Chapter 6

A Knowledge-building Process in Interaction-based E-Learning

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Additional information is available at the end of the chapter

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Abstract

This research articulates a knowledge-building process in interaction-based e-learning. For exploration of a knowledge-building process, an interaction-based e-learning program was developed and implemented at a college level course. Throughout the course, quantitative and qualitative data including students' perceived knowledge-building process from questionnaires, online messages, interview data, and participatory observation journal were collected and analyzed. As results, an observable action model and a conceptual model of the knowledge-building process were derived, which students and experts verified. Cognitive achievement factors and satisfaction factors were also considered in the knowledge building process model. Meaning and implication of each stage in the model were discussed.

Keywords: Learning process mechanism, CSCL, knowledge building, distance learning, interactive e-learning

1. Introduction

Education at a distance is becoming increasingly *interactive* with the ever sophisticated advances in web technology and therefore, interactive learning supported by the technology becomes a more significant field than ever, raising lots of critical issues in research and practice. Interaction-based e-learning may host many modes of communication, such as threaded discussion forums, chat, email, wiki-based boards, etc. Most of the research persists positive effects of interaction and present various strategies to improve the interaction for better learning [1, 2].

Although much of the research emphasizes the effectiveness of interaction and strategies to make the interaction more active and effective in an e-learning environment, why and how the interaction or strategies are effective has not yet been studied enough. There are some conceptual and theoretical articles on knowledge-building [3, 4]. However, there is a lack of theoretical research on a knowledge-building process based on empirical implementation. To find out more effective instructional strategies in interactive distance learning, we need to first understand how the knowledge-building process works in interaction-based e-learning[1].

Knowledge-building is said to be differentiated from *learning* [3, 5]. In [3], "Learning is an internal, unobservable process that results in changes of belief, attitude, or skill. Knowledge-building, by contrast, results in the creation or modification of public knowledge"(p. 1371). [3] also described that "knowledge-building environments enable ideas to get out into the world and onto a path of continual improvement in a form that allows them to be discussed, interconnected, revised, and superseded"(p. 1372). It focuses more on building knowledge-in-the-world as opposed to knowledge-in-the-head. To understand how the process mechanism is going and to find out better instructional strategy in interaction-based e-learning, the observable knowledge-building process rather than the internal learning process would be more useful. Also, the knowledge-building process should be more clearly disclosed in an interaction-based learning environment with active social communication, rather than resource-based instruction for basically individual learning.

The purpose of this chapter, therefore, is to articulate a knowledge-building process in interaction-based e-learning. This research is concerned with how individuals and groups build their knowledge and construct meaning in interaction-based e-learning. This research also considers learning outputs, such as cognitive achievement or satisfaction levels, for better comprehensive understanding of the knowledge-building process.

This research will focus on a process-oriented approach; such an approach is focused on '*where* it makes a difference' rather than '*whether* it makes a difference'. Many other studies that utilize a learning *product-oriented* approach—such as comparative studies of learning results with the application of certain strategies—showed various differences on their effectiveness. However, it is said to be no significant difference by meta-analysis of each research result [6]. This 'no significant difference phenomena' indicates that research needs to shift from finding differences to reasoning the cause of differences. This research focuses more on *process* than product, and presents a more meaningful contribution in the theory and practice of interactive e-learning.

2. Theoretical background

The learning process has been studied by learning psychologists in behaviorism, cognitivism, or constructivism; however, learning mainly occurs in our brain which is basically non-

1 Since there is a kind of e-learning that is for self-learning based on e-contents with little to no interpersonal interaction, this research specifies interaction-based e-learning to focus more on highly interactive e-learning. Computer and network technology have contributed into two ways in teaching and learning; one is for developing effective contents, and the other is for enhancing interpersonal interaction. Contents-based self-learning, pretty popular in Korea, is based on one-way e-contents mostly in the form of VOD (video-on-demand) or WBI (web-based instruction). To eliminate the contents factor, the course developed in this research was interaction-based, with the minimum pre-developed contents.

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observable. Only the consequences of learning can be observed. So many studies have dealt with the learning consequences rather than the learning process. However, in many cases, those studies generally turn out to be statistically insignificant when one tries to be rigorous about the learning outcome [6]. Therefore, [5] suggests that we should use the term, knowledge-building rather than learning, especially in regard to collaborative and interactive learning. According to Stahl [4, 5], knowledge-building is more tangible, concrete, and descriptive than learning. This term, knowledge-building, seems to include the whole process of external activity influencing on learning as well as internal learning itself within the brain. With care and practice, the knowledge-building process can be observed directly and empirically, because it accounts for externally observable activities and artifacts as experiential evidence. Therefore, we will use the term knowledge-building instead of learning to specify the observable and empirical approach to this research.

One who tried to disclose the knowledge-building process in interactive e-learning, such as Computer-supported Collaborative Learning (CSCL), was Stahl [4]. Stahl presented a diagram of a knowledge-building process in CSCL from theoretical discussion. His diagram consisted of two circles: one of personal understanding and the other of social knowledge-building (see Figure 1). Stahl [4] described the diagram as "*The convention in the diagram is that arrows represent transformative processes and that rectangles represent the products of these processes: forms of knowledge. To take this limited representation too seriously would be to reify a complex and fluid development—to put it into boxes and to assume that it always follows the same path. In particular, the diagram gives the impression of a sequential process whereas the relations among the elements can take infinitely varied and complex forms. Indeed the identification of the particular set of elements is arbitrary and incomplete. Perhaps despite such limitations and potential distortions the diagram can provide a starting point for discussing a cognitive theory of computer support for knowledge-building. It remains to be seen if such a phase model provides the most useful representation (In [4], pp.71)*."

He explicitly considered the relationship of processes associated with individual minds to those processes considered to be socio-cultural. The significance of Stahl's model is that he indicates the importance of social learning, which is considered to be essentially different from individual self-learning. He suggests that knowledge would be shared and constructed by social interaction in a CSCL environment. He is taking a social constructivist's perspective in which his work impresses upon a sequential process to knowledge-building and provides a starting point for discussing cognitive theory of CSCL as indicated in his research [4]. However, his model was derived from theoretical discussion and it wasn't verified by empirical evidence. As he mentioned in several papers [4, 5, 7], the research community should elaborate upon the knowledge-building process model by utilizing empirical research.

Besides, many studies on modeling the learning process have been reported [8]. Most of them, however, use a face-to-face learning environment or do not utilize empirical evidence. Moreover, they present linear learning procedures and do not consider other factors such as influential relationship between process and product. Therefore, a study on a comprehensive knowledge-building process that considers the learning output variables, such as cognitive achievement and satisfaction levels, as a form of empirical evidence is needed.

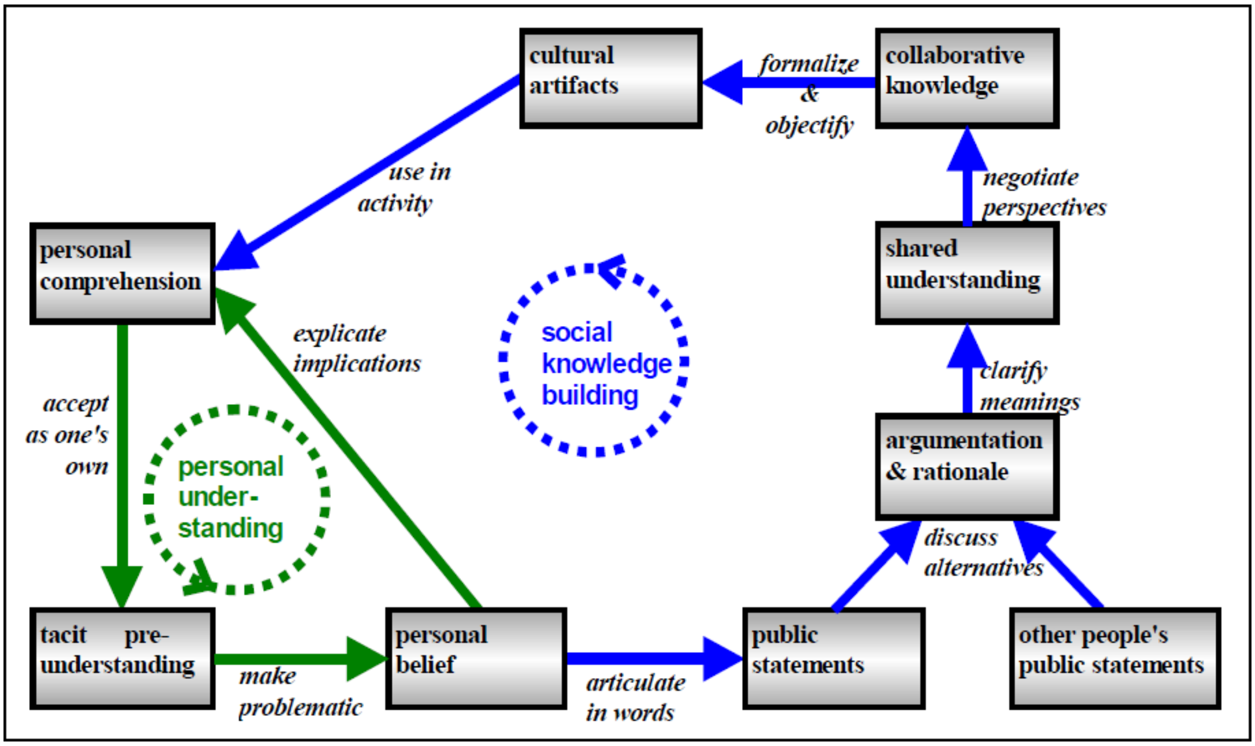

Figure 1. A diagram of the knowledge-building processes [4].

3. Method

In order to articulate a knowledge-building process, an interaction-based e-learning course at college level was developed. Four experts in instructional design practice verified the course program throughout the development process. The subject of the program was 'General Understanding of Distance Education'. Fifty-six juniors at K Cyber University in Korea, from ages 20 to 50, were required to partake in team interactions assigned in the class for a period of eight weeks. Throughout the course, the students' perceived knowledge-building process was collected and analyzed from questionnaires. Cognitive achievement tests, satisfaction queries, online messages, interviews, and participatory observation data were also collected and analyzed. Various methods of statistical analysis including correlation analyses, contents analyses, t-tests, frequency analyses, etc. were applied to the data as well. For students' perceived knowledge-building process, each student was required to describe his/her own knowledge-building process four times during the course. Four times investigations helped how students' perception changed throughout the course progress. Average return rate of the each questionnaire was 84% out of all 56 students. Question items were as follows:

- How many hours per week do you spend for this course?

- Which learning step do you spend the most time on? Write your answers in order.
- What influences your examination the most?
- While working on an assignment, what do you rely on the most?
- What is the most critical satisfactory factor in this course?
- What was dissatisfactory in the course?
- How often do you access to the web class?
- Describe your knowledge-building process in order. Write every single visit and activity on the web class site during your stay as detailed as possible.

For evaluation reliability, three evaluators graded 10% of the students' answer sheets and their responses were correlated (Pearson $r=0.84$, $p<0.01$). In terms of satisfaction level, a satisfaction measurement tool that was developed and validated by [9] was used after modification (reliability alpha=0.93).

After the course, 10 students were interviewed by telephone for 1–2 hours to verify all the quantitative data and to provide more detailed information regarding the factors of the knowledge-building process. The interview first started with the questions similar to the questionnaires in a flexible and unstructured manner and proceeded naturally to verify the knowledge-building models (an observable action model and a conceptual model reflecting the action model and other previous literature). All interview data were recorded and analyzed afterwards.

In the end, the conceptual model was verified by five experts (Ph.Ds. in Education) and ten students in the class. Respondents used a 5-point Likert scale (5 = fully verified, 1 = not verified), which was developed based on previous literature [1, 10] to rate validity, explicability, usability, generality, and comprehensibility of the conceptual model. Average rate of experts was 4.30 and average rate of students was 4.11 out of 5.00.

This study followed Rubinstein's [11] proposed procedure for modeling the knowledge-building process. According to Rubinstein, the modeling procedure is to achieve a simple high level of abstraction. So the procedure needs to be iterative until we get an abstractive pattern. In considerations of Rubinstein's perspective, the procedure in this research was as follows; Development of a treatment instructional program → Implementation of the program and collecting data → Coding questionnaire data → Deriving a rough pattern of the knowledge-building process → Analysis of learning output variables → Correlation of learning output variables and each stage of the knowledge-building process → Verification of the knowledge-building process action model by interview with learners → Conceptualization of knowledge-building process and its actual visualization → Verification of the conceptualized knowledge-building process model by experts and learners → Production of the verified conceptual diagram of the knowledge-building process in interaction-based e-learning. The more detailed procedure is shown in Table 1.

The modeling procedure of the Learning Process in this study	Product
Develop a treatment instructional program	Interaction-based e-learning program
↓	↓
Implement the program and collect data	4 questionnaires and online message analysis
↓	↓
Make first coding of four questionnaires	17 steps of the knowledge-building procedure
↓	↓
Make second coding of four questionnaires	10 main stages and some sub-steps of the knowledge-building procedure
↓	↓
Derive a rough pattern of the knowledge-building procedure	Visualization of the knowledge-building procedure
↓	↓
Analyze learning output variables	Student achievement, satisfaction
↓	↓
Correlate learning output variables and each stage of the knowledge-building process	First visualization of an action model of the knowledge-building process in consideration of learning output variables
↓	↓
Implement interview with learners	Interview recording data with 10 learners
↓	↓
Analyze interview results to verify the model	Decoding the recording, → contents analysis, → first categorization, → coding and second categorization
↓	↓
Derive a verified action model of the knowledge-building process	Visualization the action model of the knowledge-building process
↓	↓
Conceptualize the knowledge-building action process	Visualization of the conceptualized knowledge-building process
↓	↓
Validate the conceptual model of a knowledge-building process	Validation the conceptual model of a knowledge-building process by 5 experts and 10 students
↓	↓
Produce the verified conceptual model of the knowledge-building process	The verified conceptual model of a knowledge-building process in interaction-based e-learning

Table 1. Research procedure of this study.

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4. Results and discussion

4.1. An observable action model

To explore a knowledge-building process in interaction-based e-learning, we coded 56 students' perceived learning procedures in questionnaires and derived an average pattern of the students' knowledge-building process. The students' perceived learning procedure after first coding was composed of 17 stages as follows:

1. reading notices & information of the department
2. reading notice of the course
3. reading the Q/A board
4. posting messages on the free board or the Q/A board
5. reading messages on the discussion board
6. studying web-based material
7. editing and printing web-text
8. doing assignments
9. searching other materials for reference
10. reviewing peers' posting and teacher's feedback on it
11. posting questions or replies on the discussion board
12. offline interaction (telephone or offline meetings)
13. assignment submissions
14. checking the teacher's feedback
15. reflection
16. resubmitting assignments after revision
17. checking my individual learning pace in the LMS (learning management system)

Among these items, activities receiving less than 10% frequency of use were removed after first coding, and the learning procedure was re-coded iteratively until an average main pattern of the process was found. Thus, #1, #12, and #17 items were removed, and other items were relocated to the basic default procedure of #6, #8, #13 cycle; studying web-based material, doing assignments, assignment submission. Finally, ten main stages and some sub-steps were induced. For main stages: #6, #8, #13 basic cycle (studying web-based material, doing assignments, assignment submission); #14, #15, #16 activity (checking the teacher's feedback, reflection, resubmission after revision); #4, #5, #10, #11 activity (posting messages on the free board, Q/A board, discussion board, reviewing peers' posting and teacher's feedback on it, posing questions and replies on the discussion board). Sub-steps that students do sometimes but are not that critical according to the frequency are #2, #3, #7, and #9 (reading notice, Q/A board, editing and printing web-text, searching other materials for reference). All stages were analyzed and correlated with learning output variables such as cognitive achievement testing or satisfaction queries. In addition, all messages on each web board were analyzed and categorized by characteristics of message content, SDU (Social Discussion Unit), PDU (Procedural Discussion Unit), and CDU (Contents Discussion Unit), following the classification of [12]. An observable action model of knowledge-building process, in which all stages were rearranged with a logical sequence, was finally derived as shown in Figure 2.

In Figure 2, subscript 1) represents a cognitive achievement factor and subscript 2) indicates a satisfaction factor. Subscript 3) shows features of messages, such as SDU (Social Discussion Unit), PDU (Procedural Discussion Unit), and CDU (Contents Discussion Unit), categorized by [12]. Subscript 4) represents the form of interaction, such as S-C (Student-Contents), S-T (Student-Teacher), S-S (Student-Student), categorized by [13].

In the student-contents interaction (S-C) circle, students come in contact with the web material and are then involved in the process of doing the assignments. While students process their assignments, they interact with other students. This kind of action leads to the student-student interaction (S-S) circle. Meanwhile, when students get feedback from their instructor after submitting their assignments, they check and reflect the teacher's feedback. These steps are for production of assignments. This kind of action is categorized as student-teacher interaction (S-T). Throughout this entire process, students read notices and information on the bulletin board concurrently.

In the student-student interaction (S-S) circle, students referred to peers' finished assignments, read messages on the discussion board, and post messages that are social, procedural, and academic in characteristic. Students were able to see other classmates' finished assignments because all students were supposed to post their assignments on an open discussion board for this research.

In the student-teacher interaction (S-T) circle, after submitting their assignments, students receive and review the teacher's feedback on their work. After reflection, some students revised their assignments and resubmitted them.

Regarding posting messages, the numbers of postings of each student were analyzed with achievement score by correlation analysis. Only CDU was significantly correlated to achievement score by $r=0.455$($p<0.05$, $N=52$), and to satisfaction score by $r=0.407$($p<0.01$, $N=52$). As expected, posting SDUs or PDUs did not show significant correlation with cognitive achievement.

Satisfaction level result measured by a modified satisfaction scale of [9] 's was correlated to each stage of the action model in Figure 2, and found significant correlations only with "check the teacher's feedback", "read the messages on the discussion board", and "post CDU"($p<0.05$). With respect to the cognitive achievement factor, the students who checked the teacher's feedback showed significantly higher scores than the students who didn't check the teacher's feedback (Table 2). Table 3 shows that students reading messages on the board had higher scores in the final examination than students who did not read the messages.

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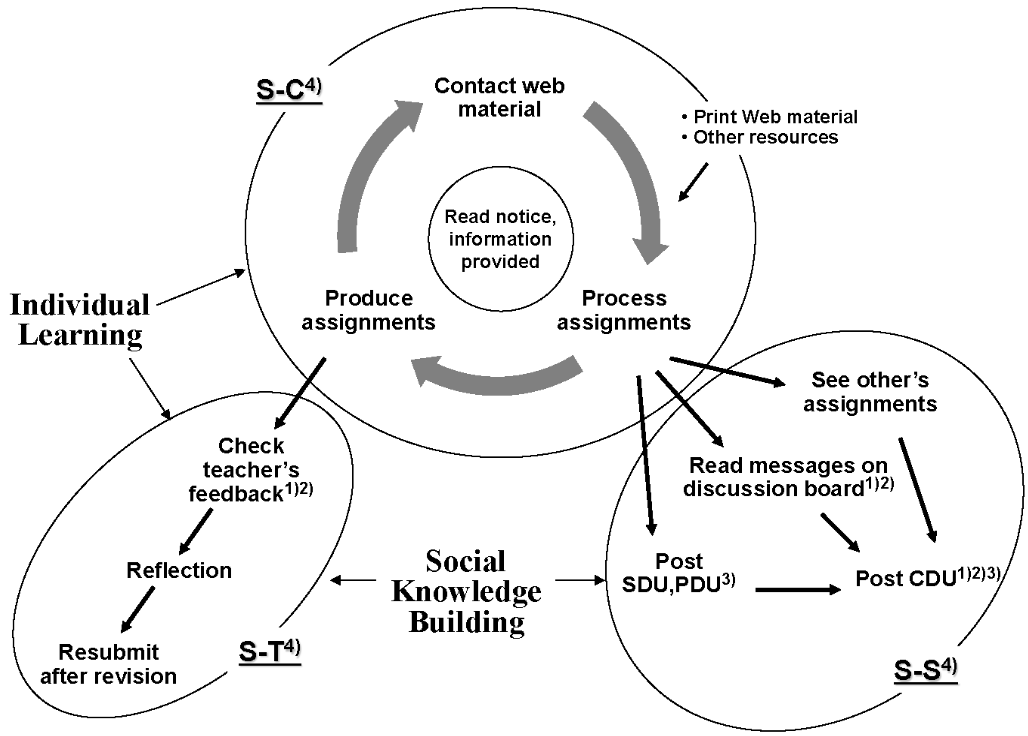

Figure 2. An observable action model of a knowledge-building process in interaction-based e-learning: 1) Cognitive achievement factor; 2) Satisfaction factor; 3) SDU(Social Discussion Unit), PDU(Procedural Discussion Unit), CDU(Contents Discussion Unit); 4) Interaction types (Students-Contents(S-C), Students-Students(S-S), Students-Teacher(S-T).

Group	N	Mean	St. Dev.	df	T
Students who checked the teacher's feedback	19	66.63	21.10	24.07	2.43
Students who did not check the teacher's feedback	33	79.33	11.31		

$p < 0.05$

Table 2. t-test result: Whether checking the teacher's feedback is a critical achievement factor.

Group	N	Mean	St. Dev.	df	T
Students who read the messages on the board	11	65.82	23.09	50	2.06
Students who did not read the messages on the board	41	79.07	13.80		

$^{*}p < 0.05$

Table 3. t-test result: Whether checking the teacher's feedback is a critical achievement factor.

Reading messages on the discussion board, posting CDUs, and reviewing the teacher's feedback are figured as satisfaction factors by frequency analysis and correlation analysis ($p<0.05$). Unexpectedly, the student achievement factors are the same as satisfaction factors in this case, but this could not always happen in other cases. It needs further investigation to differentiate the influence of achievement and satisfaction.

4.2. A conceptual model

The observable action model is abstracted into a conceptual diagram (Figure 3) in consideration of previous research [4, 14]. In Figure 3, the bold solid arrows show a major knowledge-building process and the fine solid arrows show a back process or a minor process that did not occur all the time. The conceptual model of the knowledge-building process in interaction-based e-learning constitutes two phases: a minor individual learning phase and a major social knowledge-building phase. Even though social learning is a major part of the knowledge-building process in interaction-based e-learning, individual learning occurs almost concurrently or alternately with social learning. Although the instructional program in this research was designed mainly for interactive learning, students experienced self-learning with brief material provided in the class to learn basic information for discussion preparation. So an individual learning cycle must be shown with the social knowledge-building cycle concurrently. Explanations of each stage are described below.

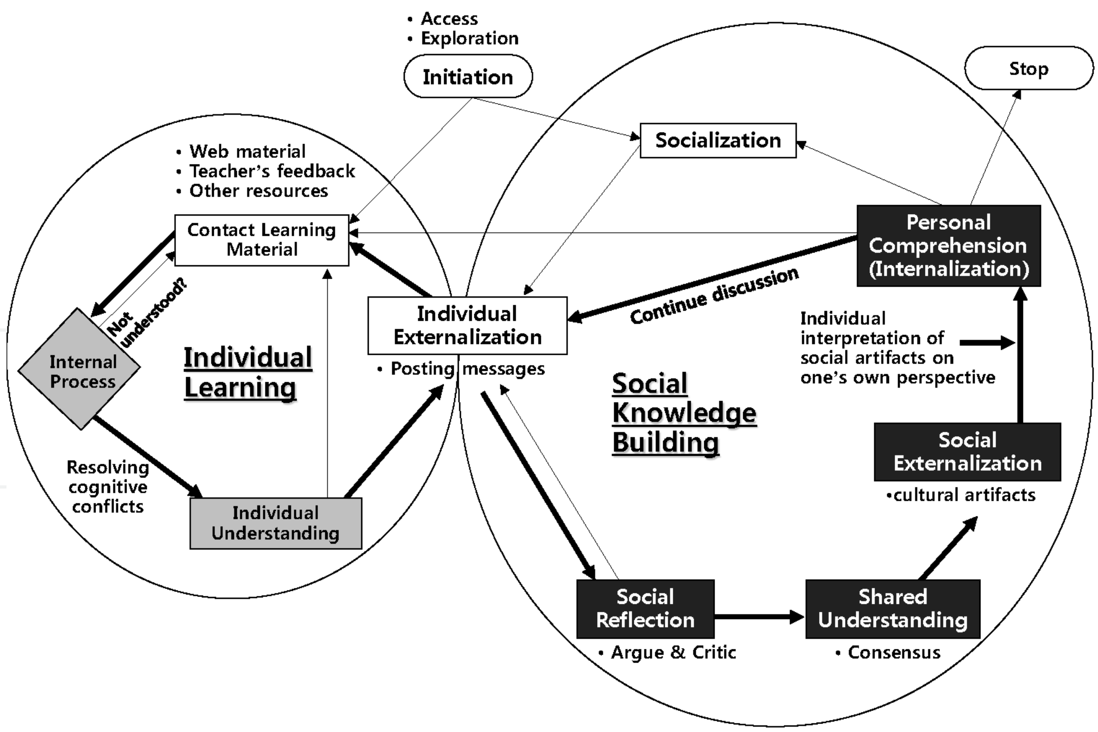

Figure 3. A conceptual model of a knowledge-building process in interaction-based e-learning (▭: from empirical evidence, ▭: from previous literature, ▬: from previous literature and empirical evidence; : major knowledge-building process, : minor knowledge-building process).

4.2.1. Initiation

In the individual learning phase, the process begins with initiation. Initiation includes access and exploration of the program sites such as reading notices or announcements, clicking menu options, etc. But this activity is not a main learning process; rather it is a pre-activity before the learning process. Once students get used to navigating their way around the site, they usually skip this stage and go to the main learning process directly. So the initiation phase is located outside of the learning cycle.

4.2.2. Contact with the learning material

After initiation, learners come in contact with the learning material that includes the web-based instruction program, ongoing teacher's feedback, or other online/offline resources. The reason why we differentiated the stage of contact with the learning material from other stages such as internal process and understanding is because even though students come in contact with the web lecture, it doesn't mean that they are really engaged in learning. If students enter the web lecture and click each page of the web material, it is possible that they are just clicking through the program, which is far from genuine learning. So this stage of coming in contact with the learning material should be differentiated for articulation.

4.2.3. Internal process

When learners digest the learning material, an internal process must take effect in their brain, which is not observable but explained by many learning theories. This is for intra-personal communication represented by thought. What's going on in this internal process will not be discussed here because it is beyond this study's scope, but it is obviously appropriate to put this step as one of the stages in the learning process model here. If students understand the contents well enough after the internal process, they arrive at an individual understanding. Otherwise, they return to the learning material and repeat this cycle until they understand the material.

4.2.4. Individual understanding

If a learner's cognitive conflicts are resolved through this internal process, students arrive at an individual understanding. Similar to Stahl's model [4], this is distinguished from personal comprehension by internalization. Although we guess that we understand something, we often find that we are unable to explain what we have learned immediately. That is because the knowledge is not fully internalized yet, though it may be slightly understood. Individual understanding, therefore, could be considered a lower level of comprehension. That is, knowledge is not internalized to a learner yet in the stage of individual understanding.

4.2.5. Individual externalization

In the e-learning course in this study, students post what they learned from the material after individual-understanding; this action is conceptualized as individual externalization in this research. Students also post messages following socialization or internalization on the knowledge-building cycle. That is, students express what they learned from social learning or individual learning. So this stage shows two facets: one is a summary of the individual learning phase and the other is the first step to the knowledge-building phase, which also follows the socialization or internalization process. The stage of individual externalization seems to be similar to making personal belief elicit to public statements in Stahl's model [4].

4.2.6. Socialization

Students participate in discussions by posting messages of what they learned through individual learning or just by socialization. In the knowledge-building phase, students begin to take part in the discussions by posting social messages (SDUs) or asking about procedure (PDUs); this non-academic activity is for their social affinity and rapport. This is conceptualized as socialization in this study. This does not always happen. Once students are socialized enough (SDU), they usually skip this stage and go straight to posting CDUs (individual externalization) after final personal comprehension of one thing. In this study, only 16% of the messages were SDUs. They are shown as fine solid arrows rather than bold arrows in order to represent a minor process. After socialization, students post content-related academic messages (CDUs) on the discussion board, which is expressed as individual externalization, as mentioned above.

4.2.7. Social reflection

When several individuals' messages are posted on the web board, students argue and criticize others' opinions. That is called social reflection in this study. Stahl [4] presents this stage as critic and argument of other people's public statements and discussion of alternatives. Social reflection is a corresponding concept to individual reflection; while one is from inter-personal interaction and the other is from intra-personal interaction, both are basically similar activities in regard to learning in a precise and concrete manner.

4.2.8. Shared understanding

Through social reflection, students obtain consensus on a topic to arrive at shared understanding. Shared understanding is distinguished from individual understanding. This stage implicates that meaning is constructed by social practice as [4]. Social constructivists assert that meaning is constructed by social interaction until people share a common understanding. Shared understanding is from interpersonal interaction, whereas individual understanding is from intra-personal interaction.

4.2.9. Social externalization

When one of the team members summarizes his/her cultural artifacts—product of discussion, summary of consensus like Stahl [4] mentioned—this activity is conceptualized as social externalization that is differentiated from individual externalization. While individual externalization consists of activities such as note-taking or summarizing of what students understand individually, social externalization consists of external expression of socially

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constructed and shared understanding. Usually one of the team members posts his/her summary or conclusion after discussion, while other team members watch and apply corrections if there is something incorrect or missing.

4.2.10. Internalization

Finally, students internalize knowledge into their personal comprehension schema. How knowledge is internalized into a personal comprehension schema after social externalization is one of the critical issues. In [7] on Meaning and Interpretation, he indicates that meanings in computer-supported collaborative learning are necessarily shared and must be interpreted by individuals. That is, learners interpret social artifacts, which are constructed by social interaction, on each individual's own perspective to reach personal comprehension. This is the only stage of intra-personal and non-observable stage in social knowledge-building, whereas other stages are mostly inter-personal and observable.

Another piece of empirical evidence of this process is that students who only read messages were found not to be inferior to students who write and post messages in terms of cognitive achievement ($p<0.05$). In this research, reading messages as well as writing and posting messages were found to be a critical achievement factor and a satisfaction factor. This finding implicates that one can get meaningful learning though he/she doesn't partake in social externalization after obtaining shared understanding; if one is not a team representative who is summarizing their discussion, he/she is hardly able to get an opportunity to externalize what they share from social reflection and just to watch and read other's externalized messages. In spite of not partaking in social discussion, these students showed high cognitive achievement just like those who posted social externalization messages. This means that there is some process for those who don't undertake observable externalization. It may be explained that people internalize their shared understanding by interpreting of social artifacts with each individual's own perspective to reach personal comprehension.

Regarding satisfaction, there was no significant difference between students who actively participated in social discussion by writing and posting messages and students who only read messages on the board ($p<0.05$). This implicates that students who only read messages also get meaningful learning and satisfaction through the dynamic interaction in the web class and there must be a certain stage to go to internalization. One study [15] gives a significant implication in this context. In [15], perception of overall interaction was a critical predictor of satisfaction. They suggested that overall dynamics in interaction might have a stronger impact on learners' satisfaction than strict personal participation. That is, vicarious interaction within the class as a whole than overt engagement of each participant may result in greater learner satisfaction. Therefore, reading only in a certain period of knowledge-building process could be considered as a meaningful learning activity.

5. Conclusion

This research was conducted to explore and articulate the knowledge-building process in interaction-based e-learning. For exploration of a knowledge-building process, an interaction-based e-learning program was developed and implemented at a college level course. Throughout the course, quantitative and qualitative data including the students' perceived knowledge-building process from questionnaires, online messages, interview data, and participatory observation journal were collected and analyzed. As results, an observable action model and a conceptual model of the knowledge-building process were derived, which students and experts verified. Cognitive achievement factors and satisfaction factors were also considered in the knowledge-building process model. Meaning and implication of each stage in the model were discussed.

The significance of this research is as follows: first of all, this study provides a conceptual framework for understanding a knowledge-building process in interaction-based e-learning such as online discussion learning. The model presented here was better articulated and elaborated based on empirical evidences, indicating social knowledge-building cycle is critically important in interaction-based learning. Historically learning has believed to occur within one's brain from an ultimately individual process. The results in this research provided a conceptual framework saying that there are two cycles and the social learning process as well as individual learning process is critical in interaction-based e-learning. Personal cognition and social activity might not be able to be separated artificially like the model in this research. Stahl [4] indicates by citing Hegel that it is the nature of a relationship of mutually constituting subjects: neither can exist without the other. But this kind of sequential visualization provides a more useful and clearer understanding of the knowledge-building process in interaction-based e-learning.

Second, this article provides a beginning to explain a mechanism of certain effectiveness of observable phenomena. For example, the report in [15] that vicarious interaction was a significant predictor of learning output could be correlated with the result that reading—as well as writing—messages on the discussion board was an achievement factor and a satisfaction factor. It is possible to explain that people learn sometimes by only reading even in interactive learning because people interpret social artifacts from socially shared understanding with an individual's own perspective to get to personal comprehension.

Third, several instructional design strategies such as externalization or group dynamics can be recommended. An interesting implication of this research is that if a student does not externalize either individually or socially, he/she cannot internalize the knowledge properly. This implies that instructors need to design *externalization* of a student's understanding as a requirement such as a 'Reflection paper' or 'Today's learning note', etc. Students who did not post messages actively during the class discussion could be required to wrap up the fierce discussions in order to experience group dynamics as well as externalization.

Besides, the knowledge-building process research in a resource-based self-learning environment or their comparative study can be proposed for further study. Research of more cases in various learning contexts or considering more various learners' characteristics will also contribute to elaborate and generalize the model presented in this research and will enrich understanding of the theory and practice of interactive e-learning.

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Note. This research was conducted while the author was at Seoul National University in Korea. An early version of this chapter was presented at 2008 ICCE (Lee, 2008). Lee, Hye-Jung (2008). A Learning Process Mechanism in CSCL. Proceedings of ICCE 2008, Taipei, Taiwan, pp. 261-268.

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