Course Achievement Evaluation Using Concept Map in Traditional Learning

Peihan Huang¹, Shaohui Lin², Junying Yuan³* and Haishan Chen⁴
¹,²,³,⁴Nanfang College of Sun Yat-sen University, Guangzhou, 510970 China

*Corresponding author email: yuanjy@nfu.edu.cn

Abstract. Concept map (CM) has been proved to be pretty efficient in learning assessment. Existing CM-based learning assessment methods tend to compare a CM delivered by a student against a standard version or expert version. This manuscript employs CM as a technique to assess students’ learning performance from the results of a bunch of traditional performance assessments. The experimental results show a more comprehensive result for interpreting students’ learning performance and provide some indications of the gap between teaching and learning for future teaching reforms.

Keywords: Concept map; Course achievement assessment; Learning performance assessment.

1. Introduction

Concept map has been a way of illustrating the relationships among concepts in a graphical way [1,2]. It consists of three elements which are labeled nodes, connections between nodes (which is termed as connections below) and propositions. A labeled node represents a concept, a connection links two nodes with a meaning label, the labeled connection and the two nodes forma a proposition. Besides, concept maps generally use a hierarchical method to express the relationships between concepts, such as the leader-member relationship and correlativity.

Concept map has a wide range of applications in educational areas [3-5], according to the application scenarios, it can be divided into two types of tools, for teaching assistant or for teaching quality evaluation. As a teaching assistant, concept map can not only assist teachers to improve their teaching abilities and teaching effect, but also help them develop teaching activities such as course design, instructional design, the construction of knowledge and more [6-8]. Besides, it can also be employed to improve learning effect and efficiency as a learning skill [9-11]. On the other hand, as a tool for teaching and learning performance evaluation, concept maps can be used to provide an evaluation model that can effectively and comprehensively evaluate learners' learning performance by measuring their understanding of knowledge structure and the relationship between concept points [12-16].

In traditional learning performance evaluation, various question forms and test forms are employed, but can only reflect how well students have mastered the overall course. However, tests generally rely on students’ abilities of memory and regeneration of knowledge, which tend to lead to a situation that traditional leaning performance evaluation can’t fully indicate how well students understand the relationship between the knowledge and the related concept structures. On the contrary, concept map is good at using a number of graphs and colors to show the characteristics of concepts and reflect what is called the ‘dual coding theory’ [17], namely that human cognition is a process of handing language objects and non-language objects. Compared to traditional evaluation methods of learning effect, concept map brings a lot of advantages. Therefore, concept map has become a comprehensive teaching evaluation tool [12-16], and has a wide range of applications in the area of formative assessment [18].
This manuscript employs concept map, in the course of C programming language, as a new way of assessing students’ learning performance by utilizing traditional learning performance test results. Unlike existing concept-map-based evaluation patterns which tends to assess the differences between the concept map delivered by students and the concept map made by teachers, this manuscript designs a new pattern of course learning performance evaluation by employing concept map in the evaluation of traditional test results made.

We first illustrate the concept map of C programming language course, then describe the collected data set from traditional test results, and finally presents the evaluation method and the corresponding analysis results.

2. The Concept Map and the Dataset
This course takes the C programming language as the research course, with a course concept map as shown in figure.1. The concepts are shown in a tree structure, and the rightmost concept nodes (including the three connection labels in green) with a digital number at the beginning are termed as leaf nodes.

The form of traditional tests including mid-term exam, final exam, a set of theory homework and experiment homework, and a course design. According to the course concept map, the relationships between test questions and the concept map, and the test performance of students, are combined together to provide a data set for analysis. In the prepared data set, there are two teaching classes, 175 students, 96 test questions. Note that each test question in the data set covers one to three concepts or propositions in the concept (see figure.1)

![Figure 1. The employed course concept map.](image)

3. Course assessment
This manuscript aims to evaluate students’ learning performance using concept map and with traditional test results. The degree of learning performance has some relationship with the emphasis degree of concepts in the concept map, and also the way of how important the learning performance of a concept is assessed at test stage. The weighting coefficient on how much a concept is emphasized is presented by the normalized teaching hours which are assigned to the leaf concepts in figure 1 as. The weighting coefficient for the importance of learning performance of a concept is designed as the normalized sum of scores for a concept from those assigned to relevant test questions.

We first illustrate the distributions of the two weighting coefficients together with the normalized score for each concept, then we show the degree of learning performance for each concept, at last, we illustrate the obtained level of course achievements by comparing to the normalized course scores. For
the convenience of analysis, the following notations are used. Variable $c \in [1, N_i]$ denotes the sequence number of a leaf node in the concept map (see figure 1), where $N_i$ is the number of leaf concept nodes, and $g(c)$ is used to represent the normalized test score allocated to a concept indexed by $c$.

### 3.1. The Weight of Concept

Conventional learning performance assessment just simply sum up all obtained scores of the test questions without considering the impact of teaching hours and the evaluation emphasis on different concepts at the test stage.

In this manuscript, during the evaluation of learning performance, we consider the impacts from both the teaching hours and the evaluation emphasis by designing two weighting factors, including node weight of teaching denoted by $w_t(\sum_c w_t(c)=1)$, and the node weight of test denoted by $w_e(\sum_c w_e(c)=1)$. The weight of teaching reflects the distribution of teaching hours, and the weight of test indicates the distribution of test scores on different concept nodes.

Figure 2 gives the distributions of the two weights and the average normalized score for each concept. In figure 2, the horizontal axis and vertical axis represent the sequence number of concepts and average normalized score (denoted by $g_m$), respectively. Note that there exist some correlations between the weight of teaching $w_t$, the weight of test $w_e$ and the average normalized score $g_m$. Among them, the correlation between the weight of test $w_e$ and the average normalized score $g_m$ is higher, while their correlation to the weight of teaching $w_t$ is slightly lower.

![Figure 2. The weights of concept.](image)

### 3.2. Level of Concept Attainment

The level of concept attainment (LCA) is a quantitative description of students’ learning performance of a concept. In this manuscript, LCA, denoted by $\beta_c$, is expressed by the division of the test score of a concept to the given score of the concept. The definition of LCA is given by Eq. (1), and its value falls in the range of $[0, 1]$.

Figure 3 illustrates the distribution of average LCA of all students in a descending order and the distribution of the weight of teaching. In the distribution of LCA, there are 19 concepts with LCA higher than 60%, but LCA of 16 concepts are lower than 80%. When comparing with the weight distribution of teaching hours, it can be found that in general, LCA has a positive correlation with the weight of teaching hour $w_t$, and the greater the weight of class hours, the higher the LCA. According to the distribution of LCA and combined with the weight of teaching hour, it is not difficult to see that in the future, more teaching hours should be allocated to those concepts with smaller LCA values.

$$\beta(c) = \frac{g(c)}{w_e(c)}$$ (1)
3.3. Degree of Course Attainment

The degree of course attainment (DCA) is a quantitative measure to describe the overall learning performance of all students. When summing up LCAs, the weight of teaching hour must be considered to evaluate DCA. Therefore, DCA is defined by Eq. (2). When \( w_e(c) = w_t(c) \), DCA is the same as the score of traditional learning performance \( \sum_g g_m(c) \).

Figure 4 presents the distribution of students' DCA in a descending order. As a comparison, the score of traditional score is also shown in figure 4. Note that the distribution of DCA is similar to that of traditional score, but with a slightly difference. Since DCA can better reflect the influencing factors of teaching hours, DCA can be used as another effective way to evaluate students' course achievements.

\[
\Psi = \sum_c \beta(c)w_t(c) \tag{2}
\]

Figure 4. Distribution of DCA and traditional score

4. Conclusion

Traditional course learning performance failed to reveal how concepts have been mastered and how well students master the course, and thus concept map is employed to measure the level of concept attainment and the degree of overall course attainment. The concept-map-based approach are verified through a set of data analysis and can be used in pointing out future teaching reform directions.

Acknowledgments

This work was financially supported by the Guangzhou Science and Technology Plan Project of China under grants 201804010292 and 201904010276.

References

[1] Novak J and Cañas A J 2006 The theory underlying concept maps and how to construct and use them (Technical Report IHMC CmapTools 2006-01 Rev 01-2008). Pensacola, FL:Institute for Human and Machine Cognition. Retrieved from, http://people.cs.vt.edu/~shaffer/CS6604/Papers/Novak2008.pdf on 5th Feb.2020
[2] Novak J D 1998 Learning, creating and using knowledge: Concept maps as facilitative tools in schools and corporations Lawrence Erlbaum (NJ: Mahwah)

[3] Ryan J 2005 Improving teaching and learning practices for international students, in J Carroll & J Ryan (eds), Teaching International Students (UK: Routledge, Milton Park) pp 92-100

[4] Jonassen D H, Reeves T, and Hong N 1998 Concept mapping as cognitive learning and assessment tools Journal of Interactive Learning Research (vol 8) pp 289–308

[5] Markham K, Mintzes J and Jones G 1994 The concept map as a research and evaluation tool: Further evidence of validity Journal of Research in Science Teaching (vol 31:1) pp 91-101

[6] Simon J 2010 Curriculum changes using concept maps Accounting Education: An international Journal (vol 19:3) pp 301-307

[7] Peters R and Beeson M 2010 Reducing the gap between skills sought by employers and developed by education The Teacher (vol 43:04) pp. 773-777

[8] McClean P and Ransom L 2005 Building intercultural competencies: Implications for academic skills development in J Carroll & J Ryan (eds), Teaching International Students (UK: Routledge, Milton Park) pp 45-62

[9] Baig M, Tariq S, Rehman R, Ali S, and Gazzaz Z J 2016 Concept mapping improves academic performance in problem solving questions in Biochemistry subject. Pak J Med Sci. (vol 32) pp 801-805

[10] Schaal S 2010 Cognitive and motivational effects of digital concept maps in pre-service science teacher training Procedia Social and Behavioral Sciences (vol 2) pp 640-7

[11] Nesbit J C and Adesope O O 2006 Learning with concept and knowledge maps: A meta-analysis Review of Educational Research (vol 76) pp 413-48

[12] Kou H and Wan Z 2012 Practical Research on Concept Map Applied to Teaching Evaluation of C Programming China Educational Technology (vol 10) pp 114-119

[13] Pinto M, Doucet A V and Fernandez-Ramos A 2010 Measuring students' information skills through concept mapping Journal of Information Science (vol 36:4) pp. 464-80

[14] Kinchin I M and Hay D B 2000 How a qualitative approach to concept map analysis can be used to aid learning by illustrating patterns of conceptual development Educational Research (vol 42:1) pp 43-57

[15] McClure J R, Sonak B and Suen H K 1999 Concept map assessment of classroom learning: Reliability, validity and logistical practicality Journal of Research in Science Teaching (vol 36:4) pp 475-92

[16] Ruiz-Primo M A and Shavelson R J 1996 Problems and issues in the use of concept maps in science assessment Journal of Research in Science Teaching (vol 33:6) pp 569-600

[17] Paivio A 1990 Mental Representations: A Dual Coding Approach Oxford Psychology Series (New York: Oxford University Press)

[18] Pailai J, Wunnarsi W, Yoshida K, Hayashi Y and Hirashima T 2017 The practical use of Kit-Build concept map on formative assessment Research and Practice in Technology Enhanced Learning (12:20) pp 1-23