the students build rich and interconnected knowledge, the teachers should connect the content with social management practice in a well-arranged teaching planning. Whereas, consider about the ethical problems, there should also have some rules or limitations in the content discussion and project work, as the participants are all work at their own companies. Therefore, the teachers in this kind of course should additionally act as guidance and supervision except traditional lecture.

6.3 Online education/e-Learning (TCK)

Technological content knowledge (TCK) is knowledge about the manner in which technology and content are reciprocally related (Koehler & Mishra, 2006). E-Learning is to conduct learning in online environment.

From my interview, the teacher describe their experience as the learning with technology has progressed from video conference/distance learning to advanced ICT and online media learning. With the development of internet and smart phone, the e-learning is gradually been implemented with work-integrated learning. This kind of convenient and flexible way of learning could provide an opportunity for employees to access in-service training in their busy work life. Furthermore, same as Gibson, et al. (2004) presented that, the online education could also help the employees build confidence and maturity, and increase motivation to learn. However, in manufacturing education field, it can seldom find work-integrated learning teaching material online so far, so it is a completely new area to develop.

The digital tool (TK) in teaching is widely known as educational multimedia. It uses different media such as text, graphics, animation, video, and sound, to present information online. Multimedia software can be a powerful tool in enhancing learning by helping learners to construct their own knowledge (Kaufman, et al., 2009). However, from the teachers’ perspective, to make videos will be time consuming, and it even cost more for a new comer to learn the technology.

For the virtual labs, it requires high quality graphics and need high budget. In MERIT project, the virtual lab is not demanded at the current situation.

The course content given in online environment is highly demanded for good structure, well planning, attractive enough and high interaction. Today’s online education is more focus on
constructivist, collaborative, student-centered pedagogy, and global scale (Hiltz & Turoff, 2005). In work-integrated learning, the interaction with media and learner’s reflection is more emphasized than traditional course. Similarly with the opinion clarified by Violante and Vezzetti (2012), the online course content should be attractive and useful with examples, case studies, short exercises; the course plan and assignment requirements should be clear and well clarified; the content should be reasonable and avoid excess; more video and graphic might improve interactivity; the schedule should be well planned.

Moreover, for the review work, weekly PowerPoint or video summary will benefit for both teacher and participants. Preparation work for next learning section is also very important. However, there are many challenges for teachers to design course content for work-integrated e-learning. It is difficult to implement engineering course in online environment as it is vibrant, highly distributed, and fragmented; close associated with professional practice; and unique compare to normal science learning (Johri & Olds, 2011). Also it is hard to catch workplace knowledge exactly and give suitable knowledge in the right way. According to the interview, the teachers’ perspective is that the course content should be limited due to different scale of participants. It is to ensure the teaching quality and effectiveness.

For the assessment in work-integrated e-learning, it should be customized depending on what the user/company need. The principles to judge online education are: learning effectiveness, student satisfaction, faculty satisfaction, cost effectiveness, and access (Lorenzo & Moore, 2002). In work-integrated e-learning, to keep the learning effectiveness and the students’ satisfaction, the students’ background of knowledge and work experience should be adequately considered about. For manufacturing education, examination is a very important and indispensable part for student. Therefore, the assessment is a big challenge for teacher in this online course. To operate examinations, we could know from the interview that, for engineering teachers in work-integrated e-learning, synchronous communication and multiple choice questions might work for online examinations.

However, the basic requirement for participant is they should be motivated to attend learning. As Biggs (1999) described that what each student gains from learning depends on their motives and intentions (Erin, et al., 2004). Therefore, it is very important for the participants, to keep interesting and motivation to attend learning. In addition, the students’ motivation measurement should be a part of the course assessment. While another issue from the teacher’s perspective, for use the technology, the complex function and annoying way of examination should be avoided.

### 6.4 Work-Integrated Learning (PCK)

Pedagogical content knowledge (PCK) includes knowing what teaching approaches fit the content. It is concerned with the representation and formulation of concepts, pedagogical techniques, knowledge of what makes concepts difficult or easy to learn, knowledge of students’ prior knowledge, and theories of epistemology (Koehler & Mishra, 2006). In work-integrated learning, the combination of collaboration with workplace environment and situated learning is a kind of PCK. As work-integrated learning should contain both classroom knowledge – basic theory, and workplace knowledge – practices, the courses should able to be tailored into different course modules and formulated according to various customer need.

Today’s workplace knowledge is not only restricted in profession anymore. It is more emphasis on social and cooperative perspective. The work-integrated learning course could provide a suitable environment for employees to participate in learning during their work time. The knowledge in work-integrated learning courses are aim to improve worker’s ability for solving problems in current situation. Similar as Mills (2011) described, work-integrated learning should
be understood as situated in a complex web of social organization, and the learner could get situated knowledge from the community of practice.

“Wherever you are working in the manufacturing industry, depend on the position you have, you might need to negotiate with other departments, with new company. Maybe you need to buy new equipment, so you need to look at what is the best, where should you buy from and how will you negotiate with them. I mean you could use the knowledge in many ways. I think it is useful for the engineer to get the idea how negotiation works, what principles there are, what technique there are, how people think, how you could get agreement with people, etc. It will give a way of how you do it the best. So I think it’s very useful in many ways.” — Teacher D

Follow the research of Johri and Olds (2011), the three aspects of situated learning also can be regarded as content requirements of work-integrated learning are: social and material context, activities and interactions, participation and identity. Firstly, as engineering education is one of the most material-saturated disciplines, it has a high demand of technology and cooperation, the social and material context is very important. Secondly, to engage in social activity and improve the interactivity is essential for manufacturing study. Finally, the motivation to participate in learning and reflect on self-identity is the core value of work-integrated learning.

“I think they will be here, they need this in their work, they want to take the course so they will improve their work and develop, and they actually want to participate.” — Teacher D

In my interview findings, from the teachers’ perspective, it is necessary to get more input from the cooperative company as for design qualified teaching content. Moreover, the project work and assessment also need company’s cooperation. The cooperative company should provide their requirements and expectation.

“For this type of work-integrated learning when the company is actually bought from us, I think they should have a very clear goal/vision, what they should do with this knowledge, what they want to achieve by educating their staff.” — Teacher C

Considering workers who are experienced but lack theory in some specific areas, such as communication, negotiation, etc., the teachers could give project works to bring out their tacit knowledge in the practice.

“We can see their tacit knowledge as a hook. You can just give knowledge as hook something to it. I just bring their tacit knowledge forward so they see and organized that, because they all have the work experience already. Then it is important to know what they want to achieve, what knowledge do they have, and how should I capitalize on that.” — Teacher C

The pedagogical knowledge (PK) refers to deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values, and aims (Koehler & Mishra, 2006). Work-integrated learning could be seen as a new pedagogy approach which is more flexible and purposeful compare to traditional way. It is more like to constitute environments in which knowing and learning are co-constructed through ongoing and reciprocal processes (Billet, 2001). This kind of course should make connection between workplace experience and learning content, as to develop new work-integrated learning knowledge and improve the employees’ work competence. Based on the research of Trede (2012), in work-integrated learning education, non-conscious learning and tacit knowledge needs to be made explicit through collective reflective dialogues in order to share practice knowledge and develop expertise.
For the course content design, “it is depending on us that not only presenting the theory, we try to base it on their own, what is their own situation in their own company, and based on that, we go through with theory to discuss that.” – Teacher B

Also from the companies’ perspective, “if we have people come from different companies, especially different type of companies, they can learn from each other. E.g. the car company they think one way to do it and the house company might think totally other way of automation. So you can see the knowledge transfer between different manufacturing areas.” – Teacher B

However, the work-integrated learning also raises more requirements for teachers. According to the interview, the teacher is supposed to well plan and clearly clarify the course content, schedule, deadline for hand-in assignment and exam. As it is difficult for teachers to design suitable course content, the cooperated company and participants should provide their background, requirement and demand in detail. Furthermore, the participants should also be motivated to achieve the cooperation and interactivity.

“Based on our experience when we go to people work in industry, if they not have studied for couple of years, it’s not easy for them to just take a book and start to read. When you have worked for some years, then it’s hard to come up and do that.” – Teacher B

“This is a new target group, which will have other requirement than usual requirements. And it’s hard to find a book in teaching this.” – Teacher A

As a result, the teacher should be careful and pay more attention to this kind of work-integrated e-learning course.

### 6.5 Collaboration/Community of Practice (TPK)

Technological pedagogical knowledge (TPK) is knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies (Koehler & Mishra, 2006). In work-integrated e-learning, the collaborative learning and community of practice are the important concepts belong to TPK.

As teacher D described, “As they choose to participate and they have jobs, they always have something in common. If the students started to communicate, and build network, it could be very useful for teaching,”

– Teacher D

The communication tool (TK) can be categorized as synchronous and asynchronous. Synchronous technology include live webcasting and chat rooms, are used as live face-to-face teaching strategies such as delivering lectures, seminars; while asynchronous communication tools (e.g., threaded discussion boards, newsgroups) allowing users to contribute at their convenience, provide a flexible approach for users (Zhu, 2010). In manufacturing teaching, the synchronous communication is highly required. However, to communicate with numbers of students and have group discussion, the synchronous technology could not support the activity in the current situation. The information safety and teaching efficiency also need to be considered about. Moreover, the quality of technology will affect the communication efficiency. As it is hard to deal with these difficulties, some rules should be carried out.

The collaborative learning (PK) is a new pedagogy approach. In this work-integrated learning course, the teacher-learner and the learner-learner interaction is very important to consider in developing the courses (Naaji, et al., 2013). The cooperation between teachers and students, and
the communication among students from different company, position or profession can both be seen as community of practice.

Following the concept raise by Wenger (1998), for students’ community of practice, their similar background and common ambition can motivate the mutual engagement. The students’ individual work experience and social knowledge can increase the negotiation of joint enterprise. And the knowledge transfer among different experiences and subjects is the shared repertoire. Learning becomes embedded within a social context, social membership, identity, and knowledge are mutually dependent (Mills, 2011). From the teacher’s perspective, their roles have move from being at the center of the interaction or the source of information to the ‘guide on the side’ (Anderson, et al., 2001; Berge, 2009). It is very important for the engineering teachers to understand the landscape of practice, recognize the challenges, and create curricular resources and constructing new knowledge (Capobianco, et al., 2006). Furthermore, similar to the perspective of Lawton, et al. (2012), the community of practice could be seen as informal activity which is required in engineering workplace education.

The collaborative learning among students is an important component of work-integrated e-learning. By contrast with traditional education, in work-integrated e-learning, similar to the idea presented by Anderson, et al. (2001) and Berge (2009), the learners be responsible for their learning by coordinating and regulating their learning activities.

7. TEACHING GUIDELINE

The outcome of this thesis work provides a teaching guideline for teachers to plan and implement work-integrated e-learning with a major in the production technology field. Although the course content mainly focuses on engineering education, the provided suggestions are general for the pedagogy in work-integrated e-learning. The following are suggestions and analysis that will guide teachers’ preparation in work-integrated e-learning courses with a major in the engineering education field.

7.1 Production technology education (CK)

Engineering practical/theoretical courses (e.g. Automation, Machining):

a) Normal lecture is less in demand for participants with engineering background. For people without engineering background, the teaching content should be straightforward and simplified for the participants to learn the engineering knowledge in a short time.

b) Project work and seminar is necessary as the practice-based situated learning is important and effective in both engineering education and work-integrated learning.

c) The examination could be customized according to different pedagogical requirements. In general, the online exam with multiple choice questions, hand-in project report and synchronous communication are the common ways of assessment.

Management oriented courses (e.g. Operations Management):

a) Normal lecture is required to be carried interactively. Presentation with interesting videos, synchronous communication in online classroom, and real case study are suggested approaches.
b) Project work and seminar is necessary for work-integrated learning. The situated experience learned from project-based case study and the communication ability gained during the process of collaborative learning are the validated knowledge for workers in manufacturing industry.

c) The examination can be carried with phased assignments, project report, online seminar and reflection of self-identification. The process of exam is actually a useful method to do knowledge recognition.

### 7.2 Online education/e-Learning (TCK)

a) In work-integrated e-learning, the teacher should design the course content essential and easily accessible. Excess works and difficult operations should be avoided.

b) The course content, teaching material and pedagogy approach should be tailored according to the target group.

c) In running the e-learning, for improve the work efficiency, to invite technique assistant or have guidance for teacher to do preparation, even repackage former teaching material can save time and cost. Whereas, one thing should be avoided is long film with no interactive content, the video should be lively and attractive.

d) Flexibility and accessibility are key factors to carry on the work-integrated e-learning course.

The suggestion for technology is provided in the section 7.5.

### 7.3 Work-Integrated Learning (PCK)

The theory work-integrated learning has requirements both from the participants and educator.

a) For the participants (employees in companies), they should have some degree of work experience and workplace knowledge; high motivation to join in the course.

b) The company should have a clear goal for the education purpose; provide more input and define the focused section.

c) For the educators, they should design the suitable course content according to the requirement from different customers; provide knowledge from broad field; enhance the students’ basic (tacit) knowledge and strengthen new knowledge; know the participants’ knowledge background, and give optimal course content; provide flexible way of teaching; and take the examination in a suitable way.

d) The review work is also very important in online teaching. The teacher could make films or give tips to remind the course content; or give home task for next meeting; make weekly summarize in PowerPoint, and upload/shared. It is of benefit for the educator themselves, but will cost more time.

The teacher should design the work-integrated learning course content according to different students:

a) One kind of students who have already known the background theory. They are in practice and full of work experience. What they need is the social competence (e.g. negotiation,
communication) and creativity (it can be said a new way to look upon things). So they could have the social/management oriented course to help with solving their problems.

b) Another kind of students is those who are totally new to the engineering background, but are expected to have the practical oriented engineering knowledge for work requirements. For this kind of students, they could join in the theoretical/practical oriented course modules to have general lectures and study case based projects to acquire the engineering experience during a period of time.

c) Except these two kinds of target group, the other could be the community of practice. The above two are teacher-student collaboration. However, the student’s community of practice is more like to form a communication organization of employees from different work area or different company. Then the teacher acts as supervisor and coordinator. In this situation, work-integrated learning course is providing a platform for people from different background to learn and practice together as a community. The community of practice and situated learning are both important elements in work-integrated learning.

7.4 Collaboration/Community of Practice (TPK)

Teacher-student communication:

a) The collaborative learning between teacher and students is should run parallel and interactively in work-integrated e-learning courses.

b) There should have clear rules for online meetings and the usage of technology. The teachers should be more focused on interaction with students and stimulate their motivation and interest for work-integrated e-learning.

c) In addition, to keep the education efficiency, the preparation work should also emphasis on the information provided by company and participants, same as the analysis in work-integrated learning.

The students’ community of practice is widely accepted in work-integrated learning.

a) The students could share knowledge/experience among different companies/industry/business. Also students from different companies, different positions can build knowledge together, with the teacher’s support.

b) For students’ community of practice, teacher should give initiate and guidance for the topic and content in collaboration. But do not over regulating, leave sufficient space for students is the purport of community of practice.

c) However, it might requires specific rule of discussion content as they are work in different companies. For some course content, to have specific topics (given by teacher) to work with will increase the learning efficiency.

d) In addition, it should be notice that it is difficult to deal with large number of student/group work in real-time communication.

7.5 Technology guidance

Technology knowledge (TK) is knowledge about standard technologies, such as books, chalk and blackboard, and more advanced technologies, such as the Internet and digital video (Koehler &
Mishra, 2006). For work-integrated e-learning, the technology should be deeply interacted with workplace knowledge and collaboration.

Table 2 shows a list of technology guidance for teachers to do preparation work in work-integrated e-learning course.

**Table 2. Technology guidance**

<table>
<thead>
<tr>
<th>Activities</th>
<th>Functions</th>
<th>Tools (example)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material (content) making/preparation</td>
<td>Text</td>
<td>Word; WPS; PowerPoints; PDF; Blog; Webpage; CloudBoard.</td>
</tr>
<tr>
<td></td>
<td>Graphics</td>
<td>Photoshop; CorelDraw; Adobe Illustrator; AutoCAD; 3Dmax.</td>
</tr>
<tr>
<td></td>
<td>Labs</td>
<td>Virtual shop floor simulation; Virtual factory.</td>
</tr>
<tr>
<td>Video making /Acting or Screen record</td>
<td></td>
<td>Movie Maker; Adobe Premiere; Camtasia studio; Ezvid; Virtual dub.</td>
</tr>
<tr>
<td>Communication</td>
<td>Synchronous/online meeting</td>
<td>Lync; Skype; TeamViewer; Adobe Connect; smart phone.</td>
</tr>
<tr>
<td></td>
<td>Asynchronous/discuss forum</td>
<td>Internet forum; Message board; Wikipedia.</td>
</tr>
<tr>
<td>Assessment online</td>
<td>Live seminar</td>
<td>Lync; Skype; Adobe Connect; TeamViewer.</td>
</tr>
<tr>
<td></td>
<td>Report hand-in</td>
<td>DisCo (hand-in function); Mofile.</td>
</tr>
<tr>
<td></td>
<td>Online exam (question)</td>
<td>Classmarker; Quia; VirtualX; ProProfs; Google Docs.</td>
</tr>
</tbody>
</table>

### 7.5.1 Teaching material

Text is the most traditional way to show information in online education. The information on the Internet could be shown in webpage, blog or homepage. The common software to produce text file are Word, PowerPoints and PDF. In the project that I researched with, the technicists is going to develop a new function called CloudBoard. It is an online “white board” that is initially empty, and then cast continuously with images, videos, sound files and other learning resources by pulling them into the browser window. Same as the traditional white board, the teacher can edit the texts together and draw figures. This is done in a browser, and lives together with others. By ensuring that all activities are stored in a history function that enables the users to “rewind” CloudBoard and see and recreate older material and audiovisual discussions within each course. This is a creation that supposed to be continuously developed with the MERIT project.

Graphics is a very important factor to increase the interactivity in online education. For the engineering teaching, high quality image and 3D model is required generally. The AutoCAD, Photoshop, Adobe Illustrator, CorelDraw and 3Dmax are the common software to produce graphics. Photoshop is a common image making software. It is good at bitmap processing, graphic design and image processing. Adobe Illustrator mainly works as design graphics. It is strong at vector drawing. CorelDraw is used as vector drawing, layout design and typesetting. For the new technology, PDF with 3D image could be a good choice for engineering education.
Lab is hard to realize for small or middle courses. It has a high demand of time and budget. For engineering education, virtual shop floor simulation and virtual factory are the general type of virtual labs. For the Swedish industry, as Sweden has many good game companies, to cooperate with these companies might increase the creativity and image quality of the virtual labs.

Video making is general in online education. The common tool has Movie Maker, Adobe Premiere, Camtasia studio, Ezvid, and Virtual dub. However, to make short films or video clips with clear information and interactivity are the important requirements for work-integrated e-learning education. Furthermore, long and boring video content must be avoided. If a video last for hours with only a man stand in front, speak slowly and not bring any interaction, it will make the student asleep and lose interest. Therefore, the film should be more lively, creative and interactive with students.

### 7.5.2 Communication

The communication is very important for work-integrated e-learning. The communication tool needs long time to investigate, choose, test, and try. Synchronous communication is highly demanded for engineering education. The common tools are Lync, Skype, TeamViewer, Adobe Connect, and smart phone. From the experience of my respondents, Lync is the best choice.

In online communication, the teacher should be more interactive with students, and stimulate the participants’ motivation and interesting for study. And for some problem solution course content, asynchronous is hard to deal with that kind of teaching, so the communication should be synchronous. Moreover, it should be noted that the number of students must be limited in real-time group communication. The quality of Internet is also very important, which might influence the teaching effectiveness. In addition, it should be notice that there are some extra problems with information safety and firewalls, IT department, etc.

Asynchronous communication is usually carried with Internet forum, Message board, Wikipedia. It is easy and flexible to deliver information in e-learning. But it should be noted that, as to keep the participants’ enthusiasm and quality of teaching, the teacher should encourage the participation of online discussion, give initial topic and supervise during the discussion process. In addition, the discussion online could also be a way to assess students as they provide their knowledge by this asynchronous communication.

### 7.5.3 Assessment

Hand-in report is common for assessment in e-learning. Mofile and file transfer in learning system are general tool to get hand-in files. As to keep the teaching effectiveness, clear deadline for report hand-in must be defined and executed.

Online exam is the most commonly used in online education. The Classmarker, Quia, VirtualX, ProProfs, and Google Docs could be used to carry online examination. However, to ensure the exam quality, the content of questions and time schedule must be well planned.
8. DISCUSSION

8.1 General study

As the background of this thesis research is work-integrated e-learning major focus on manufacturing education, the relevant literature research is around engineering education, work-integrated learning, online education, collaborative learning and the TPACK model. The data collection is done by interview five teachers who with different background and experience in MERIT project which the research work is based on. Through data analysis with theories, the formulated question is answered by provide a teaching guideline to help teachers overcome the challenges when running work-integrated e-learning courses.

The first focused point in the research is the content knowledge of manufacturing education. To train to “engineering way of thinking”, Godfrey and Parker (2010) described that the engineering course always emphasis on product design or problem solving solution in a traditional way. However, when facing the increasing requirements for workplace knowledge and social management skills, the engineering knowledge in work-integrated e-learning should also aim to develop the good communication ability, understanding professional and ethical responsibilities, and increase the situated learning competence (Shuman, et al., 2005). However, these characters might bring many challenges for teachers to work in this kind of courses. The traditional engineering way of thinking and the social oriented management competence should both been involved to develop the work-integrated e-learning courses. It can be said that the work-integrated e-learning is more sensitive and high-demanding compare to the traditional classroom education. The teachers should pay more attention and enthusiasm in this kind of courses.

The second focused point is the pedagogy knowledge of work-integrated e-learning and collaboration. As the participants in work-integrated e-learning course are more mature and experienced in workplace, they are more autonomous but busy with work. Therefore, work-integrated learning could provide the employees the opportunity to enrich both generic and discipline specific skills, relevant to professional practice. Through this kind of education, the participants could build confidence and maturity, and increase motivation to learn (Gibson, et al., 2004). Except regular classes in schedule, nonbinding and informal communication can be useful and efficient for them to learn together and produce solution for solving work problems. As the aim of workplace learning is to understand learning as situated in a complex web of social organization (Johri & Olds, 2011), the social network can also provide a platform for employees to study together. In the work-integrated learning, teacher should act a role as supervisor and coordinator in the community of practice. Then the challenges for teachers concern how they have to well organize the collaboration, how to raise participants’ motivation, and how to ensure learning quality. Furthermore, as the engineer is generally short of self-identification ability (Anderson, et al., 2010), the community of practice could provide more consideration from societal and ethical. It can be concluded that, in order to design a suitable teaching content and keep the project going on, the suitable pedagogy approach is a key factor.

The last focused aspect is the technology. The technology challenges for teachers can be separated into online teaching material making and online communication tool selection. One important factor to ensure the teaching quality is the teaching material. In response to calls for change in manufacturing industry, the curriculum design should encourage the students to make linkages and connections across courses to build rich, interconnected knowledge (Litzinger, et al., 2011). Therefore, in order to make suitable teaching content and enhance the interactivity in online environment should be more emphasized on in work-integrated e-learning courses. Moreover, the communication quality and the form of community are always uncertainties that
affect participants’ interest and enthusiasm. From the literature research we can see that, the various formats of learning content, the time management and personal organization skills (Tomei, 2010), the multimedia resources, the teacher-learner and the learner-learner interaction, the presentation/delivery mode (Naaji, et al., 2013) could all affect the development of online courses. As a result, to arrange proper number of participants in online communication group, and carry on the community of practice with valuable information transfer should be more emphasized as to enhance the work-integrated e-learning run on the right track.

8.2 Challenges

The above three aspects are the main factors that affect work-integrated e-learning. However, during my interview with MERIT project members, I found that the most difficult for the teachers are to grasp exactly what the customers are demanding. Certainly to make new teaching material will take a lot of time, and to gain good quality technology will cost a lot. Nevertheless, the pedagogy knowledge which could be suitable for the requirements coming from companies are nevertheless changing every day, it’s dynamic. The cost on content and technology will be reused within some years, but the development of manufacturing industry and the workplace knowledge is hard to remain in duration. It means that the input in pedagogy will last for a long time. This is one reason that the pedagogy becomes the most difficult work. Another problem aspect of pedagogy knowledge is people come from different company might have different background, experience, and even different demand of knowledge. With the idea of mixed subjects in community of practice and the work-integrated learning, to deal with that problem is a hard issue. It will influence the cost of teacher’s work and time, and the validity of the courses.

For the collaborative learning, a new idea received from the interview is the teacher-student oriented collaboration should be two-way. From the traditional aspect, the teachers deliver knowledge to students, guide their exercise, and examine their assignment. The communication is one-way and carried as superior to lower. In high-level course, the communication is discussions at equal. However, regarding the communication in work-integrated e-learning course, the teachers will also get knowledge from the students, as the students are all experienced at the workplace. They have more current real work experience than teachers. Under this circumstance, the student – teacher communication is also a good pathway for teacher to get up to date information from the current industry. This collaborative learning is actually interactant. But the limitation of work content with different companies/business should be pay attention to. The collaborative learning also provides an opportunity for teachers to learn from industry. Moreover, the engineers come from different professional field, different educational background and different work experience. In fact, they have more common and interest points to discuss and exchange. As they are in the same status as student, their communication is totally free and equal. With the popularity of communication technology, the collaboration is increasingly facilitated and mature. In work-integrated e-learning, the community of practice is an indispensable pedagogy approach that helps knowledge transfer among students.

Except the pedagogy aspect, I also provide a general list of technology guidance in the teaching guideline section. It is because through the interview and relevant literature research, I found that there is no such general technology guidance for the current work-integrated e-learning education for production technology. Although the engineering teacher all have general level of using educational technology tools, when regarding the work-integrated e-learning course modules, the teachers are still unfamiliar with that type of functions and techniques. However, as the information technology developed continuously, to do intensive study on educational technology is not the focus of this research. But a general teaching technology could help teacher with their preparation work to some extent. The specific function and tool will be decided according to different course content and requirement from the customers. To solve the technology problem
in an efficient way, a good IT support from university or cooperated organization is very important. That is also a part of the collaboration in work-integrated e-learning.

To think deeply, the teaching content – engineering, the pedagogy – work-integrated learning and collaboration, the technology – e-learning and online communication are all developing with the step of social development. The progression of society influences people’s work and life in increasingly varied ways, so becomes the pedagogy and the technology. It can be seen that more and more pedagogy approaches and technology will emerge. The work-integrated e-learning will keep on developing in the future.

8.3 The other considerations

The following discussions will focus on teacher’s competence, and creativity aspects, also the negative aspect of work-integrated e-learning.

In any course, there will be different kind of teachers with different background and specialized in different directions of teaching. In the work-integrated e-learning course, some of the teachers have close cooperation with companies during their work. They could catch the customers’ requirements brilliantly and organize good communication with companies. While another type of teacher is good at “traditional teaching” and doing experiment. They are more active in research theory, course content, technology, etc. For this competence management problem, it is important to arrange the division of work for the project manager and coordinator. To measure and fully use each one’s ability is also an indispensable factor for a successful project.

For the creativity, some teachers are full of enthusiasm in their work, and provide a lot of interesting and meaningful suggestion for the project development. But due to the limitation of time and expenditure, some creative idea cannot be realized in a short time. That is a pity, and also is an acceptable reason that gives up the creation. For this problem, one approach could be transforming the creativity into case study or virtual experiment, and deliver the idea to the student. As the idea and creation are actually derived from the teachers’ teaching experience and theory basis, this is a kind of informal knowledge. However, the informal communication and knowledge transfer is an important approach for the student to get useful knowledge in work-integrated learning. This kind of activity can be regarded as a fun, and as an inspiration. Just like a big invention always begin from a ridiculous idea. If the time is sufficient, to add some creativity in the work-integrated learning course could be effective. Another aspect that I want to discuss is the pedagogy approach of work-integrated learning is not very special and different from the traditional one. Similar as the basic education, the teaching and learning knowledge will take amounts of time and effort, that’s inescapable. At most of times, simple method will make things going better and efficient. Generally, in the work-integrated learning level of study, learning should not be a pressure and task of work. This learning platform should be a part of the work and the social activity, common and meaningful.

However, there is also a negative aspect of the work-integrated e-learning course. If the situation of the project is changed for the purpose of business, it’s hard to achieve nowadays. Firstly, high devoted and demanded employee training always exists in famous enterprises around the world. They always search for suitable cooperative organization according to their need, develop their own courses and rarely share knowledge with similar/competitive companies. Secondly, up to the current state of technology, to build virtual lab in engineering will be expensive. It’s hard to afford for small or middle size organization. Nevertheless, the lab is necessary for the engineering education. To some extent, the work-integrated e-learning in MERIT project is incomplete. MERIT is a research project that belongs to the University. It has many precondition and constraint. In addition, the current cooperated organizations are not heavily investing in
employees’ education and training. The focus of MERIT is collaboration and communication, the skill practice is mainly missing, it leads the incomplete of work-integrated e-learning in this project. Actually, the theory and target of work-integrated e-learning are contradicted to some extent. It requires high contribution from both company and university, and the best collaboration is among participants from different companies or different work areas. It’s hard to be just suitable from the ethical consideration. As a result, in the current development of work-integrated e-learning, there are also negative and controversial aspect among the positives and advantages.

9. CONCLUSION

With the development of education and technology, the work-integrated e-learning is gradually popularized. This thesis work is a qualitative research with interviews and theory analysis mainly focusing on the engineering education. The research aims to investigate the challenges for teachers when design and implement work-integrated e-learning courses. Though work with the MERIT project, studies relevant literatures, interviews the project team members, and the analysis with collected data, a teaching guideline is designed as the outcome of research work.

The challenges for teachers are from three aspects: teaching content, pedagogy approach and online technology. The challenge of teaching content is that the knowledge should be specific to workplace requirements. The content knowledge could be separated into practical oriented and social management oriented knowledge in engineering courses. The practical knowledge is the traditional teaching content in engineering field. It requires amounts of lectures, projects and hand-on practices to train the programming and problem solving ability. While for the management oriented course content, lectures and project works should be more interactive, and with more emphasis on communication. As this kind of course is conducted at advanced level, traditional one-way teaching is inefficient for work-integrated e-learning. The learning material should be essential and easy to connect with workplace knowledge, as the basis of work-integrated learning is aim at improving students’ competence of solving problems in their work. Moreover, the teaching content should be carried with advanced pedagogical approach.

The challenge of pedagogical aspects is how to use the right approach to operate different course content and different type of communication. The pedagogical knowledge includes work-integrated learning, e-learning and collaborative learning. The workplace knowledge, situated learning, self-identification, communication and community of practice are key elements to present the work-integrated learning pedagogy. In a work-integrated learning course, the pedagogical approach should be combined with relevant content knowledge. Except the traditional way of teaching, the most different pedagogy approach in work-integrated e-learning is its emphasis on communication and collaboration. The collaboration could be both teacher-student oriented, and students’ community of practice. As the participants are adults work in the society, they have mature experience and knowledge. The teacher could receive more valuable feedbacks and information about industries from them. It is a good way to benefit the educators. The students’ community of practice is more like to build a network among the participants. In this network, mutual engagement, knowledge transfer, and new idea creation could improve the learning initiative and efficacy. However, the most important factor of pedagogical approach is to use suitable methods to teach useful knowledge to the people who really need it. That’s the ideal state of the best pedagogy approach. Furthermore, this pedagogy approach will also deal with technology problems in work-integrated e-learning.

The challenge of technology is mainly from teaching material making and online communication. The technology knowledge contains material making, video making, online communication and
online assessment. To make new teaching material online will be time consuming. The course information should be clear clarified and the learning material (files and videos) should be interactive and attractive. The online communication could be synchronous like online meeting and asynchronous like chat-forum. If the pedagogy is emphasis on community of practice, the online talking in forum could be a part of assessment. While the other assessment methods could be online seminar, hand-in project report, etc.

From a societal consideration, the teachers are facing competitions as well as the developing engineering industry. To improve the competence management ability is increasingly required by educators. This research analysis is expected to help understanding the behaviors and opinions from the online teachers’ perspective. Furthermore, the teaching guideline is hopefully can help teachers with the preparation work in work-integrated e-learning courses.

In conclusion, through interviews and relevant theories research, the thesis outcome provides a teaching guideline for teachers in work-integrated e-learning to do preparation before new work start. The guideline is designed mainly focus on the aspects of manufacturing knowledge content, work-integrated e-learning, collaborative learning and the technology support. Besides the general perspectives regarding traditional engineering education and online learning, the guideline is more emphasize on new pedagogy approach in workplace learning, collaborative learning and the challenges of technology.

9.1 Further research

This thesis work is a design oriented qualitative research. A teaching guideline is presented as to support the teachers overcome the challenges in work-integrated e-learning. More supplement and improvement might be done in the future work.

One important aspect which the future work should pay attention to is the technology. As we can see from the analysis section, the technology is a big challenge for teachers to overcome. To learn new technique will cost a lot of time and money. While for some functions, e.g. synchronous communication, virtual labs, are restricted by the current technology as well. The project that I have researched with is developing work-integrated e-learning courses. Most of the course modules are supposed to be carried online. However, due to the limitation of technology, the participants can be separated in two types, learn at workplace and learn at home. For the intention of work-integrated learning, the e-learning should also be carried in workplace. But in the current situation, the communication technology in work environment is hard to reach the demanded quality. Especially for the synchronous communication, it has a high requirement of the Internet quality, the bandwidth. To keep a good teaching effect, the teachers and participants should use the same software or application, the voice has to be smoothly and the video image has to be clearly. Moreover, there are other problems, e.g. company’s firewalls, information security, which seriously restrict to the implementation of work-integrated e-learning. Owing to the various restrictions, some participants choose to take the work-integrated e-learning at home. Despite stay at home will improve some problems caused by technology, there might be other disturbances as home has much freedom compare to workplace or classroom. To sum up, the technology will be an important and determinant factor for work-integrated e-learning.

In the MERIT project, for increasing the interactivity of e-learning, a new application called CloudBoard is being developed (Nilsson, et al, 2011). The general description of the CloudBoard functions in the project planning report shows that, it aims to make the course participants and teachers/tutors: 1) be able to share information with each other, 2) linking into external services, documents/files of various formats, 3) provide feedback to the documents/files in the form of e.g. text or recorded audio file, 4) discuss issues that arise during the course, 5) be able to log
various activities that occur in the application. The CloudBoard is expected to be implemented in the future work.

With the project going on, more future research work will evaluate the TPACK guideline when teachers running the work-integrated e-learning courses. In addition, the advantages and inadequacy of the teaching model will be assessed during the implementation of the course modules in MERIT project.
Reference


Appendix

Interview question list for MERIT project

1. Background
   a. Focus field
      • What knowledge area/courses do you teach in, can you describe it?
   b. Traditional experience
      • What is your general teaching model/pedagogical approach for campus courses? (Do you have some specific workflow/habitual way of operation in teaching?)
   c. On-line teaching (distance learning) experience
      • What experience do you have in the online education area?
      • How can you use the experience in your former learning/teaching for guiding the work in the MERIT project?

2. E-learning technology
   a. Challenges with e-learning courses
      • What are the challenges for using the information technology/software when developing your course into online learning resource? (Why do you think them are difficult to operate with?)
      • What effect/function do you expect the digital technique to realize in your course?
   b. Course content (resource) development online
      • How will you design the course content? (Will it customized according to company's requirement or will you use former teaching material?)
      • What other online education resource will you use in your course content? (Kahn academy, MOOCs, etc. And why do you believe it will be helpful in your course?)
      • How will you digitize your course content? (Will you need support from others?)
      • What media will you use to make the course content? (And why you choose this type of tool to support this online education course?)
      • How will you digitize the laboratory sessions/virtual labs?
3. **Communication**

- How do you prefer to communicate with the participants in the online course? (Especially the students are high-educated engineers.)
- Do you prefer students have free discussions or more focus on specific topic discussions? (And why?)
- What ICT (Information Communication Technology) would you like to support the online discussions?

4. **Examination/Assessment**

- How would you like to examine and assess the participants in the online education? (And why do you think these principles are suitable in the online situation?)
- What advantages/perspectives in your examine principles do you like to illustrate or clarify?

5. **Work-Integrated E-Learning aspect**

As the target group in MERIT is high-educated engineer from manufacturing company, and the course is aim to improve their work ability:

- How would you like to estimate your course when facing this situation? (And what improvement you expected the participants to get from your course?)
- What preparation work/new skill will you do/learn as a course teacher in this project?
- What differences would you prefer to explain in detail as the course is differing from the tradition?

6. **Other difficulties**

- Are there other difficulties for you when designing the course? (such as Online teaching resource, communication, engineering lab, customer need ...)
- Are there any difficulties that you worried about in this online education system?