ADAPTIVE FEEDBACK BASED ON CONCEPT MAP AND CONFIDENCE INFORMATION

(概念マップと確信度情報に基づく
適応的フィードバックに関する研究)

by

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DISSERTATION SUMMARY

The feedback is a key to improve the learning achievements, which appropriate feedback should be adapted the content of feedback regarding the evidence of learners. The concept map is a graphical tool that is utilized to representing and organizing knowledge. The learning evidence in the form of concept map can be gathered and assessed for representing the current understanding of learners through the ability of Kit-Build concept map (KB map). Thus, the KB map can visualize the assessment results where the instructor can access and adapt the correctness of learner maps for designing and providing feedback. The confidence information is another evidence of learners that is available in KB map where the system can associate the correctness and confidence information to visualize the current learning situation. The instructor can adapt these information for designing and providing the feedback, and the system can also utilize these information for generating and providing individual feedback adaptively.

Formative assessment is utilized to create an opportunity for improving learning achievements through three critical tasks: certifying a learning goal, gathering and assessing learning evidence, and providing feedback. A primary objective of the formative assessment is monitoring the learning of learners before providing feedback for helping the learners to achieve the learning goal. The Kit-Build concept map (KB map) is a digital tool for supporting the concept map strategy, which its ability can be arranged for implementing the formative assessment adequately. A framework of KB map can encourage an instructor to create a learning goal of class in the form of a goal map. The learners can create a learner map for representing the learning evidence by integrating the decomposed components of the goal map. Diagnosis results are generated automatically via a propositional level exact matching assessment method, which is a comparison between the goal- and learners-map. The variety visualization of diagnosis results can indicate the learning achievements where the learners can reach the learning goal and indicate the learning gaps where the learners struggled to understand the lecture. Furthermore, the analyzer of KB map can inform the valuable information in both individual- and group-diagnosis results, which the instructor can access the diagnosis results immediately for estimating the correct understanding of learners before designing feedback for helping the learners to reach the learning goal. The

adaptive feedback of an instructor is a strategy to improve learning achievements in the classroom situations.

The Kit-Build concept map with confidence tagging (KB map-CT) was developed for more eliciting learning evidence and associating the correctness- and confidence-information. The learners can represent their understanding and can indicate the certainty of the understanding via KB map-CT. The reinforced diagnosis results can visualize the association between the correctness and confidence for illustrating the quality of learner's understanding. The instructors accepted and utilized the reinforced diagnosis results for implementing the formative assessment in lecture classes, which the correctness and confidence of learners are the learning evidence. In addition, an adaptive feedback was developed as a learning evidence-based strategy for providing individual feedback in a reading situation. The goal map structuring task is associating each component of a goal map with each sentence of learning material for matching the related sentence of each proposition during a learning goal was defining. The correctness- and confidence-information are utilized to classify the characteristic of each proposition. The adaptive feedback will provide the different activity based on each characteristic in a reflection task, and the related sentences are also utilized in the reflection task for improving the understanding and increasing the confidence of learners.

The thesis consists of six chapters. In **Chapter 1**, the research context and the goals, contribution, evaluation methods, and the structure of the thesis are described. **Chapter 2** outlines relevant research on the formative assessment and digital tools for supporting the concept map strategy. **Chapter 3** presents the arrangement of KB map on the formative assessment and the results of practical uses for illustrating the valuable information of the diagnosis results. In **Chapter 4**, the mechanism of KB map-CT is described that includes the confidence tagging and reinforced diagnosis results. The results of experimental uses in lecture classes demonstrate the encouraging of the diagnosis results in the behavior of the instructors. **Chapter 5** presents the adaptive feedback of KB map-CT, which comprises the goal map structuring task, the reflection task, and the correctness- and confidence-based adaptive feedback. The conclusion of this thesis and future work directions are given in **Chapter 6**.

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PREFACE AND NOTES

Publications

Journal articles

RPTEL 2017: Pailai, J., Wunnasri, W., Hayashi, Y., & Hirashima, T. (2017). The practical use of Kit-Build concept map on formative assessment. *Research and Practice in Technology Enhanced Learning, 20*(12), pp. 1-23.

doi:10.1186/s41039-017-0060-x

IJACSA 2018: Pailai, J., Wunnasri, W., Hayashi, Y., & Hirashima, T. (2018a). Kit-Build Concept Map with Confidence Tagging in Practical Uses for Assessing the Understanding of Learners. *International Journal of Advanced Computer Science and Applications, 9*(1), pp. 79-91.

doi:10.14569/IJACSA.2018.090111

Conference paper

ICCE 2016: Pailai, J., Wunnasri, W., Hayashi, Y., & Hirashima, T. (2016). Ongoing Formative Assessment with Concept Map in Proposition Level Exact Matching. *Paper presented at the Poster session of the 24th International Conference on Computers in Education*, Mumbai, India, pp. 79-81.

AIED 2018: Pailai, J., Wunnasri, W., Hayashi, Y., & Hirashima, T. (2018b). Correctness- and Confidence-based Adaptive Feedback of Kit-Build Concept Map with Confidence Tagging. *Proceeding of the 19th International Conference on Artificial Intelligence in Education*, London, United Kingdom, pp.

Doctoral Student Consortium

ICCE 2016: Pailai, J., Wunnasri, W., Hayashi, Y., & Hirashima, T. (2016). Reference Information Model of Concept Map for Improving Learning Achievements. *Paper presented at the Doctoral Student Consortium session of the 24th*

International Conference on Computers in Education, Mumbai, India, pp. 13-16. ISBN 9789868473584.

Source and Original Work

Original material of my own from the above publications has been included in this thesis, with a citation to the appropriate publication appearing at the beginning of each chapter. Other external sources are cited, with the bibliography appearing at the end of the thesis. All figures are created originally by my own for supporting the above publications.

Use of Work by Others

The dataset of experimental uses in Japanese elementary school that is analyzed in this thesis was collected through a study conducted by the fellow researcher. It was gathered by Yoshida et al. (2013). However, the analysis of the dataset is part of the original contributions of studies in this thesis.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Summary: This chapter describes the research context of the thesis, the identified learning problem and the methodology followed to address it. This thesis proposes applied formative assessment approach that the objective is to assess the current understanding of learners for improving learning achievements. The thesis proposes an arrangement of the Kit-Build concept map for implementing formative assessment, which demonstrates a concrete scenario in a classroom situation. The thesis presents how to utilize the ability of the Kit-Build concept map in lecture classes since create a learning goal of the class, gather and assess learning evidence, and design appropriate feedback of the instructor based on the diagnosis results. The thesis places a strong emphasis on identifying the quality of learner's understanding, which the confidence tagging was integrated to elicit more learning evidence for clarifying the quality of the understanding. Moreover, the thesis demonstrates a mechanism of correctness- and confidence-based adaptive feedback in a reading situation for improving the understanding and increasing the confidence of learners. This chapter outlines the goals, contributions, evaluation methods and the general structure of the thesis.

1.1 Context and Motivation

Formative assessment is a process which is used by instructors and learners during instruction. It provides feedback to adjust ongoing teaching and learning to improve learners' achievement of intended instructional outcomes (Melmer et al., 2008). For implementing formative assessment in lecture class, there are the key questions series of formative assessment that we will mention as the requirement of formative assessment as follows: "Where are learners going?", "Where are learners now?" and "How to close the gap?" (Moss & Brookhart, 2010). The information through formative assessment can encourage the

instructor for giving the feedback to improve the understanding in a timely manner, which is the most efficient feedback (Wiliam et al., 2004). Also, the interaction based on formative information is formative assessment key feature (Ballantyne et al., 2002). Accordingly, gathering and assessing the learning evidence for providing the feedback in a class period is the processes of completing formative assessment, and is also creating an opportunity for improving learning achievements concurrently. Nevertheless, the effective implementation of formative assessment is problematic of an instructor on observing and interpreting the learning evidence in a class period. The instructor should recognize the current learning situation clearly before deciding the ways for improving learners' understandings. Particularly, it is difficult to identify the current common understanding and misunderstanding of learners when the instructor duel with a large number of learners in the lecture class. Hence, the essential characteristic of formative strategy not only elicits the current learning situation but also visualizes the observing information in an easily understandable form. Also, the technology-enhanced learning produces an accessing ability which can inform the information whenever the instructor needs to know the current learning situation.

The Kit-Build concept map (KB map) is a digital tool for supporting concept map strategy. The ability of KB map includes a construction tool where users can construct concept maps, and an automatic concept map assessment where the system can report diagnosis results (Hirashima et al., 2015). We propose an arrangement of KB map on formative assessment. The main contribution of KB map on formative assessment in a lecture class is creating, gathering, and assessing the evidence of learners to generate instant practical information for designing and providing instructor's feedback. The proposition level exact matching methodology is an automatic assessment of KB map. The diagnosis results of propositional exact matching can inform the current understanding of learners to the instructor immediately, and also can inform where learners understand the lecture content differently from the instructor's expectation. The diagnosis results are a confirmation of the understanding between an instructor and learners on lecture contents. Especially, the group-diagnosis results can inform overview of class on only one map, which is the common understanding and misunderstanding based on the assessment results of learner's evidence.

Feedback has a powerful influence in helping the learners to improve their learning achievements, thus it should be individually aligned with the characteristics of each learner as much as possible (Jonassen & Grabowski, 1993). The correctness of learner's answer is

generally used to estimate the characteristic of the learner, which the correct answer was interpreted as a representing the knowledge, while the incorrect answer was interpreted as a representing the misunderstanding. Especially the incorrect answers indicate that the learners require help to correct their misunderstandings. Moreover, the certainty of knowledge is an essential component to represent the belief of the learner as the quality of the knowledge (Efklides & Tsiora, 2002; Hunt, 2003; Kleitman et al, 2004; Efklides, 2006; Bruinr de Bruin et al., 2017; Kleitman & Moscrop, 2010; Kleitman et al., 2012). For instance, confidence can encourage a deeper understanding of the material (Heon & Lerpiniere, 2013) and can increase reflection and justification of the answers (Stankov et al., 2009). Consequently, the answers of learners represent their understanding, and the confidence in their answer indicates the degree of their understanding, such as the different degrees of the understanding between a learner who is sure in the correct answer and a learner who is unsure in the correct answer.

For more emphasize on assessing and informing the current understanding of learners, we propose Kit-Build concept map with confidence tagging (KB map-CT) for eliciting learning evidence of learners and informing the correctness and confidence information of the learners to the instructor. The confidence tagging is integrated into the structuring task of the KB map, which learners can construct the map to represent their understanding and identify their confidence on each unit of meaning. A completed proposition, which is able to tag the confidence, comprises one connected linking word between two concepts. The confidence of an answer is simplified in the form of confidence- and unconfidence-value, which the learner can assign to every complete proposition. Thus, the system can elicit learning evidence that includes the understanding of learners and the degree of the understanding in the gathering process. The confidence information of learners is utilized in the diagnosis results of the KB map for visualizing the degree of learner's understanding.

Although the correctness and confidence information can describe the degree of learner's understanding, this two information is not utilized to provide individual feedback for improving the understanding of learners generally. Because of the different degrees of learner's understanding, learners should be given different feedback in the same way as the different correctness which is given the feedback differently. Furthermore, the adaptive feedback regarding confidence information aims to ensure the confidence of learners who have an accurate understanding but lack confidence for encouraging the retaining of their understanding. The adaptive feedback also aims to reduce the confidence of learners who are confident in their misunderstanding, then correct the misunderstanding. We propose a

mechanism to provide individual feedback based on the correctness and confidence information as an adaptive feedback of the KB map-CT. The KB map-CT can elicit learning evidence that includes the understanding of learners and the degree of the understanding in the gathering process. The adaptive feedback based on the correctness and confidence information is provided for learners in a reflection task for improving their understanding individually. The mechanism of the adaptive feedback is to provide different interactions as different feedback for encouraging the learners to reconsider their current understanding according to the correctness and confidence information of each proposition. For instance, the evidence identification task requests the learners to identify the evidence of all their confident propositions for ensuring the confidence of correct propositions by themselves and for reducing the confidence of incorrect propositions before correcting the misunderstanding. The related content of the material and the correct proposition of the goal map will be visualized along with the proposition of learners to promote the learners to reconsider their incorrect propositions. Therefore, we present an experiment of the adaptive feedback of the KB map-CT in a reading situation for illustrating the effectiveness of the feedback.

1.2 Thesis Statement

This thesis aimed at improving the learning achievements and increasing the confidence of learners, which the feedback is the influence of these objectives. Although the objective of formative assessment approach directed essential process for improving the learning achievements, an appropriate strategy with a practical mechanism is required to implement formative assessment in a classroom situation. Moreover, the quality of learner's understanding and the retention of the understanding are considered in this thesis. The thesis statement is stated as follows:

> To improve the learning achievements through the ability of Kit-Build concept map with confidence tagging for creating a learning goal and learning evidence, assessing the quality of current understanding of learners, informing the valuable information, and generating the correctness- and confidence-based adaptive feedback.

Figure 1-1 (context) lists a set of keywords that can represent the direction of each process of formative assessment approach. In order to implement formative assessment, the ability of KB map was arranged to facilitate implementation of each formative assessment process. Additionally, the quality of learner's understanding is necessary to be considered because the

different degree of the understanding affects the retention of the understanding. The correctness and confidence information of learners are the valuable information to identifying the quality of learner's understanding, which the different degree of the understanding of learners should be treated by the feedback differently.

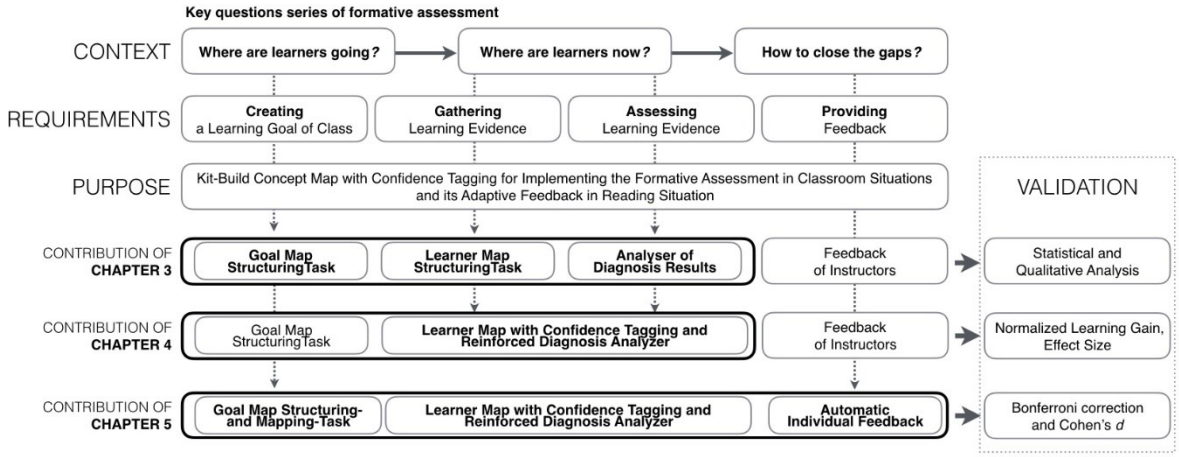

Figure 1-1 *Overview of the context, goals, contributions and evaluation of this thesis*

1.3 Thesis Goals

Having described the research context and stated the thesis statement, we have formulated the main goals of the thesis (see Figure 1-1, Goals):

1. *Arrange the ability of the Kit-Build concept map on formative assessment for facilitating the implementation of formative assessment in a classroom situation as technology-enhanced learning*. Improving learning achievements is a primary objective of formative assessment approach, which the approach aimed to identify the gaps between a learning goal and current learning situation, and subsequently, fulfill the gaps to help learners archive the learning goal by the feedback based on the learning evidence. Nowadays, the technology-enhanced learning is significant strategy for elevating and facilitating the learning environments. The framework of KB map is proposed for automatic diagnosis (Hirashima et al., 2015). The KB map facilitates the learners in building a concept map as a learner map for representing their understanding by reconstructing the provided decomposed components of the instructor-built map. The KB map can visualize the results of proposition level exact matching methodology through the several overlaying

maps in the form of the diagnosis results. Accordingly, the diagnosis results of the KB map can utilize in the aspect of confirming the understanding between the instructor and learners. The goal of the first study addresses a question: *Does the system can facilitate the instructor for implementing formative assessment in a classroom situation, and inform the valuable information to the instructor for designing the feedback to improve the understanding of learners?* It was aimed to arrange the ability of KB map in each process of formative assessment approach since a goal map creation and a learner map construction until a diagnosis visualization, which the ultimate goal is improving the learning achievements. This arrangement, practical uses, and discussion are mainly described in Chapter 3 and were published in (Pailai et al., 2016; Pailai et al., 2017).

2. *Elicit the confidence of learners as the learning evidence for assessing the quality of current learner's understanding.* The results of assessing learning evidence indicate the current learning situation and indicate the learning gaps, which the results effect to design and provide the feedback directly. The valuable information should indicate "*where are learners now?*" according to "*where are learners going?*" as represented as the learning goal. The correctness of learner's response is generally used to estimate the knowledge of learners that is the answer to where are learners now question. However, there is the different degree of the same correctness which can be classified by the certainty of the knowledge where the confidence of learners stated in each response. The confidence tagging is integrated into the learner map construction task where the system allows learners to identify their confidence in each proposition of the learner map. Thus, the Kit-Build concept map with confidence tagging (KB map-CT) can gather the learning evidence to assess and visualize the quality of learners, which is the additional information for recognizing the current learning situation clearer. This goal addresses the second question: *Does the visualization of quality of learner's understanding in the form of reinforced diagnosis results influence the behavior of the instructors for illustrating the value of the reinforced diagnosis results?* For this, we present experimental uses in classroom situations for investigating the instructor's behavior when they can access the different degree of learners' understanding. The five experimental uses are described in Chapter 4, and the results of the experimental use associated with this goal were published in (Pailai et al., 2018a).

3. *Adapt the correctness and confidence information to generate the individual feedback for improving the understanding and increasing the confidence of learners.* Although

the correctness and confidence information can describe the degree of learner's understanding, this two information is not utilized to provide individual feedback for improving the understanding of learners generally. Because of the different degrees of learner's understanding, learners should be given different feedback in the same way as the different correctness which is given the feedback differently. The goal addresses to the question: *Does the correctness- and confidence-based adaptive feedback can improve the understanding and increase the confidence of learners?* The goal calls for the adaptation of the correctness and confidence information for providing the feedback on each characteristic of the proposition, which aimed to promote the learners to revise their map appropriately. The design and implementation of the adaptive feedback of KB map-CT described in Chapter 5. The result of the experimental use was presented in the thesis (Pailai et al., 2018b).

1.4 Thesis Contributions

The main contribution of this thesis is the arrangement of KB map in formative assessment, enhancement the KB map with confidence tagging, and adaptation the correctness and confidence information for improving the learning achievements.

The subsidiary contributions are listed in Figure 1-1 (Contributions) and can be described as follows:

1. *The arrangement of Kit-Build concept map ability on formative assessment.* This thesis contributes to demonstrating a concrete scenario for utilizing the KB map in a classroom situation, where the system facilitates the instructor to create a learning goal of the class, gather and assess the learning evidence, and inform the valuable information of current learning situation when the instructor deal with a large number of learners.
2. *Gathering and visualizing the quality of learner's understanding*. The contribution of gathering the learner's confidence is encouraging the learners to reconsider their response in a different aspect, which promotes the self-assessment of learners. The contribution of visualizing the quality of learner's understanding is an identification of the learning situation clearer, which the current learning situation affect the design of instructor's feedback directly.

3. *Development the correctness- and confidence-based adaptive feedback.* We develop a mechanism of individual feedback based on the correctness and confidence information of each characteristic of the proposition. The adaptive feedback demonstrates a mechanism to utilize the associating between the correctness and confidence of learners for improving the understanding and increasing the confidence of learners concurrently.

1.5 Research Methodology and Validation Methods

Following the research areas involved in each objective of the thesis, we started conducting the implementation of formative assessment via KB map, investigating the instructor's behavior, and analyzing the learning achievements. Three practical uses were conducted for investigating the arrangements of KB map on formative assessment regarding the first goal of this thesis, where the instructor utilized the KB map for completing three critical processes in their lecture class. Five pair lecture classes were conducted to investigate the behavior of the instructor when they access the different information of learning evidence regarding the second goal of this thesis. According to the last goal of this thesis, the preliminary use was conducted in the reading situation.

The main validation approach consisted of the investigation of instructor's behavior, and analyzation of learner's achievements, and satisfaction evaluation. The investigation of instructor's behavior illustrates the acceptation of the instructor as the contribution of KB map, while the analyzation of learner's achievements represents the indirect contribution of utilized KB map. The satisfaction was evaluated in the form of the questionnaire of learners when they utilized the structuring task to create the learning evidence for representing their understanding. The validation approach of each goal can be described as follows:

1. *The valuable information of Kit-Build concept map.* The arrangement of KB map on formative assessment is a mechanism for facilitating both instructor and learners in a lecture class, which the instructor accepted and utilized in their lecture class. The valuable information is illustrated where the instructor considered the diagnosis results of KB map as the suggestion for designing and proving feedback. On the other hand, the behavior of the same instructor was investigated to indicate the different behavior when the instructor received the different visualization of learning evidence.

2. *Statistical and qualitative analysis*. The learning achievements of learners were analyzed following each objective of thesis goal. Statistically significant was used to indicate the improvement of learner's understanding. The normalized learning gain and effect size were used to indicate the importance of the difference in the comparison study.

1.6 Thesis Structure

This section describes the chapters of the thesis. Figure 1-2 illustrates the structure of the thesis and the publication associated with each chapter.

Chapter 1 – Introduction: describes the research context and outlines the goals, contributions, evaluations methods, and the general structure of the thesis.

Chapter 2 – Background: outlines relevant research of formative assessment in classroom situation. The related research of the KB map and the previous practical uses.

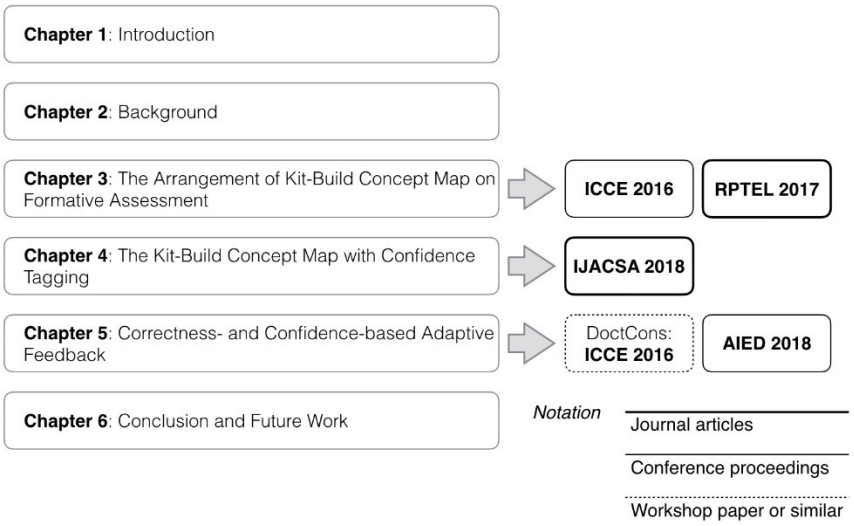

Figure 1-2 *Structure of the research covered in this thesis and related published paper*

Chapter 3 – The Arrangement of Kit-Build Concept Map on Formative Assessment. This chapter describes how to utilize the ability of KB map in each critical process for responding a series of key questions on formative assessment which are as follows: "*Where are learners going?*", "*Where are learners now?*" and "*How to close the gap*?" respectively.

The practical uses of the arrangement were conducted to illustrate the contribution of KB map when utilized on formative assessment in the lecture class.

Chapter 4 – The Kit-Build concept map with Confidence Tagging. The integration of confidence tagging into the KB map enhance the gathering and assessing ability. The experimental uses were conducted to demonstrate the different behavior of the same instructors when s/he received the different diagnosis results in the lecture class. This chapter focused in observing the instructor's feedback content regrading the visualizing of learning evidence. The learning achievements were also analyzed to indicate the positive behavior of the instructor.

Chapter 5 – Correctness- and Confidence-based Adaptive Feedback. The automatic individual feedback of KB map was designed based on the information of gathering and assessing ability. The correctness- and confidence-based adaptive feedback was developed for emphasizing the correctness and confidence information for each proposition type, which the instructor's feedback cannot deal with a large number of learners. The preliminary use was conducted to demonstrate the effectiveness of the adaptive feedback.

Chapter 6 – Conclusion and Future Work. revisits the studies presented in this thesis and describing the promising research avenues for future studies.

CHAPTER 2

BACKGROUND

Summary: This chapter reviews the relevant research of formative assessment approach for summarizing the requirements as the key questions series of formative assessment. Next, the related research of concept map strategy is referred in this chapter to introduce a core component, evaluation methodology, and utilization of concept map. Finally, the framework of the KB map is described to present the ability of each map and its meaning for supporting the learning process.

2.1 Formative Assessment

Formative assessment approach is used to monitor learning of learners for providing ongoing instructor's feedback, which is a key for helping the learners to achieve a learning goal. Also, the monitoring is an assessing learner's evidence of class for examining the learner's knowledge via formative assessment strategy. The selected strategy is used to illustrate both of the learning goal and the evidence of learners for determining a learning gap. An appropriate strategy should present an expectation of the instructor as well as the "where are learners going?" obviously, and also should represent the understanding of learners as more as possible for identifying the "where are learners now?" clearly.

A lecture class is an educational talk of an instructor for sharing knowledge to learners, while the instructor expects learners to understand the lecture contents positively. The instructor is an expert of lecture contents who has the content expertise and can use his/her experience to raise the understanding of learners. While the learners are the participant of knowledge sharing, who is a creator of evidence to present their understanding what they can grasp and perceive following the lecture. The evidence of learners can represent the current learning situation in the class, which can be used to determine the gaps in learning when comparing against the learning goal of the class. Thus, the results of the comparison can indicate the learning achievements when learners reach the learning goal, and also indicate the learning gaps when learners struggled to understand the lecture. The gaps are critical

areas of the class where require the supplementary explanation of the instructor to improve the learner's understanding as well as the answering of "How to close the gap?"

For applying a strategy of formative assessment, it requires to create both a learning goal of class and evidence of learners. For instance, the perfect score of multiple choices questions is a learning goal of the class. Also, the learner's evidence is the answer sheets, and difference scores can determine the gaps between the expectation of instructor and the understanding of learners. However, the characteristics of the proper strategy for implementing formative assessment should represent the understanding of learners as more as possible. Concept maps become to be the proper formative assessment strategy because its characteristics can be a response to formative assessment strategy's requirement which can adequately represent the expectation of an instructor and the understanding of learners clearly.

2.2 Concept Map Strategy

Concept maps are graphical tools that are used to representing and organizing knowledge (Novak & Cañas, 2008). A proposition of concept map is a unit of meaning, which is constructed by connecting two concepts via a relation with linking word. The propositions include concepts and relations that are a core component of measuring a map score. The traditional concept map assessment is evaluated by using criteria or rubric via human-based. The principal point of each criterion depends on the objective of assessment. For instance, Novak's assessment methodology emphasizes the hierarchy and cross-links (Novak & Gowin, 1984). A correct proposition can get only one score. While the specific propositions, which are the connection between two concepts from the different segment of the map will be increased the score from one to ten. It indicates the characteristic of the cross-link. Moreover, five additional scores will be given for every correct hierarchy in a map. The other rubrics attend to graph structure like branching and grouping of propositions (Cronin et. al, 1982) or continuous rating scales of linking words, sophisticated and cooperation (Bartels, 1995; NCSEC, 2000; Mueller, 2007). In addition, the concerns of concept map assessment are quality and quantity of proposition, which are the general discussion when the assessment methods are proposed.

Concept maps strategy is used in education areas to represent and assess knowledge of learners in classes. An instructor can gain the current learning information, and then give the feedback based on the information in various situations. For instance, using concept maps on

the individual or group discussion can contribute self-awareness of learners (Buldu & Buldu, 2010). An instructor can use concept maps as a formative strategy. The criteria map represents a learning goal of class in concrete form, which is used to compare with concept map of learners to find discrepancies based on the criteria map before instructor gives the feedback to learners (Trumpower & Sarwar, 2010). Accordingly, several researchers presented that the concept map strategy is simple to use, effective, and satisfy on problem-solving in classroom situations (Schacter et. al, 1999; Hsieh & O'Neil 2002). The concept map is an effective strategy in a classroom situation that affects to learners achievements and interests. Although the traditional lecture class contributed learning achievements and meaningful learning in the classroom situation, the concept map can significantly improve learning achievements of learners when compared with lecturing and is also more effective than lecturing in encouraging meaningful learning (Schacter et al., 1999; Chularut, 2004; Chiou, 2008; Aghakhani et. al, 2015).

The traditional concept maps strategy is a useful strategy for representing knowledge, and its characteristic can respond to the requirement of formative assessment on where are learners going question and also where are learners now question suitably. Although the remaining requirement is how to close the gap question, the instructor should identify the gap before finding the way to close it. "What is the gap?" is an implicit question of how to close the gap question. Thus, the comparison results of the criteria map against the learner's concept map can identify what the gap based on traditional concept maps strategy is. However, it is very difficult for the instructor to examine each concept map built by learners in the class in the real time. So, the using of the traditional concept map as the formative strategy without technology enhancement is an important focused issue when it is implemented in classroom situation practically.

2.3 Kit-Build Concept Map

The framework of KB map is designed based on concept map strategy, which includes concept maps construction tool, an automatic concept map assessment, and an analyzer of instructor. The significant component of KB map is a "Kit." The kit consists of the concepts and the relations with linking word. These components are extracted from a concept map of an instructor (as we called "goal map") on the segmentation task. An automatic assessment methodology of KB map is a proposition level exact matching between a goal map and

concept map of learners (as we called "learner map"). These abilities response to the concerns of concept map assessment following a kit which is the quantity controller, and propositional exact matching based on the goal map which is the quality controller.

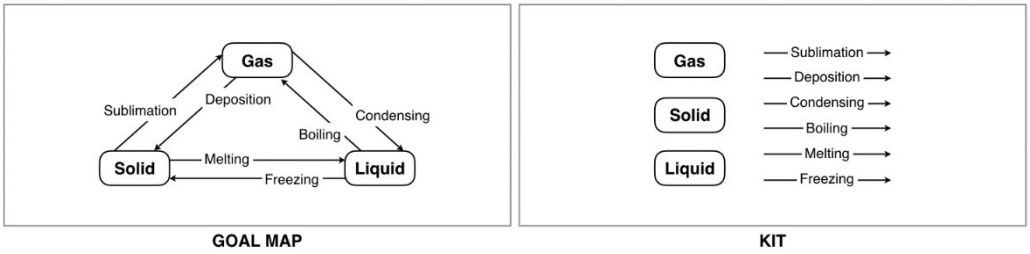

Figure 2-1 *An example of the goal map and its kit*

Figure 2-1 shows an example of a goal map and its kit. An example of learner map on "Change of State: Solid, Liquid, and Gas" is shown in Figure 2-2, which are integrated from the kit on the structuring task. The learner map of the KB map is constructed by using only the components of the kit, which is different from the traditional concept maps where all of concepts and links are drawn by the learner. All of the learner maps components are the same concepts and relations with the goal map, but the propositions can be possible to be different from the goal map. So, it is practicable to use the proposition level exact matching for indicating the difference between the goal map and the learner map directly. Moreover, the KB map can generate an additional evidence of learners as a group map for displaying the common understanding of all learners in the class (Figure 2-2). The thickness line and a tagged number in parenthesis refer to the number of learners who connect those links. The weight of line represents the degree of learners which means the bolder line present the number of learners more than the other thin line, and also correspond to the tagged number of each link.

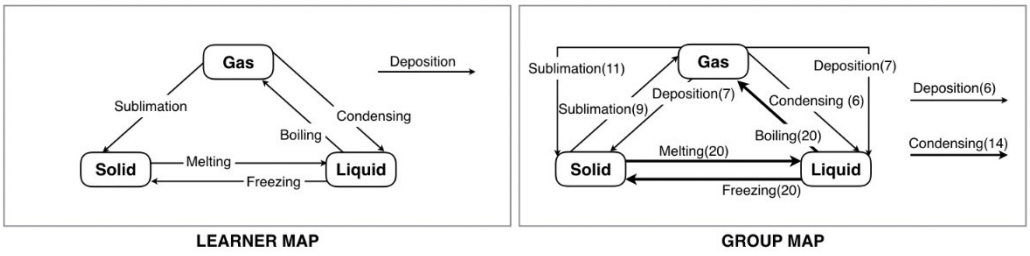

Figure 2-2 *An example of the learner map and the group map*

The proposition level exact matching is an assessment methodology of the KB map, which can implement as automatic assessment. The proposition level exact matching is the comparison of each proposition of learner maps against the goal map for identifying the similarity and difference of current understanding of learners and the instructor's expectation. The analyzer can provide the diagnosis results that include similarity scores, a group map, and a difference map. A similarity score is percentages of each learner map when a learner map is compared with the goal map. The results can show achievements of learners based on the instructor's expectation. Also, the difference map displays the mismatch of each learner map or the group map based on the goal map in the form of three types of error link, which include lacking links, excessive links, and leaving links. The link that is used to connect two concepts in learner map but at least one concept which is different from the goal map is called excessive link. The link that is not connected to any concept is leaving links. And the lacking links are used to call the link that is in the goal map but does not exist in the learner map.

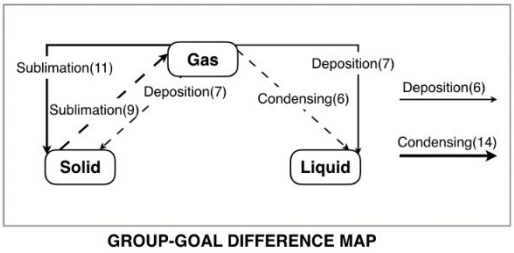

Figure 2-3 *An example of the group-goal difference map*

In the difference map, the concepts will be located as same as the concepts in the goal map and only relations of mismatch propositions are displayed. An example of a group-goal difference map is shown in Figure 2-3. The map displays three types of error link as same as the individual-goal difference map. The excessive link is represented in the form of solid line which the link connected with two concepts. It can identify the relations that have the confusing or the misunderstanding of learners, and the tagged number presents the number of learners who constructed the link. The leaving link is represented in the form of solid line which the link is not connected with any concept. This link indicates that the learners do not understand the linking word. Also, the tagged number means the number of learners who do not use the link to connect with any concept. The dashed line represents the lacking link which is an error correction for displaying the correcting information of excessive- and leaving-links. The tagged number of lacking link is the total number of excessive link and leaving link, which related to the weight of line. The more tagged number in each relation

will represent with a thicker line. For instance, “Deposition (13)” dashed line is the lacking link while “Deposition (7)” is the excessive link, and “Deposition (6)” is the leaving link. Moreover, the diagnosis results of KB map are divided into individual-diagnosis results and group-diagnosis results. The individual-diagnosis results include individual-goal similarity scores and individual-goal difference maps. The individual-goal similarity score represents the achievement of each learner. Also, the individual-goal difference map represents the mismatch propositions between each learner map based on the goal map.

The group-diagnosis results include a group map, a group-goal similarity score, and a group-goal difference map. The group map displays the common understanding of learners on the lecture content, while the group-goal difference map displays the common misunderstanding of learners based on the instructor’s expectation. The filtering function of the Kit-Build analyzer can provide more efficient investigation by adjusting the intensity of three error types. The filtering function of group assessment is more explicit with the line weight. A thickness line and a number in parenthesis refer to the number of learners who connect those links. In addition, the link of each proposition is available for clicking to discover the learners who are the constructor of the link. Figure 2-4 illustrates the workflow of the analyzer when learners construct a map as a learner’s evidence. The learner maps will be evaluated through the propositional level exact matching methodology that is the procedure for reporting individual-diagnosis results. Also, the system can provide the additional procedure for reporting the group-diagnosis results at the same time.

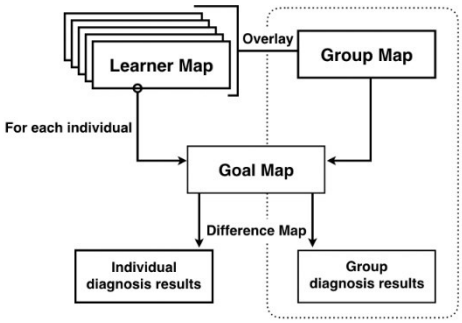

Figure 2-4 *The analyzer workflow of the Kit-Build concept map*

Providing the components of the concept map is a kind of “closed-end” approach which is realizing the automatic diagnosis of the concept map built by a learner (Taricani & Clariana, 2006). The learner maps of KB map are composed of the same components with the goal map. Hence it is possible to detect the difference between them in the form of the diagnosis

results. The learners are able to make a map in the limitation of providing parts, which is the difference from the traditional concept maps where learners can create concept map components by themselves. Therefore, the learners deal with only recall and understanding level in Bloom's taxonomy (Bloom et. al, 1956). Also, the components providing includes concepts and links is a middle of directedness of the mapping task and its score is an indicator of learner's performance based on the maximum possible (Ruiz-Primo, 2004; Ruiz-Primo et. al, 2011). Thus, the components providing of the KB map can use in the aspect of confirming the understanding between the instructor and learners in classroom situations with the benefit of the automatic assessment for implementing formative assessment.

In addition, several researches demonstrated the contribution of KB map on learning effect (Alkhateeb et. al, 2015, 2016a, 2016b; Funaoi et. al, 2011). The contribution of the KB map framework has been researched in reading comprehension topic where a direct interaction between the digital tool and learners has been examined. And the results show that KB map can help the learners to retain and recall the information for the longer period of time. The providing concept map component illustrates effective towards memory same as the traditional concept map when the learning materials were the clear structure. In next chapter, we emphasize the contribution of formative assessment on learning effect which an instructor used the suggestion of the diagnosis results for improving learning achievements.

CHAPTER 3

THE ARRANGEMENT OF KIT-BUILD CONCEPT MAP ON FORMATIVE ASSESSMENT

Summary: This chapter presents the arrangement of the ability of Kit-Build concept map on formative assessment in a lecture class for creating an opportunity to assess current understanding of learners as more as possible. The effectiveness of Kit-Build concept map is described through three practical uses in various lecture classes, which illustrate the contribution of Kit-Build concept map when utilized on formative assessment in the lecture class.

3.1 Introduction

The methodology of formative assessment is gathering and assessing the evidence of learning for designing and providing the instructor's feedback, which improves learning achievements. Also, technology-enhanced learning can minimize the time of gathering the evidence through assessing process, which is suitable for responding the time-limitation of a class period. It can inform the assessment results to the instructor in a short time that is necessary for implementing formative assessment in both of inside and outside the classroom.

Reducing time-consuming is an obvious reason to use digital tools. Storing and accessing on the Internet are an ability of cloud-based that simplifies sharing data. Storing by learners and accessing by an instructor are a basic requirement of digital tools for implementing formative assessment. For instance, learners use computers and connect to the Internet for doing and submitting an assignment. It can simplify many tasks about assignment procedure, such as the Google Spreadsheets can help an instructor to make questioning and answering easily. An instructor creates a sheet, writes questions, and then requests learners

to answer on reserve locations. The AudioNote is available for upload voices of answers. Answers in the form of shape, sketch, and annotation are available in the Evernote Skitch. The effectiveness of cloud-based is the reducing of time-consuming in the gathering evidence task, but it cannot reduce the running time of assessing task. For developing formative assessment in a classroom situation, the automatic assessment is required to empower the suitable strategy.

3.2 A Comparison of Automatic Concept Map Assessment Tools

The human-based assessment is one alternative of concept map assessment, but its major issue is time-consuming when there are many concept maps. Another alternative method to reduce the time-consuming is the automatic concept map assessment based on a computerized assessment. Several researchers proposed the designing and implementing software to support a construction of concept maps and developed automatic concept map assessment for using in their tasks (Luckie et. al, 2004, 2011; Cline et. al, 2010; Hirashima et. al, 2011). A criteria map is the most popular for using in an automatic assessment that can influence the effective assessment. The criteria map is constructed by an expert and is used to control quality and quantity of propositions. The different point between handmade assessment and computerized assessment is a flexibility because the computerized assessment requires the strict rules for calculating concept map score. Although the handmade method is more flexible than the automatic method, the handmade method takes time more than computerized assessment.

For increasing the flexibility, some systems assign an additional condition of scoring methodologies such as graph theory, pattern of propositions, ranging scoring, or synonym words (Tsai et. al, 2001; Hoeft et. al, 2003; Kornilakis, 2004; Harrison et. al, 2004; Anohina-Naumeca & Grundspenkis, 2009). It seems like the flexibility of handmade assessment, but the additional condition is defined depending on the objective. For example, an additional of graph theory disregards linking words for giving more score. The learners who construct the incorrect proposition can receive a partial score when two concepts have a relation or can be connected to each other, even though the linking word is incorrect.

Table 3-1 shows the systems that use the automatic concept map assessment and their criteria (Pailai et. al, 2016). In this table, we divide the group of criteria to three groups. The first group is component providing based on the criteria map which includes the label of

concepts and the label of relations. A group symbol is represented as the superscript number. The additional components provided of C-TOOLS (Luckie et. al, 2004, 2011) are distractor of concept labels or linking words, and blank cards. Also, the blank cards are the additional component of CMT (Cline et. al, 2010), while Kit-Build (Hirashima et. al, 2011) concept map provides only the label of concepts and label of relations. The provided components have a direct effect on the assessment method. That means the method should cover and complete all of the propositions which are possible in learner maps.

Table 3-1 *The systems and assessment criteria*

System	Criteria*
C-TOOLS (Robograder)	C^1, R^1, D^1, B^1, P^2, CM^2, S^2, I^3
CMT (Rule based)	C^1, R^1, D^1, P^2, CM^2, S^2, I^3
Kit-Build concept map	C^1, R^1, P^2, CM^2, E^2, I^3, G^3

[1] Provided component, [2] Assessment, [3] Results

* C – Concepts with Word/Label, R - Connected link with Linking word, D – Distractor of concept labels/linking words, B – Blank cards, P - Propositions, CM - Criteria Map, S – Synonym Matching, E – Exact Matching, I – Individual assessment, G- Group assessment

The second group is assessment methodology. The primary methodology of the assessment process is proposition level exact matching, which can identify correct and incorrect propositions clearly and can report the results immediately. An additional method is a synonym matching for measuring the label of the incorrect proposition. After using the proposition level exact matching, the incorrect proposition will be sent to the synonym finder such as WordNet (Kornilakis, 2004; Harrison et. al, 2004). In this case, the synonym finder will annotate a value (density value) of label word of the incorrect proposition. So, the automatic assessment will generate a total score of the map that includes proposition level exact matching score and synonym matching score. The synonym matching is the additional assessment when the system provides the extra component such as blank cards to learners.

The last group is the results of the automatic assessment. These three systems can provide individual results between the criteria map and each learner map. Besides, an additional result is a group assessment, which includes a group map, a group-goal similarity score, and a group-goal difference map. It only occurs in the KB map. The automatic concept map assessment can inform the information of learners to the instructor in a short time, which can reduce the running time of assessment process immediately. However, the number of learners is still the problem when designing and providing the instructor's feedback in a class

period. To find the overview of class shortly, the group assessment can provide the information better than picking some individual results. Thus, the group assessment ability is an advantage of KB map over the other automatic assessment systems when it is utilized in the environment with time limitation.

3.3 An Arrangement of Kit-Build Concept Map on Formative Assessment

The arrangement of KB map on formative assessment in a lecture class consists of six steps as shown in Figure 3-1. The first step as the general scenario of the lecture class, an instructor creates lecture contents and then constructs a goal map for representing a learning goal of the class. The next step is giving the lecture to learners in a class period. During the lecture, the instructor can check the learner's understanding by requesting learners to construct a learner map. Then, the diagnosis results are reported to the instructor immediately for informing about current understanding of learners. These steps are gathering and assessing the evidence of learners. The fifth step is providing intra-class feedback during the class period, which requires an instant practical information for capturing an overall understanding of class. This requirement is responded by the group-diagnosis results that include the group map which can inform the common understanding, and the group-goal difference map which can inform the common misunderstanding of class in one map. Finally, the inter-class feedback is information analysis of the previous class to improve the understanding of learners on next chance and to improve the lecturing of next classes. It is possible to use both individual- and group- diagnosis results for discovering the issue of the previous lecture.

The arrangement of KB map on formative assessment is efficient flow to fulfill formative assessment cycle. The automatic concept map assessment can help the instructor to reduce the workload of an assessment process, and the diagnosis results can provide an opportunity of an instructor to improve understanding of learners immediately. Based on these abilities, the KB map can create a chance as much as possible to form and complete formative assessment cycle. (Pailai et. al, 2016). For answering the key questions of the formative requirement, a goal map is an answer of where are learners going question. Gathering and assessing learner's evidence in the form of concept maps can identify the current understanding of learners, which is an answer of where are learners now question. The diagnosis results are the practical useful information that can contribute instructor's

feedback, which is an answer of how to close the gap question. Not only gathering the evidence of learning in the class period, KB map covers assessing the evidence for designing and providing the feedback of the instructor.

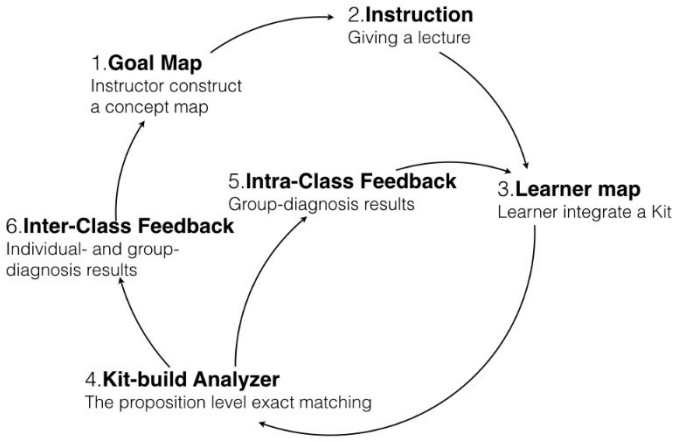

Figure 3-1 *A cycle of the Kit-Build concept map on formative assessment*

3.4 Practical Uses in the Lecture Classes

3.4.1 Participants and Procedure

The investigation will focus on the improvement of learners after they received instructor's feedback. In practices setting, we have a topic "See from northern hemisphere, the sun rises from the eastern sky, passes through the southern sky, and sets in the western sky" (Yoshida et. al, 2013a). An instructor divided this topic into two sub-topics that include "the sun's orbit seen from northern hemisphere" in the 1st practice and "the sun's orbit seen from southern hemisphere" as an advanced topic in the 2nd practice. The participants are learners in the third grade in elementary school, which contain 2 classrooms as group A and group B. The number of participants is 38 in each group, and the class period is 45 minutes for each group. The instructor requests learners to construct learner maps three times in each class, which learners have to construct each map in five minutes.

The first map request happened in the middle of the class period. The first request is to identify the current understanding of learners after a lecture. Afterward, the second request is given after instructor provided the feedback as supplementary lecture to learners. So, the results of the 2nd learner maps can report a progress of learners and shows an effectiveness

of instructor's feedback which is designed based on the diagnosis results. The last request is a chance to reassess the understanding of learners, and report the effectiveness of instructor's feedback through the improvement of learners. In this context, the instructor already has the expectation on lecture contents before a class that is the learning goal of the class in the form of a goal map. To accomplish the learning goal, instructor anticipates learners to have more progress at every checkpoint.

3.4.2 An Effectiveness of Intra-Class Feedback

The practice is designed for assessing the effectiveness of intra-class feedback by repeated three times of an inner loop of the cycle (Figure 3-1). Figure 3-2 illustrates the practical flow that is used in both groups. The 1st, 2nd, and 3rd checkpoint are gathering learner maps (LM) and assessing the learner maps (AS) by using KB map. The results of these processes are diagnosis results (DR), which are used to design instructor's feedback (IF) and decide next actions of the instructor. We present the practice results to investigate the effectiveness of intra-class feedback that can be explained in more detail of each step in practical uses. From this section, the group-goal difference map will be shown only the lacking link for focusing on the mistake of learners. And the improvement of learners is represented by decreasing the number of lacking links which also presents the effectiveness of instructor's feedback together.

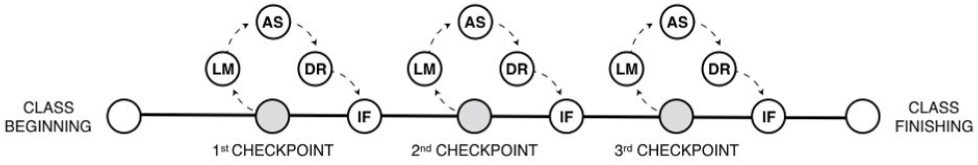

Figure 3-2 *Practical flow of intra-class feedback in the lecture class*

In the lecture class of the first practical use, the instructor requests learners to construct learner maps in the middle of class. Figure 3-3 shows the goal map of "the sun's orbit seen from northern hemisphere" and the diagnosis results in the form of the group-goal difference map at the 1st checkpoint of the group A. The group-goal difference map reports the lacking links tagged with the number of learners who did not construct those propositions. It shows the weakness of learners on the lecture content. The maximum tagged number of each lacking link is equal to the number of learners of the class, so the total of maximum tagged number is the multiplying number between the number of learners and the number of goal map links.

In this case, the group-goal difference map can identify critical areas that suggest the instructor to focus at the time. The most different understanding of the 1st checkpoint is "pass through" link that is connected to "Southern sky" concept and "Sun" concept.

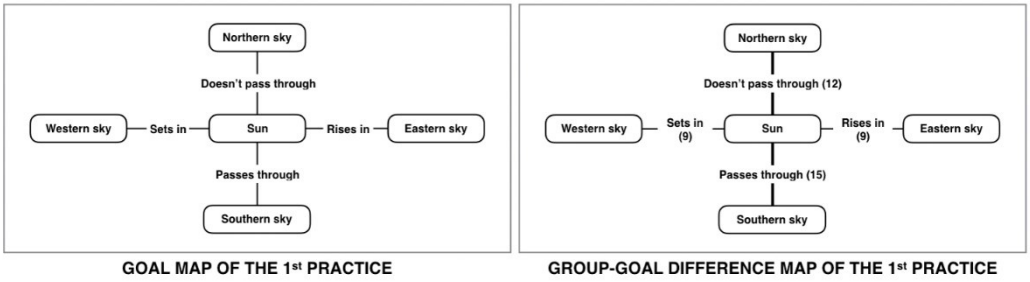

Figure 3-3 *The goal map and the group-goal difference map of the first practice*

The diagnosis results point out the critical areas and suggest the instructor to analyze those areas based on the results of the proposition level exact matching methodology. Even though the instructor explained about the content which covers the related contents of those lacking links in lecturing, the instructor judged that the explanation was not clear enough. Accordingly, the instructor relocated the visualized lacking links of group-goal difference map for clear visibility and showed to learners directly when the instructor gave the feedback as supplementary lecture. Since gathering and assessing the learner's evidence until providing the feedback of the instructor, these processes are the implementing to fulfill a cycle of formative assessment in the lecture class. The improvement of learners is usefulness when implementing each formative assessment cycle. To complete another formative assessment cycle, the instructor requested the learners to reconstruct the second map and the third map for reassessing the understanding of learners after received each instructor's feedback, which is repeating of formative assessment cycle. Figure 3-4 show the number of lacking links of each group. The practice results represent the decreasing the number of each lacking link in every time after learners received the instructor's feedback. The practice of intra-class feedback can demonstrate instantaneous assessment ability of KB map which is the contribution to the implementation of formative assessment.

In this situation, the KB map generated the diagnosis results of each learner automatically that are the similarity score of each learner map and 38 individual-group difference maps. The instructor can recognize the current understanding of each learner individually based on those results, which need to take a long time for analyzing all of them. The time-limitation is the most significant problem of a lecture class. Although automatic

concept map assessment can reduce time-consuming of assessing learner maps, the number of learner maps is still a problem when instructor analyzes the individual-diagnosis results. This problem means it is hard to recognize all of the individual-diagnosis results on the class period such as 38 results in one class period. Thus, the valuable information of KB map is group-diagnosis results which are practical information on a class period. The group map presents common understanding, while common misunderstanding is presented in form of the group-goal difference map. Especially, the group-goal difference map where the instructor can use to recognize the most common misunderstanding of learners as the first priority for helping the learners. The number of each lacking link indicates the number of learners who struggle on the propositions, and who need help from the instructor to raise their understanding.

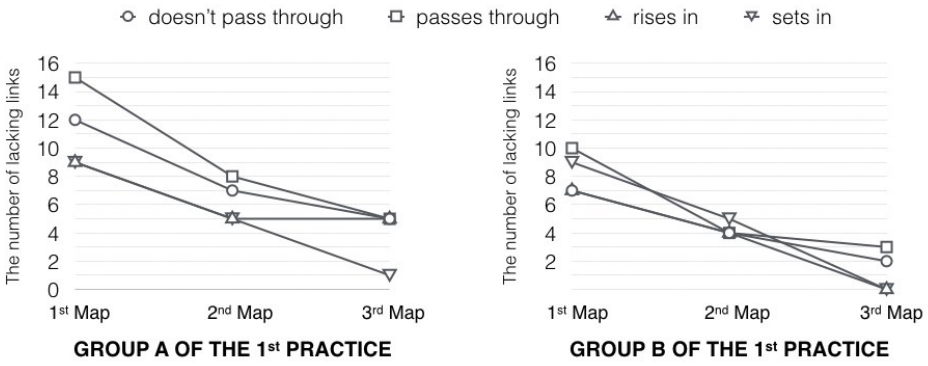

Figure 3-4 *The number of lacking links of each group of the first practice*

The diagnosis results of the 1st checkpoint present the effectiveness of the lecture. As instructor's expectation on learners, learner maps should be same with the goal map that can reveal learners' understanding about the lecture content well. This situation is a positive lecture of the classroom situation. However, the practice results present that learners cannot follow all of the instructor's expectation at the 1st checkpoint. The group-goal difference map of the 1st checkpoint of group A is illustrated in the right-hand side of Figure 3-3. The lacking links are used to indicate the misunderstanding of learners which the degree of misunderstanding is indicated by the indicator that includes tagged number and the weight of line. There are four possible lacking links based on the goal map (the left-hand side of Figure 3-3) before the instructor was informed the group-goal difference map. Even all of four links are possible to appear on the diagnosis results, the diagnosis results can suggest which the most important lacking link is. Therefore, the instructor focused on the highest

tagged number of the lacking links on the group-goal difference map that becomes the first priority for solving at the time (Sugihara et. al, 2012). In other words, the information of the diagnosis results can indicate evidently the misunderstanding of learners for confirming or redirecting the supplementary lecture of the instructor. Accordingly, the diagnosis results can contribute the informative feedback and can encourage the effective action of the instructor.

In the 1st map of group A, the total number of lacking links is 45 links as shown on the right-hand side of Figure 3-3, which is equal to 29.61 percentages of all possible lacking links (152 links from 4 links of each 38 learner maps). Moreover, the diagnosis results suggest an important link that is the most number of lacking link. So, the "pass through" link is the most misunderstanding of learners (15 learners from 38 learners of the class), and the instructor took the link as the main content of feedback in the form of the supplementary lecture. Subsequently, the instructor gave the feedback that emphasized on the "pass through" link especially more than the other lacking links. A line graph on the left-hand side of Figure 3-4 represents the effectiveness of the feedback. The line graph of group A shows the decreasing of lacking links of all three map. In this context, the number of lacking links at "2nd Map" was decreased when compare with the lacking links of "1st Map" that means the learner's understanding was increased after the instructor gave the feedback to learners. The total number of lacking links at the 2nd map of group A remained 25 links that were decreased 55.56 percentages from the 1st map, and the lacking links of this 2nd map are equal to 16.45 percentages of all possible lacking links. Also, the diagnosis results of the 2nd checkpoint of group A suggest that the "pass through" link still the most number of lacking links, although the "pass through" link is the most decreased link among the lacking links from the 1st map. Another candidate link is the "doesn't pass through" link (7 tagged number), which the number of the link is not too much different from the "pass through" link (8 tagged number). So, the instructor designed the second feedback of group A based on these lacking links. Finally, the lacking links of the 3rd map are presented in the line graph on the left-hand side of Figure 3-4 as "3rd Map". The total number of the lacking links is 16 links that means in the 3rd map remained only 10.53 percentage of all possible lacking links.

Afterward, the instructor conducted the second class on the same topic with the same instructional plan for investigating the effectiveness of intra-class feedback. The line graph on the right-hand side of Figure 3-4 represents the number of each lacking link in every map of group B. The diagnosis results of the 1st checkpoint of group B identify that the "pass through" link is the most misunderstanding, which is the same most misunderstanding of the

previous class (group A). So, the instructor gave the intra-class feedback by using the "pass through" link as the main content of supplementary lecture before the instructor requesting learners to construct the map again. Subsequently, the number of lacking links of the 2nd checkpoint is shown at "2nd Map" of the right-hand side of Figure 3-4. The most lacking link is not the "pass through" link, but it changed to the "sets in" link that means the feedback can help the learners to understand the content of the "pass through" link. However, the situation of group B was different from group A. From the suggestion of the diagnosis results, the "sets in" link became the most number of lacking links instead of the "pass through" link. Then, the instructor changed the main content of supplementary lecture to the "sets in" link following the current learning situation. Next, the 3rd checkpoint of group B presents the number of lacking links at "3rd Map" on the right-hand side of Figure 3-4. The "sets in" link were indicated the most misunderstanding of the 2nd checkpoint that was disappeared in the 3rd checkpoint after the instructor took the link as the main content of the feedback. Hence, the emphasis of the instructor on "sets in" in the second feedback can remove the "sets in" link from lacking links of the 3rd checkpoint directly.

Accordingly, the 1st practical use of KB map can illustrate the ability of KB map that is adequate technology-enhanced learning for implementing and facilitating the learning environment of formative assessment. It was used to complete three cycles of formative assessment in the lecture class, and the results of practical use demonstrated the effectiveness of intra-class feedback when the instructor received the current learning information in the form of the diagnosis results.

Table 3-2 *Correlation coefficients in the first practice*

	Group A	**Group B**
Standard test of science learning[1]	0.337 ($p = 0.039$)	-0.170 ($p = 0.307$)
Mini-test[2]	0.395 ($p = 0.014$)	0.284 ($p = 0.081$)

[1] The National Japanese Exam (NJE)
[2] The quiz at the end of the topic.

In addition, we have the comparison between learner map score and standard test score, and we produced mini-test about the same topic in each practice. The standard test of science learning is the National Japanese Exam (NJE), which the content is general science domain. And the mini-test is a quiz at the end of the topic that examines in the same topic with the lecture topic of the practical uses. The learner map score is the ratio of the number of correct

propositions in learner map to the number of propositions in the goal map. It presents the degree of accordance between the learner map and the goal map that takes a value of 0 to 1. The correlation coefficients between the third map score and standard test of science learning, and the correlation coefficients between the third map score and mini-test score are contained in Table 3-2. The average of the third map score in the group A is 0.882 (SD = 0.285) that have the correlation coefficient with a standard assessment of science is 0.337. The result is statistically significant (N = 38, p = 0.039). Also, the correlation coefficient between the average third map score and mini-test is 0.395. The result is statistically significant (N = 38, p = 0.014). These results suggest the quality of learner map would reflect the understanding of learners on the lecture content. In contrast, the correlation coefficient in the group B is low because of ceiling effect of some learners. The average of the third map score in the group B is 0.967 (SD = 0.117). The summation between the average score of the third map and the standard deviation is higher than the maximum value of learner map, which is statistically confirmed of the ceiling effect. The results represent the inter-class feedback of the instructor can improve learning achievements in the lecture class when utilized the KB map on formative assessment.

3.4.3 An Effectiveness of Inter-Class Feedback

Following the 1st practice that explains the contribution of KB map on intra-class feedback, the group-diagnosis results can identify the critical areas, and encourage the instructor to produce proper feedback. And the intra-class feedback can help learners to achieve the learning goal of class in the class period immediately. In the 2nd practice, we present another classroom situation that the intra-class feedback cannot improve learning achievements immediately. The practice flow is designed for assessing the effectiveness of intra-class feedback and inter-class feedback by repeating both the inner and outer loop of the cycle (Figure 3-1). The 2nd practice setting requests learners to construct learner maps three times, and the instructor provides the feedback every time after he/she got the diagnosis results as the same as the previous practice. Also, the lecture content relates to “the sun’s orbit seen from southern hemisphere,” which is an advanced topic of the previous practice. The class period of the 2nd practice is 45 minutes, and the learners have to construct each learner map in five minutes, which the first map request happened in the middle of the class period. Figure 3-5 illustrates practice flow of intra-class feedback and inter-class feedback in the lecture class.

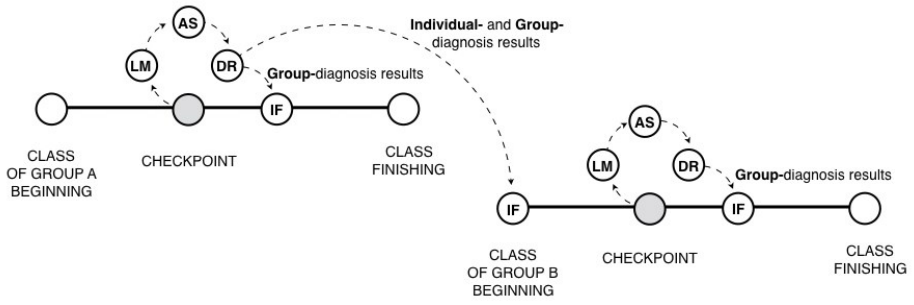

Figure 3-5 *Intra-class feedback and inter-class feedback in the lecture class*

The instructor received the diagnosis results that is the information of current learning situation in the class. The first diagnosis results of group A is presented at "1st Map" in the line graph on the left-hand side of Figure 3-6. The information of the diagnosis results suggests that the most number of lacking links consists of the "rises in" link and the "sets in" link. Thus, the instructor emphasized the lecture content of these links for improving learner's understanding. The main content of intra-class feedback based on the current learning situation as the "rises in" link and the "sets in" link is emphasized more than the two-other links. Afterward, the instructor requested his/her learners to construct the learner maps again for reassessing the learning situation after they had been given the intra-class feedback, which is the same activity when using the KB map in the lecture class and also started the new cycle of formative assessment. The "2nd Map" on the left-hand side graph of Figure 3-6 show the number of lacking links of the 2nd checkpoint that represents the effectiveness of the intra-class feedback, which the instructor emphasized on the lecture content of the "rises in" link and the "sets in" link intentionally. The line graph illustrates the decreasing of the lacking links which are the main content of supplementary lecture following the "rises in" link was decreased 82.14 percentages and the "sets in" link was decreased 75.00 percentages from each its number of lacking links of the 1st checkpoint.

However, the negative situation happened in group A of this 2nd practice because all of the lacking links should be decreased after the learners received the intra-class feedback as the situation of the 1st practice. There is the increasing of lacking links that include the "doesn't pass through" link and the "passes through" link. In this situation, the learners have more understanding about the "rises in" link and the "sets in" link because they had been given the supplementary lecture on these related lecture content. So, they can construct the correct propositions on the second learner maps more accurately. On the other hand, the reconstructing of the learner maps effected to the other links and the learners still have the

confusion about the “doesn’t pass through” link and the “passes through” link. Hence, the instructor tried to emphasize on the related lecture content of the most number of lacking link again. The main content of the second intra-class feedback was changed from the “rises in” link and the “sets in” link to the “doesn’t pass through” link and the “passes through” link based on the active information of the diagnosis results. Finally, the “3rd Map” in the line graph of the left-hand side of Figure 3-6 presents the number of lacking links after the instructor gave the second intra-class feedback of group A. The results indicate the number of lacking on the “doesn’t pass through” link and the “passes through” link still higher than the 1st checkpoint. There is no more chance for gathering and assessing learner’s evidence because the time of class period is running out. Thus, these lacking links requested the instructor to analyze them after over the class when the instructor has more time to analyze the issue of the previous class.

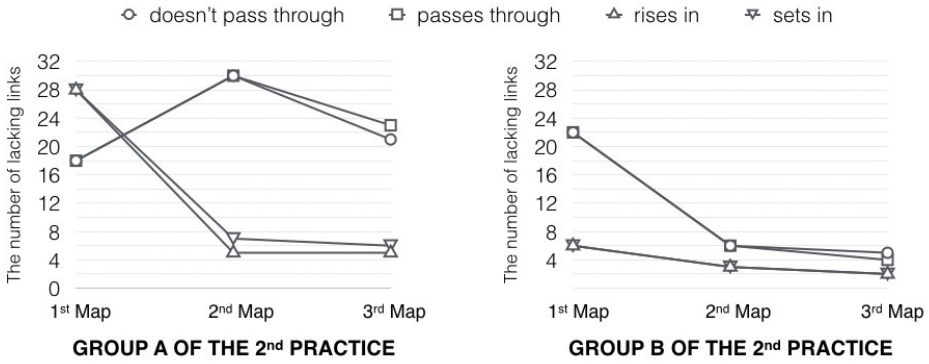

Figure 3-6 *The number of lacking links of each group of the second practice*

Subsequently, the instructor investigated the information of the group A for finding and solving the ineffective of lecturing and intra-class feedback. The diagnosis results of the group A identify that the intra-class feedback can improve the understanding on the “rises in” link and the “sets in” link. However, there is the confusion between the “doesn’t pass through” link and the “passes through” link which cannot improve the understanding by using only supplementary lecture. The analysis results of the instructor following: 1) The lecture topic of “the sun’s orbit seen from southern hemisphere” is an advanced topic of “the sun’s orbit seen from northern hemisphere.” The instructor judged that the lecture content was more difficult for learners than instructor’s expectation and the problem is the difficulty in thinking in which direction in the sky that the sun can be seen. 2) Based on the confusion between the “doesn’t pass through” link and the “passes through” link, the instructor found that the relative position was not indicated in the lecture content of group A. 3) The results of group

A represent ineffectiveness of intra-class feedback on the “doesn’t pass through” link and the “passes through” link, so it is necessary to adjust the instructions plan by using supplementary material that includes terrestrial globes, lights, and small dolls. Thus, the inter-class feedback is the adjusted instructional plan for referring to the relative position and the enhancement lecturing by using the supplementary material. Also, the instructor expected the inter-class feedback could help the learners to understand the lecture content more than the previous class.

Afterward, the lecturing of group B was conducted following the adjusted instructional plan which the effectiveness of lecturing is presented at “1st Map” in the right-hand side graph of Figure 3-6. The number of lacking links is less than the previous class on the same checkpoint. The lacking links have the characteristic as the instructor expectation following: 1) the “rises in” link and the “sets in” link are possible to decrease by adjusted the lecture content as the supplementary lecture of group A. 2) the learners of group B also confused on the “doesn’t pass through” link and the “passes through” link which is the same situation of group A. So, the intra-class feedback of group B was not only given the supplementary lecture but using the supplementary material for improving the learner’s understanding which the results of the second learner map can demonstrate the effectiveness of these approaches. The number of lacking links of the 2nd checkpoint is shown at “2nd Map” of the right-hand side graph of Figure 3-6. The line graph illustrates the decreasing of the “doesn’t pass through” link and the “passes through” link obviously. The number of lacking links of the 2nd checkpoint of group B was decreased 67.86 percentages from the 1st checkpoint, which is the effectiveness of inter-class feedback in the form of intra-class feedback. The adjusted instructional plan and the supplementary material can improve learning achievements since the 1st checkpoint of the group B. Based on the information of the previous class and instructor’s experiences, the additional materials can improve the achievements of the group B immediately. Moreover, the effectiveness of intra-class feedback was turned into positive in the group B. In this context, the results mention to the issue of the previous class is the instructional plan, which is insufficient to explain the meaning of lecture content. The average of the 3rd checkpoint score was 0.914 (SD = 0.201). Also, the correlation coefficient between the average score and standard assessment test score was 0.391 (p = 0.015) that is significant.

3.4.4 Continuous effectiveness improvements

In the previous practices, the 1st practice results display the effectiveness of intra-class feedback, and the 2nd practice results show the effectiveness of inter-class feedback when intra-class feedback is insufficient to improve the understanding of learners. Finally, the 3rd practice is designed for displaying the continuous effectiveness when both of intra-class feedback and inter-class feedback are effective for improving learning achievements in the lecture class. The 3rd practice has two groups from the sixth grade that contain 36 subjects in the group A, and 40 subjects in the group B. An instructor requested learners to construct learner maps two times in each group, and the topic of both groups is "decomposition of starch made by photosynthesis in leaves into sugar, and transfer to water-melted sugar through stalk" (Yoshida et. al, 2013b). The class period of the 3rd practice is 45 minutes, the learners have to construct each learner map in ten minutes, and the first map request happened in the middle of the class period. The goal map contains five concepts and six relations with linking word which are six propositions in a map. Figure 3-7 shows a goal map that is used in both groups, and the 1st group-goal difference map of the group A.

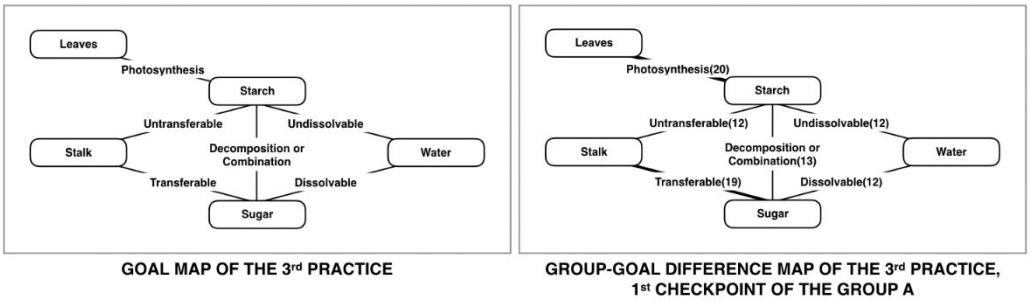

Figure 3-7 *The goal map and the group-goal difference map of the third practice*

The group-diagnosis results of the 1st checkpoint of the group A display that the "Photosynthesis" link is the most common current misunderstanding of learners, which instructor should pay particular attention to this link more than the other lacking links. The instructor emphasized on "Photosynthesis" link and focused on the information about the "Leaves" concept and the "Starch" concept. The instructor made supplementary lecturing as intra-class feedback based on the suggestion of the diagnosis results for improving the understanding of learners on critical areas. Subsequently, the instructor provided the feedback to the learners and requested learners to reconstruct a map again. Then the results of intra-class feedback present the number of "Photosynthesis" link decreased to less than

the “Transferable” link, which is illustrated in Figure 3-8. Accordingly, the instructor already has individual- and group- diagnosis results which are the previous class information when finishing the practice of the group A. It can help the instructor to adjust and improve their instructional plan. Especially, the instructor already knows the way to improve on learners understanding based on the information of the previous class.

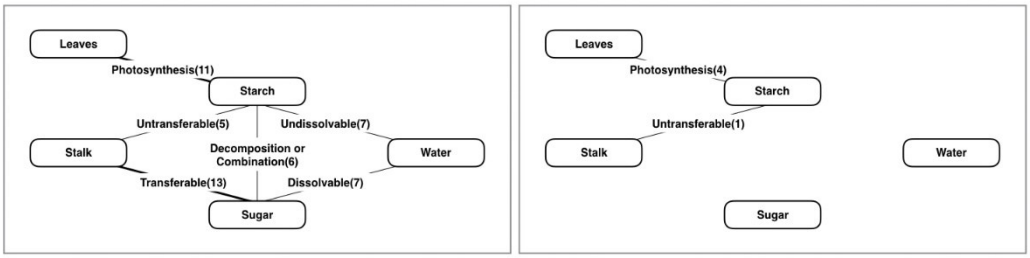

Figure 3-8 *The group-goal difference map of the third practice*

Table 3-3 shows the percentage of average score that includes science test of science learning score, the 1st checkpoint score, and the 2nd checkpoint score. The average score increases 17.7 percentages and responds to the number of lacking links which decreases more than 50 percentages. Moreover, the instructor improved the instructional plan for the group B based on the information of the group A in order to emphasize the links that over the instructor’s expectation of the group A. The results show an average score of the 1st checkpoint in the group B is more than the average score of the 2nd checkpoint in the group A. The results demonstrate the effectiveness of both intra-class feedback and the inter-class feedback, which contributes the higher average score in the group B. The average score of the 2nd checkpoint of the group B increases 18.7 percentages that respond to the number of lacking links, which decreases more than 90 percentages.

Table 3-3 *Correlation coefficients in the first practice*

Average score	**Group A**	**Group B**
Standard test of science learning*	63.2	63.6
1st checkpoint	61.4	79.2
2nd checkpoint	79.1	97.9

* The National Japanese Exam (NJE)

3.5 Discussion

3.5.1 The Advantage of Kit-Build Concept Map

Educational enhancement through technology can help to improve learning achievements. An instructor remains to be the most influential of the class who cooperate and select the learning strategy in the instructional plan. The KB map is a digital tool for supporting concept map strategy, which is instantaneously available on a wide variety of scenario in class. Correspondingly, the practices results have illustrated that the ability of KB map can arrange on formative assessment to fulfilments the cycle as more as possible. The details of formative assessment might be different that depends on the instructor, although KB map has adequate ability to contribute gathering and assessing the evidence of learners and encourage the instructor to develop the positive classroom situation. The concept map strategy uses to create the learning goal of class, and use to elicit the understanding of learners. The goal map and the learner maps can be used to confirm the current understanding between the instructor and the learners on the same lecture content that represents in the form of the diagnosis results. Exclusively, the diagnosis results of learner's evidence (individual-diagnosis results) and additional evidence of learners (group-diagnosis results) are practical information on the contribution of instructor's feedback designing of both intra-class and inter-class feedback. Accordingly, the classroom environment of KB map can provide opportunities to close the gap between current and desired performance, and also provides information to the instructors that can be used to shape the lecturing. These are principles of good feedback practice (Nicol & Macfarlane‐Dick, 2006).

3.5.2 The Valuable Information in Lecture Class

The class period is time-limitation of a lecture class, which the instructor can control his/her class following the preparation of the class as an instructional plan in general situation. Also, the instructional plan includes the expectation and prediction of the learners based on the instructor's experience in managing the positive and negative situation on the class. The positive case is an ideal situation such as all of the learners can understand well on the lecture content, which the learning achievements are represented through the test score or map score. Another situation is the negative case such as unexpected situation. Accordingly, the instructor can select the ways to duel with the immediate situation based on the preparation

and his/her experience as the prompt immediate feedback to the learners. The importance of providing immediate feedback is beneficial for learning achievements and motivation (Narciss & Huth, 2006; Draper, 2009; Li et. al, 2010). However, observing evidence of the situation and identifying the problem are the most important task of deciding the effective actions. The learning evidence can identify the current learning situation obviously whatever positive- and negative- situation in the class, which is the information for contributing the effective actions of the instructor.

The KB map takes action as an assistance to duel with time-limitation, which facilitate learners to create learning evidence in a class period and also identify the current learning situation on time. Subsequently, the instructors can observe the information via the diagnosis results immediately. The expected situation was presented in the 1st practice, and the instructors can improve learning achievements by intra-class feedback. Because the instructors can address the critical problem of the class and then give the supplementary lecture on the problem to elevate the learner's understanding. Also, the 2nd practice represents the unexpected situation which cannot solve in the class period immediately. The ineffective of the intra-class feedback was showed as the unexpected situation of the class. Eventually, the problem was solved in the next class in the form of the inter-class feedback based on the learning evidence of the previous class. The supplementary material was used to enhance lecturing and the learning achievements were increased.

3.5.3 Stakeholders Feedback

The practices emphasis on encouraging learning in a lecture class and supporting instructor who wants to share knowledge to learners. The instructor anticipates learners to understand lecture content following instructor's expectation. Misunderstanding of learners is an undesirable situation that often appears in classroom situations. Correcting the misunderstanding is the simple way for improving learner's understanding, but it is difficult to find the critical areas, which is the misunderstanding of learners on the lecture contents. Correspondingly, the diagnosis results of the proposition level exact matching methodology are a crucial ability of KB map to identify the critical areas quickly and obviously. The diagnosis results can address exact critical parts of the contents that the learners make mistakes and the instructor could not think about those parts before, which is considered to be useful information. These are positive opinions from the instructors who used KB map in the practices. In addition, we conducted a questionnaire survey about the usefulness of the

KB map from learners' aspect when using in the classroom situation. The questionnaire survey consists of nine questions of five-point scale. And the learners are the participant in the 1st practice and the 2nd practice. Accordingly, we gained totally positive opinions from learners such as "It was fun to make maps" and "It was easy to make a map." It can present the usefulness and usability of KB map when using in the lecture class from learners' aspects.

3.6 Chapter Summary

The KB map is a digital tool for creating the learning environment to improve learning achievements, especially formative assessment in lecture class which is reported in the form of practical uses when using in elementary school. The evidence-based feedback of an instructor is a key of formative assessment to improve learning achievements in the classroom situations. The contribution of the KB map is the ability for cooperating with the instructor to implement formative assessment via concept map strategy, facilitating the learning process in the form of digital tool, and creating an opportunity to improve learning achievements in the classroom situation. The ability of Kit-Build can create a chance for completing formative assessment cycle as more as possible and saving the time of instructor and learners. Hence, gathering, assessing, and providing the information of current learning situation are the crucial contribution on formative assessment of the KB map. The kit and the proposition level exact matching methodology are used to confirm the understanding between instructor and learners on the lecture content. Also, the diagnosis results can identify the propositions which require supplementary lecture for filling on lacking understanding of learners. Lastly, the results of the practices can describe the effectiveness of formative assessment when the KB is utilized in the lecture class. It can illustrate that KB map is a suitable digital tool for applying on formative assessment in a lecture class.

CHAPTER 4

THE KIT-BUILD CONCEPT MAP WITH CONFIDENCE TAGGING

Summary: KB map with confidence tagging allows a learner to give confidence information to each proposition. The confidence information will be provided on each proposition for identifying the degree of the understanding. The correctness and confidence information are provided to the instructor in the form of diagnosis results for informing the information of current learning situation. The instructor can design and provide the feedback based on the diagnosis results for improving the understanding of learners. The practical uses were conducted for demonstrating the valuable of correctness and confidence information in the lecture class. The correctness information was visualized in the control classes, while the correctness and confidence information were visualized in the experiment classes. The observed evidence illustrates that the different information was used for selecting and ordering the supplementary content when the system visualized the different information. The normalized learning gains and effect size demonstrate the different learning achievements between control- and experiment-classes. The results suggest that the confidence information of learner affects the instructor behaviors, which is the positive changing behavior for improving the understanding of their learners. The results of questionnaire suggest that the KB map with confidence tagging is an accepted mechanism for representing the learner's understanding and their confidence. The instructors also accepted that the confidence information of learners is valuable information for recognizing the learning situation.

4.1 Introduction

In this chapter, we propose KB map with confidence tagging for eliciting learning evidence of learners and informing the correctness and confidence information to the instructor. The confidence tagging is integrated into the structuring task of the KB map, which learners can

construct the map to represent their understanding and identify their confidence on each unit of meaning. A completed proposition, which is able to tag the confidence, comprises one connected linking word between two concepts. The confidence of an answer is simplified in the form of confidence- and unconfidence-value, which the learner can assign to every complete proposition. Thus, the system can elicit learning evidence that includes the understanding of learners and the degree of the understanding in the gathering process. The confidence information of learners is utilized in the diagnosis results of the KB map for visualizing the degree of learner's understanding. Therefore, we present the practical uses of the KB map with confidence tagging in the classroom situations when the instructors implement formative assessment in the lecture classes for illustrating the encouragement of correctness and confidence information in their instruction. Five paired classes were conducted in the practical uses, which each paired class was conducted by the same instructor, the same lecture topic, and two different classes. Only the correctness information was provided to the instructors of five control classes as a control group, while both correctness and confidence information were provided to the instructors of five experimental classes as an experiment group.

The investigation procedure focuses on the different behavior of the same instructor when s/he received the different information on the diagnosis results. From this procedure, we assume that the confidence information of learners affects on the supplementary content ordering of the instructor. The actual ordering of supplementary lecture was used as observed evidence to indicate how the instructor used the correctness and confidence information. Moreover, the normalized learning gains of class and the effect size demonstrate the different learning achievement between both groups, which can illustrate that the correctness- and confidence-based feedback of the experiment group can contribute the improvement of learning achievements better than the correctness-based feedback of the control group in several classes. The learners of the experiment group have an ability to discriminate and interpret their understanding between correctness and confidence better than the learners of the control group significantly. Analysis of change of proposition type presents that the unconfident propositions are easier to be changed than the confident proposition. Finally, the questionnaire presents that the KB map with confidence tagging is an accepted mechanism. The learners accepted the mechanism for presenting their understanding as propositions and for tagging their confidence to each proposition. The instructors accepted that the confidence information of learners was the valuable information to identify learning situation and identify the degree of learners' understanding.

4.2 An Assessment by Using Correctness and Confidence

The confidence was used to ensure the performance of learning outcomes as the quality of knowledge or the actual performance (Chiou, 2008) as one of assessment criteria. Confidence based learning promotes a fusion of correctness and confidence to identify the answer of learners in four quadrants. There is a definition of correctness and confidence for referencing following:

- *Correctness* is the justification of an answer, which consists of a correct answer and an incorrect answer.
- *Correct*- or *incorrect*- answer is justified by the criteria.
- *Confidence* is the certainty of an answer, which can be simplified the values as confidence and unconfidence.
- *Confidence*- or *unconfidence*- of the answer is stated by learners on their answer.

The two-dimensional assessment process was used to classify the answer into four quadrants based on the correctness and confidence simultaneously. The four quadrants of two-dimensional assessment following:

- A correct answer with confidence.
- A correct answer with unconfidence.
- An incorrect answer with confidence.
- An incorrect answer with unconfidence.

Several researchers have already proposed the scoring method based on the correctness and confidence for promoting the critical awareness and self-assessment (Gardner-Medwin & Gahan, 2003; Gardner-Medwin & Curtin, 2007; Gardner-Medwin, 2013; Yuen-Reed & Reed, 2015; ARGM, 2016), for instance, Certainty-based Marking (CBM), Confidence-based Scoring (CBS), Certainty-based Assessment (CBA). The correct answer that learner has a confidence can get the score more than the correct answer with unconfidence. While the learner can get some score on the incorrect answer when s/he has no confidence on the answer. Zero scores or penalty score is given to the incorrect answer with confidence. The task to identify the confidence of learners on their answer is provided to learners in various strategies such as the answering of descriptive question, True/False question, or the multiple-choice question. The different values of confidence were applied to the scoring method. For

instance, the two different values of sureness consist of sure and not sure, or the three different levels of certainty consist of low, middle, and high.

4.3 Integration of Confidence Tagging into the Kit-Build Concept Map

For gathering learning evidence and identifying the degree of learner's understanding, the KB map with confidence tagging was developed for eliciting learning evidence, and associating the correctness and confidence information. In this study, the KB map is reinforced by uniting with the confidence tagging, which is a mechanism for representing learner's understanding on lecture content, and identifying learner's confidence on each proposition of a learner map. The confidence tagging is integrated into the structuring task where the learner constructs a learner map, and a tagging tool (Figure 4-1) appears when two concepts and a linking word are connected as a completed proposition. Learners are required to identify their confidence by selecting "sure" or "not sure" on each completed proposition. It is also expected that the tagging task promotes learners to reconsider about their proposition again. The confidence values include "sure" for stating the certainty on the proposition, and "not sure" for indicating unconfidence on the proposition and the system allows the learners to change the values freely. If the learners disconnected the link of the completed proposition, the confidence tagging tool of the link would be disappeared, and the confidence value is reset then. The learners have to identify the confidence value again even they constructed the same proposition after disconnecting. Accordingly, the structuring task of learners can gather the answer of learners and confidence on their answer. Through this task, the system is able to gather the correctness and confidence information of each proposition in all learner maps, and then, the results of the diagnosis about the correctness and confidence are visualized at the same time.

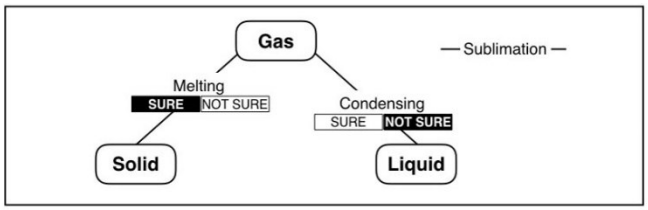

Figure 4-1 *An example of a learner map with confidence tagging*

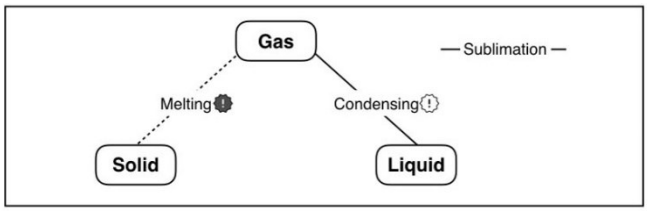

Figure 4-2 *An example of an individual-goal overlay map*

Figure 4-2 shows an example of individual-overlay map and Figure 4-3 shows an example of a group-difference map, where the correctness and confidence information are reported to the instructor. An additional visualization is a confidence badge. The badge is added into the linking word to indicate the confidence of learners on the link. For instance, a dark tone badge on the dashed line illustrates the incorrect answer with confidence in the individual-overlay map (Figure 4-2) of individual-diagnosis results, while a light tone badge on the solid line represents the correct answer with unconfidence.

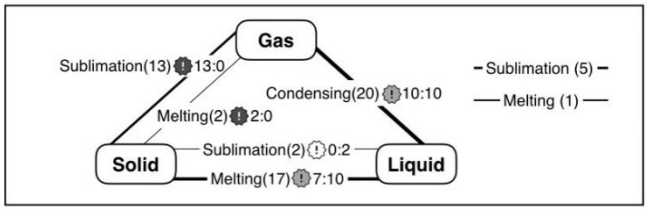

Figure 4-3 *An example of a group map with confidence information*

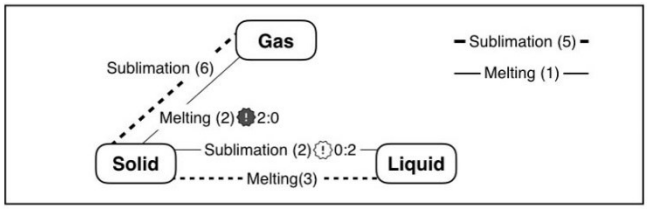

Figure 4-4 *An example of a group-goal difference map with confidence information*

On the other hand, the mismatch propositions are visualized in group-goal difference map (Figure 4-4) of group-diagnosis results where the excessive link indicates the incorrect answer and the lacking link represents the correcting information. A dark tone badge on the solid line illustrates the excessive link with confidence, while a light tone badge on the solid line represents the excessive link with unconfidence. The group-diagnosis results have more details about the confidence information, which the color tone of the badge is varied according to the number of learners who have confidence against unconfidence on the same

proposition. For instance, the darkest tone badge has appeared on the link that all of the constructors pressed on “sure” value. A middle tone badge has appeared on the link that the number of “sure” and “not sure” values are equal. The lightest tone badge appeared on the link that no one “sure” on the link. Another indicator is a tagged number of confidence information on the right-hand side of the badge. The colon is punctuation mark for separating the number of learners. The number of learners who pressed on “sure” is displayed on the left-hand side of the mark, while the right-hand side number displays the number of learners who press on “not sure.” Figure 4-4 shows an example of a group-difference map, where the correctness and confidence information are visualized.

4.4 Practical Uses of Kit-Build Concept Map with Confidence Tagging in the Lecture classes

4.4.1 Participants

The practical uses of the KB map with confidence tagging is an implementation of formative assessment in lecture class for investigating the encouragement of the correctness and confidence information. The instructors can recognize the current learning situation for selecting and ordering the content of supplementary lecture through the analyzer of the KB map with confidence tagging. The participants are three instructors from three different schools, and learners from three different elementary schools who study in the fourth-, fifth-, and sixth-grade. The instructor of fourth grade conducted one practical use, the instructor of fifth grade conducted two practical uses, and the instructor of sixth grade also conducted two practical uses. Ten basic science classes of five paired class are separated into five control classes and five experiment classes.

4.4.2 The Utilization of the Arrangement of Kit-Build Concept Map on Formative Assessment

The arrangement of the KB map on formative assessment was used in the practical uses of this study following (Pailai et al., 2017): the first step is the general scenario of the lecture class, the instructors created lecture contents and then constructed a goal map for indicating a learning goal of the class. The next step is to give the lecture to learners in a class period.

During the lecture, the instructor checks the learner's understanding by requesting learners to construct learner maps and identify their confidence. Then, the diagnosis results are provided to the instructor immediately for informing about current understanding of learners. These steps are gathering and assessing the evidence of learners. The fifth step is to provide intra-class feedback during the class period, which requires an instant practical information for capturing an overall understanding of class. This requirement is responded by the group-diagnosis results that include the group map which can inform the common understanding, and the group-goal difference map which can inform the common misunderstanding of class in one map. Even the inter-class feedback of the sixth step was ignored in the practical uses of this study; we have an additional short discussion session with the instructors after finished classes for summarizing the classroom situation. Figure 4-5 illustrates the arrangement of the KB map on formative assessment in a classroom situation.

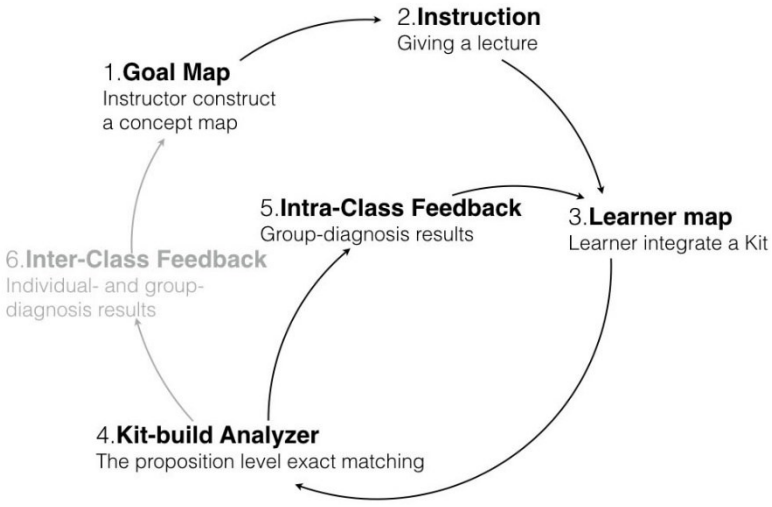

Figure 4-5 *The arrangement of the KB map on formative assessment*

The supplementary lecture is a feedback of the instructors in the lecture class, which a supplementary content should correspond with the misunderstanding of learners. Even the diagnosis results can identify the understanding and the misunderstanding of learners, the instructor still remains to be the most influential of the class who select the content of the supplementary lecture to raise the understanding of learners as a fulfilling the gaps. The valuable of correctness and confidence information investigation focusses on the behavior of instructors in selecting and ordering the supplementary lecture when the instructor received the different the diagnosis results. The correctness information is also available in the control group, while both the correctness and confidence information are available only in the

experiment group. The excessive links of the group-goal difference map present the correctness information, indicate an overview of the incorrect answers, and represent the misunderstanding of learners. The number of excessive links was generally used to order the content of the supplementary lecture. The location of each excessive link was also used for ordering the excessive links that have an equal amount of the constructors (unordering of correctness information). Hence, an assumption of the control group is that the instructor selects the excessive links to provide the supplementary lecture following the correctness information and the location of visualization. The group-diagnosis results arrange the location of concepts and lacking links at the same location with the goal map's location. An alignment of each excessive link location is central between two connected concepts. The Z-pattern layout is the route of the instructor's eye traveling when they used the location for selecting the proposition in unordering of correctness information. The direction to select the content follows the shape of the letter Z as left to right, top to bottom of visualization screen. It can be used with a hierarchy of concept map that the components are ordered the most important from top to bottom. It can help the instructor to remember the selected- and unselected-excessive links even in the unstructured concept maps. We call this way to provide supplementary instruction as "basic strategy" in this chapter.

On the other hand, because the correctness and confidence information are provided in the experiment group, it is assumed that the ordering of supplementary content is different from the ordering of the basic strategy. The difference between the basic strategy and the actual ordering in the practical uses in the experiment group demonstrate the effect of confidence information.

4.4.3 Procedure for the Comparative Investigation

The KB map with confidence tagging was utilized in ten science classes. All of the learners were requested to construct the learner map and tagging the confidence two times in each class. The first constructing was requested at the middle of class after the instructor lectured the content, and the second constructing was requested after the instructor gave the supplementary lecture at before the end of class. On the other hand, the different diagnosis results were provided to the instructors for investigating the behavior. A paired class consists of a control class where only the correctness information was visualized, and an experiment class where the correctness and confidence information were visualized. Three instructors from three different elementary schools are the participants of the practical uses. An

instructor A is the lecturer of fourth-grade who conducted one parried class. An instructor B is the lecturer of fifth-grade that conducted two paired classes, and an instructor C is the sixth-grade lecturer who conducted two paired classes. The instructor lectures the same content in both control- and experiment-classes of each paired class. Figure 4-6 displays the practical flow of the paired class to distinguish the different diagnosis results between control- and experiment-group. The correctness information was visualized in both classrooms. The confidence information was blinded as the diagnosis results without confidence in the control classes, while the confidence information was visualized as the diagnosis results with confidence in the experiment classes.

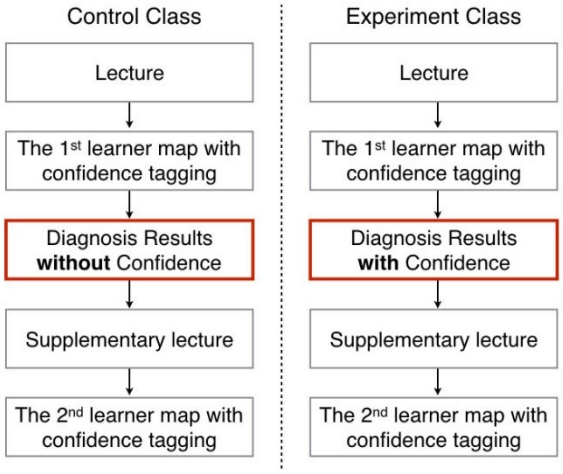

Figure 4-6 *The practical flows of each paired class*

Accordingly, there are no different activities in the learner role, while different information visualizing is the different factor of the instructor role. The different behavior of the same instructor should be observed in each paired class, which is the basic assumption to indicate the relation between the instructor's behavior and the confidence information. The same content of lecturing was conducted with the same instructor, but the supplementary lecturing may be different based on the provided information. The instructor will use the confidence information of learners when s/he accepted the information as the valuable information. In contrast, the behavior of the instructor in the experiment class has a possibility to behave as same as in the control class, even the confidence information was visualized.

The primary investigation is about how is the different behavior of the instructors when the system provided the confidence information of their learners. From the assumption, the instructor will use the confidence information for selecting and ordering supplementary

content. The gathered evidence of the instructor's behavior consisted of the order of supplementary content in each class, the discussion session at the end of class, and an information evaluation session of the instructor's questionnaire. "What is an effect of the different behavior of the instructor?" is analyzed to be three values which contain a normalized learning gain, a discrimination value, and a hit rate. The normalized learning gain of each group was referred to describe the effectiveness of the different behavior of the instructor. The discrimination value illustrates the recognition of the different understanding based on correctness and confidence information. The discrimination value presents how learners have the confidence on the correct proposition and have no confidence on the incorrect proposition. The hit rate focuses only on the correct proposition that learners have confidence. Lastly, the questionnaire was conducted to assess the satisfaction of the KB map with confidence tagging in the aspect of both the learners and the instructors when it was utilized in the classroom situation.

4.5 Results

4.5.1 The Different Behavior of the Same Instructor

The investigation of the control group is a comparison of excessive links ordering between basic strategy and the actual ordering of each control class, which the assumption is a perfect similarity between the basic strategy and the actual ordering of the class. Figure 4-7 shows the goal map of the first paired class. Figure 4-8 shows a part of diagnosis results of the control class in the first paired class where the instructor used the filtering function to screen out some excessive links that have the number of the constructor less than three.

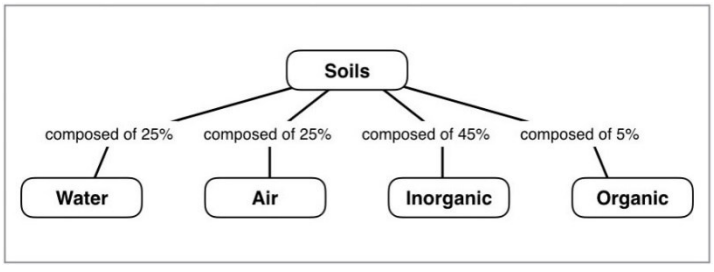

Figure 4-7 *The goal map of the first paired class*

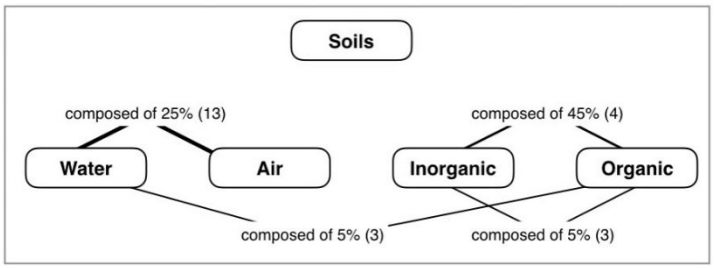

Figure 4-8 *The group-goal difference map of the control class in the first paired class*

An observed evidence is the ordering of supplementary content based on the diagnosis results of the class. The first selected excessive link was "composed of 25%," and supplementary content mentioned to "Water" and "Air" which the action indicates that the most number of excessive links was selected for providing the feedback. The second selected excessive link was "composed of 45%". These selected excessive links can be ordered by using the correctness information, while the remain excessive links have the same tagged number as in ordering of correctness information. The supplementary lecture mentioned to "Water" again with the explanation of "composed of 5%" and the content of "Organic." Thus, the third selected excessive link was "composed of 5%" on the left-hand side. Then the "composed of 5%" was mentioned with the content of "Organic" again with "Inorganic" content. Hence, the fourth selected excessive link was "composed of 5%" on the right-hand side. The third- and fourth-selected excessive links demonstrate that the location visualization can help the instructor to select the excessive links in unordering of correctness information. Accordingly, the actual ordering of the instructor is the same ordering of basic strategy. The similarity value between basic strategy and actual ordering of the class is 100%. The perfect similarity value illustrates that the instructor used the correctness information and location visualization for ordering feedback, and there are no other factors in this ordering process.

Table 4-1 displays the similarity values between the basic strategy and actual ordering of five paired classes. In the control group, all of five control classes can get the perfect similarity value that represents that the instructors used the basic strategy for ordering the supplementary content where the correctness information was provided. On the other hand, the different order of supplementary content was found in the experiment group where the system provided the correctness and confidence information to the instructor. Imperfect similarity values were found in three of five experiment classes, which indicate the different behavior of the instructors in selecting and ordering the supplementary content.

Table 4-1 *The percentage of similarity between basic strategy and actual ordering of five paired classes*

Lecturer	Grade of learners	Paired class	Percentage of similarity	
			Control class	Experiment class
Instructor A	4	1st paired	100.00	100.00
Instructor B	5	2nd paired	100.00	60.00
	5	3rd paired	100.00	14.29
Instructor C	6	4th paired	100.00	100.00
	6	5th paired	100.00	16.67

4.5.2 How the Instructors Used the Information of the Diagnosis Results

The different behavior of the same instructor was found when the system provided the different information, and the confidence information has the possibility to encourage the different behavior of the instructor. This section summarizes how the instructors used the diagnosis results from the short discussion sessions with the instructors after finished classes and the evaluation session from the questionnaire of the instructors. The summary mentions to the importance of each information in the diagnosis results, which consist of correctness, confidence information, and location visualization. The instructors commented that the correctness is only one learning evidence in the control group and they focused on the correctness information from the diagnosis results firstly, while the location visualization can help them to point out selected- and remain-excessive links. On the other hand, two learning evidences are provided in the experiment group. The correctness information is still the most important information, and confidence information becomes valuable information as the second priority, then the last priority is visualization location. The result of questionnaire also presents the order of information, which the instructors tried to pay attention to the incorrect proposition first and then looked for its tagged number of confidence information. The incorrect with confidence is the most crucial type of proposition that the all of the instructors want to provide the feedback for this proposition type before the others. Besides, even the strategy of ordering between the control- and experiment-group is different because the different behavior of the instructor on the different diagnosis results, the ordering of the first- and fourth-classes of both groups are the same order with basic strategy as shown in Table 4-1.

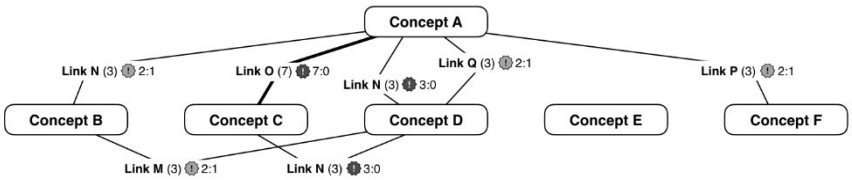

Figure 4-9 *The layout of the group-goal difference map of the experiment class in the third paired class*

Figure 4-9 shows an example of the group-goal difference map layout that visualize the group-goal difference map in blinded concept label and linking words for investigating the ordering of the experiment group where the system provides both correctness and confidence information to the instructor. The correctness information is visualized in the form of the number of excessive links for indicating the misunderstanding of learners. The most number of the excessive link is displayed as "Link O (7)" for informing seven learners who connected "Concept A" and "Concept C" with the "Link O." Thus, the first selected excessive link was selected by using only the correctness information. However, only the correctness information cannot suggest the next selected excessive link because there are six candidates that are possible to be the second selected excessive link. The confidence information is visualized for informing how many learners have the confidence and unconfidence on each excessive link. The tagged number of confidence information on six candidates suggests that three of three confidences on two excessive links, and two of three confidences on four remaining excessive links. Subsequently, the supplementary lecture mentions to "Link N" with the error explanation, which is according to the "Concept A" and the "Concept D," and then still keep an attention on the "Link N" again but the error explanation is according to the "Concept C" and "Concept D." The order of supplementary content demonstrates that the confidence information was used for selecting these selected excessive links. The second selected excessive link is the upper "Link N (3) 3:0", and the third selected excessive link is the lower "Link N (3) 3:0". Hence, the order also demonstrates the location visualization was used for ordering when the correctness and confidence information have an equal amount.

Table 4-2 displays the used information of ordering process which can represent the amount of time that the instructor used each information. The instructor tended to incorporate the confidence information with the correctness information and location visualization. Thus, we define "CCL" strategy as the ordering supplementary content based on correctness, confidence information, and location visualization respectively. Moreover, there is the possibility, that the instructor used different strategy but both strategies can produce the same order of supplementary content. For instance, the ordering of selected excessive links in the

first experiment class was ordered by using five times of correctness and two times of confidence based on CCL strategy. The same ordering can be produced from the basic strategy.

Table 4-2 *The information used of ordering in the experiment group based in CCL strategy*

Classroom	Selected excessive links	The number of used time information			Percentage of similarity*
		Correctness	Confidence	Location	
1st experiment class	5	5	2	0	100.00
2nd experiment class	5	5	4	0	60.00
3rd experiment class	7	7	6	6	14.29
4th experiment class	5	5	3	2	100.00
5th experiment class	6	6	6	5	16.67

4.5.3 Normalized Learning Gain and Effect Size

The same instructor and the same lecture content are lecturing in each paired class, while the different feedbacks produced the different intervention between the control- and experiment-classes. The investigation of normalized learning gains and effect size are presented in this section, and an assumption is the different behavior based on different used strategy affects learning achievements. That means the confidence information effects to the behavior of the instructor, and then the different feedback also effects to the understanding of learners. The normalized learning gain (g) is used to represent the effectiveness of the educational intervention (Hake, 1998, 1999; Madsen et al., 2016; McKagan et al., 2017). The first learner map was constructed after the instructor gave the lecture (Formative map) and the second learner map was constructed after the instructor gave the supplementary lecture (Final map), which correspond to the arrangement of the KB map on formative assessment. The learner map scores and the normalized learning gain of each learner can be calculated following:

$$Map\ score = \frac{Correct\ propositions\ in\ learner\ map}{The\ number\ of\ propositions\ in\ the\ goal\ map} \quad (1)$$

$$g = \frac{Final\ map\ score - Formative\ map\ score}{1 - Formative\ map\ score} \quad (2)$$

Correspondingly, the gain of averages ($< g >$) was used to indicate the normalized learning gain of class that can be classified into three regions of g for substantial using following "Low" when ($< g >$) less than 0.3, "Medium" when ($< g >$) from 0.3 to 0.7, and "High" when ($< g >$) more than 0.7 (Hake, 1999; Madsen et al., 2016; McKagan et al., 2017). Table 4-3 presents the gain of averages and its region of each class. Four experiment classes out of five got better the normalized learning gains than their paired control classes. Especially in the fourth- and fifth-paired classes, there were significant differences in normalized learning gains between experiment class and control class.

Moreover, regarding effect size (Cohen's d) as difference of normalized learning gains between control class and experiment class, they are "large" in the 3rd and 5th paired classes and they are "medium" in the 4th one. There results suggest that the experiment classes were better for learning than control classes.

Table 4-3 *Normalized learning gain of class and effect size of each paired class*

Paired class	**Type of class**	**The number of learners**	$< g >$	**S.D.**	**Region of g**	d	p-value[a]
1st paired class	Control	34	0.57	0.48	Medium	0.23	0.5570
	Experiment	36	0.67	0.38	Medium		
2nd paired class	Control	24	0.85	0.46	High	0.13[b]	0.2660
	Experiment	26	0.79	0.43	High		
3rd paired class	Control	25	0.50	0.53	Medium	0.83	0.3019
	Experiment	25	0.93	0.51	High		
4th paired class	Control	16	0.29	0.23	Low	0.56	0.0389[c]
	Experiment	20	0.47	0.41	Medium		
5th paired class	Control	17	0.18	0.33	Low	1.49	0.0003[c]
	Experiment	20	0.71	0.38	High		

[a] The p-value of g between control- and experiment-class of each paired class.
[b] The value presents $|d|$ when the control class has the $< g >$ more than the experiment class, which produces a negative value of d.
[c] Statically significant difference

4.5.4 The Discrimination of the Understanding

The discrimination value (d_r) represents the recognition of the difference between what they know and what they do not know (Hunt, 2003). The value is measured based on a proportion of the confident correct proportion and the unconfident incorrect proposition against all of the complete propositions in the learner map. The perfect score indicates the learners are able to discriminate according to an appropriate confidence, which implies the learner has confidence on all of the correct understanding and has no confidence on the misunderstanding.

$$d_r = \frac{Correct\ with\ confidence + Incorrect\ with\ unconfidence}{The\ number\ of\ complete\ propositions\ in\ the\ learner\ map} \quad (3)$$

Table 4-4 shows the discrimination value of learners and the significant difference between the control group and the experiment group. There was no significant difference between the formative map of the control- and experiment-group ($p = 0.794$), which means that the learners have an ability to discriminate about their knowledge not much different after lecturing. The feedback of instructors improved discrimination of learners in both groups significantly ($p < 0.01$). Then, there was a significant difference of final map between the control- and experiment-group ($p < 0.01$). These results suggest that the correctness- and confidence-based feedback can improve the discrimination of their confidence on their understanding better than the correctness-based feedback.

Table 4-4 *An average of discrimination value*

Group (*N*=10)	**Formative map**	**Final map**	***p*-value**
Control group (*5 classes*)	0.6007	0.7624	$p < 0.01$
Experiment group (*5 classes*)	0.6820	0.8842	$p < 0.01$
p-value	0.0794	$p < 0.01$	

4.5.5 The Certainty of the Understanding

The confidence on the incorrect proposition is the worst situation that the instructors attempt to correct those misunderstanding by providing the supplementary lecture based the diagnosis results. On the other hand, the confidence on the correct proposition is the best situation for representing the certainty of the understanding. The hit rate (*HR*) represents consistency with the interpretation that if a correct response is covertly selected, then its execution helps the

learner to confirm its correctness (Hunt, 2003). The value is measured based on a proportion of the number of confident correct propositions against the number of correct propositions in the learner map.

$$HR = \frac{Correct\ proposition\ with\ confidence}{The\ number\ of\ correct\ propositions\ in\ the\ learner\ map} \quad (4)$$

Table 4-5 shows the hit rate and the significant difference between two learner maps of two groups. There was no significant different between control- and experiment-group (p = 0.1976) that means learners have not much different confidence on the correct answers after lecturing. Then the feedback of instructors can improve confidence on the correct answers in both groups significantly ($p < 0.01$). There was also a significant difference of final map between the control- and experiment-group ($p < 0.05$), which suggests that the correctness- and confidence-based feedback can improve the certainty of the understanding better than the correctness-based feedback.

Table 4-5 *An average of hit rate*

Group (*N*=10)	**Formative map**	**Final map**	***p*-value**
Control group (*5 classes*)	0.7430	0.8888	$p < 0.01$
Experiment group (*5 classes*)	0.6714	0.9587	$p < 0.01$
p-value	0.1976	$p < 0.05$	

4.5.6 The Changing of Proposition based on the Confidence

For more emphasis on the confidence of learners, Table 4-6 shows a possibility of proposition changing based on the confidence information from the formative map to the final map. The analysis of change of proposition type presents that the propositions with unconfidence are easier to change than the propositions with confidence. Particularly, the changing of unconfidence propositions to confident correct propositions of experiment group is 80.30%, while 69.60% unconfidence propositions of the control group are changed to confident correct propositions. The proposition changing suggests that the correctness- and confidence-based feedback can help the learners to improve their understanding and get more confidence better than the correctness-based feedback.

Table 4-6 *A proposition changing based on the confidence of learners from formative assessment map to the final map*

Group (*N*=10)	**Percentage of proposition changing**	
	Confidence	Unconfidence
Control group (*5 classes*)	33.07%	66.97%
Experiment group (*5 classes*)	33.08%	85.40%

4.5.7 The Satisfaction Results

The questionnaire was conducted to the learners who participated in the practical uses, which content of the questionnaire contains three sessions following the overview of the KB map with confidence tagging, emphasizing on the effect of confidence tagging, and the effect of instructor's feedback. Figure 4-10 displays a part of the questionnaire of learners. The positive evaluations received from the learners by the questionnaire. Such as the first questions, 60.70% of learners "strongly agree" enjoy constructing the learner map and tagging of the confidence. 51.26% "strongly agree" and 29.14% "agree" are the results of the second question about constructing the map and tagging confidence are useful for expressing the understanding of lecture content. The confidence tagging as an additional task did not disturb the learners in the structuring task, which 34.67% and 31.66% "strongly agree" and "agree" on they feel free to tagging their confidence respectively as the results of the fourth question. Finally, the results of seventh- and eighth-questions have more than fifty percent on "strongly agree" that the instructor's feedback in the form of the supplementary lecture can help learners to get more understanding and get more confidence. The results of learner's questionnaire illustrate the satisfaction of learners that suggests that the learners accepted the mechanism of the KB map with confidence tagging.

The questionnaire of the instructor was also conducted for investigating the aspect of the instructors when the KB map was utilized in their lecture classes. Figure 4-11 displays a part of the instructor's questionnaire. The results of the questionnaire demonstrate the positive satisfaction of the instructors. The goal map creating can help the instructors to express the lecture content, and indicate the learning goal as the result of the first question. The results from the second- to sixth-questions present that all instructors gave "strongly agree" to the diagnosis results, which are useful information for visualizing the current learning situation, identifying the critical misunderstanding of learners, until selecting and ordering the

supplementary content. Moreover, the instructors also strongly agreed on the eighth question that their learners enjoyed with the mechanism which formed the positive environment for the learning situation. On the other hand, the instructor gave “strongly disagree” on the seventh question that the confidence information was more workload when analyzing the diagnosis results. Thus, the instructor accepted the diagnosis results that include the correctness and confidence information. Notably, the diagnosis results with the confidence information are useful information for selecting and ordering the supplementary feedback, which is more satisfactory than no confidence information.

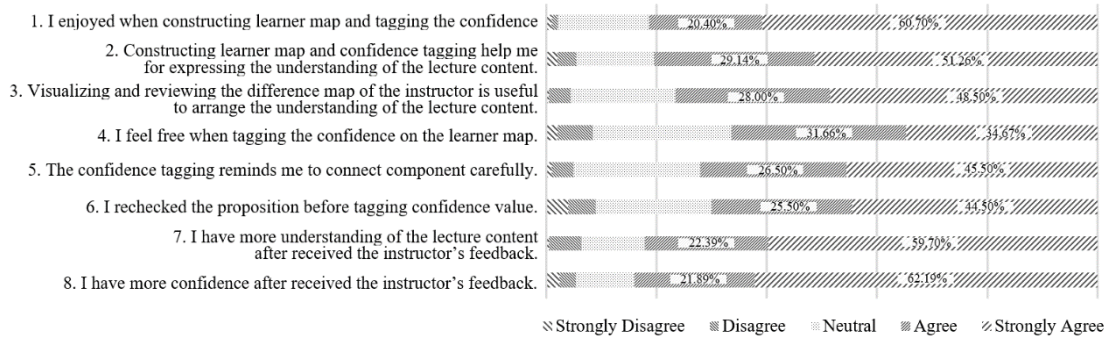

Figure 4-10 *A part of learner’s questionnaire and its results*

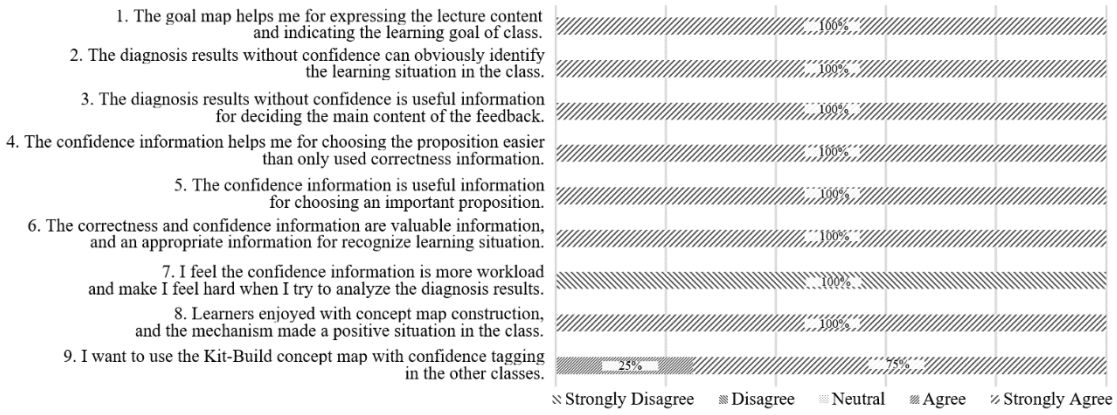

Figure 4-11 *A part of instructor’s questionnaire and its results*

4.6 Discussion

In this study, we present the encouragement of correctness and confidence information with the KB map with confidence tagging for selecting and ordering the supplementary content as the feedback of the instructors in the lecture classes. The KB map creates an opportunity for

an instructor to assess a current learning situation, which the instructor can give the feedback to learners for improving learning achievements in the class period. The different behavior of the instructors was observed when the system provided only the correctness information in the control group, while the correctness and confidence information were provided in the experiment group. The ordering of the supplementary content demonstrates how the instructor used the correctness, confidence information, and location visualization.

The observed evidence of the practical uses can represent the relation between the instructor's behavior and the confidence information of learners. The instructors did not only use the confidence information in selecting and ordering the supplementary content, but we also found the mentioning to the confidence of learners on some selected excessive links in the supplementary lecture of the experiment group when the instructor received the confidence information. Correspondingly, the relation of instructor's behavior and learning evidence suggests that the different behavior of the instructors is positive changing to improve the learning achievements and also improve the confidence of learners. The normalized learning gain of class ($< g >$) and effect size (Cohen's d) illustrate that the correctness- and confidence-based feedback of the experiment group is more effective than the only correctness-based feedback of the control group. The discrimination value (d_r) demonstrates that the learners of experiment group can discriminate the different understanding based on correctness and confidence better than the learners of control group significantly. Similarly, the hit rate (HR) shows that the learners of experiment group have an ability to represents consistency with the interpretation better than the learners of control group significantly. These results of the practical uses suggest that the confidence information of learners affects the instructor's behavior and then the different behavior of the instructor effects to the learning achievements continuously. In addition, the results of questionnaire present the positive satisfaction of both instructors and learners when the KB map with confidence tagging was utilized in the lecture classes. The learners accepted the mechanism for representing their understanding and their confidence. The instructors accepted that the confidence information of learners is valuable information for recognizing the learning situation. Nevertheless, the content details of the supplementary lecture were not investigated in this experiment such as what kind of feedback was designed from only correctness, or correctness and confidence information.

4.7 Chapter Summary

Even the correctness assessment can determine the knowledge of learners, the quality of that knowledge cannot be identified by using only the correctness information. We propose the KB map with confidence tagging that can provide the mechanism to learners for representing their understanding and identifying their confidence on their understanding. The learner map and confidence of each proposition are the learning evidence, which the learner map can represent the understanding of learners in the lecture content and the confidence tagging promotes them to reconsider their propositions again. The system facilitates learners to create learning evidence in a class period and identify the current learning situation through diagnosis results immediately. Subsequently, the learning evidence of learners affects the instructor behavior directly when they accepted the information as a valuable information. The supplementary lecture based on the correctness and confidence information are utilized as evidence-based feedback of the instructor, which is a key of formative assessment to improve learning achievements in the classroom situations.

Moreover, the different behavior of the same instructor illustrates the utilizing of the confidence information on the supplementary lecture that can demonstrate that the instructor accepted the confidence information as the valuable information. The confidence information can encourage the strategy for selecting and ordering the supplementary content. The results of the practical uses suggest that the different feedback of the instructor is important through normalized learning gains and effect size, which the correctness- and confidence-based feedback can improve the learning achievements and confidence of learners concurrently.

For the next chapter, the individual feedback will be focused based on the current ability of KB map with confidence tagging. Even the instructor can improve the learners understanding, some propositions are disregarded such as the correct proposition with unconfidence. Consequently, we aim to direct to all learners and support all their propositions via the KB map with confidence tagging for improving the learning achievements in the form of system feedback.

CHAPTER 5

CORRECTNESS- AND CONFIDENCE-BASED ADAPTIVE FEEDBACK

Summary: The previous chapter described the ability of KB map-CT, which the correctness and confidence information are available in the system. The chapter presents an adaptive feedback of KB map-CT for improving the understanding of learners in a reading situation. The system can utilize both correctness and confidence information for each proposition to design and distinguish feedback, that is, (1) correct and confident, (2) correct and unconfident, (3) incorrect and confident, and (4) incorrect and unconfident. An experiment was conducted to investigate the effectiveness of the adaptive feedback. The results suggest that learners can revise their maps after receiving feedback appropriately. In "correct and unconfident" case, adaptive feedback is useful to improve the confidence. In the case of "incorrect and confident," improvement of the propositions was the same ratio with the case of "incorrect and unconfident." The results of the delay test demonstrate that learners can retain their understanding and confidence one week later.

5.1 Introduction

In this chapter, we propose a mechanism to provide individual feedback based on the correctness and confidence information as an adaptive feedback of the Kit-Build concept map with confidence tagging (KB map-CT). The Kit-Build concept map (KB map) is a digital tool for supporting the concept maps strategy (Hirashima et al., 2015). The instructor-built map is called a goal map, illustrating a learning goal, and the goal map will also be used as criteria for identifying the correctness. The goal map is decomposed into a list of concepts and linking words (called the "kit"), while the learner-built map, which is called a learner map, is used to represent the understanding of learner. The diagnosis results of the KB map were utilized by the instructor for recognizing the current learning situation. The instructors

used the diagnosis results to design and provide feedback to improve the learning achievements in the lecture classes effectively (Yoshida et al., 2013a, 2013b; Pailai et al., 2017). In addition, the propositional level exact matching of the KB map can attain almost the same validity as the well-known manual method (Wunnasri et al., 2017, 2018).

The structuring task of the KB map-CT is to gather learning evidence that consists of the learner map and the confidence of the learner. Learners can construct learner maps as the learning evidence by connecting the kit to form the propositions (Pailai et al., 2018). A completed proposition, which can be tagged with the confidence of the learner, comprises one connected linking word between two concepts. The confidence of the learning evidence is simplified in the form of confidence- or unconfidence-value, which the learner can assign to every complete proposition. Hence, the KB map-CT can elicit learning evidence that includes the understanding of learners and the degree of the understanding in the gathering process.

The adaptive feedback based on the correctness and confidence information is provided for learners in a reflection task for improving their understanding individually. The mechanism of the adaptive feedback is to provide different interactions as different feedback for encouraging the learners to reconsider their current understanding according to the correctness and confidence information of each proposition. For instance, the evidence identification task requests the learners to identify the evidence of all their confident propositions for ensuring the confidence of correct propositions by themselves and for reducing the confidence of incorrect propositions before correcting the misunderstanding. The related content of the material and the correct proposition of the goal map will be visualized along with the proposition of learners to promote the learners to reconsider their incorrect propositions. Therefore, we present an experiment of the adaptive feedback of the KB map-CT in a reading situation for illustrating the effectiveness of the feedback.

5.2 Motivation

Table 5-1 *The revision rate of each proposition type in the experiment of KB map-CT*

Proposition Type	**INC-CON**	**INC-UNC**	**COR-CON**	**COR-UNC**
Revision Rate	66.66%	84.72%	5.93%	71.27%

Table 5-1 illustrates the revision rate of each proposition type from 2,067 complete propositions in the uses of the KB map-CT in classrooms. The instructors provided feedback to improve the understanding of learners based on the diagnosis results of the KB map-CT. The results of the experiment demonstrate that the propositions without confidence are easier to be changed than the confident propositions. Although the instructor's feedback can improve the understanding of the learners, the correction rate of the incorrect propositions is different, depending on the learner's confidence. The results suggest that adequate feedback should be different, depending on the confidence of learners.

The correctness information of the concept map is primarily used as feedback. Several concept mapping tools provide the correctness for each component to learners based on the criteria map, such as COMPASS (Gouli et al., 2004, 2005, 2006), ICMLS (Wu, 2012), KAS (Grundspenkis & Anohina, 2009; Lukasenko et al., 2010), and CMfl (Filiz et al., 2015). Some special assessment methodologies were used for scoring the map, such as the weight of the important components of ICMLS and KAS, and the modified pathfinder of CMfl. Although different mapping tools have different details of their systems, the common methodology is a criterion-referenced assessment with the benefit of automatic assessment. The systems can identify the correctness of each component of the learner's map compared to the criteria map. The results of the comparison are provided for the learners as the system feedback for informing their performance, and the display of the related material content is general feedback for correcting the misunderstandings of learners regarding their incorrect propositions.

In this chapter, we present the correctness- and confidence-based adaptive feedback that promotes improving the understanding and ensuring the confidence of an individual learner. A goal map structuring task for an instructor and a reflection task for learners were developed to support the automatic adaptive feedback. The goal map structuring task facilitates building a goal map for the instructor and linking each component of the goal map with the content of the material. The reflection task facilitates accessing personalized feedback and revising their learner maps for the learners. Accordingly, the system has adequate information for providing individual feedback according to each learner's characteristics. The adaptive feedback was designed for emphasizing the correctness and confidence information for each proposition type, which the instructor's feedback cannot deal with a large number of learners.

5.3 The Implementation of Adaptive Feedback

5.3.1 Goal Map Structuring Task

The traditional concept map is constructed by an instructor to represent the learning goal. The instructor must type keywords to create labels of concepts or linking words. In this study, the goal map construction tool of the KB map-CT facilitates displaying the learning material in the form of a sentence by sentence for the instructor. The instructor can easily select keywords from the learning material instead of typing, can choose between concepts and linking words to create the components of the goal map. Then the instructor can connect them to each other. The goal map structuring task encourages a clear learning goal because all of the words that appear in the goal map also appear in the learning material. Moreover, the system can track the relationship between the content of the material and each component of the goal map as a related sentence. That means the system can link between each component of the goal map and the content of the material. The related sentences are utilized in the adaptive feedback that is described in the next section.

5.3.2 Reflection Task

The reflection task is provided for learners after they completed learner maps, where the adaptive feedback is available. The learners will receive the information for recognizing their performance that includes a learner map score and an overlay map between their map and the goal map. The four different proposition types are distinguished using the different displayed line, while the confidence tagging also appears to determine the confidence in each proposition. The adaptive feedback is promptly provided for the learners according to each proposition type. The system allows learners to revise their map and change their confidence freely. Figure 5-1 demonstrates the system architecture of the KB map-CT and its adaptive feedback.

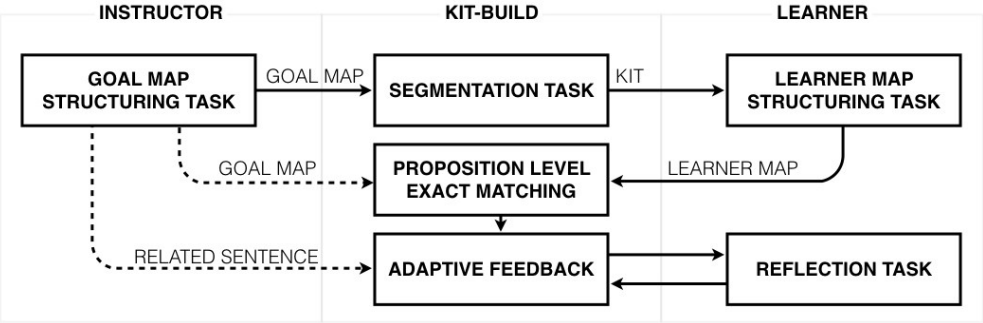

Figure 5-1 *The system architecture of the KB map-CT and its adaptive feedback*

5.3.3 Adaptive Feedback

The adaptive feedback of the KB map-CT was designed to deal with both the correctness and confidence information of learners. The objective was defined based on four types of the propositions to encourage a positive change of the learning achievements. The primary objective is to correct the misunderstandings of learners in both INC-CON and INC-UNC, while increasing the confidence in COR-UNC. For the remaining proposition type, COR-CON, the aim is to encourage the learners to retain both the correctness and confidence. In other words, the adaptive feedback should correct the misunderstandings of learners and give more confidence to learners regarding the understanding appropriately. Accordingly, the adaptive feedback of the KB map-CT consists of four layers following:

Error Identification Layer

The error identifying layer visualizes the correctness and confidence information of the learner map in three different lines. Solid lines present COR-CON and dashed lines represent INC-CON. COR-UNC and INC-UNC are displayed as a dotted line. An example of the error identification layer is displayed in Figure 5-2.

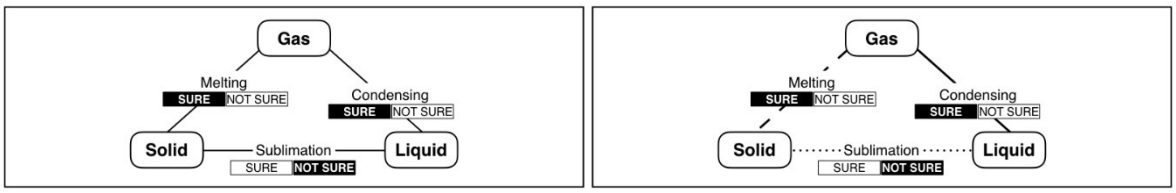

Figure 5-2 *An example of a learner map and the error identification layer*

Evidence Identification Layer

The evidence identification layer emphasizes learners who have the confidence in their propositions by promoting them to identify the evidence for each confident proposition. Its procedure contains a sentence selection and a sentence suggestion. The sentence selection requests learners who have the confidence to select a sentence of the material as a selected sentence for tracking the source of their understanding. The objective is to ensure the confidence of learners who can construct COR-CON and can select the sentence accurately. On the other hand, the sentence selection aims to reduce the confidence of learners who constructed INC-CON. The sentence suggestion provides the related sentence regarding the linking word of the unconfident proposition to the learners who do not have confidence. The objective is to increase the confidence on COR-UNC and to correct the misunderstandings on INC-UNC.

Explanation Layer

The explanation layer emphasizes the proposition revision. Its procedure contains a proposition suggestion and a proposition selection. The proposition suggestion provides the proposition of the goal map to learners as the affirmation of learner's understanding on COR-UNC. The proposition selection aims to change the misunderstanding of learners who constructed INC-CON and INC-UNC. The feedback requests the learners to select an appropriate proposition of the selected sentence (INC-CON) or the provided related sentence (INC-UNC) between their incorrect proposition and the proposition of the goal map.

Guidance Layer

The guidance layer is an instruction suggestion of the next actions regarding the previous activities of learners. For instance, the confirmation message is displayed when the learners selected the appropriate sentence in the same way as the related sentence of the goal map for ensuring the confidence of COR-CON.

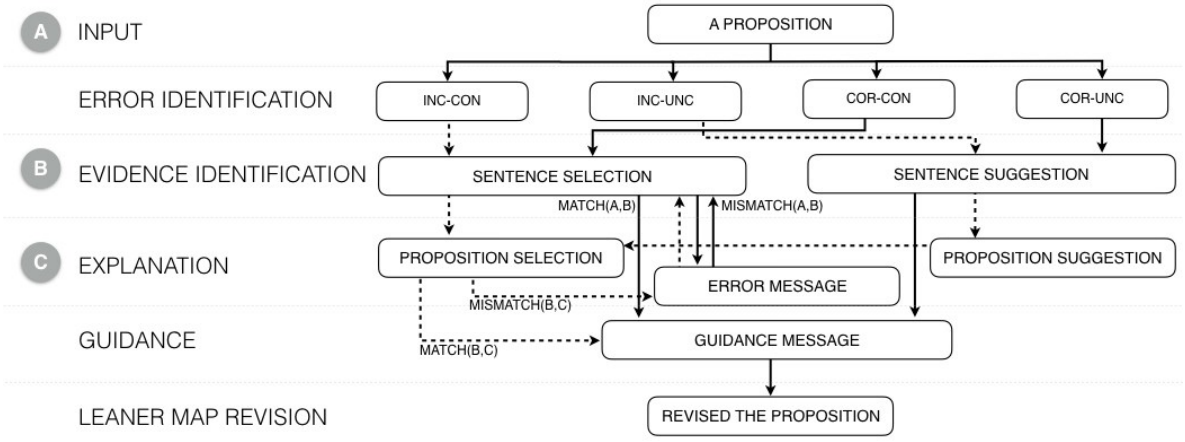

Figure 5-3 *The scenarios of the adaptive feedback for each proposition type*

Figure 5-3 represents scenarios of the adaptive feedback based on the correctness and confidence information that demonstrates the provided different feedback for each proposition type. The different scenarios create different feedback, which aspires to provide adequate feedback based on each combination of correctness and confidence information. The confidence information is utilized in the evidence identification layer to separate the learners into two cases. The learners who have confidence in their understanding have to indicate the source of the confidence in the sentence selection task. This task leads learners to reconsider their proposition and the material content thoroughly. For the learners who have no confidence, they are necessary to receive the accurate source of the material in the sentence suggestion task.

The correctness information is utilized in the explanation layer for correcting the misunderstanding of learners. Despite only visualizing the correct proposition, it may directly guide how to revise their incorrect proposition. The adaptive feedback requests learners to determine the proper proposition according to the related sentence in case of the incorrect proposition. The proposition suggestion is to affirm the understanding of learners by presenting the related sentence of the material according to the correct proposition for ensuring the confidence.

Figure 5-4 illustrates an example of the adaptive feedback on INC-CON, in which the proposition is incorrect with confidence of the learner. The system will provide the sentence selection to request learners to identify their evidence as a selected sentence and then will provide the proposition selection for adjusting the misunderstanding according to the selected

sentence. Even if the learner can select the correct proposition in the proposition selection task, they have to revise their learner map by themselves after this process.

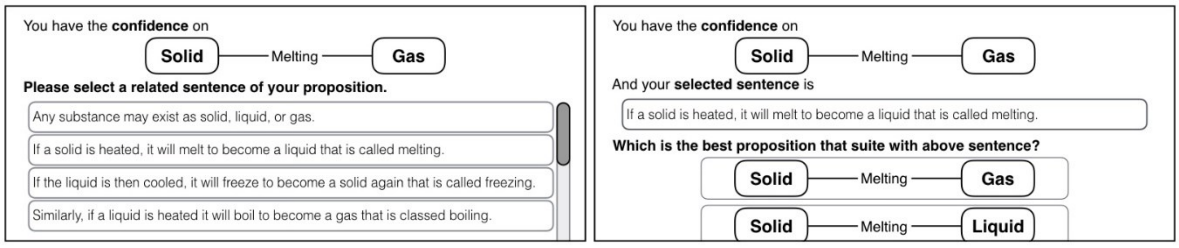

Figure 5-4 *An example of the adaptive feedback on the incorrect proposition with confidence*

5.4 Preliminary Use

The experiment was conducted to investigate whether the adaptive feedback encourages the learners to correct the misunderstanding and increase their confidence. The goal map was constructed via the goal map structuring task to create a learning goal, generate a kit, and pair the related sentence of each proposition. The goal map consists of eight propositions from eight linking words and seven concepts. The participants are 24 university students who read a 104-word article in five minutes and constructed a learner map in five minutes to represent their understanding as a formative map. The reflection task is provided for learners who uploaded the formative map. The learners have ten minutes to receive feedback and revise their map as a reflective map. Lastly, the learners have to construct the learner map again one week later as a delay map to evaluate the retention of the understanding. Hence, there are three learner maps for each learner: the formative map, the reflective map, and the delay map.

In this chapter, the investigation emphasizes on the proposition changing from the formative map to the reflective map to observe the direct effect of the adaptive feedback on the learning achievements. Moreover, the correctness and confidence of each proposition type were analyzed to demonstrate the effectiveness of the adaptive feedback. Using the adaptive feedback, we expected that (1) INC-CON and INC-UNC would be changed to correct propositions, (2) COR-UNC would be changed to COR-CON, and (3) COR-CON would be retained as the same proposition type.

5.5 Results

5.5.1 Learner Map Score

The learner map is used to estimate the understanding of learner, and the average learner map score represents an overview of the learning achievements. Table 5-2 presents the average score of each map in the experiment. The formative map score shows the first understanding of learners after they read the material. The reflective map score presents the understanding of learners after they received feedback. The delay map score represents the understanding of learners one week later.

Accordingly, the average score demonstrates that the adaptive feedback can encourage the learners to improve their map score, which the average score of the reflective map is higher than the formative map. There were also significant differences between the formative map scores and the reflective map scores, and between the formative map scores and the delay map scores according to the t-test with Bonferroni correction. Their effective sizes were large by Cohen's *d* criteria. These results suggest that the adaptive feedback can effectively encourage learners to improve their map score.

Table 5-2 *The average scores and p-value of the formative-, the reflective-, and the delay-map*

Variables	**Formative Map**	**Reflective Map**	**Delay Map**
Average score: full mark is 1.00	0.69 (*SD* = 0.21)	0.90 (*SD* = 0.14)	0.84 (*SD* = 0.16)
p-value from t-test with Bonferroni correction (Cohen's *d*)	*p* = 0.00 (*d* = 1.15)		*p* = 0.70 (*d* = 0.35)
	p = 0.02 (*d* = 0.83)		

5.5.2 Proposition Transitions

The different feedback was provided for learners according to the correctness and confidence information of each proposition. The changing of the proposition type from the incorrect propositions to the correct propositions after the learners received the adaptive feedback produced the significant improvement in the learner map score. Figure 5-5 demonstrates the forward transition of the propositions from the formative map to the delay map. The dashed line of Figure 5-5 represents the proportions transitions that less than or equal to five percent. Although a few INC-CONs are unchanged to the other proposition types, the learners revised

all of those propositions after receiving feedback. The revised propositions mean the learners changed at least one component of the two concepts and one linking word. The results suggest that the adaptive feedback promotes the revising INC-CON and feedback is possible to reduce the confidence of learners and encourage them to correct their misunderstanding.

Moreover, the previous study of the KB map-CT (Pailai et al., 2018) demonstrated that the propositions without confidence tend to change more easily than the propositions with confidence when the learners received the instructor's feedback. The results suggest that the INC-CON should be the most difficult to overcome in the classroom situation. However, the adaptive feedback is possible to reduce the number of INC-CON similar to that of the INC-UNC on the reflective map. The forward proposition transition suggests that the adaptive feedback is adequate for correcting the misunderstanding of learners, even those learners who have the confidence in that misunderstanding. The learners can change the INC-CON to the correct proposition, similar to INC-UNC.

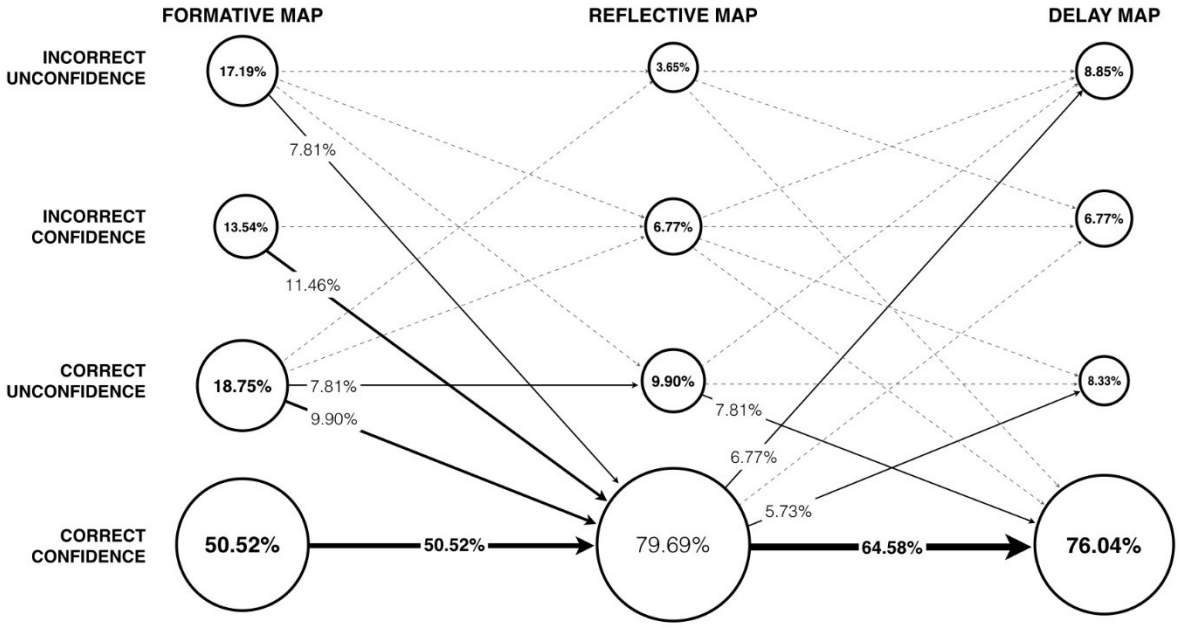

Figure 5-5 *The forward transition of the propositions from the formative map to the delay map*

The retaining of COR-CON is one of the objectives of the adaptive feedback. The forward proposition transition illustrates that the learners can keep all COR-CON from the formative map to the reflective map. The transition suggests that the adaptive feedback did not disturb the learners from maintaining confidence in their accurate understanding. On the other hand, ensuring confidence is another objective of the adaptive feedback for COR-UNC.

The most revised COR-UNC were changed to COR-CON following the objective. There are some COR-UNC that retained the same type, and a few propositions were changed to INC-UNC and INC-CON. Moreover, the results of the experiment demonstrate that the learners can keep COR-CON of the formative map 46.88% from 50.52% through the delay map. The average score of the delay test is 84.28% correct propositions with and without confidence, which comprise 53.10% of the first understanding, 19.63% from the improvement between the formative map and the reflective map, and 11.55% are undescriptive.

5.5.3 Discrimination and Certainty of the Understanding

The discrimination value (d_r) represents the recognition of the difference between what they know and what they do not know (Hunt, 2003). The value is measured based on COR-CON and INC-UNC against all of the complete propositions in the learner map. A perfect score indicates that the learners are able to discriminate their understanding according to the appropriate confidence. Table 5-3 shows the improvement of the discrimination value after the learners received feedback. The results suggest that the adaptive feedback encourages the learners to discriminate progressively between the different understandings based on correctness and confidence. Moreover, the hit rate (*HR*) represents the consistency with the interpretation that, if a correct response is covertly selected, then its execution helps the learner to confirm its correctness (Hunt, 2003). The value is measured based on COR-CON against the number of correct propositions in the learner map. The hit rate of the experiment is displayed in Table 3. The results suggest that the adaptive feedback encourages the learners to present consistency with the interpretation of the correct proposition more accurately.

Table 5-3 *The discrimination value (d_r) and hit rate (HR)*

Variables	Formative Map	Reflective Map	Delay Map
Discrimination of the understanding (d_r)	0.68	0.83	0.85
Certainty of the understanding (*HR*)	0.73	0.89	0.90

5.6 Discussion

The general feedback aims to correct the misunderstanding of learners based on the correctness of learning evidence. The automatic assessment of the concept maps creates an

opportunity to provide individual feedback, such as visualization of the discrepancies of learner map against the goal map. The related content of the material can be part of individual feedback with some preparation. Only incorrect answers of learners are regularly treated with one kind of feedback, while the correct answer is interpreted as accurate understanding without treatment, which indicates that even if the learners have a different degree of the misunderstanding, they will receive the same feedback. Moreover, it is necessary to ensure the accurate understanding of the learners who are unsure in their understanding. However, it is impossible to identify the degree of the learner's understanding with only the correctness information.

The confidence information of learning evidence demonstrates the difference in the same correctness of the evidence, which is used to represent the degree of learner's understanding. Correspondingly, the association of correctness and confidence information can describe the learning situation. The different correctness information is treated with different approaches, the different confidence also requires different approaches. Thus, the combination of correctness and confidence information should be treated appropriately. The adaptive feedback of the KB map-CT represents the utilization of correctness and confidence information to reduce or ensure the confidence, correct the misunderstanding, and confirm the accurate understanding of learners, which is the effect of confidence information on automatic individual feedback implementation. The results of the experiment present the improvement of learning achievements and retention of the understanding of learners. The forward transition of the propositions demonstrates that the learners can change INC-CON in the same way as INC-UNC, which is different from the previous experiment in the classrooms in which all learners received the same feedback from the instructor. Moreover, the learners who received the adaptive feedback are also able to associate the appropriate confidence in their understanding more accurately.

5.7 Chapter Summary

The correctness and confidence information is valuable for recognizing the understanding of learners and identifying the degree of learner's understanding. Thus, the adaptive feedback of KB map-CT utilized both correctness and confidence information to correct the misunderstandings of learners and ensure the confidence of learners. The goal map structuring task and the reflection task were developed to support the automatic adaptive

feedback. The experiment in the reading situation was conducted to demonstrate the effectiveness of the adaptive feedback. The results suggest that the adaptive feedback based on the correctness and confidence information can significantly improve the learning achievements. Moreover, the adaptive feedback encourages the ability of learners to discriminate the different understandings based on the correctness and confidence, and encourages the learners to promote their confidence in the correct propositions accurately.

CHAPTER 6

CONCLUSIONS AND FUTURE WORK

6.1 Summary of Studies

The arrangement of KB map on formative assessment presents several situations in lecture classes, where evidence-based feedback strategy was utilized by the instructor for improving the understanding of learners. The concept map strategy was applied to represent the learning goal of the class in the form of a goal map, and to represent the learning evidence in the form of learner map. The learning goal and leaning evidence are constructed by appropriate available methodology of KB map. The propositional level exact matching assessment methodology can indicate the correctness of learning evidence for representing the current understanding of learners, while the confidence of learner reinforced visualization to indicate the quality of learner's understanding. The significant component of KB map is the kit, which is the decomposed components of the goal map. The individual- and group-diagnosis results can be generated automatically based on the equivalent of the components among the goal map and the learner maps. The automatic assessment is the advantage of KB map when the instructors have to recognize the learning situation. The diagnosis results can inform the practical information for capturing an overall understanding of class. Thus, the KB map is integrated concept mapping tool for implementing the formative assessment. The diagnosis results empower the instructors to address the gaps of learners before providing the feedback based on the evidence of learning for helping the learners to achieve the learning goal. The instructors who applied the KB map in their classes accepted and utilized the correctness to ordering and providing the feedback as the primary information. The confidence information is secondary information that the instructor accepted and utilized to ordering and mentioning when they can access the confidence of learners' understanding. The practical uses and experimental uses suggest that the evidence-based feedback can improve the learning achievements in the lecture classes.

The individual feedback is another strategy that adapts the correctness and confidence information to provide the different feedback regarding each learner's characteristics. The goal map structuring task facilitates the instructor to construct the learning goal of class while mapping the related sentence of each linking words concurrently. Hence, the system can reference the related sentences to every linking word. The reflection task of KB map can provide the personalized feedback automatically based on the correctness and confidence information of each proposition in the learner map. The different activities were provided to learners according to the correctness and confidence of their propositions. The preliminary uses demonstrate that the correctness- and confidence-based adaptive feedback can improve the understanding of learners immediately, and the learners' understanding retained in a week later. The result suggests that the adaptive feedback of KB map is an appropriate strategy for improving the learning achievements in the reading situation.

6.2 Future Directions

This thesis focused on illustrating the ability of KB map, especially the gathering and assessing process for visualizing the information of current learning situation. The evidence-based feedback of the instructor can be provided in the lecture class, and the evidence-based feedback of the system can be provided in the reading situation. For future work, more emphasizing on the analysis of the feedback's effect and comparing with the other feedback should be considered to contextualize the effectiveness of evidence-based adaptive feedback. Continuous research may be planned to conduct the comparative experiment between the correctness-based adaptive feedback against correctness- and confidence-based adaptive feedback for analyzing in more detail the proposition transition strictly that can indicate where the direct effect of provided evidence-based feedback, and the retention of the effectiveness. Besides, improvement of the adaptive feedback is possible based on the future results.

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