Application of the Failure-Based e-Learning Process for Building Construction Education

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Abstract—**The purpose of this paper is to improve the current lecture-based approach of building construction education with the PBL method by utilizing construction failure information as educational material. In this paper, the failure-based e-learning (FBeL) process is proposed and tested. The difficulties in implementing PBL in building construction education are described by analyzing the characteristics of PBL. The features of failure information in terms of applicability to PBL are discussed. The FBeL process could be developed as an e-learning system and this could solve the limitation of the current lecture-based approach while building on the advantages of PBL.**

Index Terms—**problem-based learning; failure-based e-learing; building construction education**

I. INTRODUCTION

The Construction industry has emphasized the need for college graduates with soft skills like critical thinking and problem-solving [1]. However, most building construction curriculums in Korea have relied on a lecture-centered approach. To improve this, problem-based learning (PBL) has been widely adopted as an educational strategy and has been proven to be effective [2], [3]. However, when implementing PBL, the characteristics of each course need to be carefully considered in order to maximize the benefits of PBL methodology in terms of the class size, number of group, duration, applicability, and the difficulty level of the presented problems [5], [6].

The purpose of this paper is to improve the current building construction education with the PBL approach by utilizing construction failure information as educational material. In this paper, the failure-based e-learning (FBeL) process is proposed and tested. The FBeL process could be developed as an e-learning system and this could solve the limitation of the current lecture-based approach while building on the advantages of PBL.

II. PBL, FBL AND E-LEARNING

A. Characteristics and Limitations of PBL

Various studies on the characteristics of PBL have been presented and discussed by researchers. The PBL problems can be classified as ill-structured and realistic problems. First, ill-structured problems are defined by the provision of insufficient information. This in turn stimulates students to pose questions in order to explore possible solutions [4]. In addition, the problem-solving process is complex enough to carry out in groups [8]. The learner has to expand his/her thinking process by integrating the fragmented pieces of learned knowledge in the problem-solving process. Second, the realistic problem, which places the learner in practical learning situations, positively affects his/her motivation and interest in finding a solution. Through this, learners indirectly experience the thinking process and apply theoretical knowledge in a closest-to-reality situation [9].

These characteristics of PBL have positive learning effects through the problem-solving process. In other words, the characteristics of the problem-solving process in PBL develop learning outcomes. Through analyzing previous studies, the general PBL process and learning outcomes are summarized as shown in Fig. 1. Many researchers insist that developing a suitable problem is necessary for successful implementation of PBL. However, this is still challenging because the process of creating a PBL problem has not yet been officially published in detail [7]. In addition, it is difficult to adapt PBL to building construction classes because of the lecture circumstances which may impose limitations, such as the number of students and tutors.

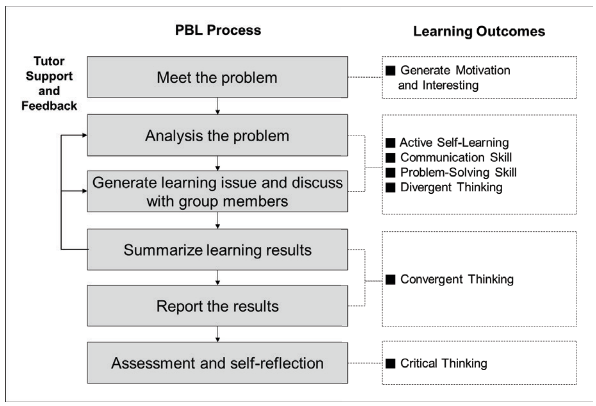

Figure 1. Problem-based learning process.

This work was supported by a National Research Foundation of Korea (NRF) grant, funded by the South Korean government (MEST) (No. 2012-0005662, 2010-0016597).

B. Sutability of e-Learning Using Failure Information in PBL

Lee [7] proposed a failure-based learning (FBL) model that considers traditional PBL's "P" (problem) as FBL's "F" (failure information). He claims that utilizing the failure information in FBL can solve the various limitations of PBL implementation because FBL does not need to develop problems like PBL. Indeed, the failure information of the problem has already occurred. This simple difference makes the adaptation of FBL easy. In terms of developing the problem, construction failure information includes the failure causes and surrounding circumstances, which in itself provides the characteristics of the realistic and ill-constructed problem in PBL. Failure information can be readily found in our surroundings. However, the FBL, as a conceptual model under development, has still not been implemented in lectures.

On the other hand, failure events occur due to various causes, but each failure case has a key point to be managed. Therefore, if the failure information is provided without the main causes, the learners have an opportunity to explore new knowledge through the thinking process in order to understand and solve the failure cause. Therefore, utilizing failure information as the PBL content through an e-learning system could have much potential.

III. FAILURE-BASED E-LEARNING PROCESS AND EXAMPLE

The FBeL process is developed based on PBL utilizing failure information and also considering e-Learning system development. This process has sequential steps that show activities of learner and tutor. And each step is matched by expected learning outcomes. The FBeL process enable learner to explore failure cases in a short period of time experiencing various learning outcomes. The process is shown in Fig. 2. The process is described through an example illustrated in Fig. 3.

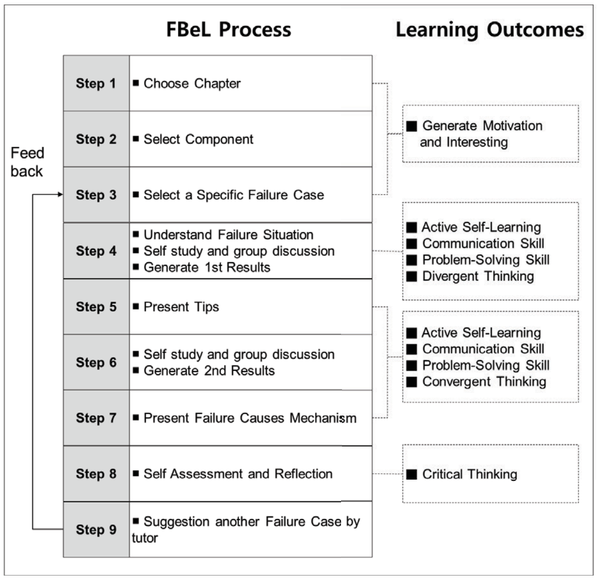

Figure 2. Failure-based e-Learning process.

The suggested the FBeL process was developed to educate college students and new employees in the construction industry. The FBeL content example that was developed concerns a rooftop waterproof construction area. The defects related to water have been pointed out in many studies as a frequently occurring fault. When waterproofing methods are not successful, the cause of the defect is hard to find, and repairs can be time-consuming and costly. In practice, the development mechanism is important to prevent water leakage. The FBeL process comprises nine steps which are illustrated using the waterproofing example:

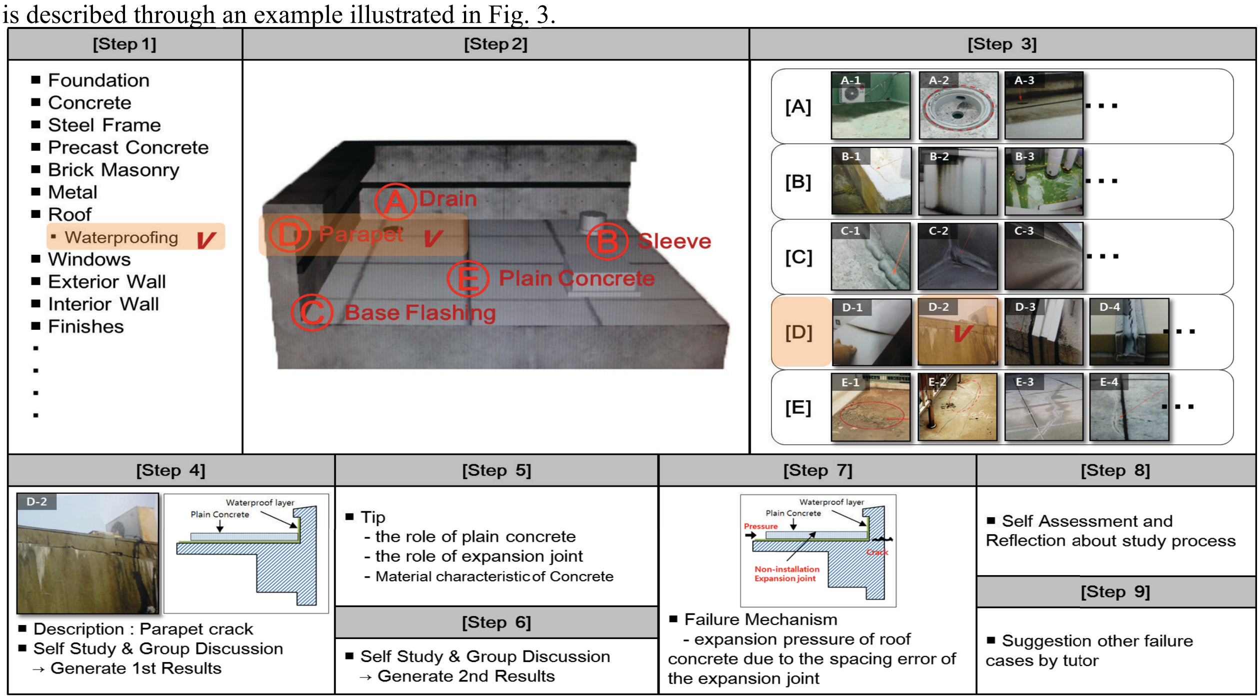

Figure 3. Procedure for implementing FBeL content.

In Step 1, learners choose the waterproofing chapter. Step 2 promotes the understanding of shapes and parts through 3D models, and a point of interest, the parapet, is chosen. In Step 3, among the parapet-related defect information, an item of interest, D-2, is selected. D-2 is a parapet crack defect where the plain concrete for protecting the waterproof layer, due to the expansion of the plain concrete, has put pressure on the lower part of the parapet. The goal of this learning is to understand the characteristics of the concrete materials and the expansion joint spacing, thus connecting a real-life situation to learned theory. In other words, the plain concrete is installed to protect the waterproof layer, but if the basics are not understood, then it may damage the waterproof layer and the other components. Step 4 provides the defect pictures, related 2D drawings, and simple defect explanations. Using this limited amount of information, the learner can draw upon his/her own knowledge of construction method theory to find the cause of the defect. This allows the learner to experience the process of divergent thinking. The group members can carry out their study of the cause of the defect on their own, and freely show their first conclusion on the web. The tutor can then see the learners' conclusions online and, if the discussion moves in the wrong direction, he/she can provide feedback to steer them back on track. Step 5 provides tips to streamline thinking into a more analytical and critical thought process. In this instance, the tips provided are the role of the plain concrete, the role of the expansion joints, and the material characteristics of the concrete. Step 6 gathers the opinions of the group members, based on these tips, to come up with their final conclusion. Step 7 shows the defect causes in a diagram format, and reveals the defect occurrence mechanism. Step 8 compares the discussions of the group members with the actual cause of the defect to allow learners the opportunity to evaluate and reflect on their deliberations. Step 9 allows the tutor to provide similar defect cases to assist the learners' understanding based on their conclusions, and apply these to the other cases. For example, the concrete defects are E-1~4 and C-1, and the expansion joint defects are E-2, 3, and 4.

IV. Evaluation of Failure-Based e-Learning Process

To evaluate the FBeL process, the test was carried out with six college students and eight new employees. After the test, the learning outcomes (ability to generate motivation and interest, active self-learning, communication skills, problem-solving skills, divergent thinking, convergent thinking, and critical thinking) were evaluated through a 7-point Likert scale, and questions on the feasibility of the e-learning system were asked in individual interviews.

Most learning outcomes resulted in a range between 5 and 6 points on the Likert scale, which is a relatively positive response, but communication skills were evaluated as quite low, with 1 to 4 points, due to the short test time and non-systemic test process. Learners gave positive responses because, among other reasons, they felt they were able to go through a thinking process to find the cause when limited clues for the failure case were given, despite the short test time. In terms of the learners' evaluation of the efficiency of the FBeL process itself, the majority agreed that, if the key failure cases are well established for the overall chapters, then they would be highly utilized.

V. Conclusion and Disccussion

The purpose of the FBeL process is to improve the limitations of the current building construction education as well as gain the PBL effects by utilizing failure information. Compared to designed problems, the actual failure case provides real pictures taken on construction site, which enables learners to better understand the field situation with interest. In addition, the FBeL process can be utilized in a short period of time through an e-learning approach, which can improve the PBL application problems in real lecture. For the feasibility of this process was evaluated through interviews. The results show that the proposed process helps learners in cultivating the problem-solving skill and critical thinking. However, the merits of PBL like interpersonal skill were difficult to obtain. This process could be adopted at various engineering areas by analyzing the characteristics of failure information occurred at each field. In conclusion, even though the potentials of the proposed the FBeL process are described with the simple test, as future work, the system applicability should be developed more clearly under e-learning environment such as the way to select and organize suitable failure information, the way to enhance group working, and the database structure of failure information.

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