รายงานวิจัยฉบับสมบูรณ์

โครงการ ระบบสร้างโครงสร้างขององค์ความรู้ เพื่อแนะนำสื่อการเรียนการสอนอิเล็กทรอนิกส์

โดย ดร. อาทิตยา นิตย์โชติ

เมษายน 2561

สัญญาเลขที่ MRG5980096

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ดร. อาทิตยา นิตย์โชติ มหาวิทยาลัยสงขลานครินทร์

สนับสนุนโดยสำนักงานกองทุนสนับสนุนการวิจัยและ
ต้นสังกัด

สารบัญ

<u>เอกสารแนบหมายเลข 2</u>

รูปแบบ Abstract (บทคัดย่อ)

Project Code: MRG5980096
(รหัสโครงการ)

Project Title: ระบบสร้างโครงสร้างขององค์ความรู้ เพื่อแนะนำสื่อการเรียนการสอนอิเล็กทรอนิกส์
(ชื่อโครงการ)

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(ระยะเวลาโครงการ)

Abstract

E-learning and web-based learning are intended to support learners. It is still difficult, however, for learners to identify and choose study materials that match their current and desired abilities. In addition, learners may fail to recognize missing prerequisite learning, and may fail to understand the relationships between the knowledge they seek. Most e-learning systems in Thailand do not provide the information needed to assist learners and avoid these difficulties.

This research proposes pedagogically-informed knowledge structures and associated applications, including a tool for designing and building such structures, a tool for navigating the structures for particular purposes (e.g., identifying knowledge missing from learners' existing knowledge), and a tool for recommending appropriate materials. Experimental studies will be conducted to validate the design of the knowledge structures and the methods for their construction, and to evaluate the effectiveness of the tools. Learners will be expected to gain significantly higher levels of achievement by using the knowledge structures and associated tools proposed in this research, and educational communities in Thailand will be able to share the knowledge structures and use the tools to support learners.

บทคัดย่อ

ระบบการเรียนออนไลน์และระบบการเรียนออนไลน์ผ่านเว็บเป็นสิ่งที่สนับสนุนผู้เรียน แต่อย่างไรก็ตาม ระบบที่มีอยู่ทั่วไปยังไม่สามารถระบุความสามารถของผู้เรียนและแนะนำสื่อการเรียนที่ตรงกับความสามารถและความต้องการของผู้เรียนได้ นอกจากนี้ผู้เรียนเองก็มีโอกาสที่ไม่สามารถระบุความรู้พื้นฐานของตนเองและความสัมพันธ์ระหว่างองค์ความรู้ได้

งานวิจัยนี้นำเสนอระบบในการแสดงโครงสร้างขององค์ความรู้และการนำไปใช้ในรูปแบบต่างๆ เช่น เครื่องมือในการออกแบบ สร้างโครงสร้างขององค์ความรู้ และเครื่องมือในการสืบค้นโครงสร้างขององค์ความรู้ พร้อมระบุความรู้พื้นฐานของขาดหายไปของผู้เรียน และเครื่องมือในการแนะนำสื่อการเรียนการสอนที่เหมาะสม นอกจากนี้ได้มีการทดสอบเกี่ยวกับการออกแบบโครงสร้างขององค์ความรู้ และทดสอบระบบที่สร้างขึ้น โดยผลสัมฤทธิ์ของผู้เรียนหลังจากใช้ระบบคือผู้เรียนมีพัฒนาระดับการเรียน นอกจากนี้จะมีการแลกเปลี่ยนโครงสร้างขององค์ความรู้ที่ออกแบบกันระหว่างผู้สอนได้

Keywords : Knowledge structure, Knowledge representation, e-Learning, Web-based learning
(คำหลัก)

Executive Summary

Knowledge Representation is the study of representing knowledge formally and explicitly, so supporting unambiguous knowledge sharing. This issue becomes particularly important when machines facilitate knowledge management (Guarino, 1995). In the learning and teaching environment, knowledge representation has been used to: represent a content structure of learning documents (Yang & Sun, 2013), support learners in their own knowledge acquisition (Chu, Lee, & Tsai, 2011; Shaw, 2010), and enable suggestions to learners (Chiou, Lee, & Liu, 2012). Knowledge relationships can be represented in many forms: maps, trees, networks, and graphs. They may be called concept maps, knowledge maps, and knowledge structures.

There are several methods of building knowledge structures (Li-Yu, Yu-Shih, & Chih-Ping, 2012; Nitchot, Gilbert, & Wills, 2011; Novak & Canas, 2006), and an interesting question is how such structures can pedagogically support learning and teaching activities. In the early stage of this research, literature related to methods of knowledge structure/concept map building and use in educational technology was reviewed, and Thai school teachers were surveyed and interviewed (as discussed in Section 8, Methodology). The questions asked about the teaching experiences and the uses of knowledge structures in teaching. The preliminary findings suggested that the teachers did not report using knowledge structures in teaching, but did use “mind maps” to support learners’ conceptualization and understanding of the course content. These were a rather rough note of content knowledge where the relationships among the content items were usually vague and imprecise (D'Antoni, Zipp, Olson, & Cahill, 2010). The teachers felt that mind maps were useful and that they could benefit education, helping learners think about and understand the relationships in the knowledge shown.

‘Resources’ are an important factor to complement a knowledge structure and support its use. There is still a lack of good resources for learning (Thai Education Testing Oranization, 2009). E-learning is one type of resource, comprising electronically-supported online courses, online websites, lesson videos, instructional TV, and so on. Such resources allow learners to study and practice/solve lesson problems at times and in places which may suit them better. While learners can retrieve supplementary online resources and familiarize themselves with missing knowledge before their course starts, it is difficult for them to find and access materials which match their intended learning outcomes (ILOs) or their current level of ability. Learners may not be able to identify their competences on their own, identify the relationships among both prerequisite and desired knowledge, or obtain learning materials which properly relate to their current and desired abilities.

This research suggests a method of constructing and applying knowledge structures to support learning and teaching which is based upon the ILOs in a targeted knowledge domain. The ‘MyTeLeMap’ application is a tool for building and visualizing knowledge structures. Instructors or knowledge structure designers (which could include learners themselves) can use this tool to develop, extend, and share knowledge structures. Importantly, the tool supports identifying knowledge missing from a learner’s current understanding and suggesting both learning paths and learning resources in respect of particular desired learning outcomes.

เนื้อหางานวิจัย

เนื้อหางานวิจัยประกอบด้วย วัตถุประสงค์ วิธีทดลอง ผลการทดลอง สรุปและวิจารณ์ผลการทดลอง และข้อเสนอแนะสำหรับงานวิจัยในอนาคต

1. วัตถุประสงค์

- เพื่อวิเคราะห์หลักการสร้างโครงสร้างขององค์ความรู้เพื่อนำไปใช้สำหรับนักเรียนและครูอาจารย์
- เพื่อออกแบบและสร้างเครื่องมือสำหรับสร้างและแสดงโครงสร้างขององค์ความรู้โดยผู้เชี่ยวชาญ
- เพื่อทดสอบเครื่องมือสำหรับสร้างและแสดงโครงสร้างขององค์ความรู้ 2 ระดับคือ ระดับความคิดเห็นเกี่ยวกับการใช้งานและการแสดงผลของโครงสร้างขององค์ความรู้ (ระดับ Reaction) และระดับการเรียนรู้ (ระดับ Learning)

2. วิธีการทดลอง

การทดสอบเครื่องมือสำหรับสร้างและแสดงโครงสร้างขององค์ความรู้ (MyTeLeMap) 2 ระดับ คือ ระดับความคิดเห็นเกี่ยวกับการใช้งานและการแสดงผลของโครงสร้างขององค์ความรู้ (ระดับ Reaction) และระดับการเรียนรู้ในรายวิชา Fundamental Programming (ระดับ Learning)

ในระดับความคิดเห็นเกี่ยวกับการใช้งานและการแสดงผลของโครงสร้างขององค์ความรู้นั้น ได้สำรวจผู้ใช้ทั้งในระดับคุณครู อาจารย์ และในระดับนักเรียน นักศึกษา เป็นการสอบถามความเห็นโดยทั่วไป โดยเน้นการทดสอบในเชิงสมรรถนะของระบบ (Utility) การใช้งานทั่วไป (Usability) และความพึงพอใจโดยรวมของผู้ใช้งาน (User’s satisfaction) รายละเอียด ผู้ทดสอบคือผู้ที่สามารถใช้คอมพิวเตอร์และค้นคว้าหาข้อมูลทางอินเทอร์เน็ต และมีความสนใจเกี่ยวกับการเรียนผ่านระบบออนไลน์ เอกสารในการทดสอบระดับความคิดเห็นในภาคผนวก A

ในระดับการเรียนรู้ในรายวิชา Fundamental Programming เพื่อทดสอบการใช้งานของระบบ Google เปรียบเทียบกับระบบ MyTeLeMap โดยเน้นการทดสอบในเชิงสมรรถนะของระบบ (Utility) การใช้งานทั่วไป (Usability) ความพึงพอใจโดยรวมของผู้ใช้งาน (User’s satisfaction) และการพัฒนาทางด้านการเรียนรู้ (Learning improvement) เอกสารในการทดสอบระบบระดับการเรียนรู้สามารถดูได้จากภาคผนวก B

3. ผลการทดลอง

ผลการทดสอบในระดับ Reaction สรุปได้ว่าผู้ใช้มีความพึงพอใจในการใช้งานของระบบโดยรวม โดยผลการทดลองแยกตามตัวแปรตามแสดงดังตารางที่ 1 ตัวแปรทั้งหมดคือ ความชัดเจนของการแสดงองค์ความรู้ ความชัดเจนของการแสดงความสัมพันธ์ระหว่างองค์ความรู้ ความพึงพอใจของความสัมพันธ์ระหว่างองค์ความรู้ ง่ายต่อการใช้ ความพึงพอใจโดยรวม สื่อที่แนะนำตรงกับองค์ความรู้

ตารางที่ 1: ผลการทดสอบระดับความคิดเห็นโดยใช้ one sample T-test

No	Dependent Variables	Mean	Sig. (2-tailed)
1	Clarity of node appearance	4.33	< 0.007
2	Clarity of the relationship between nodes	4.25	< 0.007
3	Satisfaction on the relationship between nodes	4.11	< 0.007
4	Tool is easy to use	4.20	< 0.007
5	Overall user's satisfaction on tool	4.38	< 0.007
6	Matching the materials with the structure nodes	4.31	< 0.007
7	Suggestion for future use	4.52	< 0.007

ผลการทดสอบในระดับ Learning สรุปได้ว่าระบบ MyTeLeMap และ Freely browsing สามารถช่วยให้นักเรียนเรียนรู้ได้เพิ่มขึ้นอย่างมีนัยสำคัญ แต่ระบบ MyTeLeMap สามารถช่วยนักเรียนเรียนรู้ได้มากกว่า Freely browsing อย่างมีนัยสำคัญ ดังตารางที่ 1, 2 และ 3

ตารางที่ 2:ค่า Means and Standard Deviation ของผลคะแนน

Test_Type	Learning_Mode	Mean	Std. Dev.	N
Pre_Test	Freely_Browsing	3.8	0.83	20
	MyTeLeMap	3.9	0.93	20
	Total	3.8	0.87	40
Post_Test	Freely_Browsing	5.5	1.10	20
	MyTeLeMap	7.5	1.10	20
	Total	6.5	1.50	40

ตารางที่ 3: Tests of Within-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	p.
Test_Type	140.45	1	140.45	154.48	<0.01
Test_Type * Learning_Mode	20.00	1	20.00	22.00	<0.01

ตารางที่ 4: Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	p.
Learning_Mode	22.05	1	22.05	20.36	<0.01
Error	41.15	38	1.08		

4. สรุปและวิจารณ์ผลการทดลอง

ผลการทดสอบในระดับ Reaction สรุปได้ว่าผู้ใช้มีความพึงพอใจในการใช้งานของระบบโดยรวม และมีข้อเสนอแนะเพื่อนำไปพัฒนาต่อไปเช่น การคัดกรองสื่อการเรียนรู้ออนไลน์อัตโนมัติ การแนบเอกสารการสอนในตัวองค์ความรู้ต่างๆ และการนำสื่อโซเชียลมีเดียมาใช้ในการเผยแพร่โครงสร้างขององค์ความรู้ที่สร้าง

ผลการทดสอบในระดับ Learning สรุปได้ว่าระบบ MyTeLeMap และ Freely browsing สามารถช่วยให้นักเรียนเรียนรู้ได้เพิ่มขึ้นอย่างมีนัยสำคัญ แต่ระบบ MyTeLeMap สามารถช่วยนักเรียนเรียนรู้ได้มากกว่า Freely browsing อย่างมีนัยสำคัญ และมีข้อเสนอแนะเพื่อนำไปพัฒนาต่อไปเช่น การพัฒนาเครื่องมือสืบค้นสื่อการเรียนการสอนออนไลน์ในระบบ MyTeLeMap

5. ข้อเสนอแนะสำหรับงานวิจัยในอนาคต

- การรวมระบบ Learning Management System กับระบบ MyTeLeMap เพื่อสามารถให้ครูอาจารย์แนบเอกสารการสอนในตัวองค์ความรู้ต่างๆ
- การพัฒนาเครื่องมือสืบค้นสื่อการเรียนการสอนออนไลน์ในระบบ MyTeLeMap

<u>เอกสารแนบหมายเลข 3</u>

Output จากโครงการวิจัยที่ได้รับทุนจาก สกว.

1. ผลงานตีพิมพ์ในวารสารวิชาการนานาชาติ (ระบุชื่อผู้แต่ง ชื่อเรื่อง ชื่อวารสาร ปี เล่มที่ เลขที่ และหน้า) หรือผลงานตามที่คาดไว้ในสัญญาโครงการ
    - ชื่อเรื่อง Monitoring, Teaching and Learning using Knowledge Maps and Structures วารสาร Chiang Mai University Journal of Natural Sciences (indexed in SCOPUS) ตีพิมพ์ภายในปี 2561 (ดังเอกสารแนบ)
    - ชื่อเรื่อง Personalized Learning System for Visualizing Knowledge Structures and Recommending Study Materials Links วารสาร the e-Learning and Digital Media (indexed in SCOPUS) ตีพิมพ์ภายในปี 2561
2. การนำผลงานวิจัยไปใช้ประโยชน์ (ดังเอกสารแนบ)
    - เชิงวิชาการ (มีการพัฒนาการเรียนการสอน/สร้างนักวิจัยใหม่)

ได้มีการนำระบบ MyTeLeMap ไปใช้ในระดับมหาวิทยาลัยและมัธยมศึกษา ในรายวิชาต่างๆเช่น การโปรแกรมขั้นสูง คณิตศาสตร์ระดับมัธยมศึกษาตอนปลาย ดนตรีไทย (ดังรูปภาพประกอบการทดลอง)

3. อื่นๆ (เช่น ผลงานตีพิมพ์ในวารสารวิชาการในประเทศ การเสนอผลงานในที่ประชุมวิชาการ หนังสือ การจดสิทธิบัตร)

นำเสนอในงานประชุมทางวิชาการ International Conference on Digital Arts, Media and Technology (2017) บทความทางวิชาการได้รับการคัดเลือกเป็น Best Paper และได้ถูกต่อยอดเพื่อลงตีพิมพ์ในวารสาร Chiang Mai University Journal of Natural Sciences (indexed in SCOPUS)

ภาคผนวก A

(เอกสารในการทดสอบระบบ MyTeLeMap ระดับความคิดเห็น)

ข้อมูลเบื้องต้นของการทดลอง

ระบบแนะนำสื่อการเรียนรู้ที่มีอยู่
ในโลกอินเทอร์เน็ตโดยอิงตามโครงสร้างขององค์ความรู้

วัตถุประสงค์ของการทดลอง

การทดลองนี้จัดทำขึ้นเพื่อทดสอบการใช้งานของระบบแนะนำสื่อการเรียนรู้ที่มีอยู่ในโลกอินเทอร์เน็ตโดยอิงตามโครงสร้างขององค์ความรู้ โดยเน้นการทดสอบในเชิงสมรรถนะของระบบ (Utility) การใช้งานทั่วไป (Usability) และความพึงพอใจโดยรวมของผู้ใช้งาน (User's satisfaction)

ผู้ทดสอบคือผู้ที่สามารถใช้คอมพิวเตอร์และค้นคว้าหาข้อมูลทางอินเทอร์เน็ต และมีความสนใจเกี่ยวกับการเรียนวิชาคณิตศาสตร์หรือสาขาที่เกี่ยวข้อง

รายละเอียดขั้นตอนในการทดสอบสำหรับผู้เข้าร่วมการทดสอบ

1) ผู้เข้าร่วมการทดสอบอ่านและเข้าใจรายละเอียดของการทดลอง

2) ผู้เข้าร่วมการทดสอบจะถูกฝึกเบื้องต้นเกี่ยวกับการใช้งานของระบบแนะนำสื่อการเรียนรู้ที่มีอยู่ในโลกอินเทอร์เน็ตโดยอิงตามโครงสร้างขององค์ความรู้

3) หลังจากที่ผู้เข้าร่วมทดสอบได้ทดลองใช้ระบบตามระยะเวลาที่กำหนดแล้ว ผู้เข้าร่วมทดสอบต้องอ่านขั้นตอนในการเข้าถึงส่วนต่างๆของระบบเพื่อตอบแบบสอบถาม ทั้งนี้เพื่อให้ผู้เข้าร่วมทดสอบสามารถได้เห็นและใช้เทคนิคของระบบได้อย่างเต็มที่

4) ผู้เข้าร่วมทดสอบตอบแบบสอบถาม จากนั้นคืนผลให้นักวิจัยเมื่อเสร็จ

วัน เวลา และสถานที่ในการทดสอบ

สถานที่ขึ้นอยู่กับผู้ทดสอบและนักวิจัยระหว่างเดือนมิถุนายน – สิงหาคม 2560

ระยะเวลาในการทดสอบเพื่อเข้าใช้ระบบ

ระยะเวลาในการทดสอบเพื่อเข้าใช้ระบบต่อผู้เข้าร่วมทดสอบ 1 คน จะใช้เวลาประมาณ 1 สัปดาห์

ข้อมูลเพิ่มเติม

หากผู้เข้าร่วมทดสอบมีข้อสงสัยหรือคำแนะนำเพิ่มเติม สามารถขอรายละเอียดได้จากนักวิจัยตามรายละเอียดดังนี้

ดร. อาทิตยา นิตย์โชติ

วิทยาลัยนานาชาติ มหาวิทยาลัยสงขลานครินทร์ วิทยาเขตหาดใหญ่

Email: athitaya.nitchot@gmail.com

แบบสอบถาม

ระบบแนะนำสื่อการเรียนรู้ที่มีอยู่
ในโลกอินเทอร์เน็ตโดยอิงตามโครงสร้างขององค์ความรู้

จุดประสงค์ของแบบสอบถามฉบับนี้คือ ต้องการสอบถามความคิดเห็นของผู้ใช้ระบบแนะนำสื่อการเรียนรู้ที่มีอยู่ในโลกอินเทอร์เน็ตโดยอิงตามโครงสร้างขององค์ความรู้ ถึงการแสดงผลของโครงสร้างขององค์ความรู้ และการใช้งานของระบบโดยรวมถึงความพึงพอใจในการใช้งาน ความสนใจของผู้ใช้และเทคนิคที่แนะนำให้กับผู้ใช้ โดยแบบสอบถามมีทั้งหมด 10 ข้อ กรุณาใส่เครื่องหมาย ✓ หน้าข้อความที่ตรงกับข้อเท็จจริงหรือความคิดเห็นของท่านมากที่สุด

ส่วนที่ 1: การแสดงผลโครงสร้างขององค์ความรู้					
คำถาม	**ไม่เห็นด้วยอย่างยิ่ง**	**ไม่เห็นด้วย**	**ไม่แน่ใจหรือเฉยๆ**	**เห็นด้วย**	**เห็นด้วยอย่างยิ่ง**
1) การแสดงผลของโครงสร้างขององค์ความรู้มีความชัดเจน (Clarity of appearance)					
2) ผู้ใช้มีความพึงพอใจกับการแสดงผลของโครงสร้างขององค์ความรู้ (Satisfaction of appearance)					
3) ผู้ใช้มีความเข้าใจถึงการแสดงผลของโครงสร้างขององค์ความรู้ (Understanding the appearance/design of knowledge map)					
4) การใช้งานของโครงสร้างขององค์ความรู้มีความง่าย (Easy to use knowledge map)					

ส่วนที่ 2: การใช้งานของระบบแนะนำสื่อการเรียนที่มีอยู่ในโลกอินเทอร์เน็ตโดยอิงตามโครงสร้างขององค์ความรู้					
คำถาม	**ไม่เห็นด้วยอย่างยิ่ง**	**ไม่เห็นด้วย**	**ไม่แน่ใจหรือเฉยๆ**	**เห็นด้วย**	**เห็นด้วยอย่างยิ่ง**
1) การใช้งานของระบบโดยรวมมีความง่าย (Easy to use)					
2) ผู้ใช้มีความพึงพอใจกับระบบโดยรวม (User's satisfaction)					
3) ระบบแนะนำโครงสร้างขององค์ความรู้ที่หลากหลาย (Wide range types of knowledge maps)					
4) ผู้ใช้มีความพึงพอใจกับคุณภาพของลิงค์สื่อการเรียนที่แนะนำ (Quality of links)					
5) ผู้ใช้มีความสนใจที่จะแนะนำระบบให้กับผู้ใช้รายอื่นๆ (Suggestion for future use)					
6) ข้อเสนอแนะเพิ่มเติม	....				

ภาคผนวก B

(เอกสารในการทดสอบระบบ MyTeLeMap ระดับความคิดเห็น)

ข้อมูลเบื้องต้นของการทดลอง

ระบบ Google

วัตถุประสงค์ของการทดลอง

การทดลองนี้จัดทำขึ้นเพื่อทดสอบการใช้งานของระบบ Google โดยเน้นการทดสอบในเชิงสมรรถนะของระบบ (Utility) การใช้งานทั่วไป (Usability) ความพึงพอใจโดยรวมของผู้ใช้งาน (User's satisfaction) และการพัฒนาทางด้านการเรียนรู้ (learning improvement)

ผู้ทดสอบแบ่งเป็น 2 กลุ่มดังนี้

- ☐ ผู้ที่สามารถใช้คอมพิวเตอร์และค้นคว้าหาข้อมูลทางอินเทอร์เน็ต และมีความสนใจเกี่ยวกับการเรียนรู้ด้วยตัวเอง (Self learning) โดยผู้เรียนจะใช้เครื่องมือตามที่นักวิจัยระบุ
- ☐ ผู้เชี่ยวชาญในสาขาวิชาต่างๆ อาจารย์ คุณครู หรือผู้ที่สามารถออกแบบหลักสูตรได้

รายละเอียดขั้นตอนในการทดสอบสำหรับผู้เข้าร่วมการทดสอบ

1) ผู้เข้าร่วมการทดสอบระบบทุกคนจะได้รับโจทย์และมีระยะเวลาในการทำ 1 ชั่วโมงดังนี้

"หากคุณได้เข้าปฏิบัติงานเป็นอาจารย์สอนในรายวิชา Basic Programming โปรดเขียนหลักการ 10 หลักการเกี่ยวกับรายวิชาดังกล่าว"

2) ผู้เข้าร่วมทดสอบใช้เครื่องมือ Google ในการตอบโจทย์ที่ได้รับมอบหมาย

4) ผู้เข้าร่วมทดสอบตอบโจทย์เสร็จแล้ว ให้คืนผลแก่นักวิจัย

วัน เวลา และสถานที่ในการทดสอบ

สถานที่ขึ้นอยู่กับผู้ทดสอบและนักวิจัยระหว่างวันที่ 1 - 28 กุมภาพันธ์ 2560

ระยะเวลาในการทดสอบ

ระยะเวลาในการทดสอบต่อผู้เข้าร่วมทดสอบ 1 คน จะใช้เวลาประมาณ 2 ชั่วโมง

ข้อมูลเพิ่มเติม

หากผู้เข้าร่วมทดสอบมีข้อสงสัยหรือคำแนะนำเพิ่มเติม สามารถขอรายละเอียดได้จากนักวิจัยตามรายละเอียดดังนี้

ดร. อาทิตยา นิตย์โชติ

วิทยาลัยนานาชาติ มหาวิทยาลัยสงขลานครินทร์ วิทยาเขตหาดใหญ่

อำเภอหาดใหญ่ จังหวัดสงขลา 90110

Email: athitaya.nitchot@gmail.com

ข้อมูลเบื้องต้นของการทดลอง

ระบบแนะนำสื่อการเรียนรู้ที่มีอยู่
ในโลกอินเทอร์เน็ตโดยอิงตามโครงสร้างขององค์ความรู้

วัตถุประสงค์ของการทดลอง

การทดลองนี้จัดทำขึ้นเพื่อทดสอบการใช้งานของระบบแนะนำสื่อการเรียนรู้ที่มีอยู่ในโลกอินเทอร์เน็ตโดยอิงตามโครงสร้างขององค์ความรู้ โดยเน้นการทดสอบในเชิงสมรรถณะของระบบ (Utility) การใช้งานทั่วไป (Usability) ความพึงพอใจโดยรวมของผู้ใช้งาน (User's satisfaction) และการพัฒนาทางด้านการเรียนรู้ (learning improvement)

ผู้ทดสอบแบ่งเป็น 2 กลุ่มดังนี้

- ☐ ผู้ที่สามารถใช้คอมพิวเตอร์และค้นคว้าหาข้อมูลทางอินเทอร์เน็ต และมีความสนใจเกี่ยวกับการเรียนรู้ด้วยตัวเอง (Self learning) โดยผู้เรียนจะใช้เครื่องมือตามที่นักวิจัยระบุ
- ☐ ผู้เชี่ยวชาญในสาขาวิชาต่างๆ อาจารย์ คุณครู หรือผู้ที่สามารถออกแบบหลักสูตรได้

รายละเอียดขั้นตอนในการทดสอบสำหรับผู้เข้าร่วมการทดสอบ

1) ผู้เข้าร่วมการทดสอบระบบทุกคนจะได้รับโจทย์และมีระยะเวลาในการทำ 1 ชั่วโมงดังนี้

"หากคุณได้เข้าปฏิบัติงานเป็นอาจารย์สอนในรายวิชา Basic Programming โปรดเขียนหลักการ 10 หลักการเกี่ยวกับรายวิชาดังกล่าว"

2) ผู้เข้าร่วมทดสอบใช้เครื่องมือ MyTeLeMap ในการตอบโจทย์ที่ได้รับมอบหมาย

4) ผู้เข้าร่วมทดสอบตอบโจทย์เสร็จแล้ว ให้คืนผลแก่นักวิจัย

วัน เวลา และสถานที่ในการทดสอบ

สถานที่ขึ้นอยู่กับผู้ทดสอบและนักวิจัยระหว่างวันที่ 1 - 28 กุมภาพันธ์ 2560

ระยะเวลาในการทดสอบ

ระยะเวลาในการทดสอบต่อผู้เข้าร่วมทดสอบ 1 คน จะใช้เวลาประมาณ 2 ชั่วโมง

ข้อมูลเพิ่มเติม

หากผู้เข้าร่วมทดสอบมีข้อสงสัยหรือคำแนะนำเพิ่มเติม สามารถขอรายละเอียดได้จากนักวิจัยตามรายละเอียดดังนี้

ดร. อาทิตยา นิตย์โชติ
วิทยาลัยนานาชาติ มหาวิทยาลัยสงขลานครินทร์ วิทยาเขตหาดใหญ่
อำเภอหาดใหญ่ จังหวัดสงขลา 90110
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Pre-test (Fundamental Programming)

1) The keyword used to transfer control from a function back to a calling function is (function)

A. switch

B. goto

C. go back

D. return

2) What knowledge is required to learn about functions in programming? (testing prerequisites)

A. Parameter passing and objects

B. Objects and strings

C. Encapsulation and variables

D. Variables and strings

3) Suppose a, b, c are integer variables with values 5, 6, 7 respectively. What is the value of the expression: not((b+c) > (a+10)) (operator)

A. 1 B. 0

C. 2 D. -2

4) How would you declare a variable to store the city of birth of a person? (string)

A. Char: city

B. String: city

C. Integer: city

D. Boolean: city

5) Which of the following is a valid variable name? (variable)

A. NBasic Salary

B. NBasicSalary

C. NBasic.Salary

D. NBasic+Salary

6) With regard to question 3 and 5 above: (testing prerequisite)

A. You need to be able to answer question 3 in order to answer question 5

B. You need to be able to answer question 5 in order to answer question 3

C. Questions 3 & 5 depend upon each other equally

D. Question 3 has nothing to do with question 5

7) Statement 1: A variable must be declared before being used in a program. Statement 2: A variable can be used without being initialized. (variable)

A. Statement 1 is True and Statement 2 is false

B. Both statements are true

C. Statement 1 is false and Statement 2 is true

D. Both statements are false

8) Which type of operator is used to test the equality of two variables or of a variable and a constant? (Operators)

A. Arithmetic operator

B. Logical operator

C. Relational operator

D. Special operator

9) With regard to questions 1, 7 and 8, you need to be able to answer: (testing prerequisite)

A. Q8 before Q7, and Q7 before Q1

B. Q7 before Q1, and Q1 before Q8

C. Q1 before Q7, and Q7 before Q8

D. Q7 before Q8, and Q8 before Q1

10) In order to be able to answer a question such as Q1, knowledge of:

A: Strings is needed.

B. Objects is needed.

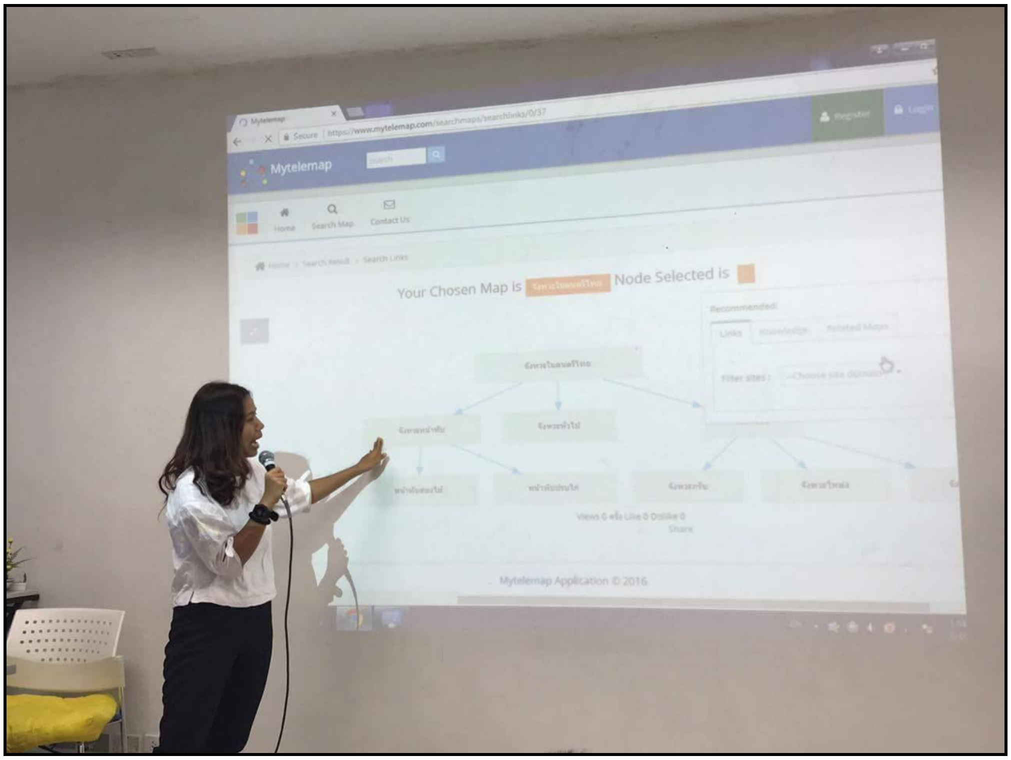
C. Encapsulation is needed.

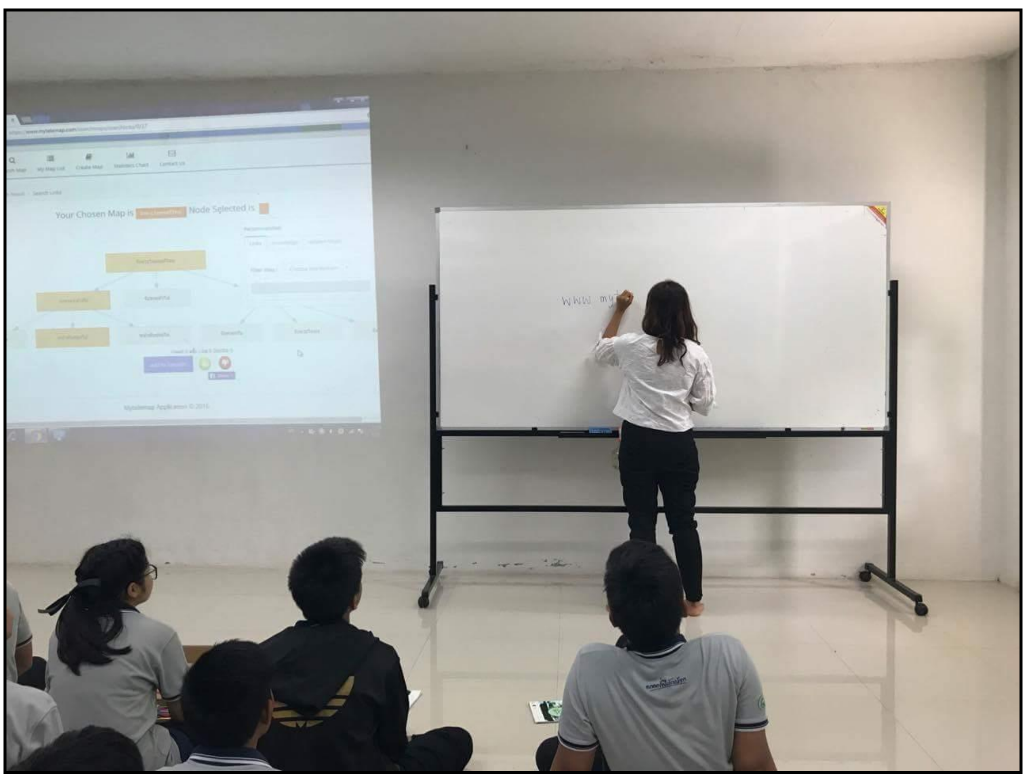
D. Parameter passing is needed.

ภาคผนวก C

(ภาพกิจกรรมที่เกี่ยวข้องกับการนำผลจากโครงการไปใช้)

มีการแนะนำระบบ MyTeLeMap ให้กับนักเรียนชั้นมัธยมศึกษา โรงเรียนมหิดลวิทยานุสรณ์





ภาคผนวก D

(Manuscriptที่ 1)

Nitchot, A., Wettayapresit, W. and Gilbert, L. Personalized Learning System for Visualizing Knowledge Structures and Recommending Study Materials Links. E-Learning and Digital Media (Under Revision)

Personalized Learning System for Visualizing Knowledge Structures
and Recommending Study Materials Links

Abstract

The aim of this research is to introduce a method of constructing knowledge structures which represent the relationships among the knowledge items in a pedagogically useful way. A prototype, ‘MyTeLeMap’, was implemented to support both learners and instructors. Learners could visualize the knowledge structures in different knowledge domains and obtain links to corresponding study materials. The system also offered learning paths and recommendations, for example, to related structures. Instructors could create and share their knowledge structures. An experiment compared the learning outcomes of learners using MyTeLemap and those using a free-browsing mode. The results showed that MyTeLeMap helped learners more than free browsing. Future work includes the incorporation of a search application for learners and of management features for instructors to upload and share learning materials linked to specific knowledge domains.

Keywords: Personalized Learning; Knowledge Structure; Web-based Learning; Internet Supported Learning; Pedagogy; Structure Visualization

Introduction

Knowledge Representation is the study of representing knowledge formally and explicitly, so supporting unambiguous knowledge sharing. This issue becomes particularly important when machines facilitate knowledge management (Guarino, 1995). In the learning and teaching environment, knowledge representation has been used to: represent a content structure of learning documents (Yang & Sun, 2013), support learners in their own knowledge acquisition (Chu, Lee, & Tsai, 2011; Shaw, 2010), and enable suggestions to learners (Chiou, Lee, & Liu, 2012). Knowledge relationships can be represented in many forms: maps, trees, networks, and graphs. They may be called concept maps, knowledge maps, and knowledge structures.

There are several methods of building knowledge structures (Li-Yu, Yu-Shih, & Chih-Ping, 2012; Nitchot, Gilbert, & Wills, 2011; Novak & Canas, 2006), and an interesting question is how such structures can pedagogically support learning and teaching activities. In the early stage of this research, literature related to methods of knowledge structure/concept map building and use in educational technology was reviewed, and Thai school teachers were surveyed and interviewed (as discussed in Section 8, Methodology). The preliminary findings suggested that even though knowledge structures have been recommended for many years, school teachers did not report using them in their teaching. While “mind maps” were used to support learners’ conceptualization and understanding of the course content, these are a rather rough note of content information where the relationships among the content items are usually vague and imprecise (D'Antoni, Zipp, Olson, & Cahill, 2010). The teachers felt that mind maps were useful and that they could benefit education, helping learners think about and understand the relationships in the information shown.

‘Resources’ are an important factor to complement a knowledge structure and support its use. There is still a lack of good resources for learning (Thai Education Testing Oranization, 2009). E-learning is one type of resource, comprising electronically-supported online courses, online websites, lesson videos, instructional TV, and so on. Such resources allow learners to study and practice/solve lesson problems at times and in places which may suit them better. While learners can retrieve supplementary online resources and familiarize themselves with missing knowledge before their course starts, it is difficult for them to find and access materials which match their intended learning outcomes (ILOs) or their current level of ability. Learners may not be able to identify their competences on their own, identify the relationships among both prerequisite and desired knowledge, or obtain learning materials which properly relate to their current and desired abilities.

This research suggests a method of constructing and applying knowledge structures to support learning and teaching which is based upon the ILOs in a targeted knowledge domain. The ‘MyTeLeMap’ application is a tool for building and visualizing knowledge structures. Instructors or knowledge structure designers (which could include learners themselves) can use this tool to develop, extend, and share knowledge structures. Importantly, the tool supports identifying knowledge missing from a learner’s current understanding and suggesting both learning paths and learning resources in respect of particular desired learning outcomes.

Knowledge Representation and Applications

Sowa (2000) defined knowledge representation (KR) as “a multidisciplinary subject that applies theories from three fields: logic, ontology, and computation.” Logic identifies the formal structure and rules of inference. Ontology refers to the kinds of things that exist in the application domain. Computation distinguishes the application of KR from pure philosophy. Bench-Capon (2014) suggested KR is a set of syntactic and semantic conventions that makes it possible to describe things. Syntax refers to a set of rules for combining symbols to form valid expressions, and semantics specifies how such expressions are to be interpreted. From these definitions, we consider KR to be a way to represent things using valid and understandable expressions which we process and visualize as knowledge structures.

Liao (2003) reviewed the literature of KR applications and found it used within fields such as human resources, management, database management, agriculture, and e-learning.

Chiu & Pan (2014) designed a knowledge structure to represent the information related to research papers (topic, name and cited frequency) and to explore the relationships among them, helping readers understand the relationships among selected topics, papers, and citation frequencies. Wickel et al. (2013) used knowledge structures to manage human resources within organizations, identifying project team roles and members’ relevant knowledge. Abel (2015) developed ‘E-MEMORAe’ as a web platform for managing and sharing knowledge within an organization (Figure 1). This system was adapted to an educational environment, where learners could use the knowledge structures to access learning resources. In this research (Abel, 2015) , knowledge is defined using ontologies which cover the knowledge structure and its functionality. Hao, Yan, Gong, Wang, & Lin (2014) proposed a method of constructing a knowledge structure with the following steps: defining the domain knowledge content, computing a keyword-by-knowledge item co-occurrence matrix, and calculating semantic similarity. A sample of a resulting knowledge structure is shown in Figure 2.

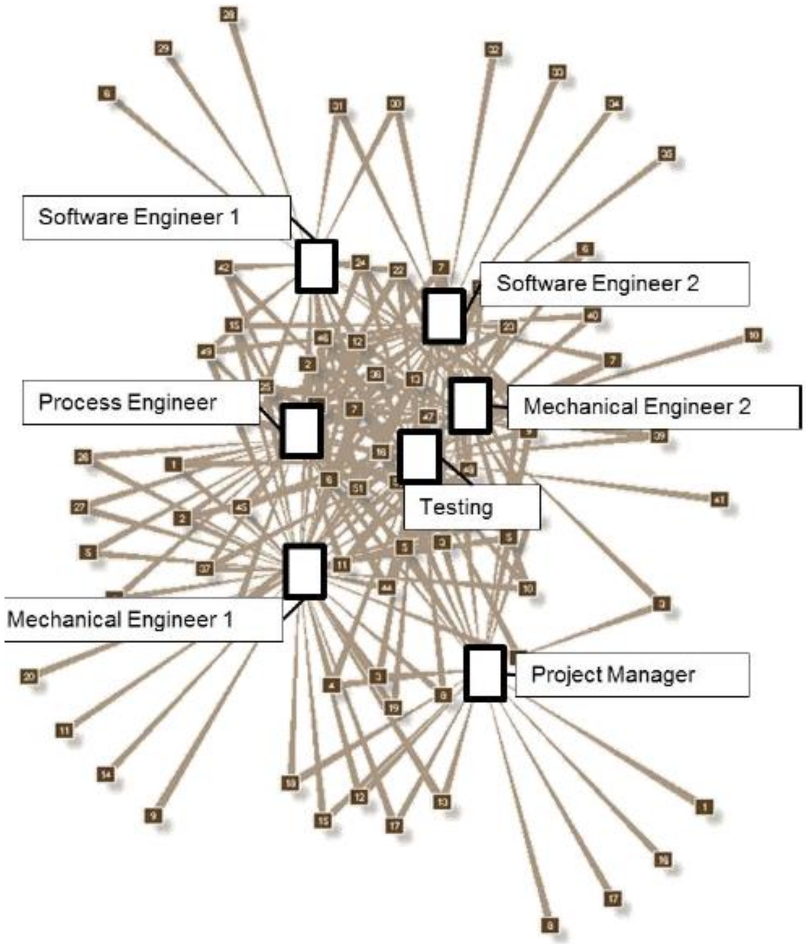


Figure 1. Knowledge Map Containing 7 Persons in a Projects and Their Identified Knowledge (Abel, 2015)

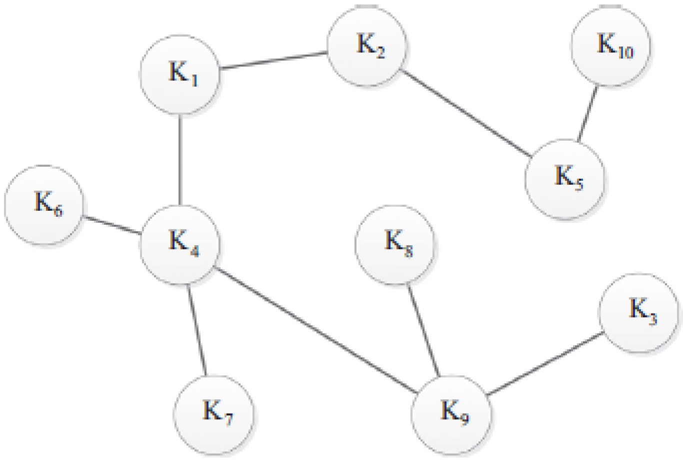


Figure 2. An Example of Knowledge Map Where k is the Knowledge Keyword (Hao et al., 2014)

Related work has adopted KR within e-learning. Melis, Budenbender, Goguadze, Libbrecht, and Ullrich (2003) proposed ‘ACTIVEMATH’, an open Web-based learning environment for mathematics. where the KR represented the content structure of mathematical learning resource documents. It used ‘OMDoc’ (Kohlhase, 2000), an extension of the OpenMath XML standard,and contained a grammar representation of mathematical objects and sets of standardized symbols (the content dictionaries). Marshall et al. (2003) proposed ‘GetSmart’, a tool to allow individuals to create and share knowledge, where users could construct concept maps and synthesize their ideas into personal knowledge representations. XML was applied to enhance modularity for concept map sharing. Mendes, Martinez and Sacks (2002) used a fuzzy clustering algorithm and ‘TopicMaps’, a tool for modelling and managing knowledge structures which are in the form of XML documents, to discover and represent knowledge. The relationships between learning materials were identified by fuzzy clustering and later used within adaptive link documents.

Personalized Search within Educational System

Gordon and Pathak (1999) discussed four different methods for locating information on the Web. Of direct interest is the use of search engines to find and then furnish information that hopefully relates to the search term. Griffiths & Brophy (2007) suggested that learners use search engines to find learning resources from the internet as a self-learning activity. Currently, there are a number of search engines, for example, Google, Bing, Yahoo, and Alta Vista. Google is often used for searches in a learning context since it gives a high probability that the first result is relevant (Hawking, Craswell, Bailey, & Griffiths, 2001). In addition, Google offers the largest index, useful services, and relatively good performance and usability (Mayr & Tosques, 2005), (Pan et al., 2007).

There is an argument, however, against Google's search engine based on the PageRank algorithm, which is that PageRank is not effective for identifying the best webpages in a university system because of its domination by internal links (Thelwall, 2003). Normally Google search results contain various kinds of webpages such as blogs, forums, electronic books, and electronic files. While some of these results could contain pages with academic purposes, others may contain internal links with nonacademic purposes. Nevertheless, a Google search remains an effective way to gather all resources from the Web which may be related to a learner's search using competence terms.

Tang & Ng (2006) used Google as a diagnostic aid for both doctors and patients. Their results showed that web-based search engines such as Google are becoming that latest tools in clinical medicine, and doctors in training need to become proficient in their use. Some studies were conducted to assess the effectiveness of Google as a tool for personal learning. Griffiths & Brophy (2007) investigated user searching behaviour and information-seeking strategies. Google was rated well for ease of use, success, and time taken to search, and was found to be the search engine of choice, though students found it difficult to locate information and resources and may trade quality of results for effort and time spent searching. Liaw, Chang, Hung, & Huang (2006) investigated individual attitudes toward search engines as a learning assistance tool. Their results suggested that experience with high quality search engines positively influenced user perception of individual enjoyment and self-efficacy. Tsai & Tsai (2003) explored students' strategies in searching for information via Web-based activities. They concluded that high Internet self-efficacy students had better searching strategies and learned better than those with low Internet self-efficacy. While Google helped learners find information and study resources, there are some limitations in the quality of found resources and in the students' self-efficacy skills.

Constructing MyTeLeMap Knowledge Structures

Some methods and approaches of how to design and construct knowledge structures were reviewed in Section 2. In this study, information on subject matter and learning outcomes was obtained from school teachers, followed by a task analysis to give a diagrammatic representation of the subject matter (Gilbert and Gale, 2008).

Knowledge structures were built as follows, adapting the process described by Nitchot, Gilbert, and Wills (2011):

Step 1: Choose knowledge domain, identify ILOs, list subject matter

The construction of a pedagogically-informed knowledge structure starts by identifying the ILOs that a student's knowledge will support. For example, the ILO 'define HTML' might be relevant for a knowledge domain of 'Web Technologies'. The ILOs are analysed to provide a list of subject matter content. The earlier example of an ILO suggests 'HTML' as an item of subject matter to be added to the list.

Step 2: Undertake task analysis of subject matter

The subject matter content is categorized into four types based on Merrill's CDT (Gilbert and Gale, 2008): fact, concept, procedure, and principle. The task analysis provides the relationships and structures inherent in each type of subject matter, using a diagrammatic approach where the type of subject matter has a characteristic notation and representation.

A 'fact' is represented by two elements which make a fact pair. Each element is notated as a circle. For example, the fact of 'HTML' is represented as a pair of two facts, 'standard markup language' and 'tags elements', as shown in Figure 3.

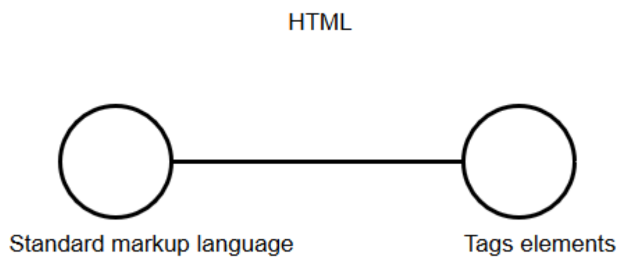


Figure 3. Task Analysis of the Fact 'HTML' as a Standard Markup Language Comprising Tags Elements.

A 'concept' involves the concept name, its superordinate class, and a number of attribute-value pairs which appropriately characterise the concept. The relationship between class and superordinate class is 'a kind of' or 'type of'. The concept is notated as triangle, and its components are shown as facts. For example, the concept of 'CSS' is illustrated in Figure 4, showing that the concept 'CSS' is a kind of 'style' characterised by its 'compatibility' with 'HTML' and its 'composition' comprising 'property' and 'value'.

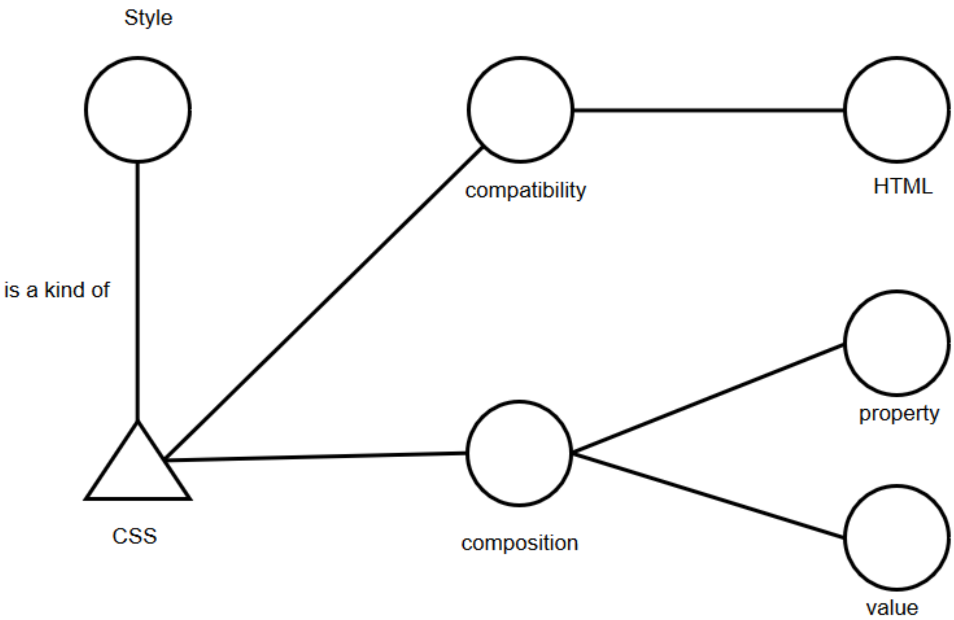


Figure 4. Task Analysis of the Concept 'CSS'

A 'procedure' is represented as a set of steps (and optionally has associated facts and concepts such as the procedure name, the situation in which it may be appropriately applied, and the goal which it achieves). A step is notated as a square (or, more elaborately, the procedure may be notated as a UML activity diagram). For example, the procedure of 'setting the website online' is shown in Figure 4.

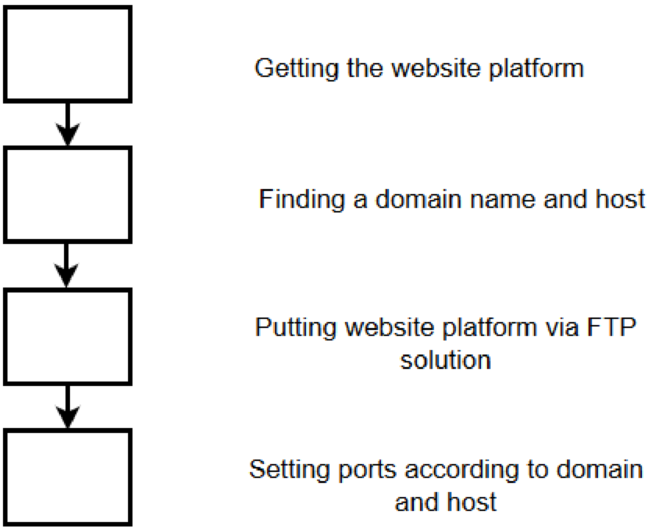


Figure 5. Task Analysis of the Procedure 'Setting the Website Online'

A 'principle' involves the specification of cause and effect. The principle itself is notated as a pentagon with something of a direction suggested by two sides. For example, a principle of CSS definition is shown in figure 6. Causes are shown on the left side of pentagon and the right side shows the effect or result of the principle. Here, the set of causes and effect is the fact

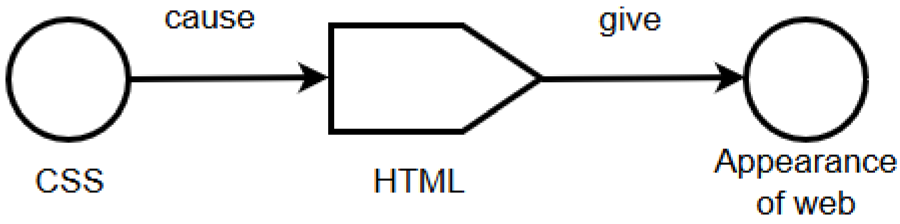


Figure 6. Task Analysis of the Principle 'CSS Definition'

Step 3: Completing the subject matter list

The task analysis of the subject matters is t reviewed and the list of subject matter enhanced to ensure completeness that all required facts, concepts, procedures, and principles are present. For example, 'HTML' comprises 'tags elements', and consideration may be given to enumerating the various tag elements in the subject matter list if these are not already incorporated. This might be appropriate if an ILO such as, "list the major HTML tags" is to be added to the knowledge domain.

Step 4: Structure the subject matter

Given the complete list of subject matter and the associated task analyses which identify the relationships between the subject matter items, a knowledge structure is created by representing each subject matter item as a node, and by connecting nodes where the items are connected in the task analysis diagrams. The relationship between subject matter nodes is parent-child, and by convention is noted by an arrow pointing to the child node. Which is the parent and which the child is given by the relationship shown in the task analysis, and, pedagogically, can be considered prerequisite. Ideally, the knowledge structure conforms to the requirements of a directed acyclic graph, in which case it is also known as a dependency graph and a number of theorems of graph theory apply on reachability and path uniqueness. This knowledge structure represents the domain subject matter. In order to develop a competence structure, each node of subject matter requires tagging with a corresponding capability (from the associated ILO) and a context (implied by the ILO). Figure 7 shows a sample of a knowledge structure of a mathematical subject (at high school level).

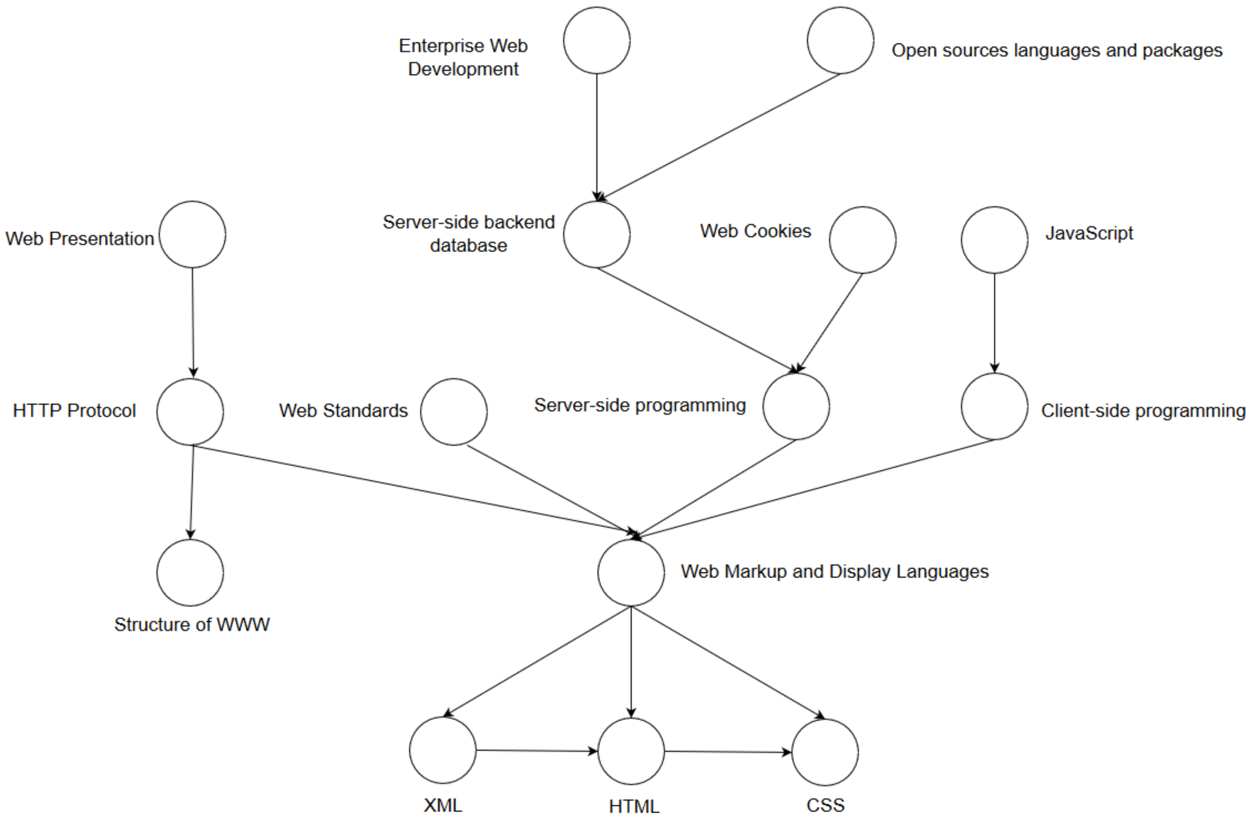


Figure 7. Knowledge Structure of Web technologies Where Arrow Indicates the Prerequisite and Circle Indicates the Subject Matter

Tools for Suggesting Learning Resources' Links

A tool for suggesting links to learning resources based on knowledge structures has been implemented as a prototype called 'MyTeLeMap'. The current tool incorporates the designed knowledge structures and their associated learning resources (mainly html links). A graph visualization library (such as Graphviz [REF] and Microsoft Automatic Graph Layout [REF]) display the graph nodes and edges from the knowledge database. The Google API is used to gather links from the web. The tool infrastructure is shown in Figure 8. Currently, a recommender system and a learning path service are under investigation (rounded rectangles with strong line).

Figure 9 and Figure 10 show screenshots of the prototype MyTeLeMap tool in use. In Figure 9, the chosen knowledge structure is shown and links associated with the selected node are suggested. The links are obtained from a Google search using the Google API and default settings, where the search keywords are extracted from the knowledge keywords in the selected node. The search results can be filtered by website (e.g., YouTube, Wikipedia). In Figure 10, the nodes are suggested based on the current selected node and previously visited nodes. The teacher role can manage all designed knowledge structures, as shown in Figure 11, and can create new knowledge structure as shown in Figure 12.

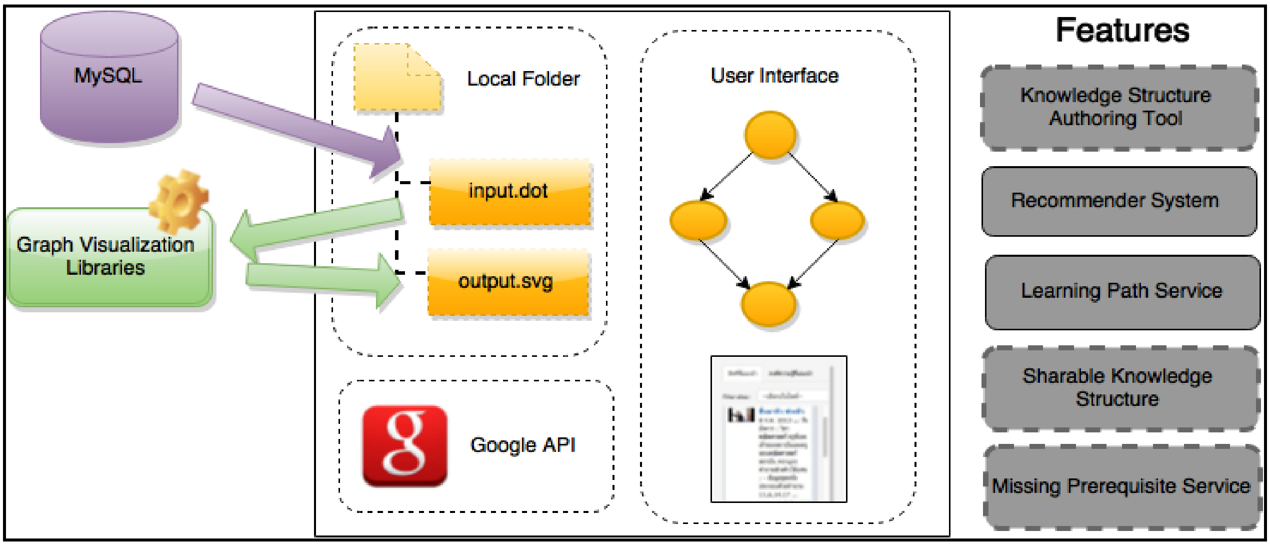


Figure 8. MyTeLeMap Tool Infrastructure

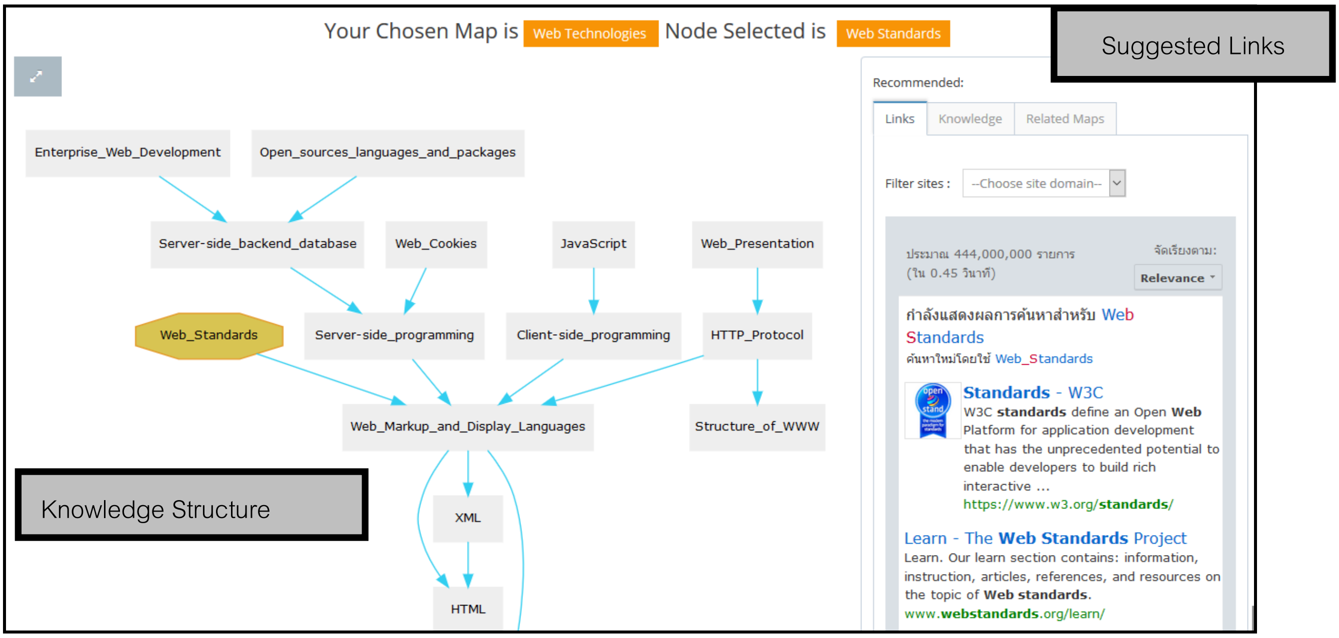


Figure 9. Screenshot of the Prototype MyTeLeMap Suggesting Study Materials Links

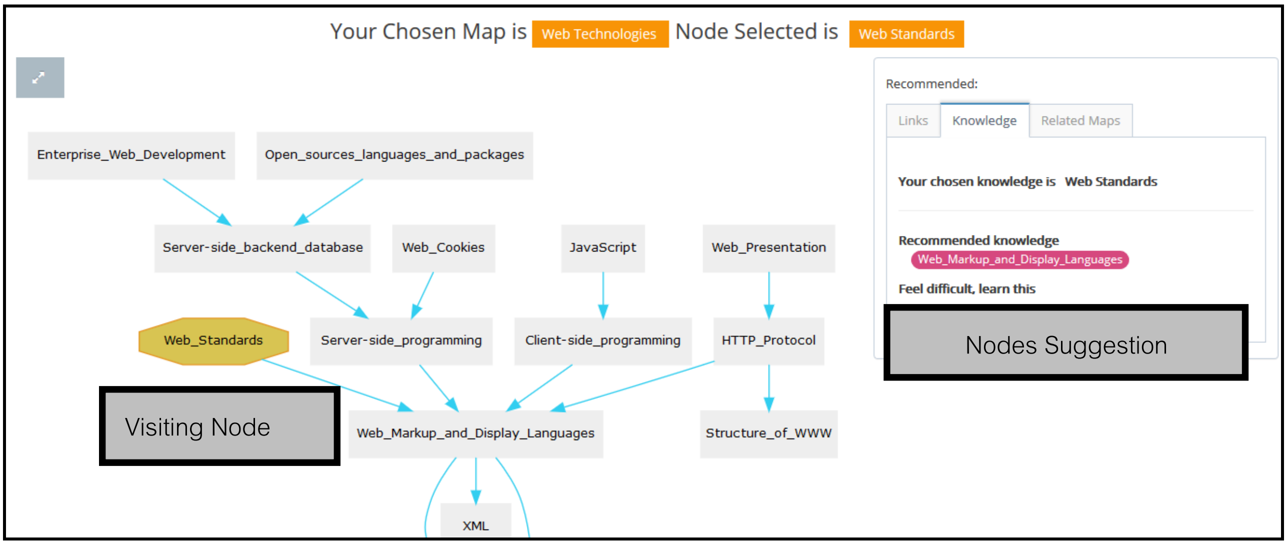


Figure 10. Screenshot of the Prototype MyTeLeMap Giving Some Suggestions

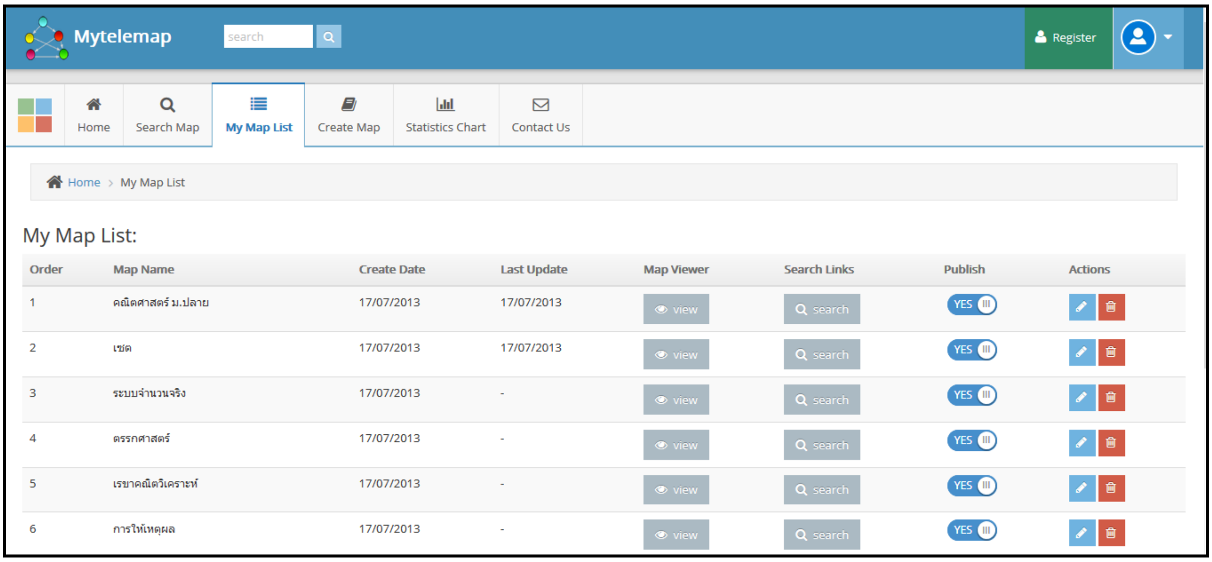


Figure 11. Screenshot of the Prototype MyTeLeMap Listing All Designed Knowledge Structures

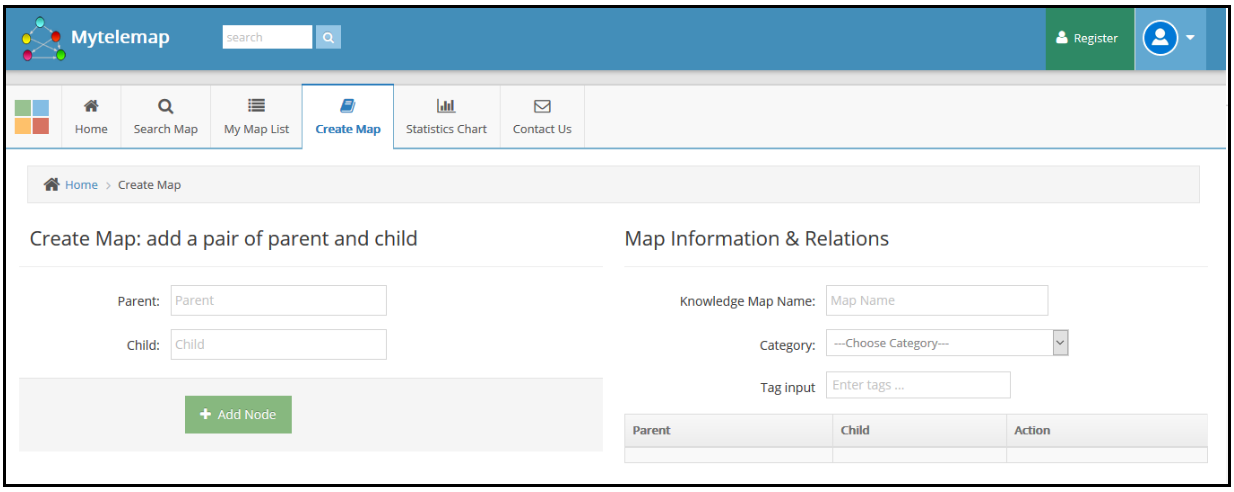


Figure 12. Screenshot of the Prototype MyTeLeMap for Managing a Designed Knowledge Structure

Questionnaire and Interview: Design and Results

A preliminary survey on teachers' experiences in using and designing knowledge structures was conducted, comprising a questionnaire and an interview. For the questionnaire study, participants were 173 school teachers from Songkhla province, Thailand. The results showed that the teachers have used some tools for building such structures, such as a mind-mapping tool and the *Cmap* tool. Most of them (136 school teachers) recognized and used mind-maps during their teaching activities. None of them represented or designed pedagogical structures with linkage among the knowledge components. They were interested in using a tool for building pedagogical knowledge structure (interested = 106, highly interested = 61) and were willing to use the structures and their applications as educational aids (interested = 101, highly interested = 62).

The interview study was conducted with 10 school teachers from the schools mentioned. Even though knowledge structures have been recommended for many years, school teachers still did not report using them in their teaching. However, the teachers felt that knowledge structures were useful and could benefit education more. For example, such structures could help learners think about and understand the relationships among the information shown. On the teachers' sides, they thought that designing knowledge structures could be another way of sharing their tacit knowledge with other teachers.

Experiment: Design and Results

An experiment was conducted to compare whether learning using the prototype MyTeLeMap was better than learning by freely browsing. The pictorial representations of these two learning modes are shown in Figure 13 and Figure 14.

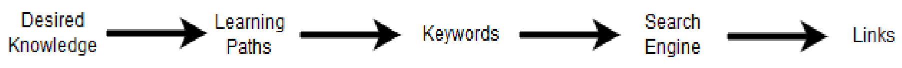


Figure 13. MyTeLeMap Learning Mode

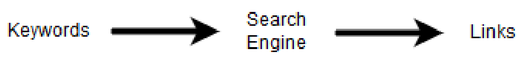


Figure 14. Freely Browsing Learning Mode

The experiment was concerned with the second, 'learning', level of Kirkpatrick's four levels of evaluation (Kirkpatrick, 2007). The participants were assigned to one of two groups: one group experienced the MyTeLeMap learning mode and the other group experienced the freely-browsing learning mode. All participants were required to take a pre-test and a post-test, before and after experiencing the respective learning modes. The pre-test and post-test were the same for all participants, being a multiple choice test consisting of 10 questions. The scores obtained from the pre-test and post-test were compared for each learning mode.

The required sample size of this experiment was 12 according to G*power, using an effect size f = 1, an alpha error probability = 0.05, power = 0.8, the test family as F-test, the number of groups = 2, and the statistical test as ANOVA repeated measures, within-between interaction. The actual number of participants was 40 as shown in Table 2.

The questions in the pre-test/post-test were based on selected knowledge of the fundamental programming. The total number of questions was 10. The chosen knowledge was as follows:

- Functions
- Operators
- String
- Variables

Table 1. Examples of Questions in Pre-test and Post-test

Knowledge	Questions in Pre-Test/Post-Test
Function	The keyword used to transfer control from a function back to a calling function is ___ ?
Operators	Suppose a, b, c are integer variables with values 5, 6, 7 respectively. What is the value of the expression NOT((b+c) > (a+10))?
String	How would you declare a variable to store the city of birth of a person?
Variable	Which of the following is a valid variable name?

A two-way repeated measures ANOVA was used to analyze the obtained test scores, in order to determine the better learning mode. 'Learning mode' comprised two levels, freely-browsing and MyTeLeMap. 'Test type' comprised two levels, pre-test and post-test.

Table 2, Table 3, and Table 4 show the descriptive statistics, the tests of within-subjects effects and the tests of between-subjects effects. Figure 7 displays the profile graphs.

Table 2. Means and Standard Deviation of Test Scores

Test_Type	Learning_Mode	Mean	Std. Dev.	N
Pre_Test	Freely_Browsing	3.8	0.83	20
	MyTeLeMap	3.9	0.93	20
	Total	3.8	0.87	40
Post_Test	Freely_Browsing	5.5	1.10	20
	MyTeLeMap	7.5	1.10	20
	Total	6.5	1.50	40

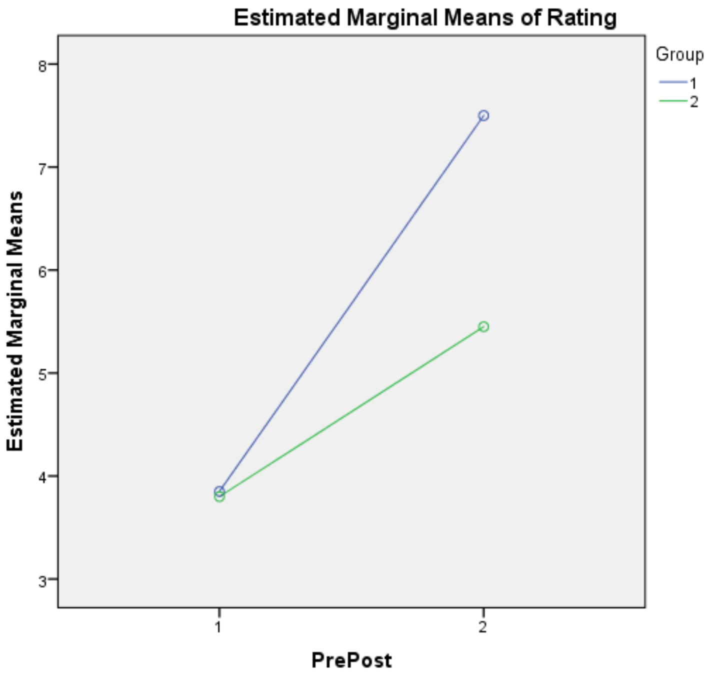


Figure 15. Profile Graph of Mean Ratings of Test Scores of Pre-test and Post-test for Two Learning Modes (where Group 1 = MyTeLeMap & Group 2 = Freely Browsing)

Table 3. Tests of Within-Subjects Effects

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**p.**
Test_Type	140.45	1	140.45	154.48	<0.01
Test_Type * Learning_Mode	20.00	1	20.00	22.00	<0.01

Table 4. Tests of Between-Subjects Effects

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**p.**
Learning_Mode	22.05	1	22.05	20.36	<0.01

Source	Type III Sum of Squares	df	Mean Square	F	p.
Learning_Mode	22.05	1	22.05	20.36	<0.01
Error	41.15	38	1.08		

The results from the statistical data obtained (as shown in Table 2, Table 3, and Table 4) were as follows.

1. There was no significant difference between two groups of students at pre-test, suggesting that the students in both group had equal knowledge on fundamental programming.
2. Both learning modes helped students significantly increasing their knowledge.
3. There was a significant interaction between learning mode and test types, such that MyTeLeMap helped students improve their learning significantly more than freely-browsing.

From the experiment, it can be concluded that both learning modes helped learners in learning, however, MyTeLeMap helped significantly more than freely browsing.

Conclusions and Future Work

A knowledge-based system (MyTeLeMap) for suggesting study material links from the Web has been proposed in this research. The aim of the approach is to assist learners to achieve their desired knowledge. The system provides learners with suggestions based on their current and previously selected nodes in a given knowledge structure. A method of constructing the knowledge structure was also proposed. An experimental study showed that the MyTeLeMap system can support learning better than free browsing. The system depends on a search engine API which tends to change regularly, and this may affect the long-term usability of the application. Future work includes a personalized search engine, improvements to the system’s user interface and user experience, and some management features to allow teachers to attach their own study materials.

References

Abel, M.-H. (2015). Knowledge map-based web platform to facilitate organizational learning return of experiences. *Computers in Human Behavior, 51, Part B,* 960-966. doi: https://doi.org/10.1016/j.chb.2014.10.012

Bench-Capon, T. J. M. (2014). *Knowledge Representation: An Approach to Artificial Intelligence*. UK.

Brin, S., & Page, L. (1998). The anatomy of a large-scale hypertextual Web search engine. *Computer Networks and ISDN Systems, 30*(1-7), 107-117.

Chiu, D.-Y., & Pan, Y.-C. (2014). Topic knowledge map and knowledge structure constructions with genetic algorithm, information retrieval, and multi-dimension scaling method. *Knowledge-Based Systems*, *67,* 412-428. doi: https://doi.org/10.1016/j.knosys.2014.03.008

Gordon, M., & Pathak, P. (1999). Finding information on the World Wide Web: the retrieval effectiveness of search engines. *Information Processing & Management, 35*(2), 141-180.

Gilbert, L., & Gale, V. (2008). Principles of E-learning Systems Engineering.

Griffiths, J. R., & Brophy, P. (2007). Student Searching Behavior and the Web: Use of Academic Resources and Google: Graduate School of Library and Information Science. University of Illinois at Urbana-Champaign.

Hao, J., Yan, Y., Gong, L., Wang, G., & Lin, J. (2014). Knowledge map-based method for domain knowledge browsing. *Decision Support Systems, 61*, 106-114. doi: https://doi.org/10.1016/j.dss.2014.02.001

Hawking, D., Craswell, N., Bailey, P., & Griffiths, K. (2001). Measuring Search Engine Quality. *Information Retrieval, 4*(1), 33-59.

Kirkpatrick, D. L. (2007). *Implementing the four levels : a practical guide for effective evaluation of training programs* (1 ed.): San Francisco : Berrett-Koehler Publishers.

Liao, S.-h. (2003). Knowledge management technologies and applications—literature review from 1995 to 2002. *Expert Systems with Applications, 25*(2), 155-164. doi: https://doi.org/10.1016/S0957-4174(03)00043-5

Liaw, S.-S., Chang, W.-C., Hung, W.-H., & Huang, H.-M. (2006). Attitudes toward search engines as a learning assisted tool: approach of Liaw and Huang's research model. *Computers in Human Behavior, 22*(2), 177-190. doi: http://dx.doi.org/10.1016/j.chb.2004.09.003

Mayr, P., & Tosques, F. (2005). *Google Web APIs - an Instrument for Webometric Analyses?*

Nitchot, A., Gilbert, L., & Wills, G. (2011). *Designing XML Schema of a Competence Structure from Course Intended Learning Outcomes.* Paper presented at the 14th IASTED International Conference on Computers and Advanced Technology in Education, Cambridge, UK.

Pan, B., Hembrooke, H., Joachims, T., Lorigo, L., Gay, G., & Granka, L. (2007). In Google We Trust: Users' Decisions on Rank, Position, and Relevance *Journal of Computer-Mediated Communication, 12*(3).

Sowa, J. F. (2000). *Knowledge representation : logical, philosophical, and computational foundations*: Pacific Grove, CA: Brooks/Cole.

Tang, H., & Ng, J. H. K. (2006). Googling for a diagnosis—use of Google as a diagnostic aid: internet based study. *BMJ, 333*(7579), 1143-1145.

Thelwall, M. (2003). Can Google's PageRank be used to find the most important academic Web pages? *Journal of Documentation, 59*(2), 205-217.

Tsai, M.-J., & Tsai, C.-C. (2003). Information searching strategies in web-based science learning: the role of internet self-efficacy. *Innovations in Education* *and Teaching International*, *40*(1), 43-50. doi: 10.1080/1355800032000038822

Wickel, M., Schenkl, S., Schmidt, D., Hense, J., Mandl, H., & Maurer, M. (2013). Knowledge structure maps based on Multiple Domain Matrices. *InImpact: The Journal of Innovation Impact, 5*(1), 5 - 16.

ภาคผนวก E

(Manuscriptที่ 2)

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Assistive Tool for Constructing Knowledge Structures and Suggesting Related Study Materials Links

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ABSTRACT

This research proposes a Web-based system for constructing knowledge structures and suggesting study materials links. Within Web-based learning, it is still difficult for learners to identify and choose study materials that match their current and desired abilities. In addition, learners may fail to recognize missing prerequisite learning, and may fail to identify the knowledge they seek. Most e-learning systems do not provide the information needed to assist learners and avoid these difficulties. We propose pedagogically-informed knowledge structures and associated applications, including a tool for designing and building such structures, a tool for navigating the structures for particular purposes (e.g., identifying knowledge missing from learners' existing knowledge) , and a tool for recommending appropriate materials. In this research the knowledge structures are derived from the subject matter within a targeted knowledge domain using task analysis. In this paper, a method of constructing a knowledge structure is proposed. An experimental study investigated users' design and use of a knowledge structure. Learners will be expected to gain significantly higher levels of achievement by using the knowledge structures and associated tools proposed in this research, and educational communities will be able to share the knowledge structures and use the tools to support learners.

Keywords: Knowledge representation, Web-based learning, Knowledge structure, Visualization, Self-study

INTRODUCTION

Web-based education is an area which makes use of resources from the Web for education purposes. The Web has become an effective resource and facilitates learning since learners can access it at any time and from any place and Web content is relatively easily updated. The aim of this research is to contribute a Web-based system which provides links as appropriate study materials. These links are generated, based upon the knowledge selected by learners and there are learning paths provided which are generated from knowledge structures.

In this paper, related literature on knowledge representation, knowledge structures, and related tools is reviewed. Knowledge representation is the study of representing knowledge formally and explicitly, so supporting unambiguous knowledge sharing. This issue becomes particularly important when machines facilitate knowledge management (Guarino, 1995). In the learning and teaching environment, knowledge representation has been adopted in many ways, such as: representing a content structure of learning documents (Yang & Sun, 2013), supporting learners in their own knowledge acquisition (Chu, Lee, & Tsai, 2011; Shaw, 2010), and enabling suggestions to learners (Chiou, Lee, & Liu, 2012). Knowledge relationships can be represented in many forms, such as maps, trees, networks, and graphs. They may be called concept maps, knowledge maps, and knowledge structures.

There are several methods of building knowledge structures and an interesting question is how pedagogically informed structures can support learning and teaching activities. In the early stage of this research, a literature review found some methods of knowledge structure/concept map building and use in educational technology. Thai school teachers were surveyed and interviewed (as discussed in Section 8, Methodology), and the preliminary data suggested that even though knowledge structures have been recommended for many years, school teachers did not report using them in their teaching. "Mind maps" were used to support learners' conceptualization and understanding of the course content. A mind map is a rather rough note of content information, though the relationships among the content items are usually vague and imprecise (D'Antoni, Zipp, Olson, & Cahill, 2010). The teachers felt that mind maps were useful and that they could benefit education, helping learners think about and understand the relationships in the information shown.

In normal classroom environments, the learners' prior knowledge is always varied. Some learners may not be aware of their missing knowledge or of the links and relationships between knowledge. This could affect their learning and their ability to achieve their desired learning. Saiyasombut & Siam Voices (Saiyasombut & Siam Voices, 2012) reported that Thai learners are not being well equipped with the type of knowledge and skills that will enable them to do well in the future in which many key aspects of life will require a more demanding level of literacy. These problems can be found in any classes with any subjects. Thai classrooms tend to provide similar learning environments and all learners are assumed to have the same level of knowledge (Sirisoonthorn, 2012). Thai learners are taught to 'remember' rather than 'understand' in their lessons. Consequently, they have inadequate 'thinking process' and 'solving problem' skills (Parinya Plicharoensuk, 2012).

'Resources' are also an important factor. There is still a lack of good resources for learning. E-learning is one type of resource for overcoming this problem, comprising electronically-supported resources such as online courses, online Web sites, lesson videos, instructional TV, and so on. Such resources allow learners to spend more time studying and practicing/solving lesson problems on their own at times and in places which may suit them better. There are many online study materials available which learners can access at any time and any place. Learners can retrieve supplementary online resources and familiarize themselves with missing knowledge before their course starts. It is difficult, however, for learners to find and access materials which match their intended learning outcomes or desired abilities. Learners may not be able to identify their competences on their own, identify the relationships among knowledge, or obtain the learning materials which match their abilities.

This research suggests the application of knowledge structures and associated tools to support learning and teaching. The first requirement is a tool to build and represent knowledge structures. Instructors or knowledge structure designers (which could include learners themselves) can use this tool to develop and share their knowledge structures. The second requirement is a tool to identify knowledge missing from a learner's existing knowledge. The tool is expected to be adopted within many knowledge domains, where there are learners who have different missing prerequisites. The third requirement is a tool to suggest learning paths and learning resources to support a learner in achieving a desired learning outcome.

KNOWLEDGE REPRESENTATION AND TOOLS

Knowledge representation (KR) can be defined in a variety of ways. Sowa (2000) defined knowledge representation as, "a multidisciplinary subject that applies theories from three fields: logic, ontology, and computation." Logic identifies the formal structure and rules of inference. Ontology refers to the kinds of things that exist in the application domain. Computation enables the applications to distinguish KR from pure philosophy.

Another notion of knowledge representation was identified by Levesque (1986), "this is simply dealing with writing down, in some language or communicative medium, descriptions or pictures that correspond to a state of the world." There is still significant disagreement among researchers, however, about many of the most fundamental issues of the current presentation scheme. The reason is that KR has evolved from a number of research areas for example, psychology, linguistics, philosophy, and logic. Levesque (1986) also suggested two major properties of KR:

1. It must be possible to interpret KR propositionally, that is as expressions in a language with a true theory.
2. A KR system should act in such a way as to match the presence of the structures.

Some work has adopted KR techniques within e-learning. Melis, Budenbender, Goguadze, Libbrecht, & Ullrich (2003) proposed ACTIVEMATH, an open Web-based learning environment for mathematics. In their research, KR was considered to represent a content structure of mathematical learning documents. It used the knowledge representation OMDoc (Kohlhase, 2000), an extension of the OpenMath XML-standard, containing a grammar representation of mathematical objects and sets of standardized symbols (the content dictionaries).

A study by Marshall et al. (2003) proposed GetSmart, a tool to allow individuals to create and share knowledge. Users could construct concept maps and synthesize their ideas into personal knowledge representations. In their study, XML format was applied to enhance modularity for concept map sharing.

Mendes, Martinez, & Sacks (2002) used a fuzzy clustering algorithm and TopicMaps to discover and represent knowledge. The relationships between learning materials were identified by fuzzy clustering and later used within adaptive link documents. TopicMaps is a tool for modelling and managing knowledge structures which are in the form of XML documents.

In this research, learning and teaching knowledge involves a pedagogically informed KR of Web content to be both machine processable and humanly understandable.

KNOWLEDGE STRUCTURES AND THEIR DESIGN

A knowledge structure provides a set of knowledge elements/nodes for a particular knowledge domain and identifies the relationships between the nodes. Ideally, a knowledge structure can be designed by one person using an unambiguous and explicit process. The resulting structure can be embedded within a learning and teaching system and used and shared by many for learning the domain it represents. It would be expected that structure designer should be an expert in the specific knowledge domain in order to structure the knowledge properly, otherwise consultation with an expert in the knowledge domain may be required. A given knowledge structure should be able to use and re-use existing knowledge structures as may be relevant. A knowledge structure should support navigation, giving the learner a variety of routes. Finally, the nodes of the structure should provide study material links for learners to achieve their desired knowledge.

Knowledge structure can be represented in several data structures such as tree structure, graph, concept map, and so on. There are some existing knowledge structures. One structure was developed by Kickmeier-Rust, Albert, & Steiner (2006) as shown in Figure 1. One node represents a competence state which is a set of all available competencies of a person. The prerequisite relationships are defined within this set of competencies. Each competency in a state represents a problem or subject matter which a learner is required to solve.

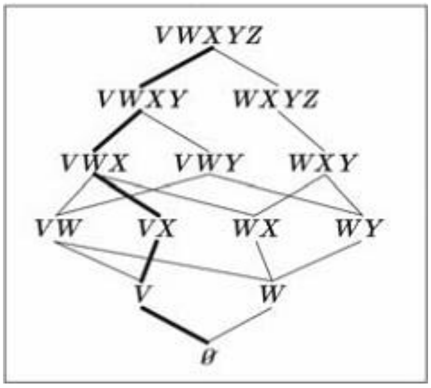

Figure 1. Knowledge Structure Established by the Prerequisite Function (Kickmeier-Rust et al., 2006)

Another structure was proposed by Heller, Steiner, Hockemeyer, & Albert (2006). However, this structure represents a competence-based knowledge structure. It is extended from a knowledge structure as is shown in Figure 2. They introduced two other sets of learning objects (LOs) and related skills for solving problems corresponding to each node within the structure. Nonetheless, this structure is based on the knowledge-based representation.

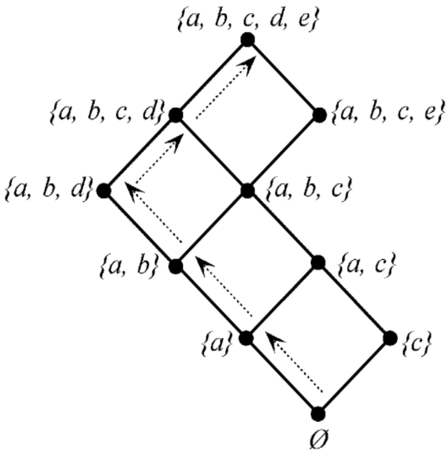

Figure 2. Overview of Knowledge Structure of Domain Q = "a, b, c, d ,e" (Heller et al., 2006)

From the samples of knowledge structures or networks above, it can be seen that some of them are structures of knowledge and are implicitly related to certain abilities (or capabilities). Each node within these knowledge structures contains descriptions of subject matter. In this research, the knowledge structure comprises a set of knowledge nodes and their relationships.

In order to design a structure of knowledge, information on the intended learning outcomes for the specific course is required, followed by an analysis of their structure to yield a categorization of subject matter content.

In the first step, information on subject matter and learning outcomes has been obtained from school teachers, and a task analysis was undertaken to give a diagrammatic representation of the subject matter (Gilbert & Gale, 2008). Knowledge structures were built by following four steps as described by Nitchot, Gilbert, and Wills (2011):

Step 1: Choose knowledge domain

To construct a knowledge structure, we need to consider the intended learning outcomes of the knowledge domain. Only the subject matters under those learning outcomes are concerned.

Step 2: Undertake task analysis of subject matter

Next, all the intended learning outcomes are summarized into a list of subject matter items. The first step is to consider the structure of the subject matter content in an e-learning system. This is undertaken by focusing on the broad understanding of the knowledge and cognitive skills of students, in order to achieve the goal. This is called in short 'subject matter content' and is normally categorized into four fields based on Merrill's analysis CDT (Merrill, 1994). Task analysis provides the relationships and structures of subject matter. At this stage, each type of subject matter is considered as a diagrammatic approach (Gilbert & Gale, 2008). Each category of subject matter has different notation representing its task analysis.

Step 3: Decompose levels and relationships in the task analysis

Task analysis of all subject matters is then levelled and the relationships are assigned.

Step 4: Structure the subject matter

An initial set of knowledge structures have been created.

During step 4, levels and relationships of designed task analysis are obtained. This information is considered. All subject matters are represented as one node, and structured. The same levels of task analysis of subject matters are in the same levels within the structure. The relationship between subject matter nodes is parent-child. An arrow points to a child node.

Figure 3 shows a sample of an initial knowledge structure of a mathematical subject (at high school level).

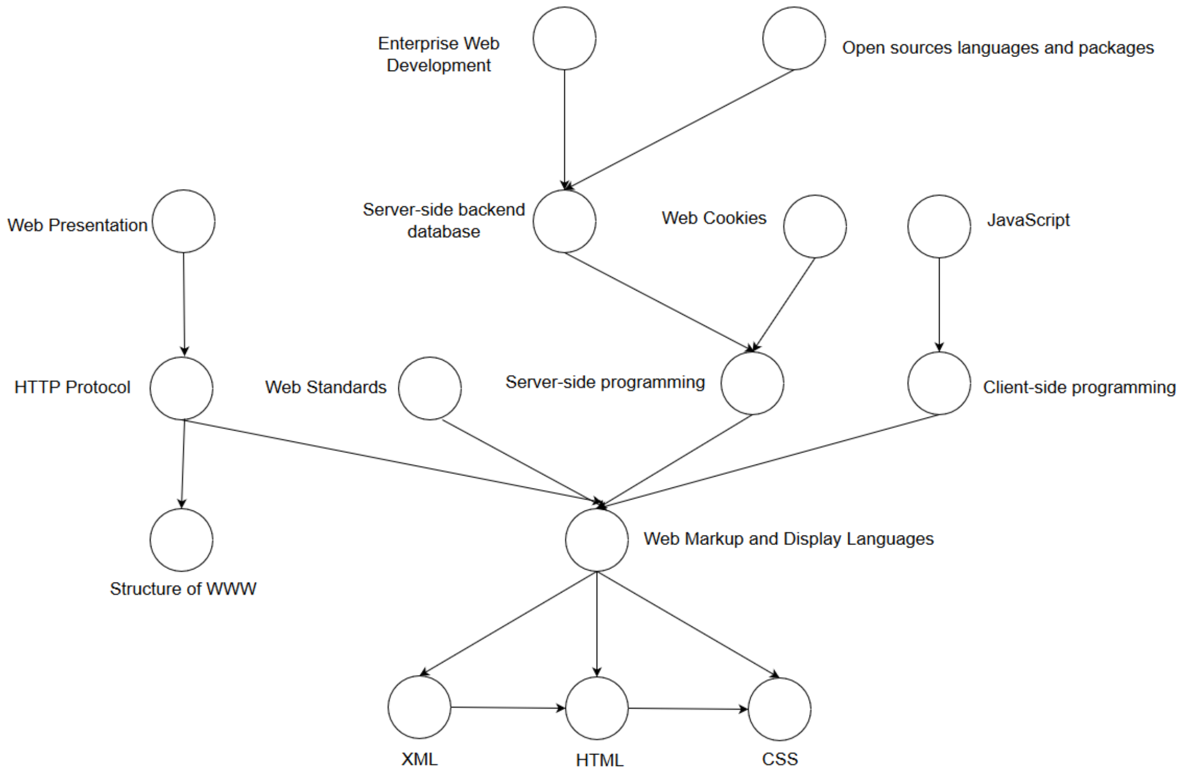

Figure 3. Knowledge Structure under Mathematical Subject

SYSTEM ARCHITECTURE AND PROTOTYPES

A tool for suggesting learning resources' links based on knowledge structures has been implemented as a prototype. Of the features identified, a recommender system and a learning path service (as shown in Figure 6) have been implemented. The current tool incorporates the designed knowledge structures and their associated learning resources (mainly html links). The graph visualization libraries (such as Graphviz (Ellson, Gansner, Koutsofios, North, & Woodhull, 2004) and Microsoft Automatic Graph Layout (Nachmanson, 2015)) display the graph nodes and edges from the knowledge database. The Google API is used to gather links from the Web. Currently, two features, a recommender system and a learning path service, are under investigation as shown in Figure 4 (rounded rectangles with strong line). The remaining features await future implementation, being an authoring tool, a sharable knowledge structure service, and a missing prerequisite service, as illustrated in Figure 4 (rounded rectangle with dotted line).

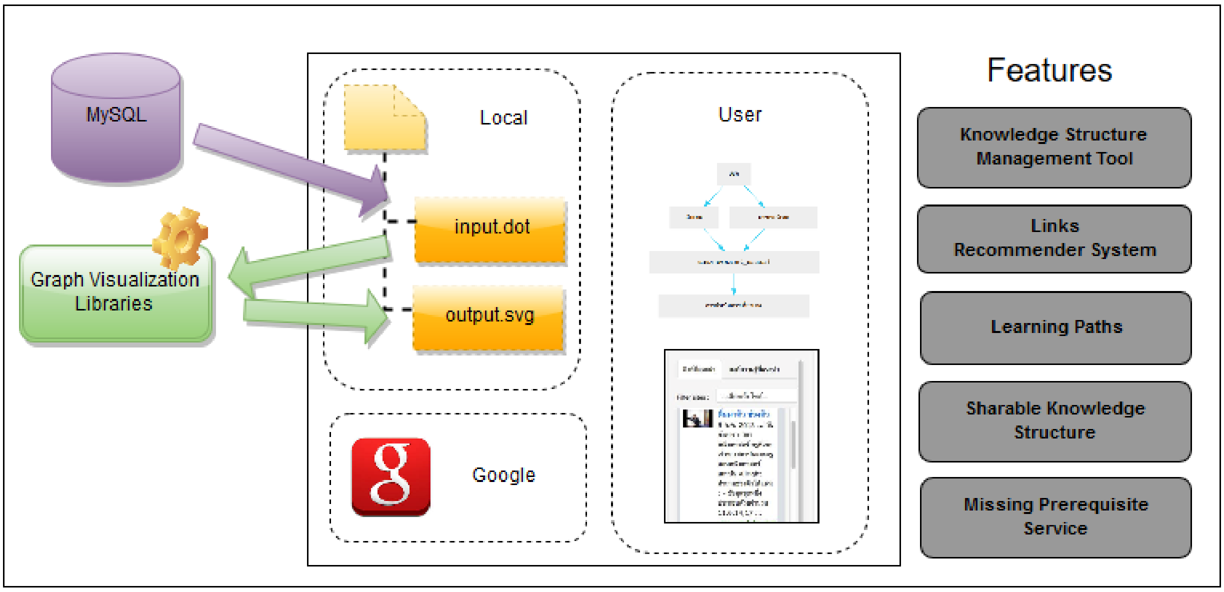

Figure 4. This Research Tool Infrastructure

The full prototype is now accessed via www.mytelemap.com, and was used to assist the class ‘Web Programming and Web Database’ within the PSUIC faculty. Figure 5 shows a page visualizing the chosen knowledge structure and associated study material links. The links themselves are retrieved using Google API. Figure 6 shows the learning paths and prerequisite features for the learners. The suggestions are based upon the current visited node. Teacher and admin roles can build their own knowledge structures for use within the class (as shown in Figure 7). Figure 8 shows the admin management of built knowledge structures and permissions. All users can choose to visualize the knowledge structure in a separated window as shown in Figure 9.

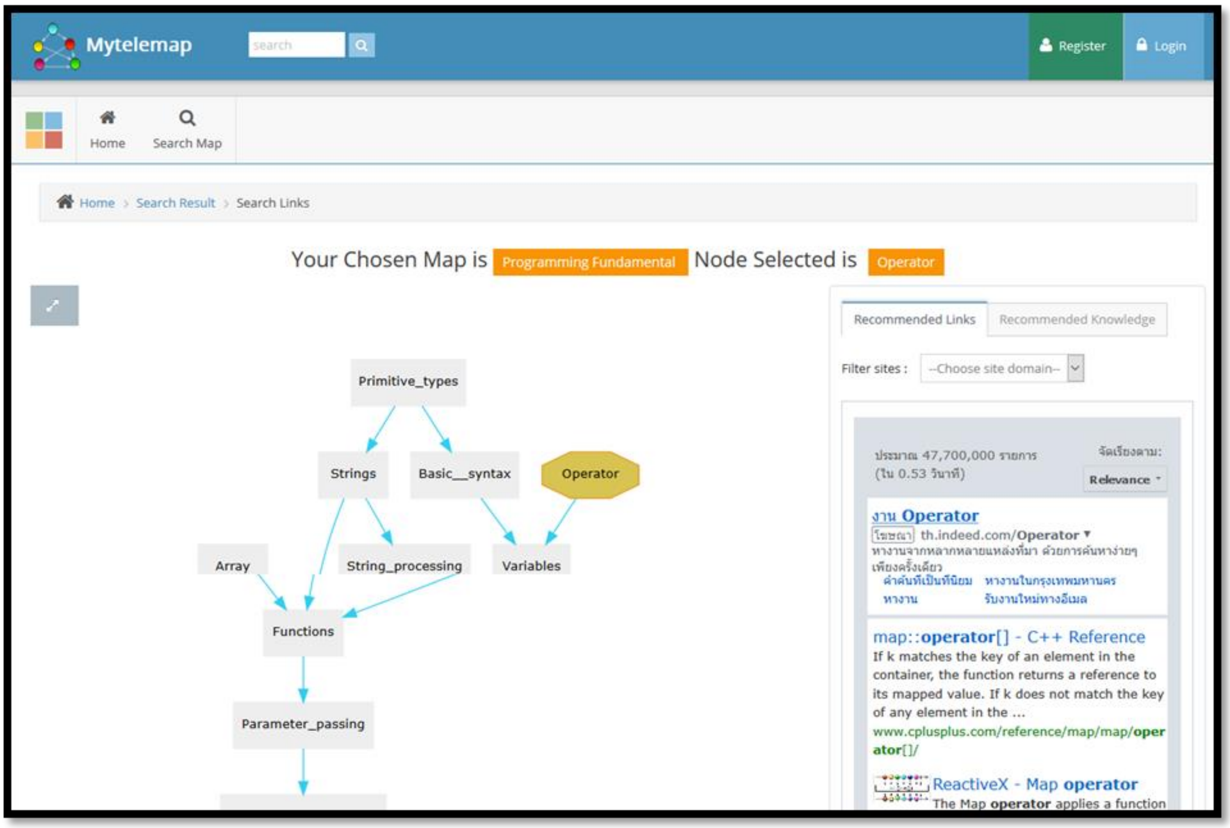

Figure 5. Prototype Page Showing the Knowledge Structures and Corresponding Links

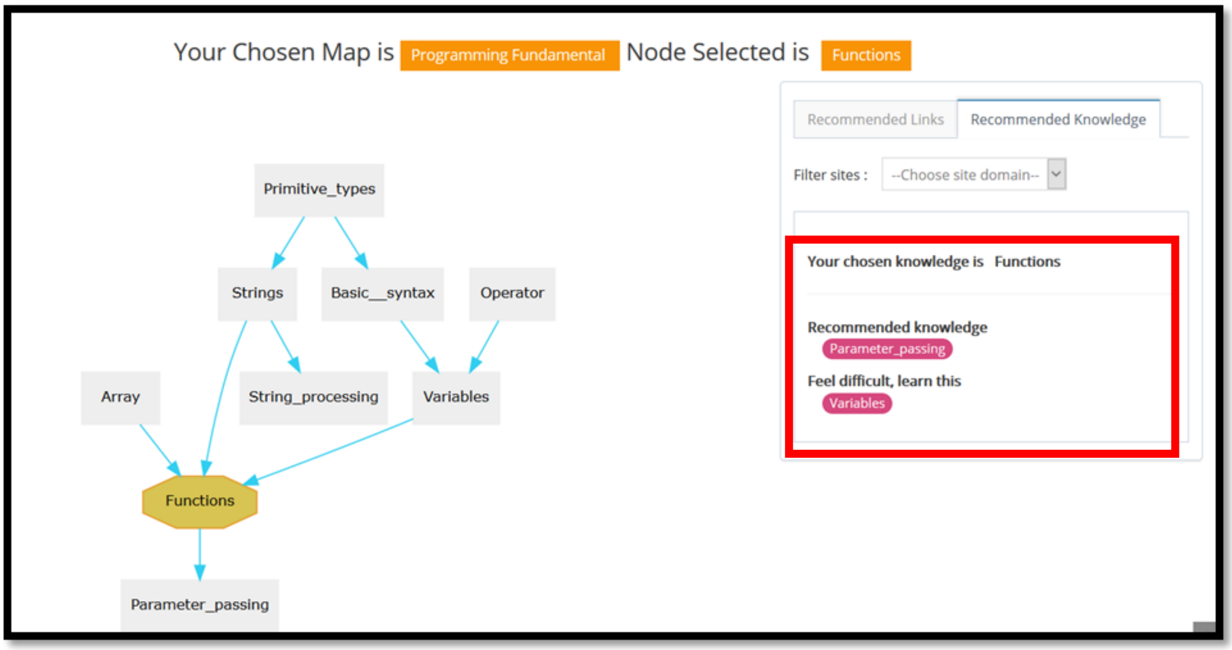

Figure 6. Learning Path and Prerequisite Features

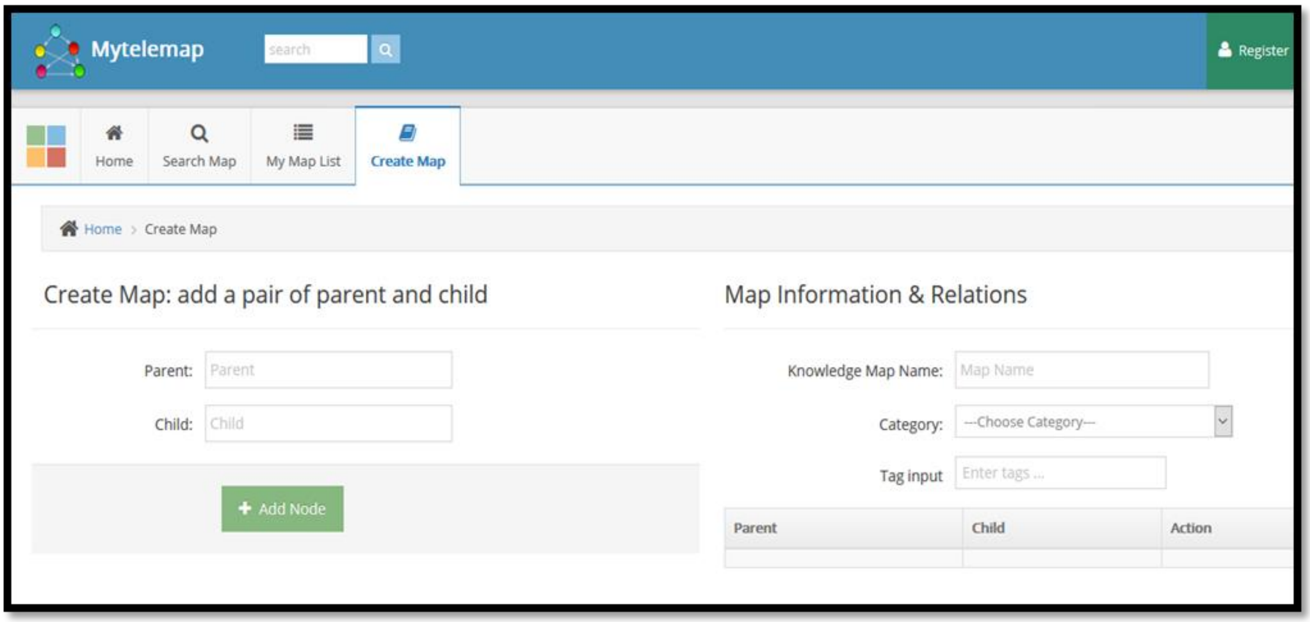

Figure 7. Knowledge Structure Building Page

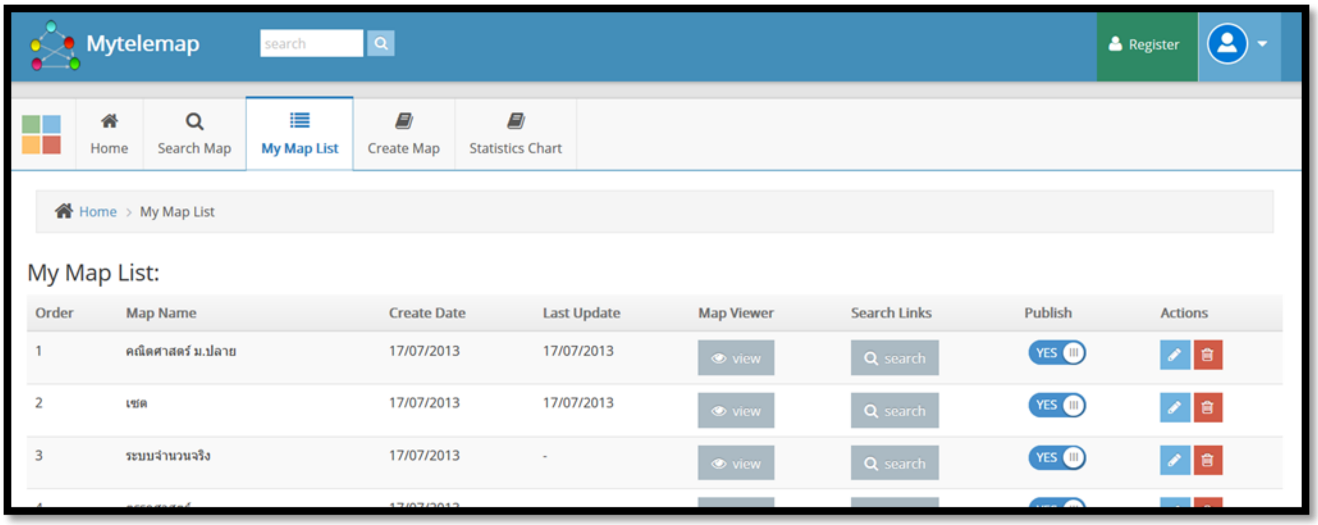

Figure 8. Knowledge Structure Management Page

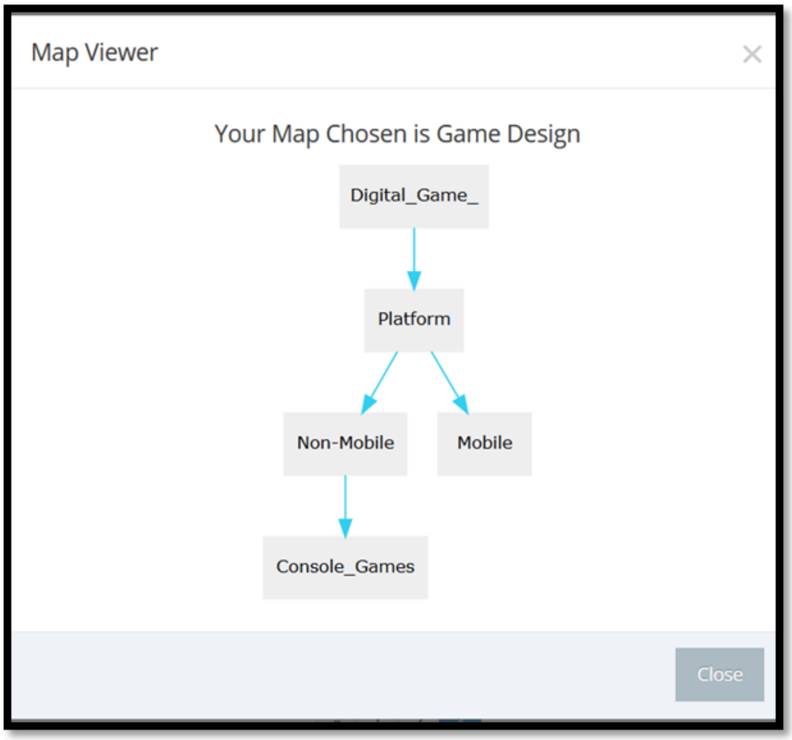

Figure 9. Viewing Knowledge Structure Page

EXPERIMENTAL DESIGN AND RESULTS

A preliminary survey on teachers' experiences in using and designing knowledge structures was conducted, comprising a questionnaire and an interview. For the questionnaire study, participants were 173 school teachers from Songkla province. The results showed that the teachers have used various tools for building such structures, such as a mind-mapping tool and the Cmap tool. Most of them (136 school teachers) recognized and used mind-maps during their teaching activities. The survey showed that most structures were mind maps. None of the mind maps represented or designed pedagogical structures with linkage among the knowledge components. Teachers were interested in using a tool for building pedagogical knowledge structure (interested = 106, highly interested = 61) and were willing to use the structures and their applications as educational aids (interested = 101, highly interested = 62).

The interview study was conducted with 10 school teachers from the schools mentioned. Even though knowledge structures have been recommended for many years, school teachers still did not report using them in their teaching. However, the teachers felt that knowledge structures were useful and they could benefit education more. For example, such maps could help learners think about and understand the relationships among the information shown. On the teachers' sides, they thought that designing knowledge structure could be another way of sharing their tacit knowledge with other teachers.

Later, another experiment was conducted. This experiment was to determine experts' overall reaction (at Kirkpatrick's level one 'reaction') to the tool developed in this research (Kirkpatrick, 2007). Participants were knowledge domain experts, high school mathematics teachers on at Songkla Province, Thailand. An estimate of the number of participants required was obtained using G*Power software (Faul, Erdfelder, Buchner, & Lang, 2009). The number of participants was 60.

The questionnaire was designed to ask experts to review and give a rating against the knowledge structure and system's features on a 5-point Likert scale, namely: 'Strongly Disagree', 'Disagree', 'Neither Agree Nor Disagree', 'Agree' and 'Strongly Agree'. The weighted ratings for each scale are 1, 2, 3, 4 and 5, respectively.

Table 1. Experimental Results

No	**Dependent Variables**	**Mean**	**Sig. (2-tailed)**
1	Clarity of node appearance	4.33	< 0.007
2	Clarity of the relationship between nodes	4.25	< 0.007
3	Satisfaction on the relationship between nodes	4.11	< 0.007
4	Tool is easy to use	4.20	< 0.007
5	Overall user's satisfaction on tool	4.38	< 0.007
6	Matching the materials with the structure nodes	4.31	< 0.007
7	Suggestion for future use	4.52	< 0.007

A one-sample Student's t-test was used to analyze the data obtained for each variable in the experiment (as shown in Table 1). For this experiment, the number of tests of significance, m, equals 8. Bonferroni correction provides a α level of 0.05/m (where m is the number of tests). Our criterion for significance was thus 0.0071. For all dependent variables, the mean ratings for the tool were significantly higher than 3 ($p < 0.007$) which is the middle, 'neutral', option.

From the experimental results, participants were in general significantly satisfied with the clarity of node and structure appearance. The experts were able to understand the appearance/ design of the structures. They thought that the system provides a wide range of types of materials which are matched with the structure nodes.

CONCLUSION

A knowledge-based system for suggesting study material links from the Web has been proposed in this research. The aim of the approach is to assist learners to achieve their desired knowledge. In addition, the system provides learners with the suggested knowledge can be identified based on the current and previously selected node. The method of constructing the knowledge structure is also proposed. This is to consider the nature and type of each knowledge in order to find the relationship among them. Experimental studies were conducted, which explored the expert reaction ratings against the approach and the results show that this research tool is overall acceptable for learners. However, there are some limitations such as, the system's dependent on search engine API. The coding function within such API tends to be changed regularly, which may affect the usability of the application. A future plan is to include a self-search engine with an application and improve the application's user interface and user experience. In addition, more knowledge domains will also be explored.

ACKNOWLEDGEMENTS

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REFERENCES

Chiou, C.-C., Lee, L.-T., & Liu, Y.-Q. (2012). Effect of Novak Colorful Concept Map with Digital Teaching Materials on Student Academic Achievement. *Procedia - Social and Behavioral*

Sciences, 64(0), 192-201. doi: http://dx.doi.org/10.1016/j.sbspro.2012.11.023

Chu, K.-K., Lee, C.-I., & Tsai, R.-S. (2011). Ontology technology to assist learners' navigation in the concept map learning system. *Expert Systems with Applications, 38*(9), 11293-11299. doi: http://dx.doi.org/10.1016/j.eswa.2011.02.178

D'Antoni, A. V., Zipp, G. P., Olson, V. G., & Cahill, T. F. (2010). Does the mind map learning strategy facilitate information retrieval and critical thinking in medical students? *BMC medical education, 10*(1), 61.

Ellson, J., Gansner, E. R., Koutsofios, E., North, S. C., & Woodhull, G. (2004). Graphviz and Dynagraph -Static and Dynamic Graph Drawing Tools. In M. Junger & P. Mutzel (Eds.), *Graph Drawing Software* (pp. 127-148). Berlin/Heidelberg.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*(4), 1149-1160. doi: 10.3758/brm.41.4.1149

Gilbert, L., & Gale, V. (2008). Principles of E-learning Systems Engineering.

Guarino, N. (1995). Formal Ontology in Conceptual Analysis and Knowledge Representation. *International Journal of Human-Computer Studies, 43*(5-6), 625-640.

Heller, J., Steiner, C., Hockemeyer, C., & Albert, D. (2006). Competence-Based Knowledge Structures for Personalised Learning. *International Journal on E-Learning, 5*(1), 75-88.

Kickmeier-Rust, M. D., Albert, D., & Steiner, C. (2006). *Lifelong Competence Development: On the Advantages of Formal Competence-Performance Modeling.* Paper presented at the International Workshop on Learning Networks for Lifelong Competence Development, TENCompetence Conference, Sofia, Bulgaria.

Kirkpatrick, D. L. (2007). *Implementing the four levels : a practical guide for effective evaluation of training programs* (1 ed.): San Francisco : Berrett-Koehler Publishers.

Kohlhase, M. (2000). *OMDoc: Towards an Internet standards for mathematical knowledge.* Paper presented at the Artificial Intelligence and Symbolic Computation (AISC'2000).

Levesque, H. J. (1986). Knowledge Representation and Reasoning. *Annual Review of Computer Science, 1*, 255-287.

Marshall, B., Zhang, Y., Chen, H., Lally, A., Shen, R., Fox, E., & Cassel, L. N. (2003). *Convergence of knowledge management and E-learning: the GetSmart experience.* Paper presented at the 3rd ACM/IEEE-CS Joint Conference on Digital Libraries, Texas, USA.

Melis, E., Budenbender, J., Goguadze, G., Libbrecht, P., & Ullrich, C. (2003). Knowledge representation and management in ACTIVEMATH. *Kluwer Academic Publishers, 38*(1-3), 47-64.

Mendes, M. E. S., Martinez, E., & Sacks, L. (2002). *Knowledge-based Content Navigation in e-Learning Applications.* Paper presented at the London Communications Symposium (LCS'02).

Nachmanson, L. (2015). Microsoft Automatic Graph Layout. Retrieved 22/7/2015, from http://research.microsoft.com/en-us/projects/msagl/

Nitchot, A., Gilbert, L., & Wills, G. (2011). Designing a Competence Structure to Generate Learning Paths and Assessment Questions for Self-Study.

Parinya Plicharoensuk. (2012). Reasons why Thai students are weak in Mathematics. from http://www.kruparinya.com/index.asp?contentID=10000004&title=%A4%C7%D2%C1%CA%D3%A4%D1%AD%E1%C5%D0%A4%C7%D2%C1%E0%BB%E7%B9%C1%D2%A2%CD%A7%BB%D1%AD%CB%D2&getarticle=40&keyword=&catid=1

Saiyasombut, S., & Siam Voices. (2012). Thai education failures – Part 3: PISA scores & a challenge for the 21st century. Retrieved 11/10/1012, from http://asiancorrespondent.com/77060/thai-education-failures-part-3-pisa-scores-and-a-challenge-for-the-21st-century/

Shaw, R.-S. (2010). A study of learning performance of e-learning materials design with knowledge maps. *Computers & Education, 54*(1), 253-264. doi: http://dx.doi.org/10.1016/j.compedu.2009.08.007

Sirisoonthorn, S. (2012). Why Thai students weak at Mathematics?, *bangkokbiznews. com.* Retrieved from http://www.bangkokbiznews.com/home/detail/politics/opinion/sirinart/20120827/467529/%E0%B9%80%E0%B8%98%E2%80%94%E0%B9%80%E0%B8%98%E0%B8%93%E0%B9%80%E0%B8%99%C2%84%E0%B9%80%E0%B8%98%E0%B8%81...%E0%B9%80%E0%B8%99%E2%82%AC

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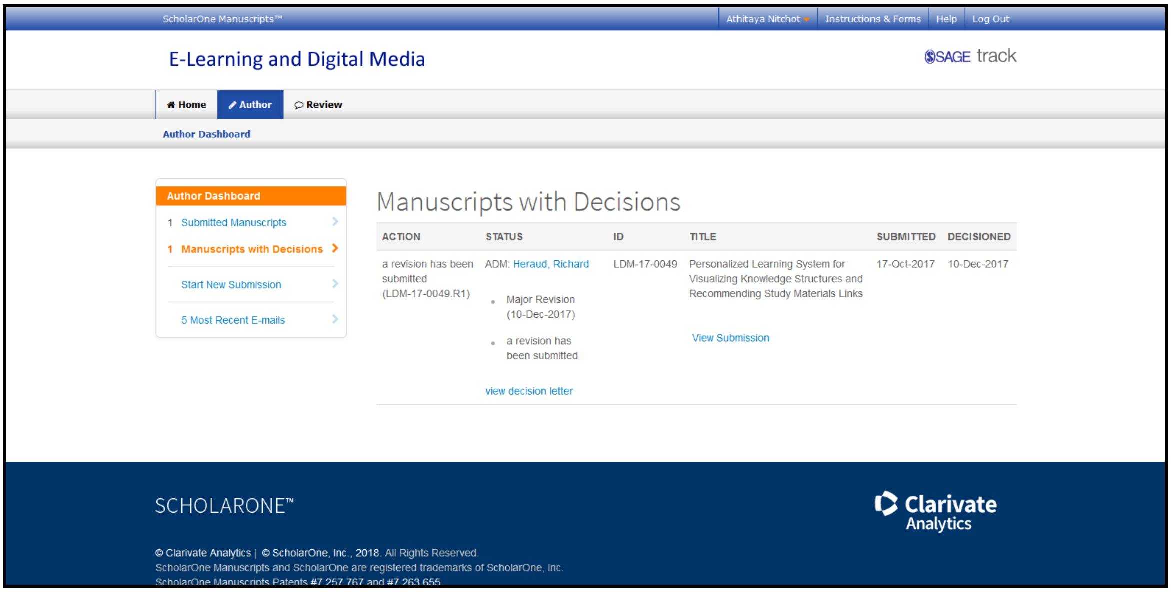
Sowa, J. F. (2000). *Knowledge representation : logical, philosophical, and computational foundations*: Pacific Grove, CA: Brooks/Cole.

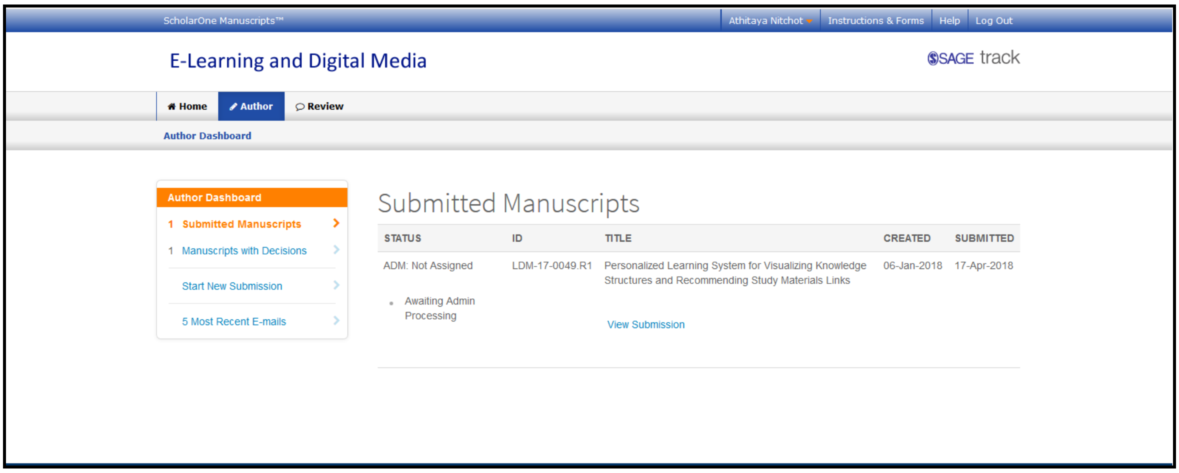
Yang, B., & Sun, Y. (2013). An exploration of link-based knowledge map in academic web space. *Scientometrics, 96*(1), 239-253. doi: 10.1007/s11192-012-0919-y

ภาคผนวก F

(สถานะของ Manuscript)

Nitchot, A., Wettayapresit, W. and Gilbert, L. Personalized Learning System for Visualizing Knowledge Structures and Recommending Study Materials Links. E-Learning and Digital Media (Under Revision)





Nitchot, A., Wettayapresit, W. and Gilbert, L. Assistive Tool for Constructing Knowledge Structures and Suggesting Related Study Materials Links. the special issue of Chiang Mai University Journal of Natural Sciences (Submitted)

Re: Invitation for Paper Submission - ICDAMT-2017 Journal Committee   Inbox x

Athitaya Nitchot <athitayanitchot@gmail.com>   27/04/2017
to ICDAMT2017

Dear Editor,

According to the invitation of the submission under special issue of Chiang Mai University Journal of Natural Science associated with ICDAMT conference committee, I would like to submit the paper with the title "Assistive Tool for Constructing Knowledge Structures and Suggesting Related Study Materials Links". There are two files attached with this email: a manuscript and submission form. If you require any further documents, do not hesitate to contact me.

Best Regards,
Athitaya Nitchot

On 25 March 2017 at 18:32, ICDAMT2017 Journal Committee <icdamt.jc@gmail.com> wrote:

> Dear Authors,
>
> We are happy to announce you that your paper presented at the conference has been recommended by the program committee to be submitted to the special issue of Chiang Mai University Journal of Natural Sciences (indexed in SCOPUS).
>
> If you are interested in publishing your paper in the journal, please follow the instructions bellow.
>
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