Knowledge Management Technology Implementation
Bridging the Gap between Theory and Practice

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Abstract: This paper presents methods employed for the teaching and learning of Knowledge Management technologies classified under KM lifecycle i.e. knowledge identification, knowledge capture, knowledge codification, knowledge storage, knowledge dissemination and sharing. The process was employed for teaching of a Knowledge Management (KM) course called E-KM (Electronic Knowledge Management) in Multimedia University (MMU), Cyberjaya, Malaysia. Given that textbooks were only available for theoretical KM courses and that all teaching materials had to be created from scratch for this course, the idea was to test if KM technologies can be successfully taught and be implemented in class to bridge the gap between theory and practise. Empirical data provided in this paper validates that there was a significant improvement in the learning and understanding amongst postgraduate students especially in appreciation of knowledge codification, ontology design, schema classification, taxonomy construction, implementation and assignment of rule generation for firing rules via reasoning engines. The process was tested over seven cohorts totalling 300 students. Students who took this course never had any formal training before and this was the first technical KM course for them in their postgraduate programme. Empirical data suggests that the methods used were effective for all six classifications of KM lifecycle taught.

1 INTRODUCTION

KM is usually taught as a non-technical course which covers softer issues that are behavioural. The implementation of KM technologies to support KM lifecycle i.e. knowledge identification, knowledge capture, knowledge codification, knowledge storage, knowledge dissemination and sharing are indeed rare. Most curriculum taught today, does not prepare students with the technical knowledge engineering and design skills in relation to KM systems. The question of how can one identify, capture, codify and store knowledge in practice is still a gap that exists in our curriculum today.

As part of our KM research, we wanted to understand how this gap can be minimized in a significant way so as to bridge the gap between theory and practice of KM technology implementation. The aim of this paper was to evaluate the overall effectiveness of the process methodology adopted and utilization of teaching tools to minimize any gap that could have existed between theory and practice of KM lifecycle implementation. A parallel objective of this study was to understand the strengths and weaknesses (if any) of the process methodology that was designed by the instructor in the effort towards improving the content and providing a model that other institutions could possibly adopt for the delivery of technical KM courses. A wide variety of tools were adopted for this study. Many were open source and free for educational purposes. The tools that were used for were: Protégé, Jess, SPARQL, SWOOGLE, UML (Unified Modelling Language) and reasoning tools such as: CLIPS, PAL, SWRL, Racer Pro and Algernon. An experiment was carried out as to how well students progressed from theory to practice. A total of 300 postgraduate students were involved in this study. The instructor taught the same E-KM course for seven cohorts over three years with the same process methodology, teaching design, content, assessment, assignments, projects and competency tests so as to maintain consistency and eliminate biasness of the study. The rest of this paper is organized as follows. Section 2 presents KM lifecycle review of literature. Section 3 presents the survey and section 4 presents preliminary discussion as well as the hypothesis. Finally section 5 presents the analysis and findings.

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2 LITERATURE REVIEW

Based on literature review using keyword search of "KM lifecycle" from the Elsevier SDOS online database, we found 10,014 articles on this topic. This was done on June 1, 2014. After topic filtering, only 73 articles covered the scope of this paper and were KM technology specific and supported KM lifecycle processes i.e. knowledge identification, knowledge capture, knowledge codification, knowledge storage, knowledge dissemination and sharing. Several tools were introduced to support KM technology implementation with regards to KM lifecycle stages. In summary, based on the 73 articles mentioned earlier, we used Protégé for knowledge identification, codification and capture based on theory (Nonaka et al, 2001), (Wiig et al, 1997), (Fernandez-Breis, 2000), (Allsopp et al, 2002) and Wilkins et al (1997).

Jess (Java Expert Shell System) was applied in the context of knowledge representation (Cauvin, 1996), Kim et al (2000) and knowledge capture (Wielinga et al, 1997). SWOOGLE was used in the context of search (Knight and Ma, 1997) and indexing (Jiang el al, 1999). CLIPS and PAL (Protégé Axiom Language), Algernon and SWRL (Semantic Web Rule Language) assisted with knowledge representation (Cauvin, 1996), Kim et al (2000) and machine leaning (Zhong and Ohsuga, 1996). External reasoning engine (i.e. Racer Pro) was applied for executing rules, checking consistency and integrity in the Ontology implemented. Description of each tool and how they were used to meet the assignments assigned and overall curriculum objectives are elaborated in the following sections.

2.1 Protégé

Protégé is an open source platform-independent ontology editor developed by Stanford University. It's a very useful tool for creating and editing ontologies (Wiig et al, 1997), (Fernandez-Breis, 2000), (Allsopp et al, 2002) and Wilkins et al (1997) and knowledge bases from scratch. The following features in Protégé are reasons that make it appropriate for Protégé to be used as a classroom technology for E-KM:

a) Easy to use graphical user interface (GUI).
b) The ability to scale up with virtually no performance degradation even if several hundreds of frames are loaded into its database all at the same time.
c) Several additional plug-ins can be easily added into the Protégé framework as components that perform reasoning, matching, alignment and graphical representation. To the best of my knowledge I have not known any other tool that can perform the same functions as Protégé does.

Students were first taught for several weeks (about 20 face-to-face contact hours) on the concepts and actual implementation process of a knowledge base from scratch. The instructor used several examples from the Protégé sample ontologies available in this tool. The wine, newspaper and pizza ontologies helped to provide a better understanding of classes, sub classes, slots, inverse slots, instances, data type definitions and relationships. In the first assignment, a student was given three weeks to build and implement ontology of their choice based on principles taught in the face-to-face session. The Protégé version used for assignment 1 was an earlier version i.e. 3.4.1 so as not to confuse students with OWL (Web Ontology Language) definitions which they were not ready to comprehend. Assignments 2 and 3 were based on the 3.4.2 version.

2.2 JESS

Jess (Java Expert Shell System) is a rule engine and scripting tool developed by Ernest Friedman-Hill at Sandia Laboratories. Since Jess was always free for educational purposes, it became an ideal choice to be used in this course. Protégé provides a component plug-in i.e. Jess Tab that can easily be configured for executing Jess rules (Cauvin, 1996), within the Protégé environment. Jess is an effective tool for building intelligence into an existing knowledge base. This can be done via an expert system rule engine (Zhong and Ohsuga, 1996) that applies rules on a collection of facts. Jess uses a special algorithm i.e. Rete to match rule to given facts. This tool was introduced to the students in subsequent meetings to meet the requirements of assignments 2 and 3. Students were first trained to use Jess for two meetings before they could use it. Jess allows forward and backward chaining and supports LISP (LISt Processing) like syntax. Students were given other options such as SWRL and PAL to implement rules into their ontology if they did not want to use Jess for any reason. An example of SWRL Jess Tab is shown below.

2.3 SPARQL

SPARQL (*SPARQL***P**rotocol and **R**DF **Q**uery

Language) is an RDF (Resource Description Framework) query language which became an official W3C recommendation. It allows students to write queries for the following purposes i.e. SELECT query, CONSTRUCT query, ASK query and DESCRIBE query (Knight and Ma, 1997). This tool was introduced to the students to meet the requirements of assignment 3.

2.4 SWOOGLE

SWOOGLE is a Semantic Web search engine developed and hosted by the eBiquity group at the University of Maryland, Baltimore County (UMBC). The purpose for the introduction of SWOOGLE is to give an appreciation of how queries can be processed across ontologies with the RDF query language which incorporates SELECT query, CONSTRUCT query, ASK query and DESCRIBE query. This tool was introduced to the students to meet the requirements of assignment 3.

2.5 CLIPS

CLIPS (*C Language Integrated Production System*) is a public domain software tool for building expert systems. CLIPS manages rules and facts like other expert system languages. This tool was introduced to the students to meet the requirements of assignment 3.

2.6 PAL

PAL (*Protégé Axiom Language*) is a tool for implementing constraints or business rules for knowledge bases. The PAL component plug-in is easily configured for executing within the Protégé environment and is available as a component as well. It is a constraint and query language as it can enforce semantics as well as search for instances that satisfy certain relationships. PAL constraint elements include constraint names, constraint descriptions, range of constraints and constraint statements (Zhong and Ohsuga, 1996). EZPAL is also a PAL tool authored by Johnson Hou which uses fill-in-the blanks approach with the aid of a template.pprj file. It is quite easy to use and deploys rule constraints. This tool was also introduced to students to meet the requirements of assignment 3.

2.7 SWRL

SWRL (*Semantic Web Rule Language*) combines OWL and RuleML (rule mark-up language) based on OWL DL (description logic) using Horn-like rules to reason (Zhong and Ohsuga, 1996) about OWL classes. Students were taught how to compose rules for knowledge bases. This tool was introduced to students to meet the requirements of assignment 3.

2.8 Racer Pro

Racer Pro (*Reasoned ABox and concept Expression Reasoner Professional*) is an interactive reasoning engine that uses the TCP/IP network interface to connect to one or more RacerPro servers. It was developed in Germany and authored by the Racer team. Students were taught how to use Race Pro to load knowledge bases, switch between taxonomies, inspect instances, visualize A-Boxes and T-Boxes and manipulate the server (Zhong and Ohsuga, 1996). A total of 10 hours face-to-face time was allocated for this purpose. This tool was introduced to students to meet the requirements of assignment 3.

2.9 Algernon

Algernon was authored by Michael Hewitt. The Algernon rule based system is implemented in Java and is interfaced with Protégé. It supports forward and backward chaining rules much like CLIPS and Jess which is needed for frame-based knowledge bases. This tool was introduced to students to meet the requirements of assignment 3.

3 MATERIALS AND METHOD

This study was purely exploratory, not much was known about how to evaluate the effectiveness of bridging the knowledge gap of KM technology implementation, especially for the KM domain. Since not much was known and information was scarce on this research topic even in developed countries, thus the study was conducted. For the purpose of this study, primary source of data gathering of data, an online questionnaire was setup and students were instructed to answer the questions and submit their responses online. The survey was divided into two sections i.e. section A and B. In the section A of the survey, respondents had to answer a total of thirteen questions with options for selection and one open ended question for suggestions as to how to improve the E-KM course in the future. In section B, the attitude and perception of the students was examined. Specifically, this research was aimed at addressing the objectives below:

i. To what extent have the tools assisted in the end to end KM lifecycle implementation?
ii. How did the process methodology produce technically sound KM knowledge among postgraduate students?
iii. What is the level of satisfaction of the students after attending the fourteen week long semester especially in mastering technical tools for KM?
iv. What is the level of effectiveness of the E-KM teaching and learning materials (i.e. hand-outs, notes, slides, online courseware and tutorials)?
v. What is the level of effectiveness of assignment 1 *(ontology design*) in terms of acquiring knowledge of designing ontologies from scratch?
vi. What is the level of effectiveness of assignment 2 (underst*anding taxonomy and ontology implementation design)?*
vii. What is the level of effectiveness of assignment 3 (*implementing business rules in ontologies)?*

4 HYPOTHESIS AND METRICS

The experiment for the study was aimed at examining the following hypotheses (see table 1). The focus group of this study was 300 carefully selected postgraduate students representing weak, average and good students as well as those who represented all six semester groups over three years. All 300 respondents answered the survey which gives it a 100% response rate.

For the purpose of analysis the data set of 300 students were divided into two groups of 150 students each i.e. those who took the earlier curriculum and those who took the modified new curriculum. All hypothesis were examined first with a t-test analysis and showed significant results with ($p>0.05$). Hypothesis 1 (H1) test resulted where 150 postgraduate students who took the E-KM course in the *last* three semesters with the new instructor designed E-KM content, assignments and projects performed better than the 150 students of the postgraduate students who took the E-KM course in the *first* three semesters, i.e. a 93% improvement. Hypothesis 2 (H2) test resulted in 92% of students who took the new curriculum made fewer mistakes during the development of a Knowledge Base (KB) after completing all three assignments. Lastly, Hypothesis 3 (H3) test resulted in 92% of students who took the new curriculum were 95% more competent in writing business rules in a very short span of time compared to those who did not.

Table 1: Research Hypothesis.

Hypothesis	Hypothesis Statement
H1	Students who went through new E-KM curriculum did better in the exam compared to those did not
H2	Students made fewer mistakes during the development of a Knowledge Base (KB) after completing all three assignments
H3	Students who completed all lessons on were more competent in writing business rules in a very short span of time

The first and second question were on demographics i.e. age and gender respectively. From a total of 300 responses 180 were females and 120 were male. Thus, females made up about 60% of the population and males made up 40%. As for age, 1 respondent was between 15 to 20 years old (3.8%), about 7 respondents were between 21 to 25 years old (26.9%), 15 of them between 26 to 30 years old (57.7%) and 3 were between 31 to 35 years old (11.5%). The following charts depict this:

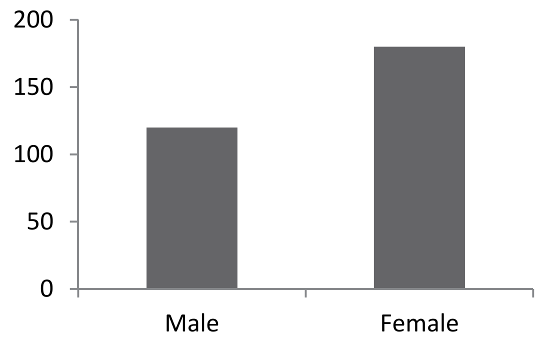

Figure 1: Response by gender (Total).

The third question was "how many times the student had taken the E-KM course?". Out of 300 responses, 288 students were taking the course for the first time i.e. resulting in 96% who were beginners. The fourth question was on "what was the student's level of satisfaction about the topics that were covered in the E-KM class?" and the responses were as follows: 50% (150 students) were strongly satisfied, 45% (135 students) were somewhat satisfied, 3.33% (10 students) were somewhat dissatisfied and 1.7% (5 students) were strongly dissatisfied.

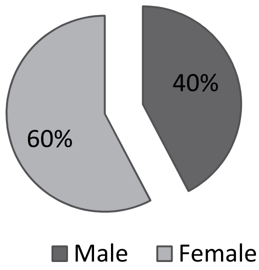

Figure 2: Response by gender (%).

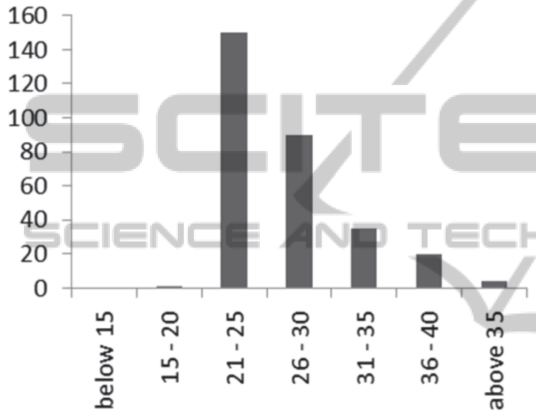

Figure 3: Response by age.

In the fifth question, "what is your level of satisfaction about materials (i.e. tools, notes, hand outs, tutorials and notes) that were used in E-KM class?" and the responses were as follows: 53% respondent answered strongly satisfied, 43% were somewhat satisfied, 3.33% were somewhat dissatisfied and 1% were strongly dissatisfied. In summary, 96% were satisfied with the materials used. The sixth question was on "in your opinion what do you think is the level of effectiveness of assignment 1 *(ontology design)* in terms of acquiring knowledge of designing an ontology from scratch?" and the responses were as follows: 57.7% respondents answered strongly effective, 34.6% answered somewhat effective, none responded to somewhat ineffective and 7.7% responded as ineffective. In summary, 92.3% were satisfied with the assignment 1

In the seventh question, "what do you rank as effectiveness of assignment 2 (*understanding taxonomy and ontology implementation design*)?" and the responses were as follows: 48.3% (145 students) answered (80-100), 44.3% (133 students) responded (60-80), and 6.7% (20 students) responded (40-60), 0.7% (2 students) answered (20-40) and 0% (none) answered as (0-20). In summary the majority of students responded favourably to

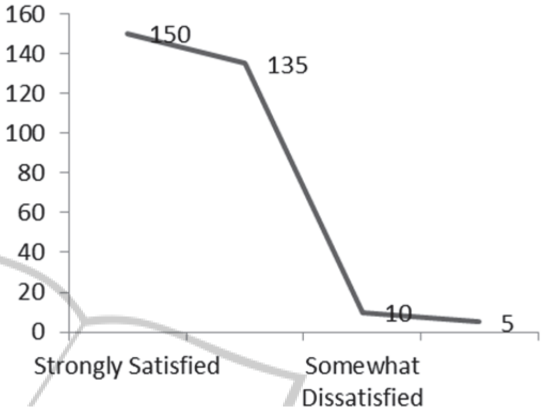

Figure 4: Level of satisfaction of topics covered in E-KM class.

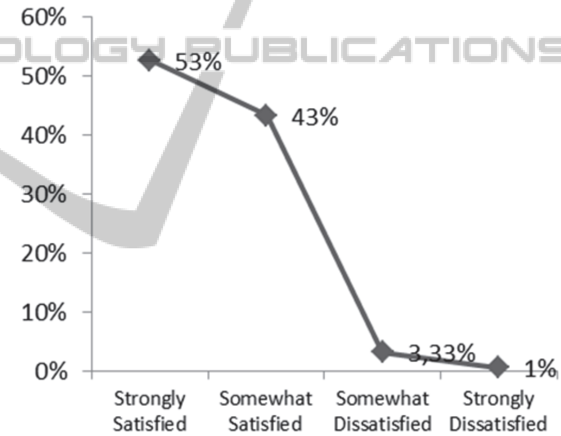

Figure 5: Level of satisfaction of materials used in the E-KM class.

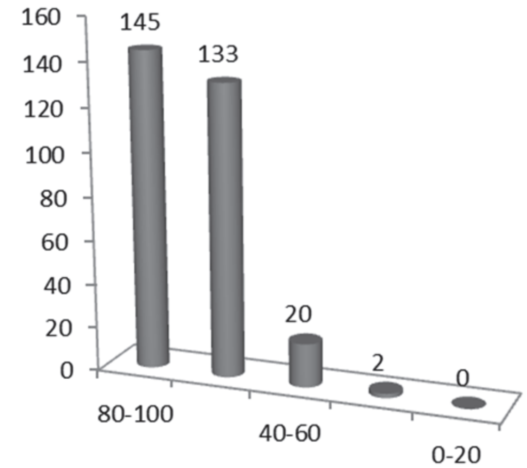

Figure 6: Effectiveness ranking of assignment 2.

assignment 2. In the eighth question, "how do you rank the level of effectiveness of assignment 3 (implementing business rules in ontologies) in helping you to assign rules for your ontology?" the responses were as follows: 50% answered very high, 38.5% responded somewhat high, 43.3% responded somewhat low and 6.7% responded very low. In summary, the majority of students responded favourably to assignment 3. The remaining students who responded unfavourably to this question really did not have any prior understanding in one more of these areas: description logic, programming, databases, query writing, software design and systems development at the undergraduate level.

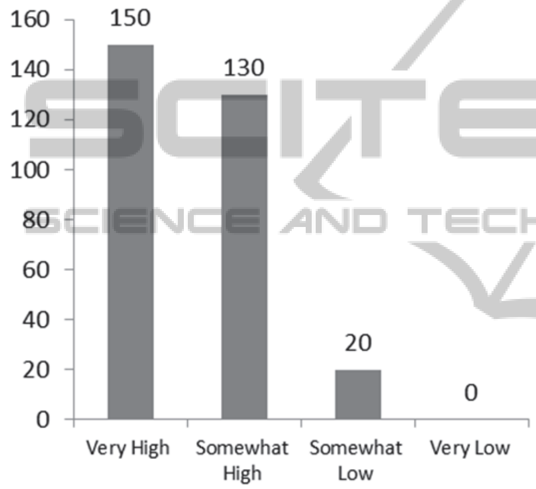

Figure 7: Effectiveness ranking of assignment 3.

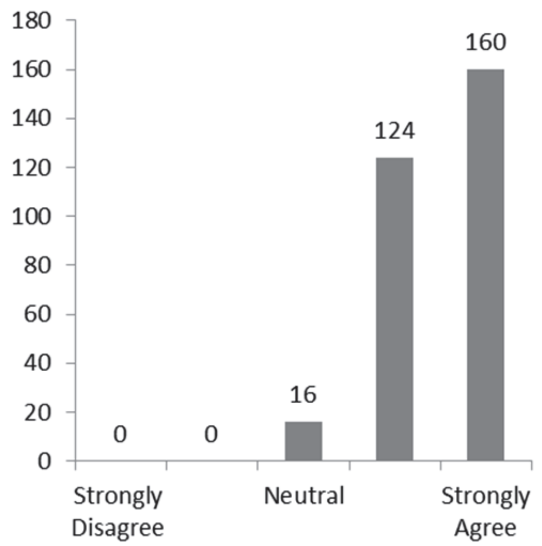

Figure 8: Instructor's knowledge to teach E-KM.

In the tenth question, "do you think your knowledge has increased after you have taken the E-KM module?" the responses were as follows: 96.2% answered "yes" and only 3.8% responded "no". In the tenth question, "do you think your knowledge has increased after you have taken the E-KM module?" the responses were as follows: 96% answered "yes" and only 4% responded "no". As a result the success of any hard KM topics depends strongly on the proper selection of students who possess these skills or foundation courses should be introduced in the early semesters to prepare the students before they move on towards higher level courses at the later stage of the programme. In the ninth question, "do you think that the instructor's knowledge is sufficient to teach the E-KM class?" the responses were as follows: 53% answered strongly agree, 41% responded agree, 5% were neutral and nobody (0%) disagreed and 0% responded strongly disagree. In summary, the majority of students almost all the students responded favourably to this question. In the eleventh question, "was the E-KM course effective in increasing your knowledge in the KM domain?" the responses were: 280 answered "yes" and only 20 only answered "no . In summary, more than 96% of the students responded favourably to this question.

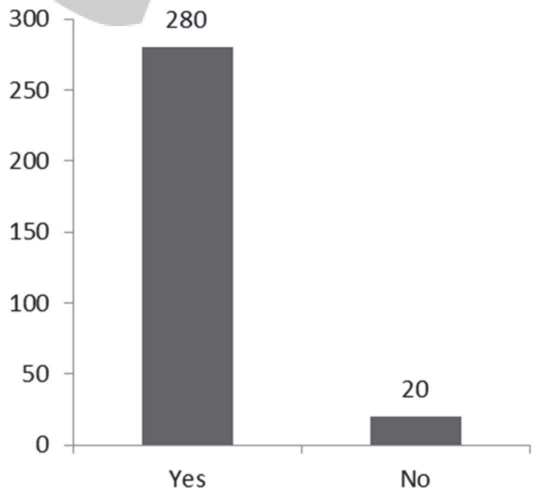

Figure 9: Has your knowledge increased after the E-KM module.

5 CONCLUSIONS

In conclusion, the contribution of this paper is twofold. Firstly, it highlights the effectiveness of bridging KM technology implementation in a postgraduate class. Secondly the effectiveness of teaching tools for the teaching and learning of E-KM such as Protégé, Jess, SPARQL, SWOOGLE, UML, CLIPS, PAL, SWRL, Racer Pro and Algernon. The study also highlights the effectiveness of the instructor's methods in teaching of this course including designing the curriculum aided in the closure of the gap between theory based models and actual knowledge engineering. Qualitative and quantitative data obtained from the survey shows that a majority of the students responded favourably to almost all questions as discussed earlier. As such, results of this experiment can be used by university authorities to confirm effective teaching pedagogies for teaching of technical courses at the postgraduate or even undergraduate levels.

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