How a digital knowledge engineering learning process can enhance technical skills in software engineering

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ABSTRACT: Digital knowledge engineering is a collection of knowledge management processes and methods provided by experts. These processes and methods lead to best practices regarding problem-solving, as well as simultaneous learning and the use of information and communication technology for knowledge management. The objectives of this study were: 1) to study the digital knowledge engineering learning process and technical skills in software engineering; and 2) to evaluate the learning process by the synthesis of derived information (content analysis) provided by five experts. The research findings suggested that a digital knowledge engineering learning process consists of six parts: 1) knowledge creation; 2) knowledge storage; 3) knowledge acquisition; 4) knowledge access; 5) knowledge sharing; and 6) knowledge application. With respect to the evaluation of the learning process, the overall result was the highest value, which indicates that this research can be now applied to learning management.

INTRODUCTION

Technology is used in many ways and is an essential factor in national development [1]. The advancement of technology has had a significant impact on the workforce of organisations, particularly regarding the adoption of new technology. Intelligent organisations are able to learn and adjust to rapidly changing ideas to create and develop innovative organisations. Additionally, knowledge management is one of the major factors that drive growth today. Accordingly, knowledge creation, concept mapping and personnel skills development have become important. A process flow diagram is also important to convey and transmit ideas, knowledge and skills to personnel in a practical way, as well as for quality improvement and the acquisition of new knowledge [2].

It is important that knowledge management is promoted and supported in educational organisations since learning from practice can help students gain a level of experience conducive to best practice. Also, this can be transferred to the next generation and be available for future use [3]. Digital knowledge engineering is a tool for knowledge management that is used to create and facilitate knowledge transfer in an easy and efficient way. It is a cognitive model of human behaviour that enables knowledge capture for solving problems and decision making. It deals with tacit and explicit knowledge via knowledge management tools, including digital technology, knowledge management systems and repository management systems [4].

The application of digital knowledge engineering in educational institutions can help teachers and learners to easily and quickly access large amounts of information via the Internet. This is in accordance with the Thailand Government's Digital Thailand Plan [5]. The third strategy of the plan involves laying the foundation for equal access to quality digital infrastructure and makes it easier for citizens to access data at a national or local level. The strategy also enforces a consistent use of best practices to ensure people have the most up-to-date information. The application of digital knowledge engineering is consistent with the fifth strategy. The fifth strategy involves developing the workforce to be ready for the era of the digital economy and society. It focuses on the development of workers' skills in every sector of the economy and the ways to creatively use digital technology for personal and career development. However, issues in software development still remain, such as indicated by Jaikaewma [6]:

- changes among users;
- uncertainty in strategic planning;
- restrictions on software developers;
- a shortage of skilled developers resulting in a lack of user software.

The software engineering competency model (SWECOM), indicates the technical skills in software engineering essential for software development [7]. These include:

- software requirement analysis skills;
- software design skills;
- software construction skills;
- software testing skills;
- software sustainment skills.

The application of software engineering skills can improve software development. The aim of this research was to investigate digital knowledge engineering learning in software engineering. A second goal was to apply the results to learning design by using digital knowledge engineering learning to enhance learners' technical skills in software engineering.

OBJECTIVES OF THE RESEARCH

1. To study digital knowledge engineering learning processes and technical skills in software engineering.
2. To evaluate digital knowledge engineering learning processes and enhancement to technical skills in software engineering.

RESEARCH METHODOLOGY

The research process was divided into two distinct stages as follows:

- Stage 1: to study the digital knowledge engineering learning process and technical skills in software engineering by gathering information from documents, textbooks and academic papers, as well as research articles from Thai and international sources. The researchers analysed and synthesised the information (content analysis).
- Stage 2: to evaluate the digital knowledge engineering learning process and enhancement to technical skills in software engineering. A questionnaire was used with a checklist of items which contained five rating scales. The data were collected from five experts. Each expert had at least three years' experience in a related field. A purposive sampling method was used to select the experts.

RESEARCH FINDINGS

Stage 1 - Results

The findings of the study of the digital knowledge engineering learning process and technical skills in software engineering are detailed in the following section. Digital knowledge engineering is a knowledge management process and methodology. Table 1 provides a review of experts on the processes involved. These experts have direct experience of best practice required for problem-solving, learning and use of digital technology [8-13].

Table 1: The findings of a study of the digital knowledge engineering learning process.

Process / Researcher	Knowledge creation	Knowledge storage	Knowledge acquisition	Knowledge access	Knowledge sharing	Knowledge application
Vasconcelos, J. et al	✓		✓	✓	✓	
Cerchione, R. and Esposito, E.	✓	✓				
Wang, M. et al	✓	✓			✓	✓
Quintana-Amate, S. et al			✓	✓		
Weinreich, R. and Groher, I.			✓		✓	✓
Garcia, J. et al		✓	✓	✓	✓	✓
Digital knowledge engineering-based learning process	✓	✓	✓	✓	✓	✓

The data shown in Table 1 indicate that the digital knowledge engineering learning process was divided into six steps, as follows:

1. Knowledge creation;
2. Knowledge storage;
3. Knowledge acquisition;
4. Knowledge access;
5. Knowledge sharing;
6. Knowledge application.

A Study of Technical Skills in Software Engineering

Software engineering is a field of study focused on analysis, design, software development, software testing and new software development processes. Under rules by the Institute of Electrical and Electronics Engineers (IEEE), the required skills involved in software development are as shown in Table 2 [7].

Table 2: Technical skills in software engineering.

Software engineering skill	Sub-skills
1. Software requirements	1.1 Software requirements elicitation 1.2 Software requirements analysis 1.3 Software requirements specification 1.4 Software requirements verification and validation 1.5 Software requirements process and product management
2. Software design	2.1 Software design fundamentals 2.2 Software design strategies and methods 2.3 Software architectural design 2.4 Software design quality analysis and evaluation
3. Software construction	3.1 Software construction planning 3.2 Managing software construction 3.3 Detailed design and coding 3.4 Debugging and testing 3.5 Integrating and collaborating
4. Software testing	4.1 Software test planning 4.2 Software testing infrastructure 4.3 Software testing techniques 4.4 Software testing measurement and defect tracking
5. Software sustainment	5.1 Software transition 5.2 Software support 5.3 Software maintenance

According to the data shown in Table 2, technical skills in software engineering consist of five parts:

1. Software requirements;
2. Software design;
3. Software construction;
4. Software testing;
5. Software sustainment.

The results illustrated above are summarised in Figure 1 (below), which relates the digital knowledge engineering learning process to the enhancement of technical skills in software engineering. A diagram such as Figure 1 can be used to design learning methods that can enhance the software engineering technical skills of undergraduate students in information and communication technology (ICT) programmes.

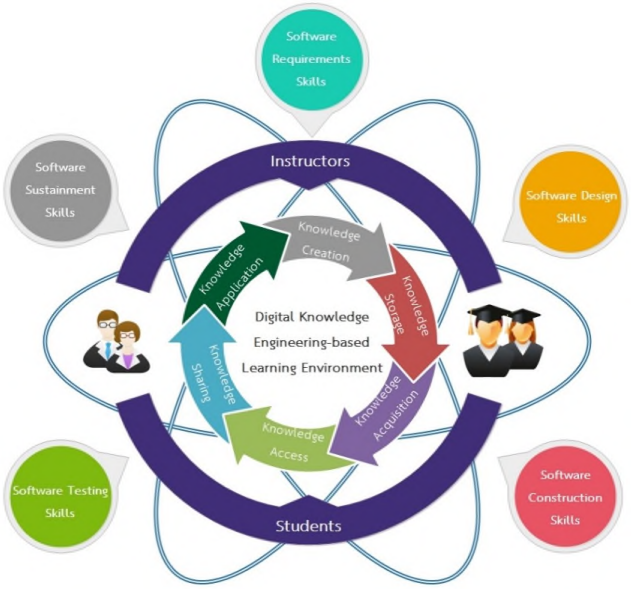

Figure 1: A digital knowledge engineering learning process that can enhance technical skills in software engineering.

These learning methods will help to develop a body of software engineering knowledge using digital technology. An example of such technology is a repository management system using Internet information services, that helps teachers improve their teaching efficiency, while learners can disseminate, distribute and transmit knowledge anywhere and at any time and using any device. Digital knowledge engineering learning management methods that can enhance software engineering technical skills are detailed in Table 3.

Table 3: Digital knowledge engineering learning methods.

Digital knowledge engineering learning management method	Teacher's roles	Learner's roles
1. Knowledge creation	Knowledge creation relating to technical skills in software engineering	Collaborative creation of technical skills related to a body of software engineering knowledge after finishing learning
2. Knowledge storage	Knowledge storage relating to technical skills in software engineering using a repository management system	New knowledge storage related to technical skills in software engineering using a repository management system
3. Knowledge acquisition	The formulation of questions regarding software development for students via a learning management system as a subsystem of a repository management system	To search for knowledge related to technical skills in software engineering on a learning management system as a subsystem of a repository management system
4. Knowledge access	Observation of students' learning behaviour	To engage in content learning related to technical skills in software engineering on a learning management system as a subsystem of a repository management system
5. Knowledge sharing	To provide advice and guidance for students on topics and express opinions regarding students' problem-solving skills	To transmit and share knowledge of technical skills in software engineering on a learning management system as a subsystem of a repository management system
6. Knowledge application	To assess student achievement regarding knowledge application derived from knowledge assessment forms	To take a test related to technical skills in software engineering on a learning management system as a subsystem of a repository management system

Stage 2 - Results

Table 4: How digital knowledge engineering learning can enhance technical skills in software engineering.

Digital knowledge engineering-based learning process	Level of proficiency		
	$\overline{X}$	SD	Overall result
1. Knowledge creation	5.00	0.00	Highest
2. Knowledge storage	5.00	0.00	Highest
3. Knowledge acquisition	5.00	0.00	Highest
4. Knowledge access	5.00	0.00	Highest
5. Knowledge sharing	5.00	0.00	Highest
6. Knowledge application	4.60	0.55	Highest
Mean	4.93	0.25	Highest

The data in Table 4, reveal that the overall results of digital knowledge engineering learning used to enhance technical skills in software engineering were ($\overline{X}$ = 4.93, SD = 0.25) i.e. *highest* value. However, when each item was taken into account and arranged in ascending order, it was found that the level of proficiency for knowledge creation, storage, acquisition, access and sharing was ($\overline{X}$ = 5.00, SD = 0.00) i.e. *highest* value. In relation to the steps of knowledge application, the level of proficiency was ($\overline{X}$ = 4.60, SD = 0.55) i.e. *highest* value.

CONCLUSIONS

According to the findings of the research regarding whether the digital knowledge engineering-based learning process can enhance technical skills in software engineering, the overall results were at the highest value and the data distribution was less than 1.0. The data were derived from documents, textbooks and academic papers, as well as related research articles from Thai and international sources, using a synthesis of derived information (content analysis) provided by five experts. It was observed that the researchers had similar opinions and evaluation scores.

This study can be applied to learning management methods in educational institutions consistent with the work of Anupan et al [14]. These authors conceive of a digital knowledge engineering learning process in educational institutions with a learning environment based on cloud technology. This can facilitate easy access to knowledge for teachers and students, including distribution and transmission of knowledge in an effective way. It was also consistent with the research of Thananchana, who claims that a digital knowledge engineering learning process could be applied to expert systems, decision support systems and knowledge management systems [15].

Further, this could be applied to knowledge archives that contain a potentially rich source of data regarding best practices in problem-solving and work improvement. In addition, the process could be integrated into collaborative learning methods to increase technical skills in engineering software consistent with the work of Hadromi [16]. Hadromi relates the design and development of collaborative learning to the enhancement of vocational students' technical skills and computing professional skills. The skills in question include problem-solving, teamwork, professional and ethical considerations, communication, and engagement in further research and learning [17].

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