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Design-based Learning: Conception and Evaluation of Group Awareness Mechanisms

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Abstract: A crucial type of awareness in collaborative applications is *group awareness*, which refers to the information of the group and its members, such as their location, the tasks they develop, knowledge, interests, and feelings. To learn concepts related to group awareness, a training experience based on the model named *Design-Based Learning* was implemented. The goal of this work was to analyze the perception of Software Engineering students from the Autonomous University of Yucatan, Mexico, regarding the implementation of the experience using the mentioned model. The methodology used was exploratory, with a mixed approach through a case study. The results indicate a favorable perception of the students about their level of development of skills such as creativity, problem solving and organization for teamwork in the development of their solutions. As future work we intend to implement the model in several Software Engineering courses in order to measure its impact on student learning.

Keywords: CSCL, design-based learning, DBL, group awareness.

I. INTRODUCTION

Collaborative application development includes the design of awareness mechanisms, which are crucial elements that keep group members informed about joint work and mediate communication, coordination, and collaboration among them [1, 2].

In Computer Supported Collaborative Learning (CSCL), group awareness refers to information about a group and its members, such as their current location, the tasks they are performing, the knowledge, and interests [3]. In [4] Dehler et al. define three basic groups of group awareness considered crucial for effective communication: cognitive, social, and behavioral.

The importance of learning concepts related to group awareness for effective collaborative applications is highlighted by [4]. Also, In [5] Li et al. consider it necessary to design and implement instructional programs that guide and inspire students in the development of tools that include group awareness in diverse learning contexts. In addition, we consider the promotion of learning based on the active participation of the trainee as a priority, involving the development of critical thinking and problem-solving skills in such learning.

In order to improve traditional session-based teaching, researchers suggest using *Design-Based Learning* (DBL) as a teaching strategy [6, 7]. DBL places students in real situations and guides them in designing solutions with relevant domain knowledge in the problem-solving process [6, 8]. Likewise, DBL allows students to learn through practice and use the knowledge learned in the classroom to accumulate practical experience and integrate it into real situations [9]. Although the DBL model has been successfully used in countries such as China, Australia, the United States, and Denmark [10, 11, 12], we consider it necessary to test its effectiveness in Mexican contexts to enrich our formative processes.

The main goal of this work is to analyze the perception of Software Engineering students, from the Tizimin Multidisciplinary Unit, belonging to the Autonomous University of Yucatan, Mexico, regarding the implementation of the DBL model, specifically in the Collaborative Systems subject, which is part of the academic curriculum as a specialization course. This subject involves students from sixth semester onwards. In addition to the development of model implementation activities, two instruments were designed and used: the first to collect students' perceptions about the usefulness of the model, and the second to identify both the perceived benefits and limitations of its implementation.

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Indeed, this research is delimited by the implementation of the DBL model in a crucial topic of the subject such as group awareness. However, we believe that the obtained results will allow us to replicate and improve the implementation of the model in order to facilitate the teaching-learning process on topics of various subjects and thus contribute to the development and improvement of skills such as critical thinking, collaborative design of solutions, and integration of experiences in real situations.

II. MATERIAL AND METHODS

To answer the proposed goal, an exploratory research was carried out with a mixed approach through a case study. For the development of each one of the exercises of the study, four teams of three members each were defined, as well as the activities to be carried out, which are described in the block diagram of figure 1. This diagram is an adaptation of the focal areas' diagram proposed in [13].

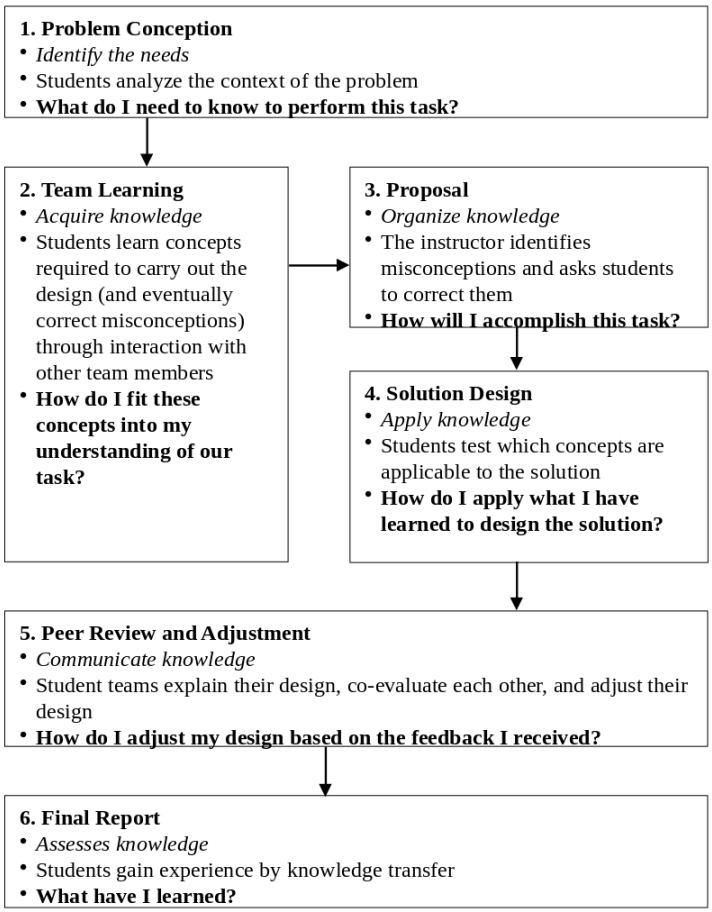

Fig. 1. Block diagram of the activities carried out in the case study (adaptation of the focal areas' diagram proposed in [13]. Each block corresponds to a teaching method or team milestone. Each bullet in the block indicates the goal, the activity description, and a question related to the student's perception of the block.

Given the goal pursued, the unit of analysis chosen for the case study was the entire group of participants in the subject. The reason is that the analysis of students' perceptions should be measured as a holistic case under the same study context. The case study protocol was developed in accordance with the guidelines established in [14].

The three exercises defined for the teams are described below:

A. *Design of a group awareness' mechanism to identify the acceptance level of the team's members with respect to each module (included in a list) of the system to be coded.* Such a mechanism should serve as support in the team's decision-making to include specific modules in the software system.

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B. *Design of a group awareness' mechanism to identify the difficulty level of a series of problems to be solved*. The difficulty level of each problem requires to be set by one or more members of the team. The mechanism must be located in the collaborative system as a means of interaction for team members who are about to solve a series of problems (for example, a list of problems for a programming contest). The mechanism must provide information on the perception of other team members about the difficulty level of each problem, in order to determine the order of resolution.

C. *Design of a group awareness mechanism to identify the status of toilets and sinks in a building (to determine if they should be repaired or replaced).* Item status can be set by any member of a contracted plumbing repair crew on a system-provided map. This mechanism must be located in the collaborative system through which the members of the work team who are about to remodel the elements described in the building interact.

As described in Fig. 1, at the end of each of the three specified exercises, the students delivered a final report that includes: (a) design of the solution (prototype); (b) changes made from its preliminary design; (c) justification of the final design; and (d) the way in which the final design was agreed upon.

After the report of each exercise was delivered, the design of each team's solution was shared with the class and co-evaluations on the perception of the usefulness and usability of the designed solutions were carried out. Each team subsequently received the results of these evaluations to perform a self-analysis of the first design and make the necessary adjustments if necessary. The members of each team adjusted and justified their final design, as well as the way in which it was agreed upon.

Additionally, at the end of all the requested tasks, two surveys were applied to the students. First, a quantitative instrument was used, which was made up of five questions related to the perceived usefulness of the implementation of the DBL model using a five-point Likert scale. Such an instrument, shown in Table I, was initially developed and used by [12] and adapted by us to the context of our research. Second, a qualitative instrument with three open questions was used, in order to collect the perceptions of benefits, limitations and skills developed in the implementation of the model.

The population was composed of Software Engineering students from the Tizimin Multidisciplinary Unit and the sample was of a non-probabilistic type made up of 12 students (established in three work teams and identified by codes from E1 to E12), who are studying the subject called "Collaborative Systems". The study was carried out during three weeks (two classes per week, each class lasting two hours and fifteen minutes) in the period August-December 2022.

III. RESULTS AND DISCUSSION

To identify the perception of students about the implementation of the DBL model in their professional training, two complementary approaches were considered. First, using a quantitative approach, the degree of acceptance regarding the usefulness of the implemented model was obtained. For each item, the percentage of students was calculated taking into account the different perceptions (see table I). Second, using a qualitative approach, perceptions regarding the benefits, limitations, and skills developed in the implementation of the model were obtained.

Next, the results obtained from the items in Table I are analyzed.

Regarding the first item "The DBL model improves my learning organization", the majority of the participants think they are "Totally agree" (50%) or "Agree" (42%), while only 8% think they are. "Neither agree nor disagree". This is reaffirmed in the opinions obtained regarding the benefits of the model's implementation:

- "better organization is achieved in the team when we identify and create awareness mechanisms"- (E11)

- "better organization is obtained when we design the required awareness mechanisms"- (E10)

TABLE I Usefulness of Implementing the Dbl Model from the Perspective of the Study Participants (Number of Students, %)

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Item (asks if..)	Totally agree	Agree	Neither agree nor disagree	Disagree	Totally disagree
1. The DBL model improves my learning organization	6 (50 %)	5 (42 %)	1 (8 %)	0 (0 %)	0 (0 %)
2. The DBL model meets the goals for teaching	8 (67 %)	3 (25 %)	1 (8 %)	0 (0 %)	0 (0 %)
3. The DBL model allows me to develop creative and problem-solving skills	7 (58 %)	4 (33 %)	1 (8 %)	0 (0 %)	0 (0 %)
4. The DBL model allows me to develop professional skills	7 (58 %)	2 (17 %)	3 (25 %)	0 (0 %)	0 (0 %)
5. We should stop working with the DBL model	2 (17 %)	1 (8 %)	1 (8 %)	5 (42 %)	3 (25 %)

With respect to the second item "The DBL model meets the goals for teaching", similar to the previous one, the majority of the participants think they are "Totally agree" (67%) or "Agree" (25%), while only 8% think they are "neither agree nor disagree". Regarding this item, the following positive opinions related to the fulfillment of the teaching goals (of group awareness mechanisms) were obtained:

- *"I get a better understanding of the interaction and design of awareness mechanisms"- (E8)*

- *"I get better results in understanding awareness mechanisms"- (E9)*

With reference to the third item "The DBL model allows me to develop creative and problem-solving skills", the majority of the participants said they were "Totally agree" (58%) or "Agree" (17%), while only 8% think they are “Neither agree nor disagree”. This coincides with the majority of student answers (67% of the total) regarding the perception of developed individual and group skills, among which the following are specifically mentioned:

- *“Our creativity in creating the solutions strengthened the way of presenting the results. We consider that the design is intuitive and will be easy to understand”- (E4)*

- *"I consider that we develop more skills to identify a problem, particularly creativity when we develop the solution" – (E10)*

- *"I develop my creativity, self-criticism, as well as the expressiveness of my knowledge through icons or images"- (E12)*

Regarding the fourth item "The DBL model allows me to develop professional skills", 58% of the participants think they are "Totally agree" and 17% think they are "Agree", while 25% think they are "Neither agree" nor disagree." Given the perceptions related to the previous items, we consider this last result as unusual. This could be explained by participants’ statements regarding: a) lack of interaction with “real” users or b) their personal limitations when building a design. Among the collected opinions we have the following:

- *"I am not sure if the interaction of the system’s end-users with the mechanism would be fully understood"- (E8)*

- *“There may be mental blocks in the search for solutions to problems that are too complex. There is a possibility that a final agreement will not be reached in the team” – (E11)*

- *"sometimes the co-designers do not know how to express their creativity when making designs, consequently the solution will be poor"- (E2)*

With regard to the fifth item "We should stop working with the DBL model", 42% of the participants think they are "Disagree", 25% think they are "Strongly disagree" (25%), 8% think they are "Neither agree nor disagree", while 8% say they are "Agree" and 17% "Totally agree" with stopping working with the model. Since this item was the only one formulated with a negative connotation, we consider that its interpretation may have caused confusion in some students. Taking the above into consideration, the participants’ perception regarding the benefits, limitations and skills developed were analyzed again. Specifically, only one of the two participants with a negative opinion focuses on the limitations found in the DBL model implementation, which shows consistency with the perception found in this item about stopping working with the model. One of those impressions is the following:

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- "Although I think it helps me to develop my creativity, adapting the model can have disadvantages depending on where you want to use it"- (E1)

In summary, according to the positive perception of the participants' majority in the case study, we can confirm that the implementation of the Design-Based Learning model in the Collaborative Systems course has been satisfactory. Among the advantages that students frequently expressed regarding the implementation of the model we can find: stimulation of creativity in the solutions' design, effective collaborative work, development of better communication and organization of teamwork.

Evidently in the development of the defined tasks some limitations were perceived by the participants, such as the uncertainty about the perception of the end users and the possibility that a designed mechanism fails in its execution. We consider that the first limitation was partially covered with the evaluations performed by the members of other teams. However, we are aware that only the development of future work could give us a complete answer to both limitations.

IV. CONCLUSION

This research work describes a case study with the aim of analyzing the perception of Software Engineering students regarding the implementation of the model called Design-Based Learning (DBL). The methodology used was exploratory in nature, with a mixed approach. The results indicate a favorable perception of the students about their acquisition level of skills such as creativity, problem solving and organization for teamwork, among others.

In the implementation of the model we obtained positive indications regarding the perception of the development of individual and collaborative skills, particularly in the development of group awareness mechanisms for collaborative applications. Among such skills we can mention the improvement of communication and coordination to agree on a collaborative design, and the development of critical thinking.

Finally, we consider it necessary to assess the implementation of practical models such as the one used in this study under diverse contexts. As short-term work, we intend to assess the impact of the DBL model's implementation on topics of diverse courses, taking into account the benefits and limitations perceived in this study.

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