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Teaching Technologies and its Effectiveness: An Empirical Study through SCALE for Semantic Web and Knowledge Engineering Tools

[1]Saravanan Muthaiyah, [2]Seethaletchumy Thambiah

[1,2]Faculty of Management, Multimedia University, Cyberjaya,Malaysia

Abstract: This paper highlights issues and challenges in the pedagogy of innovative teaching technologies for a Knowledge Management (KM) postgraduate programme at Multimedia University (MMU), Cyberjaya, Malaysia. The focus of this paper is particularly to measure the effectiveness of the methods employed for the teaching and learning of the E-KM (Electronic Knowledge Management) course, which is usually offered in the second semester of the programme. Given that textbooks were not available to the course and that all teaching materials had to be created from scratch, the instructor tested for effective learning as well as Supporting Collaboration and Adaptation in the Learning Environment (SCALE) supported by our web based Multimedia Learning System (MMLS). The idea was to test the teaching methodology for empirical data provided in this paper validates that there was a significant improvement in the learning and understanding amongst postgraduate students especially in the technical appreciation of knowledge codification, ontology design, schema classification, taxonomy construction, implementation and assignment of rule generation for firing rules via reasoning engines. Qualitative data is also provided for suggestions as to how the pedagogy can be further improved to enhance the effectiveness of the current approach in teaching tools for the Semantic Web. Students who took this course never had any formal training before and this was the first technical KM course that they had to take in their postgraduate programme.

Key words: Knowledge Management, Ontology, Engineering, Semantic Web, Taxonomy.

INTRODUCTION

KM is commonly regarded as a non-technical course i.e. that handles softer issues that are behavioural. However, the teaching and learning of soft KM issues alone will not suffice as technical expertise in arrears such as semantic modelling, ontology engineering, semantic search, taxonomy building and reasoning is in great demand today. As such, curriculum of universities today, should really be aligned towards preparing future knowledge engineers with excellent technical design skills great familiarity in technical KM tools such as: Protégé (http://protege.stanford.edu), Jess (http://www.jessrules.com), SPARQL (http://www.w3.org/TR/rdf-sparql-query), SWOOGLE (http://www.programmableweb.com/api/swoogle), UML(Unified Modelling Language) and reasoning tools such as: CLIPS (http://iweb.tntech.edu/bhuguenard/ds6530/ClipsTutorial/tableOfContents.htm), PAL (http://protege.stanford.edu/plugins/paltabs/pal-quickguide/), SWRL (http://www.w3.org/Submission/SWRL/), Racer Pro (http://www.racer-systems.com/) and Algernon (http://algernon-j.sourceforge.net). To provide a collaborative environment, a web-based, designed content from scratch for a KM postgraduate programme, particularly for a taught course called E-KM. As part of an experiment, the instructor taught the E-KM course for six semesters over three years with instructor-designed teaching content, assignments, projects and competency tests. The aim was to evaluate the overall effectiveness of the curriculum, which was taught to over 180 students. The main objective of this study was to understand the strengths and weaknesses (if any) of E-KM's instructor-designed teaching content as an effort towards improving the content and providing a model that other schools could possibly adopt.

Classroom Teaching Technologies And Tools:

Several tools were introduced in the E-KM course such as: Protégé, Jess, SWRL, PAL, EZPAL, Algernon, and an external reasoning engine (i.e. Racer Pro) for executing rules, checking consistency and integrity in the ontology implemented by our students for assignment 3.Description of each tool and how they were used to meet the assignment and overall curriculumobjectives are elaborated in the following section.

2.1 Protêgê:

Protégé is an open source platform-independent ontology editor developed by Stanford University (Protégé - http://protege.stanford.edu). It is a useful tool for creating and editing ontologies 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:

Corresponding Author: Saravanan Muthaiyah, Faculty of Management, Multimedia University, Cyberjaya,Malaysia
E-mail: seethaletchumy@mmu.edu.my

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 an 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 becomes an idealchoice 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 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 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 assignments2 and 3. Students were first trained to use Jess for twomeetings 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 SWRLJess Tab is shown below.

2.3 Sparql:

SPARQL (***SPARQL*****P**rotocol and **R**DF **Q**uery **L**anguage) is an RDF (Resource Description Framework)[10] 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. 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.

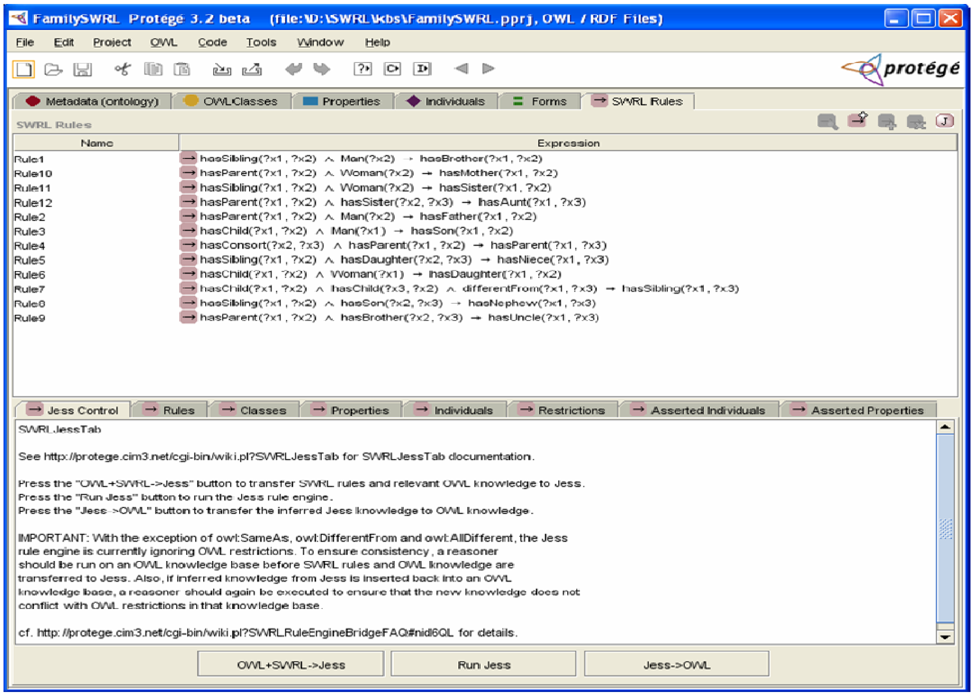

Fig. 1: SWRLJESS Tab

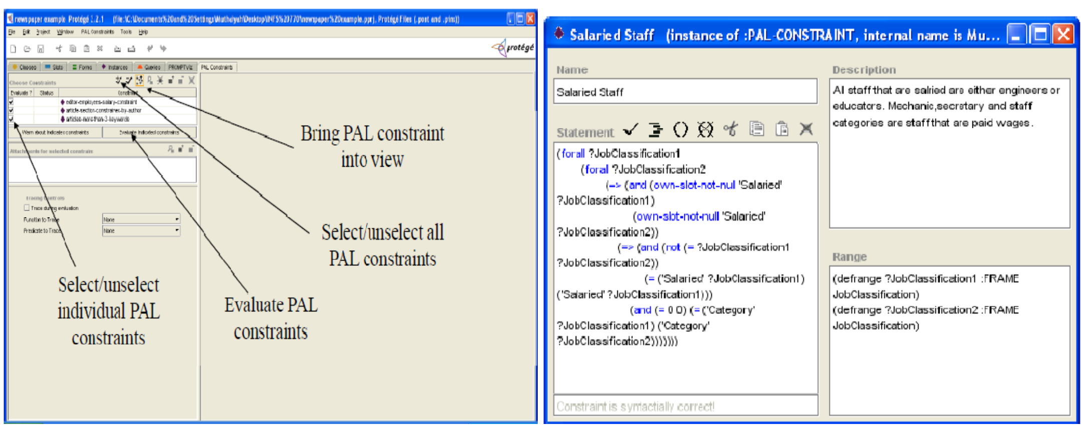

Fig. 2: PAL constraint and evaluation tabs

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 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. Figure 1 above lists the composition of ten family rules that was shown during tutorials.

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. 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.

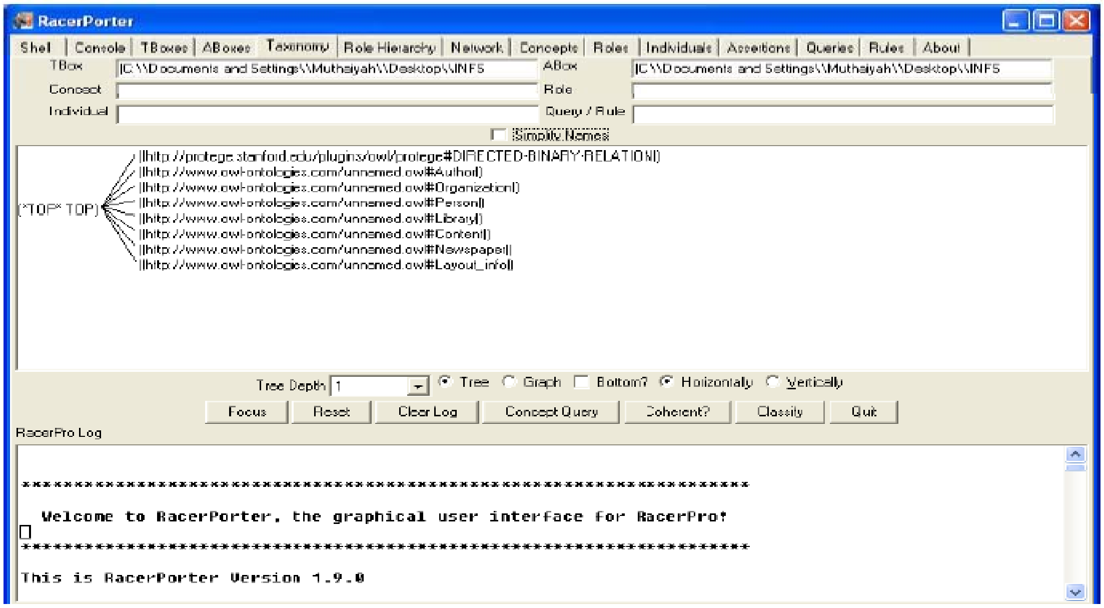

Fig. 3: SWRL constraint and evaluation tabs

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.

MATERIALS AND METHODS

This study was purely exploratory, not much was known about how to evaluate the effectiveness of the teaching and learning of technologies, especially for the KM domain. Since not much was known and information was scarce on this research topic even in developed countries, thus, the reason for this research was to generate new knowledge and improveunderstanding of what appropriate pedagogy is suitable for introducing and implementing innovative teaching technologies in KM. For the purpose of this study, primary source of data gathering was done. 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:

- To what extent has the curriculum and teaching tools used in the E-KM helped to produce technically sound KM knowledge among postgraduate students?
- What is the level of satisfaction of the students after attending the fourteen week long semester especially in mastering technical tools for KM?
- What is the level of effectiveness of the E-KM teaching and learning materials (i.e. hand-outs, notes, slides, online courseware and tutorials)?
- What is the level of effectiveness of assignment 1 (*ontology design*) in terms of acquiring knowledge of designing ontology from scratch?
- What is the level of effectiveness of assignment 2 (*understanding taxonomy and ontology implementation design*)?
- What is the level of effectiveness of assignment 3 (*implementing business rules in ontology*)?

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 26 carefully selected postgraduate students representing weak, average and good students as well as those who represented all six semester groups over three years. All 26 respondents answered the survey which gives it a 100% response rate.

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 with the aid of MMLS
H3	Students who completed all lessons on MMLS were more competent in writing business rules in a very short span of time

For the purpose of analysis the data set of 180 students were divided into two groups of 90 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 90 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 90 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 with the aid of MMLS. The MMLS factor led to better collaboration and adaptation in the learning environment by 89%. 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.

Analysis And Findings:

The first and second question were on demographics i.e. age and gender respectively. From a total of 26 responses 15 were female and 11 were male. Thus, females made up about 58% of the population and males made up 42%. 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 followingcharts depict this:

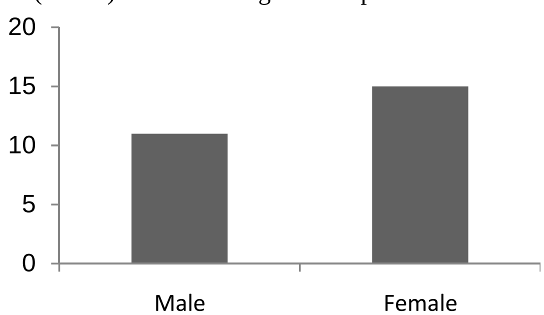

Fig. 4: Response by gender (Total)

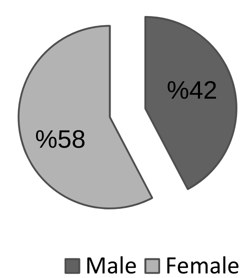

Fig. 5: Response by gender (%)

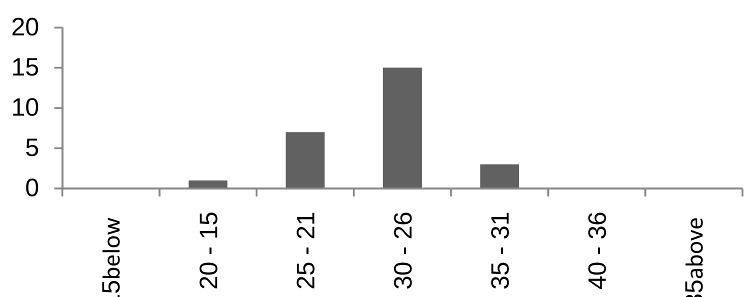

Fig. 6: Response by age

The third question was "how many times the student had taken the E-KM course?" .Out of 26 responses, 25 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: 7 respondentswere strongly satisfied (26.9%), 12 were somewhat satisfied (46.2%), 4 were somewhat dissatisfied (15.4%) and 3 were strongly dissatisfied (11.5%).

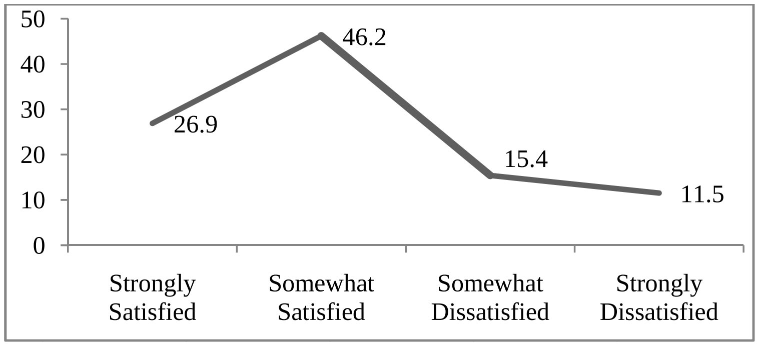

Fig. 7: Level of satisfaction of topics covered in E-KM class

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: 1 respondent answered strongly satisfied (3.8%), 16 were somewhat satisfied (61.5%), 7 were somewhat dissatisfied (26.9%) and 2 were strongly dissatisfied (7.7%). In summary, 65.3% were satisfied with the materials used.

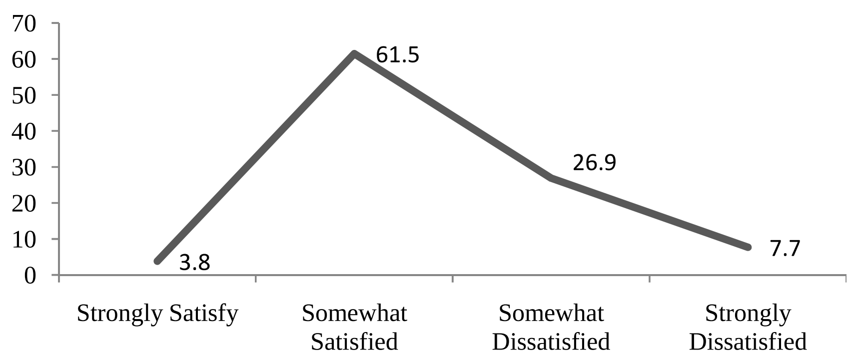

Fig. 8: Level of satisfaction of materials used in the E-KM class

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: 15 respondents answered strongly effective (57.7%), 9 answered somewhat effective (34.6%),none responded to somewhat ineffective and 2responded as ineffective (7.7%). In summary,92.3% were satisfied with the assignment 1.

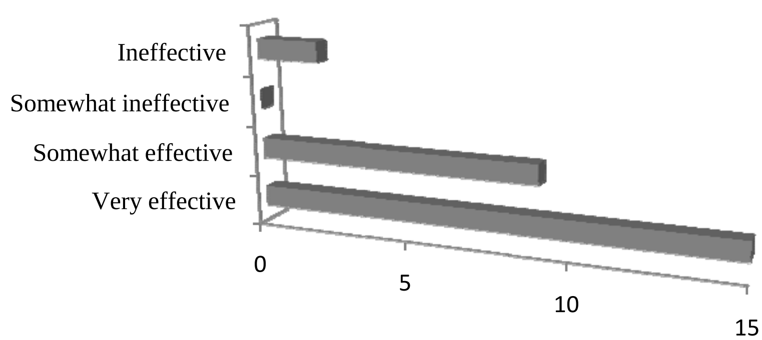

Fig. 9: Effectiveness ranking of assignment 2

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: 30.8% answered (80-100), 46.2% responded (60-80), and 11.5% responded (40-60), 7.7% answered (20-40) and 3.8% answered as (0-20). In summary the majority of students i.e. 20 out of 26 responded favourably to assignment 2.In the eighth question, “how do you rank the level of effectiveness of assignment 3 (implementing business rules in ontology) in helping you to assign rules for your ontology?” the responses were as follows: 23.1% answered very high, 38.5% responded somewhat high, 11.5% responded somewhat low and 26.9%respondedvery low. In summary, the majority of students i.e. 16 out of 26 responded favourably to assignment 3. A point worthy to note here is that the remaining 10 students who responded unfavourably to this question perhaps did not have any prior background at the undergraduate level in one more of these areas: description logic, programming, databases, query writing, software design and systems development.

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: 57.7% answered strongly agree, 15.4% responded agree, 15.4% were neutral and nobody (0%) disagreed and 11.5% responded strongly disagree. In summary, the majority of students i.e. 19 out of 26 responded favourably to this question.

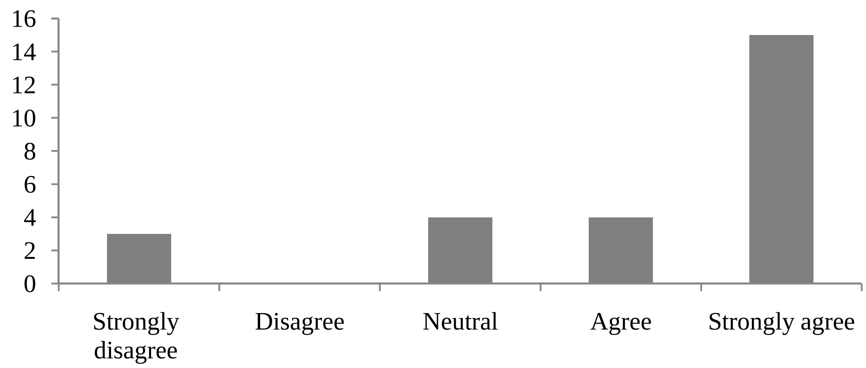

Fig. 10: Instructor’s knowledge to teach E-KM

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” andonly 3.8% responded “no”.

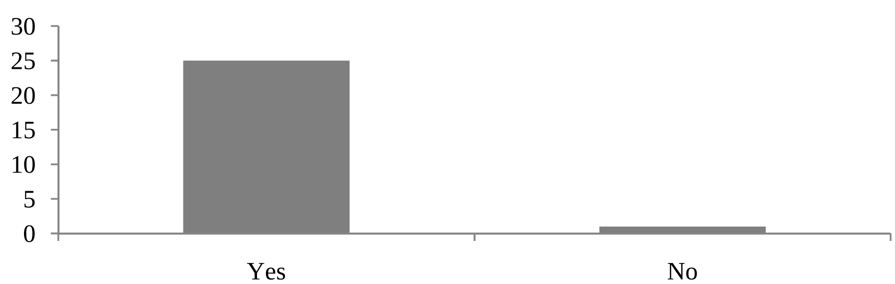

Fig. 11: Has your knowledge increased after the E-KM module

In the eleventh question, “was the E-KM course effective in increasing your knowledge in the KM domain?” the responses were: 26.9% answered strongly agree, 23.1% responded agree, 7.7% were neutral, 23.1% disagreed and 19.2% responded strongly disagree. In summary, more than 50% of the students responded favourably to this question.

Conclusion:

In conclusion, the contribution of this paper is twofold. Firstly, it highlights the effectiveness of the teaching tools for the teaching and learning of E-KM new curriculum, challenges in the development of course materials for the purpose of teaching and learning E-KM technologies i.e. Protégé, Jess, SPARQL, SWOOGLE, UML, CLIPS, PAL, SWRL, Racer Pro and Algernon. Secondly,it highlights the effectiveness of the instructor’s methods in teaching of this course including designing the curriculum that is comprehensive for the KM postgraduate programme particularly for a taught course like E-KM (discussed in detail in section two). 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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