# Competency Mapping for Training Effectiveness

**Dr. Arezou Harraf, Box Hill College Kuwait**

Dr. Arezou Harraf

Head of Department of Business Studies Assistant Professor Box Hill College Kuwait

**Dr. Yuetong Lin, Embry-Riddle Aeronautical University, Worldwide**

Yuetong Lin received the Ph.D. degree in Systems and Industrial Engineering from the University of Arizona, Tucson, in 2005. He was with Indiana State University from 2005 to 2016, where he became associate professor of Electronics and Computer Engineering Technology, and the program coordinator for Computer Engineering Technology. He joined Embry-Riddle Aeronautical University, Worldwide in September 2016 as an associate professor in the Department of Engineering and Technology.

**Dr. Ali Mehran Shahhosseini, Indiana State University**

A. Mehran Shahhosseini is an Associate Professor in the Department of Applied Engineering and Technology Management at Indiana State University. He has published over 45 articles in different journals and conference proceedings. He has served as an investigator for research projects sponsored by National Science Foundation, Ford Motor Company, and the US Army. Before working at Indiana State University, he was a faculty in the University of Louisville for 10 years. He also has over four years of industrial experience. He received his D.Eng. degree in Mechanical Engineering from Lamar University (USA) in 1999, M.Sc. in Materials Engineering from Isfahan University of Technology (Iran) in 1991, and B.Sc. in Metallurgical Engineering from Tehran University (Iran) in 1988. He is a member of ASEE, ASME, SAE, and ATMAE.

**Work-in-Progress: Competency Mapping for Training Assessment**

**Abstract**

In 2017, US companies spent over 90 Billion dollars on employee training.  Despite the intense effort, training generally is not deemed satisfactory as many studies show that trainees fail to demonstrate the ability to transfer the desired knowledge and skills to their jobs. As a result, many organizations are still looking for reliable and effective training mechanisms to ensure an adequate return on their training investment.  Competency training has presented itself as an alternative to traditional training methods as it pinpoints the skills for certain tasks and assesses the workforce's readiness in accordance with the desired levels of competence.

While the competency based method is a more linear form of training, the evaluation of trainees' level of competence is still a lengthy process.  In this paper, we propose a concept map based framework for competency training assessment. In particular, we demonstrate the use of similarity flooding algorithm in quickly determining the differences between desired competencies in the expert's map and those shown in the trainee's map.

The framework is used to develop a change management process strategy at the organizational level in accordance to the Australian Technical and Further Education (TAFE) guidelines. In this vein, the competencies identified for the change management process at the organizational are introducing, managing and assessment of the change management process. To assess the suitability of competency-based mapping, a trainee participated in a three-week course that included lectures and effective learning elements such as case study and small-scale projects. Concept maps were created by the trainee to represent the desired competencies. In this study, we present the analysis that shows the effective assessment of concept map based competency training that can help organizations achieve their training goals

.

**Introduction**

Modern organizations grapple with increased complexity and rapid changes that arise as a result of hyper completion, technological advances, and demographic changes on a continuous basis (Potnuru & Sahoo, 2016).  As a result, to stay competitive, organizations need to find innovative ways to adequately address the above changes and ensure their workforce has the needed competencies to help retain competitive advantage (Whitfield & Landeros, 2006). Diaz-Fernandez et al. (2014) posited that the analyses of factors leading to a competitive advantage in organizations reveal that individual competencies are the core resource that enables organizations to generate profits and retain competitive advantage. In this vein, such dynamic business environment compels organizations to foster and equip a competent workforce with enhanced levels of skill and quality needed for sustainable advantage.  (Markovic, 2008).  To achieve this, organizations have adopted various human resource development (HRD) interventions such as training to ensure their workforce has the necessary competencies to stay abreast of changes in the market (Potnuru & Sahoo, 2016).  Hellriegel and Slocum (2011, pg. 8) have described seven key competencies that affect individual behaviors, teams and subsequently the organization:

1. employee's ethical competency;
2. self-competency;
3. diversity competencies;
4. across cultures competency;
5. communication competency; 6.    team competency; and 7.    change competency.

To this end, organizations rely on training, defined in this context as an "extensiveness of formalized programs to develop knowledge, skills and abilities" (Evans and Davis, 2005, p. 760) to ensure the above-mentioned competencies are up-to-date and in line with the needs of the market. Organizations, therefore, rely on training with the aim of enabling their workforce to apply their newly gained knowledge and skills on the job (Zumrah et al., 2013).

Such endeavors, however, would not be successful if organizations fail to measure training success, which is to ensure employees have acquired all the desired skills and knowledge as a result of the training (Kirkpatrick, 2004; Gomez-Mejia et al., 2001).

**Training Evaluation**

Organizational evidence suggests that a substantial amount of organizational investment in training efforts does not yield in the transfer of training on the job, forcing managers to make the difficult decision whether to offer the training or not (Scaduto, Lindsay & Chiaburu, 2008; Panturo & Sahoo, 2016).  Therefore, if the decision to provide training is taken, the training managers must ensure to thoroughly monitor the three-step training process of needs assessment, conducting of training and evaluation to assess the effectiveness of the training programs (Gomez-Mejia et al., 2001). Also, since the training is expected to result in training transfer, the managers must assess the degree in which the trainees have gained the competencies to apply their newly acquired skills and knowledge to the job (Baldwin & Ford, 1988).  Moreover, since the transfer of training is to-date an integral issue in training effectiveness, Holton and Baldwin (2003) recommend different testing models in predicting training transfer.  Also, as posited by Rothwell (2007) that since traditional training evaluations consume a considerable amount of time, organizations must consider systems that identify effectiveness and pinpoint problem areas in an effective and measurable format, particularly since the market dynamics do not stand still as the training is being evaluated.

**Competency Mapping**

In 2012, researchers from Indiana State University received a National Science Foundation TUES grant to help develop software to advance diagnostic skills training for the undergraduate technology and engineering students. They developed the training modules using concept maps that required students to draw visual maps of a troubleshooting strategy. The student maps would be compared with maps created by subject experts on the same task to gauge students' mastery of the desired diagnostic skills and areas of improvement.

The potential of the software, particularly concept map based evaluation mechanism, was furthered examined when the method was applied in competency mapping based workplace training. Competency mapping is about recognizing the necessary skills and processes with which the trainees must be equipped as a result of undergoing the training process (Lin, Shahhosseini, & Janke, 2018).  This system helps the trainees to individually under a SWOT

(Strengths, Weaknesses, Opportunities & Threats) analysis compare their skill/knowledge level of content and processes with the success criteria. On the corporate level the method reinforces strategy, and vision for the training by providing a common framework for improving training program effectiveness (Lin, Shahhosseini, & Janke, 2018).

One of the biggest challenges for concept maps based methods is how to evaluate and compare maps. Not only we need to assure that the mechanism recognizes both structural and semantic differences in the maps, we also hope to ditch the labor intensive and time consuming manual comparison and let computers dissect the results without human involvement. There are several noteworthy studies on this subject. Limongelli et al. (2016) proposed seven measures of similarity among concept maps dealing with both structural and didactic aspects of the maps. A weighted concept was proposed by Chang et al. (2005) where propositions are given a weight value from 0 to 1, based on the closeness index and weighted value of each node, a similarity index is calculated for each node. Gao et al. (2015) presented an approach of string comparison with the meaning of the words–semantic similarity. Melnik et al. (2012) presented a method called Similarity Flooding Algorithm (SFA).

Our method of comparing concept maps is based on combining the weighting mechanism, SFA, and semantic similarity of two strings. The detail introduction of the method is included in the paper by Shahhosseini et al. and shown in Figure 2. In Figure 2, we adopt SFA program (Open source Java code developed by Melnik et al., 2012) to match the nodes based on their relationships. The SFA represents two input maps semantically in code first, then creates an initial map for the product of each node in both maps, calculates their similarities based on the links, and finally generates a list of best paired nodes according to the similarity of each pair. During the comparison, WordNet R is used to measure the content of nodes.

The first step in comparing process is to generate a reference similarity that is calculated based on the result of comparing an expert's map with the expert's map itself ($s_{aee}$). The reference similarity includes absolute similarity for each paired nodes, according to their links and content.
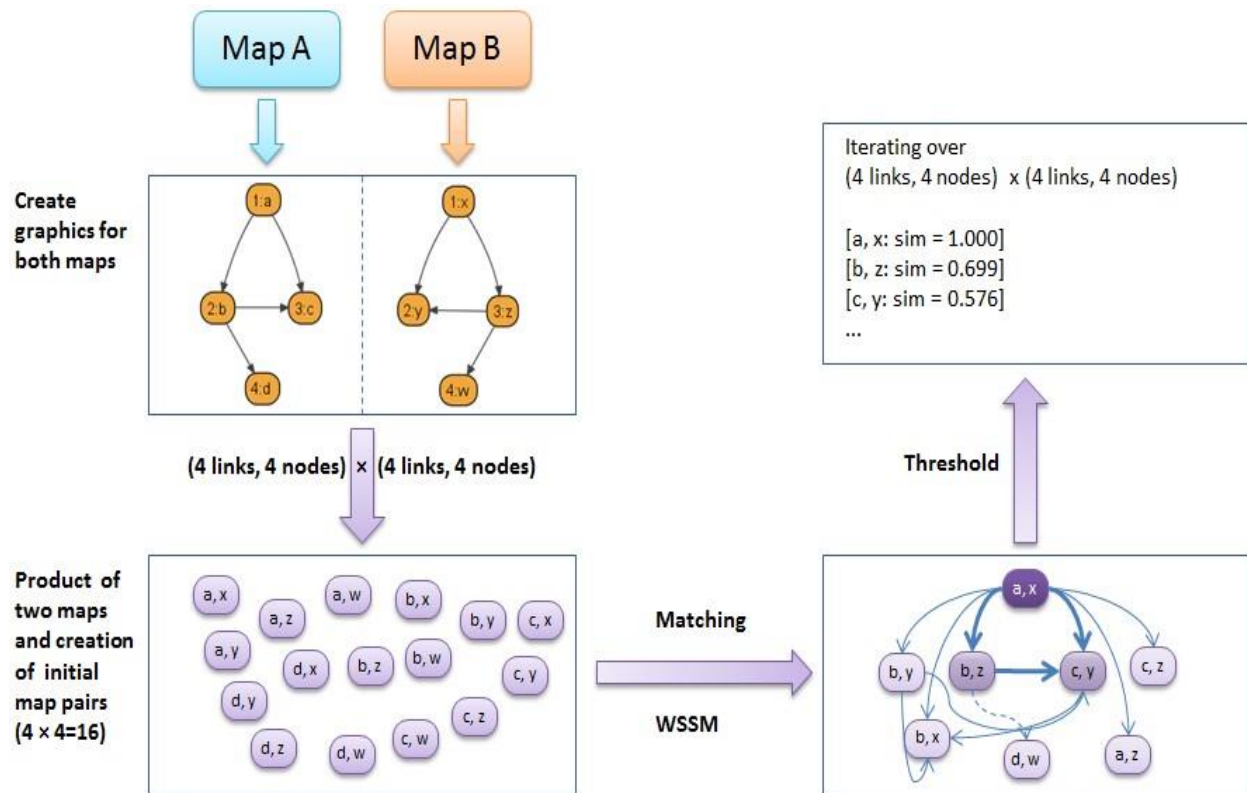
Figure 1: Similarity Flooding Algorithm (SFA) Process

The second step is to compare a student's map with the expert's map ($s_{ase}$). The comparison result includes absolute similarity for each node, which is considered as a matched pair with one node in the expert's map. The third step is to calculate the relative similarity ($s_{rse}$) for each paired nodes by the percentage of $s_{aee}$ and $s_{ase}$. And, the overall similarity of the map is calculated based on the relative similarity of each pair. In this step, weighting (w) of each pair can be considered. Important nodes can have more weighting in overall similarity.

**Case Study: Competency mapping based Change Management Strategy Training**

To examine how concept map based module would work for competency training assessment, we reference the following Change Management Strategy training. We select a trainee who participated in a three-week course that included lectures and effective learning elements such as case study and small-scale projects. We then ask an expert to develop a concept map, shown in Figure 1, that details the Change Management Strategy flow. The trainee's performance after the three-week course is assessed in two ways. First, a quiz using a traditional questionnaire on the desired Change Management process is administered and the results are used to set the baseline for comparison. Second, a concept map is created by the trainee to illustrate his/her understanding of the subject. Figure 3 shows the map that the trainee developed.

Implement Change Management Strategy

Develop Change Management Strategy

Identify Change Opportunities in accordance with company strategy

First Phase ◇

Second Phase

Third Phase

Review existing policies and practices against strategic objectives to identify change requirements

Monitor trends in the external environment to identify events or trends which impact on the achievement of organization's objectives

Identify major operational change requirements due to performance gaps, business opportunities or threats, or management decisions

Review and priorities change requirements\opportunities with relevant managers

Consult specialists and experts to assist in the identification of major change requirements/opportunities

Undertake cost benefit analysis for high priority change requirements\opportunities

Undertake risk analysis, identify barriers to change, and agree and document mitigation strategies

Develop change management project plan

Obtain approvals from relevant authorities to confirm the change management process

Assign resources to the project and agree reporting protocols with relevant managers

Develop communication/education plans in consultation with relevant groups and individuals

Develop communication/education plan to promote the benefits of the change to the organization and to minimize loss

Arrange activities to deliver the communication/education plans to all relevant groups and individuals

Consult with relevant groups and individuals for input to the change process

Identify and respond to barriers to the change in accordance with risk management plans

Action interventions and activities set out in project plan in accordance with project timetable

Activate strategies for embedding the change

Conduct regular evaluation and review, and modify project plan where appropriate to achieve change program objectives

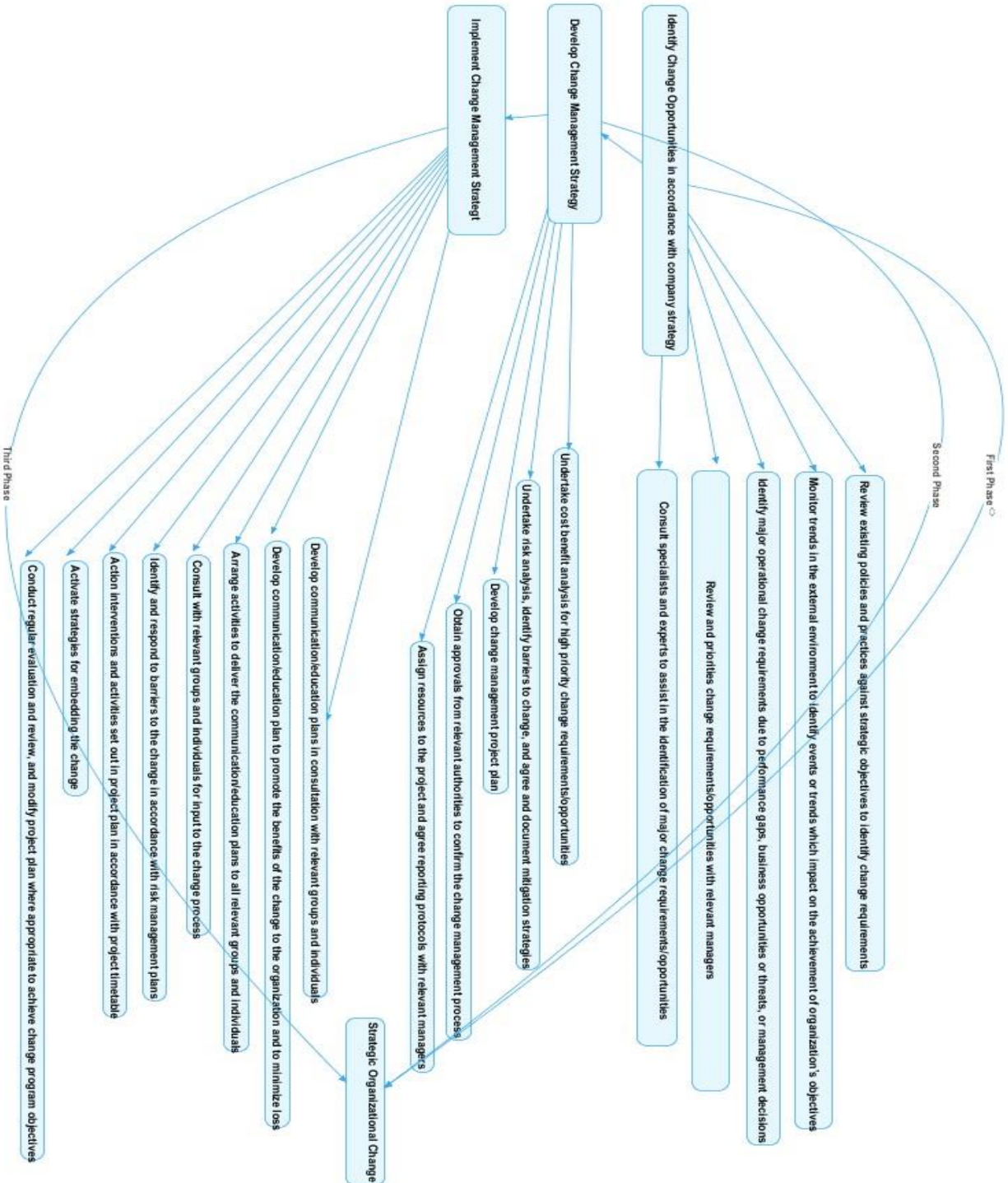Strategic Organizational Change

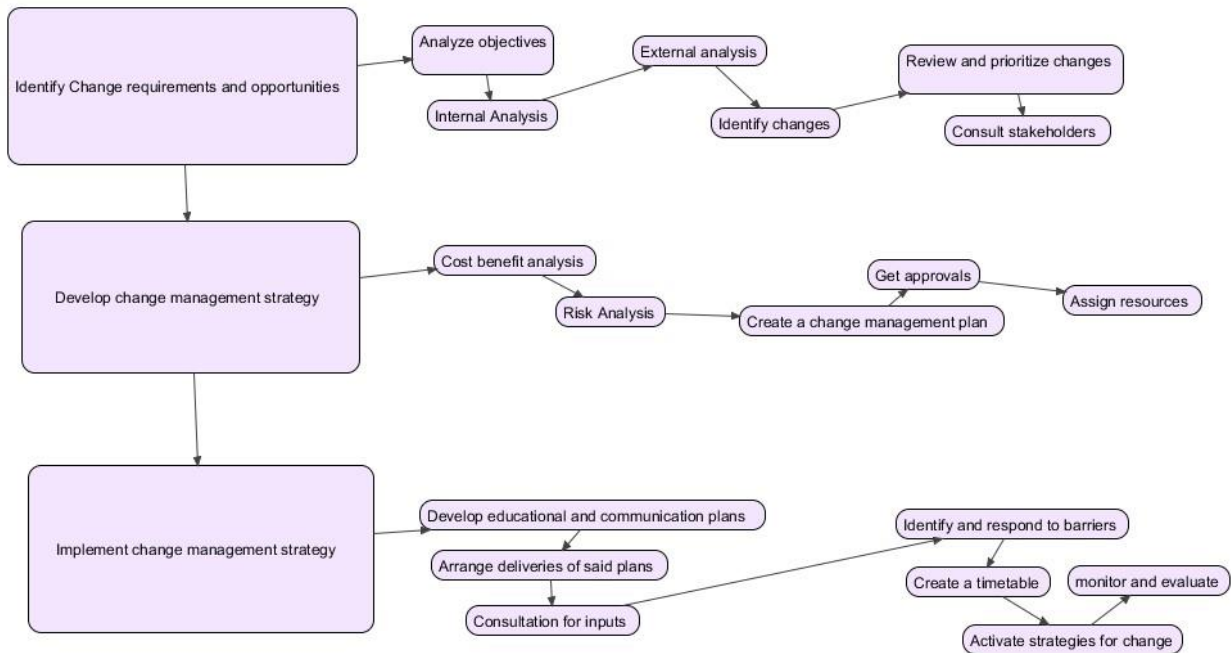Figure 2. Expert's Map for Change Management Strategy

Figure 3: Trainee's Map for Change Management Strategy

The summary of comparison between the trainee's map and the expert's map is presented in Figure 4. As we can see, the trainee's map has about 28% overall similarity and about 36% "considerable" node similarities to the expert's map (range from 51% to 96%). A more detail illustration of the closeness of the two maps is shown in Figure 5, where shade of the nodes in the trainee's map indicates nodes' semantic resemblance to their counterparts in the expert's map. There are eight nodes with green colors. Four are darker and the other four are lighter. The darker the color of the node is; the more similarity the node has.



Figure 4: Trainee's Map for Change Management Strategy Comparison - Summary: First Attempt
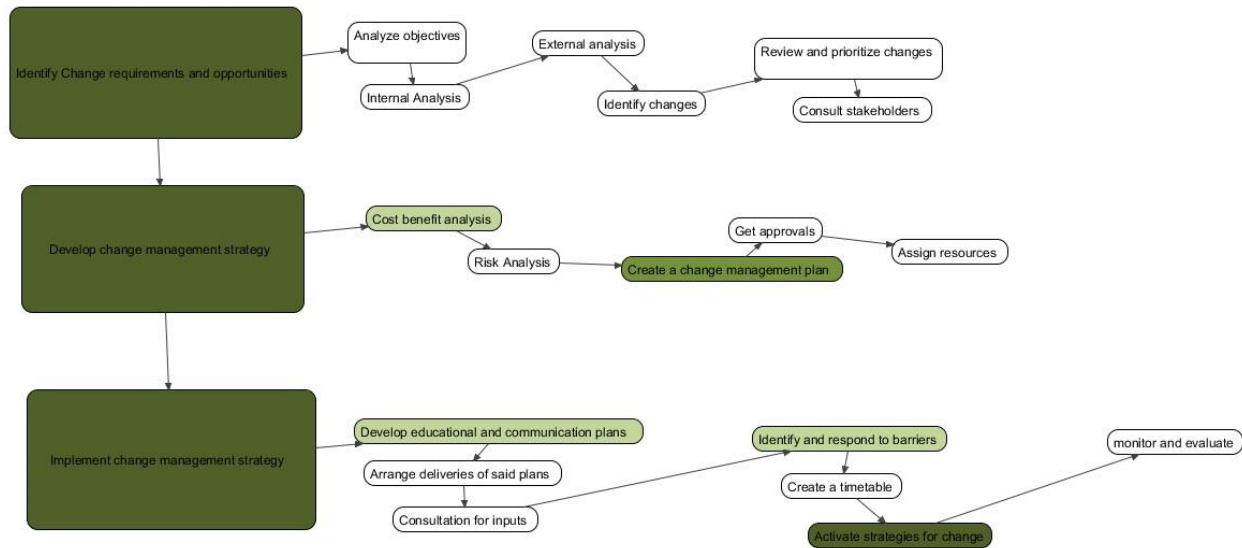
Figure 5: Trainee's Map for Change Management Strategy Comparison: First Attempt

The 27% match to the expert's map is an indication of the trainee having a poor understanding of the Change Management process.  This finding is consistent with the instructor's observation of the trainee's level of competency and the returns from the questionnaire.  Although the test is only done on a very small sample size of trainees, this consistency shows the promise of the concept map based assessment: it is able to pinpoint the areas where the trainee lacks competency in a fraction of the time of what current assessment methods would need on similar tasks.  The comparison map highlighted that the trainee had the necessary competency in regards to the actions needed for a successful change plan.  However, lacked the knowledge of the process flow to implement the strategy.  This helped the trainer identify where they would need to focus in order to follow up with the trainee and bring up their competency to the desired level.

**Conclusions**

Assessing training effectiveness and transfer is crucial for organizations (Zumrah et al. 2013; Kirkpatrick, 2004; Gomez-Mejia et al., 2001). However, since current methods of training assessment are time-consuming (Rothwell, 2007), new mechanisms are needed for more accurate and speedy assessment.  In this work-in-progress, we present a new automated tool to assess training participants' grasp of the desired processes in managing organizational changes.  The assessment tool uses conceptual map for twofold purposes.  First, it allows the trainees to graphically demonstrate their conceptual understanding of the process.  Second, it provides a visual guidance to the training providers of the level of congruency between trainee produced map and the expert's map in a matter of seconds, and subsequently helps trainers determine whether any changes to the program or a follow up training is needed. Moreover, the new competency mapping yields similar assessment as the traditional methods on the trainee's understanding of the material and competency level, signifying the suitability of the methodology for usage in organizational training.

# References

Baldwin, T. T., & Ford, J. K. (1988). Transfer of training: A review and directions for future research. *Personnel psychology*, *41*(1), 63-105.

Chang, Kuo-En, Sung, Yao-Ting, Chang, Rey-Bin, & Lin, Shui-Cheng. (2005). A new assessment for computer-based concept mapping. Educational Technology & Society, 8(3):138148.

Díaz-Fernández, M., López-Cabrales, A., & Valle-Cabrera, R. (2014). A contingent approach to the role of human capital and competencies on firm strategy. BRQ Business Research Quarterly, 17(3), 205-222.

Evans, W. R., & Davis, W. D. (2005). High-performance work systems and organizational performance: The mediating role of internal social structure. Journal of management, 31(5), 758775.

Gao, Jian-Bo, Zhang, Bao-Wen, & Chen, Xiao-Hua. (2015). A WordNet-based semantic similarity measurement combining edge-counting and information content theory. Engineering Applications of Artificial Intelligence, 39:80-88.

Gomez-Mejia, L. R., Balkin, D. B., Cardy, R. L., Dimick, D. E., & Templer, A. J. (2001). Managing Human Resources, 3rd Canadian edn,

Hellriegel, D., & Slocum, J. W. (2011). Organizational behavior (13th ed.). Belmont, CA: Cengage South-Western.

Holton III, E. F., & Baldwin, T. T. (2003). Improving learning transfer in organizations. John Wiley & Sons.

Kirkpatrick, D., & Kirkpatrick, J. (2006). Evaluating training programs: The four levels. San Francisco, CA: Berrett-Koehler Publishers.

Limongelli, C., Lombardi, M., Marani, A., Sciarrone, F., & Temperini, M. (2016). Concept maps similarity measures for educational applications. In Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), volume 9684, 361-367. Springer, Zagreb, Croatia.

Lin, Y., Shahhosseini, A. M., & Janke, C. (2018). Board 58: Concept Map-based Aviation Competency Mapping and Training. In 2018 ASEE Annual Conference & Exposition.

Lunenburg, F. C. (2011). Organizational culture-performance relationships: Views of excellence and theory Z. In National Forum of Educational Administration and Supervision Journal (Vol. 29, No. 4, pp. 1-10).

Marković, M. R. (2008). Managing the organizational change and culture in the age of globalization. Journal of Business Economics and Management, 9(1), 3-11.

Melnik, S., Garcia-Molina, H., & Rahm, E. (2002). Similarity flooding: A versatile graph matching algorithm and its application to schema matching. In Data Engineering, 2002. Proceedings. 18th International Conference, 117-128. IEEE.

Potnuru, R. K. G., & Sahoo, C. K. (2016). HRD interventions, employee competencies and organizational effectiveness: an empirical study. European Journal of Training and Development, 40(5), 345-365.

Powers, B., & Rothwell, W. J. (2007). Instructor excellence: Mastering the delivery of training. John Wiley & Sons.

Scaduto, A., Lindsay, D., & Chiaburu, D. S. (2008). Leader influences on training effectiveness: motivation and outcome expectation processes. International Journal of Training and Development, 12(3), 158-170.

Shahhosseini, A. M., Ye, Haisong, Maughan, G., & Foster, T. (2014). Implementation of similarity flooding algorithm to solve engineering problems using diagnostic skills training technique. ASME 2014 International Mechanical Engineering Congress and Exposition, pages V005T05A023–V005T05A023. American Society of Mechanical Engineers.

Whitfield, G., & Landeros, R. (2006). Supplier diversity effectiveness: does organizational culture really matter? Journal of Supply Chain Management, 42(4), 16-28.

Zumrah, A. R., Boyle, S., & Fein, E. C. (2013). The consequences of transfer of training for service quality and job satisfaction: an empirical study in the Malaysian public sector. International Journal of Training and Development, 17(4), 279-294.