Journal of Research and Curriculum Development, Vol.12, Issue.2, July – December, 2022
ISSN: 2730-387X (Online) https://so03.tci-thaijo.org/index.php/jrcd/index

A Development of Training Model for Digital Industry Executives using Principles of Knowledge Management based on Engineering Knowledge to Enhance the Digital Competency for the Production Manager of the Industrial Factory

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Received: October 6, 2022
Revised: November 5, 2022
Accepted: November 15, 2022

Abstract: This research aimed to study digital competencies of industrial production managers, create and study the effectiveness index of the training model, use and study the use of the training model, and evaluate the effects of the use of the training model for digital performance of industrial production managers using knowledge engineering in order to promote digital competencies of industrial production managers. The research included 4 Step as follows. For Step 1, digital competency of industrial production managers was studied through documents, related research, and interviewing with experts, business owners, and industrial production managers. The data were collected through an interview. The data were then analyzed using content analysis. For Step 2, the effectiveness index of the training model was created and studied through documents, related research, the results obtained from Step 1, interviewing with the experts, and trying it out with the industrial production managers. It was conducted by using the appropriateness assessment form for the training model in the form of 5-point rating scale. The data then were analyzed using content analysis, mean, standard deviation, and analysis of the effectiveness index. For Step 3, the training model was used with industrial production managers. It was conducted with a digital competency assessment form of executives in the form of rubric score. The data were then analyzed using mean, standard deviation, t-test for dependent sample, and t-test for one sample. For Step 4, the use of the training model was assessed by asking the industrial production managers to complete a questionnaire after the training. It was assessment form for the appropriateness of the training model and the satisfaction assessment form for the training model in the form of 5-point rating scale. The data then were analyzed using mean and standard deviation. The findings are as follows:

1. Digital competencies of industrial production managers consisted of digital technology management competency, digital content management, digital knowledge management, and the evaluation and digital problem solving.

2. The training model included 3 steps: 1) pre-training stage consisting of preparation, defining digital problems, and exchanging knowledge, 2) training stage consisting of knowledge capture, knowledge analysis, and knowledge synthesis, and 3) post-training stage consisting of application of knowledge and monitoring and evaluating the use of knowledge in the form of training. The effectiveness index was .8875.

3. After using the training model, the industrial production managers had higher digital competencies than before the training and above the threshold of 80 percent with a statistically significant level of .01.

4. After the training, the industrial production managers thought that input, process, and output of the training model were most appropriate, and the satisfaction with the training model was at the highest level and above the threshold with a statistically significant level of .01.

Keywords: Knowledge Management, Knowledge Engineering, Digital Competency, Training Model, Production Manager

Introduction

The development of Thailand according to the First National Economic and Social Development Plan has resulted in the country's development in all dimensions in terms of the economy that Thailand is in the upper group of middle-income countries, the society that has improved the quality of life of people to escape from poor countries, and the environment that has an ecological diversity. The economic growth rate in 2017 was 3.9% which is below potential when compared to 6.0% per year over nearly 6 decades. This is mainly due to the slowdown in domestic investment and the global economic situations that have not fully recovered. Additionally, the economic structure of Thailand is not yet fully driven by innovation. The service and agricultural sectors have low levels of productivity. They lack technology to increase production efficiency. In addition, Thai workers still have quality and performance problems that are inconsistent with the needs of driving the country's

development to keep pace with the changes of the world, globalization, and the rapidly changing advances in science and technology, such as artificial intelligence technology, the Internet of Things, big data analysis, robots and drones, modern genetic technology, and financial technology. These technologies will be the main supporting factors that help the global economy and the Thai economy grow stronger and create more diversified trade and investment groups. Competition is expected to increase in productivity and diversification of products and services that meet new lifestyles (Announcement on National Strategy (B.E.2661 -2037), 2018, pp. 3-18).

Industry adaptation is necessary for gaining a competitive advantage. Organizations must have a good organizational knowledge management system so that they can learn and keep up with the changes in the intertwined conditions of the economy and the nation. Organizational knowledge management is therefore a tool that exists in the form of activities that enable interpersonal learning, working relationships, communication, and technology as a learning ecosystem of practitioners' community. It includes knowledge creation, storage, sharing and transfer of valuable knowledge, information, data, and valuable expertise, including deep understanding both within and across communities of individuals and organizations in order to support learning and work in organizations more effectively (Davenport & Prusak, 1998). Knowledge management in organizations requires an application of using a wide range of knowledge management tools. It depends on the goals and objectives of knowledge management, Knowledge Capture, Knowledge Engineering, Artificial Intelligence, Tacit Knowledge, and Explicit Knowledge in order to create new knowledge in a systematic and easily applicable way. The development of information systems for managers to make decisions and to solve problems using knowledge engineering processes requires Knowledge Analysis and Data Structuring: Common KADS, Knowledge Capture, Knowledge Analysis, Knowledge Synthesis, and Knowledge Utilization.

From the background and importance mentioned above, the researchers developed a training model for digital industry executives using principles of knowledge management based on engineering knowledge to enhance the digital competency for the production managers of the industrial factory in order to lead the knowledge management process and knowledge engineering to integrate in the process of creating a training model for executives in the industry. This will allow trainees to gain knowledge, self-development, practical skills, and changing attitudes to accept changes in the industrial sector. This enables industrial production managers to achieve digital competency and gain competitive advantages to develop Thailand towards sustainability further.

This research aimed to study 1) to study digital competency of industrial production managers, 2) to create and study the effectiveness index of the digital industry executive training model using principles of knowledge management based on engineering knowledge to enhance the digital competency for the industrial production managers., 3) to use and study the use of the digital industry executive training model using principles of knowledge management based on engineering knowledge to enhance the digital competency for the industrial production managers. and 4) to assess the effects of the use of the digital industry executive training model using principles of knowledge management based on engineering knowledge to enhance the digital competency for the industrial production managers.

Research methodology

The research methodology input 4 step as follows.

Step 1, Digital competency of industrial production managers was studied through documents and research related to the digital competency of industrial executives and interviewing experts, which was divided into 3 areas: 3 experts in industry management, 1 expert in digital competency development with experience in developing industry managers, and 1 experts in research and evaluation with experience in the development of industrial personnel as well as 20 business owners, executives, and industrial production managers who participated in the digital industry promotion project of the Digital Industry Development Division, Department of Industrial Promotion, Ministry of Industry. It was chosen by purposive sampling. The data were collected through an interview, and the interview data were analyzed using content analysis.

Step 2, The effectiveness index of the digital industry executive training model was created and studied by using principles of knowledge management based on knowledge engineering to enhance the digital competency for the industrial production managers through the study of relevant documents and research, including the results of the study in Step 1 and interviewing 5 experts, namely 3 experts in industry management, 1 expert in digital competency development, and 1 experts in research and assessment. It was conducted by using the appropriateness assessment form for the training model in the form of 5-point rating scale in which the content validity was between .80 – 1.00. The data were then analyzed using mean and standard deviation. The effectiveness index of the model was conducted with 15 industrial production managers, and the digital competency of the trainees was assessed, before and after training, with a digital competency assessment created by the researcher. After that, the data obtained were analyzed in order to find the effectiveness index.

Step 3, The digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers was used and studied. The experimental group was 15 industrial production managers participating in the digital industry promotion program of the Digital Industry Development Division, Department of Industrial Promotion, Ministry of Industry, for a period of 24 hours, namely content training of digital technology management (6 hours), digital content management (6 Hours), digital knowledge management (6 Hours), and digital assessment and problem solving (6 hours). Each content contained both theory and practice. Before and after the training, a digital competency assessment was conducted with a digital competency assessment form of executives in the form of rubric score in which the content validity was between .80 – 1.00, and the reliability of the rater was between .718 - .923. The data then were analyzed using mean, standard deviation, t-test for dependent sample, t-test for one sample, with criteria set at 80% or mean of 2.40 ($\mu = 2.40$).

Step 4, The use of the digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers was assessed by asking 15 industrial production managers who had been trained with the digital industry executive training model. They were asked to complete a questionnaire after the training regarding the appropriateness of the training model on input, process, and output, as well as satisfaction with the digital industry executive training model with an assessment form for the appropriateness of the training model and the satisfaction assessment form for the training model in the form of 5-

point rating scale in which the content validity was between .80 – 1.00. The data were then analyzed using mean, standard deviation.

Research results

1. The digital competency of industrial production managers consists of four competencies as follows:

1.1 Digital technology management consists of 1) browsing, searching, and filtering digital data and contents, 2) assessing digital data and contents, and 3) managing digital data and contents.

1.2 Digital content management consists of 1) the use of production software programs and applications, 2) increasing productivity with digital technology, 3) using and storing data on Cloud, and 4) digital programming, applications, and digital contents.

1.3 Digital knowledge management consists of 1) managing work and people through information system, 2) managing data in the production process, 3) accessing digital information system, and 4) disseminating and applying digital knowledge.

1.4 Digital problem assessment and solution consists of 1) solving technical problems of work that relate to digitalization, 2) identifying needs and technologies to address the solutions of digital problems, 3) using creative digital technology, and 4) analyzing and identifying gaps of digital problems.

2. The digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance the digital competency of industrial production managers was created with the aims of 1) developing and enhancing knowledge and digital skills of industrial production managers by using principles of knowledge management based on knowledge engineering, 2) improving attitudes to be ready for major digital transformations for the operation of industrial production managers, 3) applying the training model for digital industry executives to be used in the development of industrial production managers. The contents of the training consisted of 4 main topics: 1) technology management, 2) digital communication management, 3) digital knowledge management, 4) digital evaluation and problem solving (6 hours per topic, 24 hours in total). The process of the training model had 3 steps: 1) Before training, consisting of preparing, defining digital problems, and exchanging knowledge, 2) in the training, consisting of Knowledge Capture, Knowledge Analysis, and Knowledge Synthesis, and 3) after training, consisting of Knowledge Utilization and Knowledge Follow-up and Evaluation. The digital industry executive training model that was created was at the most appropriate level. Additionally, the effectiveness index of the training model, overall, was 0.8875, indicating that the industrial production managers who received the training with the digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance the digital competence of industrial production managers had an overall progress in digital competency at 88.75%.

3. The results of using the digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers are shown in Tables 1 and 2, respectively.

Table 1 The results of comparing digital competency of the industrial production managers who received the training for digital competency of industrial production managers using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers, before and after the training (n=15)

Digital competency	Testing	$\bar{X}$	SD	$\bar{d}$	$SD_{\bar{d}}$	t
1. Digital technology management	Before	.33	.48	2.53	.165	15.33**
	After	2.86	.35			
2. Digital content management	Before	.40	.50	2.40	.130	18.33**
	After	2.80	.41			
3. Digital knowledge management	Before	.40	.50	2.40	.163	14.69**
	After	2.80	.41			
4. Digital assessment and problem solving	Before	.40	.50	2.46	.165	14.92**
	After	2.86	.35			
Total	Before	.38	.29	2.45	.085	28.75**
	After	2.83	.20			

** Significantly at .01 Level

From Table 1, it was found that, after the training using the digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers, these managers had higher competency in terms of overall competency and each aspect, including digital technology management, digital content management, digital knowledge management, and the digital assessment and problem solving than before the training significantly at .01 level.

Table 2 The results of comparing digital competency of the industrial production managers who received the training for digital competency of industrial production managers using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers after the training with the threshold of 80% or mean of 2.40 (μ = 2.40) (n=15)

No.	Digital competency	$\bar{X}$	SD	Level	t
1.	Digital technology management	2.86	0.35	highest	19.71**
2.	Digital content management	2.80	0.41	highest	14.63**
3.	Digital knowledge management	2.80	0.41	highest	14.63**
4.	Digital assessment and problem solving	2.86	0.35	highest	19.71**
	Total	2.83	0.20	highest	32.25**

** Significantly at .01 Level

From Table 2, it was revealed that, after the training using the digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers, the competency in terms of overall competency and each aspect, including digital technology management, digital content management, digital knowledge management, and the digital assessment and problem solving of these managers were at the highest level and higher than the threshold of 80%, significantly at .01 level.

4. The results of assessing the use of the digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers are shown in Tables 3 and 4, respectively

Table 3 The results of assessing the appropriateness of using the digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers in terms of overall and each aspect.

No.	Appropriateness of using the training model	$\bar{X}$	SD	Level
1.	Input	4.61	0.12	highest
2.	Process	4.68	0.18	highest
3.	Output	4.75	0.27	highest
	Total	4.68	0.13	highest

From Table 3, it was found that, overall, the appropriateness of using the digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers was in the highest level. When considering each aspect, it was revealed that the appropriateness of Input, Process, and Output was at the highest level.

Table 4 The result of satisfaction assessment for attending the training using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers.

No.	The satisfaction for the training model	$\bar{X}$	SD	Level
1.	The information obtained can be useful/ meet the needs/ accurate and up-to-date.	4.75	0.44	highest
2.	Skills, knowledge, and abilities of the consultant/lecturer	4.66	0.48	highest
3.	Manners, intentions, and paying attention to the service of the service staff	4.66	0.48	highest
4.	Manners, intentions, and paying attention to the service of the lecturer/consultant	4.73	0.45	highest
5.	Convenience and speed of the procedure for obtaining service with the staff	4.33	0.48	high
6.	Convenience and speed of the procedure for obtaining service with the consultant	4.60	0.50	highest
7.	Timeline for service is on schedule.	4.66	0.48	highest
8.	Suitability of the place of service	4.26	0.70	high
9.	Availability of tools, documents, and equipment to provide services	4.40	0.50	high
	Total	4.57	0.13	highest

From Table 4, the results show that the industrial production managers who attended the training felt satisfied with the digital industry executive training using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers, overall, at the highest level. When considering each

aspect, the satisfaction of the industrial production managers who attended the training regarding No.1 The information obtained can be useful/ meet the needs/ accurate and up-to-date, No. 2 Skills, knowledge, and abilities of the consultant/lecturer, No. 3 Manners, intentions, and paying attention to the service of the service staff, and No. 4 Manners, intentions, and paying attention to the service of the lecturer/consultant, No. 6 Convenience and speed of the procedure for obtaining service with the consultant, and No. 7 Timeline for service is on schedule were at the highest level. The satisfaction of these industrial production managers regarding No. 5 Convenience and speed of the procedure for obtaining service with the staff, No. 8 Suitability of the place of service, and No. Availability of tools, documents, and equipment to provide services were at a high level.

Discussion

The digital competency of the industrial production managers consisted of 4 competencies: 1) digital technology management, 2) digital content management, 3) digital knowledge management, and 4) digital evaluation and problem solving. This is because 1) digital technology management is important for the industrial production managers to manage work in the role of the managers who have the responsibility and the key role that digital technology is required to operate. They need to have good knowledge and literacy competence of information. 2) Regarding digital content management, the industrial production managers use contents for their management according to the position and responsibilities, the use of production programs, software, and applications must be at a good level that they can apply information and contents to improve the efficiency of the production process. In addition, as for the development stage, this requires programming and developing applications for use in digital content management. 3) For digital knowledge management, a knowledge engineer in an organization is someone who has expertise and experienced. A production manager is considered a knowledge engineer of the organization. Therefore, it is very necessary that he/she needs to have knowledge and skills in managing jobs and people through information systems and plan a strategy for implementing digital information systems in management, disseminating digital knowledge to personnel in the organization for use in their operations, and creating new knowledge in the organization. 4) Concerning assessing and solving digital problems, the industrial production managers are those who are important for the management of the production department in achieving the objectives and goals of the organization in the production of products. They must be able to identify the needs and use digital technology to solve work problems creatively. Besides, they are able to overcome the weaknesses and gaps of digital capability problems. Therefore, it is necessary to have techniques for solving the problems of work.

The digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance the digital competency of the industrial production managers that was created is the training model that aimed at developing and enhancing the knowledge, understanding, and digital skills of industrial production managers. This model consisted of 4 contents: 1) digital technology management, 2) digital content management, 3) digital knowledge management, and 4) digital assessment and problem solving. These contents were obtained from the study of documents and related research and interviews with entrepreneurs participating in the digital technology

development project with the Digital Industry Development Division, Department of Industrial Promotion, Ministry of Industry as well as experts in digital competency development, industrial management, and assessment and measurement. This was based on a 3-step training process as follows. 1) Before the training, the requirements for the development of digital competency of the industrial production managers and the entrepreneurs who participated in digital technology development projects of the Digital Industry Development Division, Department of Industrial Promotion, Ministry of Industry were inquired. Additionally, this is in accordance with the vision "Towards an industry that is driven by intelligence and connected to the global economy" by setting a goal for the next 20 years (2017-2036) for the Thai industrial sector to have an average GDP growth rate of not less than 4.5% per year. The average investment growth is not less than 10% per year. The average export value increases by 8% per year, and TFP growth is not less than 2.0% per year, which is the growth rate that will result in Thailand being able to become a high-income country by 2036 according to the goals of the National Strategy (Ministry of Industry, 2016). 2) The training was given to trainees to practice Knowledge Capture, Knowledge Analysis, and Knowledge Synthesis as they enhance Explicit Knowledge, and 3) after the training, they were trained to have Knowledge Utilization and Knowledge Follow-up and Evaluation since it is the application of knowledge to solve problems or develop industrial organizations effectively and directly in terms of Task, Inference, and Domain as the concept of Common KADS Methodology (Chakphithak, 2015; Schreiber, Akkermans, Anjewierden, de Hoog, Shadbolt, van de Velde, & Wielinga, 2002; Tanalertsopit & Pongwirittorn, 2014).

The digital industry executive training model that was created was appropriate at a high level. The effectiveness index of the training model was 0.8875, indicating that the industrial production managers who received the training with the digital industry executive training model had the overall progress in digital competency at 88.75%. The effectiveness index was not less than .80 or 80%. This is because the researchers studied related documents and research as well as asking experts and business owners who participated in the digital technology development project of the Digital Industry Development Division, Department of Industrial Promotion, Ministry of Industry.

After using the digital industry executive training model, the industrial production managers who received digital competency training had the overall digital competency statistically significantly higher than before the training at the .01 level. In addition, after the training, the overall digital competency was at the highest level and was higher than the 80% threshold with statistical significance at the .01 level. The reasons for this might be as follows. 1) The objectives and aims were set clearly in order to enhance the digital competency of the industrial production managers. 2) The content of this training met the needs and expectations of the industrial executives that required the production managers to have 4 parts of digital competency: digital technology management, digital content management, digital knowledge management, and the digital assessment and problem solving. These create knowledge and skills for working. 3) The training process included knowledge engineering, that is, Knowledge Capture, Knowledge Analysis, Knowledge Synthesis, and Knowledge Utilization. These are consistent with the concept of Knowledge Engineering, proposed in 1983 by Edward Feigenbaum and Pamela McCordick. It is a concept that focuses on the analysis and synthesis of knowledge. By using this conceptual

framework, there are 4 main principles: Knowledge Capture, Knowledge Analysis, Knowledge Synthesis or knowledge modelling, and Knowledge Utilization (Chakphithak, 2015).

After using the digital industry executive training model, the trainees agreed that input, process, and output were at the most appropriate level. This is because 1) the input consisting of objectives and training contents met the needs and expectations of the trainees. 2) For the process, before the training, there was a preparation by determining the problems caused by the work and exchanging knowledge with experts who were knowledge engineers with the trainees in order to create a channel for enhancing digital competency. In the training stage, the trainees thought that it was appropriate to apply what had gained from the training in their work and practice and solve the problems by capturing knowledge with experts and brining knowledge gained to analyze and synthesize, leading to new knowledge in solving digital problems. Finally, after the training, the trainees agreed that the training was appropriate because the knowledge gained in the pre-training and training stages had been put into practice for practical use in digital operations. Moreover, the learning was assessed, and outcomes of digital competency were monitored by experts. 3) The output which was digital competency that had been enhanced was appropriate in terms of knowledge and skills to be used in practice with an assessment from top managers in order to meet the requirements and expectations for digital competency.

In addition, the industrial production managers who received the training were satisfied with the digital industry executive training model at the highest level. It is because the trainees thought that the training model was relevant to the practical use in routine work that must be related to digital technology. This makes industrial production managers ready for the development and overcome weaknesses and problems that have a huge impact on performance and create morale for not being afraid of digitalization in technology changes in the future. However, in terms of suitability of the place of service, it was revealed that the participants were less satisfied than others. The reason for this is due to the epidemic situation of the coronavirus disease (COVID-19). Therefore, the online training was mainly conducted through online. This made the trainees inconvenient to use the online training equipment.

Conclusion

This research was to develop the digital industry executive training model using principles of knowledge management based on knowledge engineering to enhance digital competency of industrial production managers in the private sector only. For further research, the training model should be developed for government executives as well. Besides, it should have a target audience, develop personnel involved in the work process, and link to the structure of that organization in order to continue to develop digital competency together. Moreover, it should be more digital competency studies in the future in order to support changes in globalization or changes in the next 20 years and be in line with the country's further development of digital technology.

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