Effects of Debriefing in Computer-Supported Collaborative Learning Pyramid Scripts with Open-Ended Task

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Abstract. In this study we investigate the benefits that debriefing can add to collaborative Pyramid script with open-ended tasks. The open-ended task allows students to produce multiple possible solutions to a given problem and requires learners to express personal opinions based on previous experiences and intuitions. In this sense, misconceptions and gaps can appear in the collaboration process, demanding a teacher intervention. Debriefing, as part of teacher orchestration tasks, enables teachers to facilitate students' reflection about the learning experience, correcting mistakes and filling gaps. Qualitative analysis of students' answers through concepts and their relations was developed. The examination of concepts and relations supported the benefits of the Pyramid script with open-ended tasks and debriefing to learning. The results of the study indicate that students increased the concepts mentioned and built more relations between concepts after debriefinLg.

Keywords: Computer-supported collaborative learning · Scripts · Pyramid script · Open-ended task · Debriefing

1 Introduction

Computer-Supported Collaborative Learning (CSCL) scripts structure collaboration interactions in order to facilitate learning. CSCL scripts are important when free collaboration does not result in interaction and consequently in learning [3]. CSCL scripts structure the process of interactions, defining sequences of activities, distributions of groups, roles and resources [3]. An implementation of CSCL script based on Pyramid collaborative learning flow pattern is the PyramidApp. A Pyramid flow is initiated with students solving a task individually. Then, in a second level of the Pyramid, in small groups, the individual solutions are discussed and refined into a common answer. In the next levels of the Pyramid, larger groups are iteratively formed from small groups and group discussions continue refining the previous solution to a commonly agreed solution [10].

Pyramid activity is being used in collaborative learning activities with observable impact in learning gains [2]. Some factors that could influence the design of Pyramid activities are: the pedagogical envelope, the type of tasks, pyramid design elements, and the need for epistemic orchestration and debriefing [1].

Collaborative learning tasks can be open-ended or closed-ended. Closed-ended tasks have one correct answer that can be "yes" or "no" answer or a limited set of possible answers. In open-ended tasks, students can follow multiple solution paths to arrive at or to produce multiple possible solutions and elaborations to a given problem and often require learners to make judgments and express personal opinions or beliefs [12].

Prior research has provided first insights that pyramid activities can increase students' learning gains, measured in terms of an increased level of precision and a decreased level of confusion associated with an answer. However, in some cases learning gains immediately after participating in PyramidApp activity do not seem to significantly improve in terms of precision and confusion, especially if we consider the type of task. In [1] it was reported 3 different learning activities, 2 with closed-ended tasks and 1 with the open-ended task. The 2 activities with closed-ended tasks presented learning gains in terms of increased precision and decreased confusion, however, the open-ended one did not lead to learning gains. From another work, [2] it was presented 4 learning activities, 2 with closed-ended tasks and 2 with open-ended ones. The results were learning gains in terms of increased precision and decreased confusion for closed-ended tasks. However, the learning gain was not observed in the open-ended tasks. Moreover, both studies noticed decreased precision and increased confusion after Pyramid activity.

In [2] it was added to the learning activities a debriefing phase after the Pyramid. Notably, the learning gain appeared in terms of increased precision and decreased confusion after the teacher-led debriefing for both types of tasks. For the open-ended tasks, in one case the learning gain outperformed the individual answer and for the other case, it only outperformed the post Pyramid learning gain.

Debriefing activities require the teacher to elaborate on students' responses in real-time, being a demanding task in terms of orchestration. Orchestration refers to the real-time management of learning scenarios by the teacher [4].

In this study we are interested in type of tasks and debriefing factors, once prior research indicates that Pyramid activity with open-ended tasks followed by debriefing impacts learning gains. Moreover, how debriefing after Pyramid activity with open-ended task influences learning outcomes is not fully known. More research is needed to provide evidence of the benefits that debriefing can add to scripted collaboration with open-ended tasks. To this end, the research question proposed in this study is: "How do open-ended tasks affect collaborative experience with Pyramid activity and post debriefing?"

This paper is organized as follows. In Sect. 2 details about debriefing in collaborative learning activities are presented. In Sect. 3 the methods followed are explained. In Sect. 4 the results of the study are presented, followed by Sect. 5 which provides a discussion of the study findings. Finally, in Sect. 6 is provided concluding remarks and future research directions.

2 Debriefing and Collaborative Learning Activities

The term debriefing is used in different domains, as military training and psychological approach, enabling participants to review the facts and thoughts after an event. In educational settings or experience-based learning, debriefing is used as post-experience analysis, in simulations and game-based learning tasks [9].

Debriefing is a form of reflective practice and provides a means of reflection-on-action in the process of continuous learning. The idea behind debriefing is the belief that experience alone does not lead to learning, but rather the deliberate reflection on that experience [13]. However, reflection after a learning experience might not occur naturally, or if it does, it is unsystematic [6]. In this manner, conducting a formal debriefing focused on the reflective process is used as part of the learning process [6,13].

The debriefing can occur after the experience, the post-event debriefing, or during the event, the within-event debriefing, through interruptions to students' actions when mistakes occur [13]. The post-event-debriefing can be facilitator-guided or self-guided, when performed by individuals or conducted by teams [13]. The teacher facilitated post-event-debriefing is the recommended and most widely practiced method [5].

The design of the debriefing session must be adapted to the learning objectives and characteristics of the participants [6]. Seven common structural elements involved in the debriefing process were proposed by [9]: debriefer; participants to debrief; an experience; the impact of the experience; recollection; report and time.

In the context of collaborative learning, the experience to be reflected is the activity performed in CSCL script. In this way, ArgueGraph script activates argumentation among members and closes the activity with debriefing, where the teacher organizes the arguments produced by students, articulating them with theories [8]. In the Concept Grid script, individual students work with a part of knowledge and groups are formed composed of students with different parts of knowledge, who collectively solve a problem that requires knowledge of each of them. In the debriefing session, the teacher compares the solutions produced by different groups and requests them to explain the distinctions [3].

In this study collaborative learning is addressed by considering the learning design, processes, and outcomes. The learning design refers to group formation, type of task and type of education. The groups are formed randomly by the PyramidApp, the first group level with 3–4 students and the next group level with 7–11 students. The type of task is open-ended and the type of education is informal, conducted in a workshop format. The processes of collaboration refer to collaborative Pyramid activity, with individual and group phases followed by teacher-led debriefing. Finally, the outcomes of collaboration refer to individual achievements in terms of concepts and their relations. Figure 1 illustrates this framework for investigation of collaborative learning.

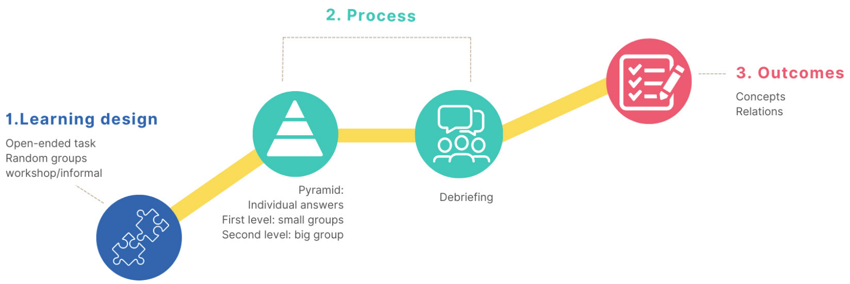


Fig. 1. Investigating collaborative learning: learning design - process - outcomes.

The experience or practice to be reflected in the context of collaborative learning is the activity performed in CSCL script. Besides the PyramidApp dashboard is not designed to support debriefing, the dashboard orients the teacher to conduct the debriefing at the end of the activity based on the winning answers from students' groups.

3 Methods

3.1 Participants and Context

A quasi-experimental study was conducted in a public high school in Brazil. The sample of the study consisted of 33 students distributed in 4 groups of 7–11 students from 2nd and 3rd year, aged from 16 to 18 years old. Data were collected in the context of media literacy workshops conducted by one teacher. Students provided their informed consent for data collection.

3.2 Tools

Each group participated in the same collaborative learning activity with the same open-ended task. Pyramid activity consisted of three levels, an individual submission level, and two group levels. The Pyramid activity duration was designed for 16 min and had a slight difference from one group to another, based on students' needs and teacher orchestration, i.e., in some cases the teacher added 1 more minute to allow students to finish a level. The open-ended task, enabling students to make judgments and express personal opinions or beliefs, was about social media awareness, asking students: "How do you think social media influences our body and appearance? That is, how we feel about our body image.". Table 1 presents the details of activity.

Table 1. Collaborative learning activity details.

Session	Number of students	Duration	Open-ended task given to students
A	7	16 min	How do you think social media influences our body and appearance? That is, how we feel about our body image
B	7		
C	8		
D	11		

The PyramidApp tool provides an authoring space where teachers can design CSCL activities. A screenshot of the design space of the PyramidApp is shown in Fig. 2, where it is possible to configure several parameters as the number of students expected, the number of levels in the Pyramid script, the number of students per level and the duration allocated to different phases.

PyramidApp collaboration structure follows some levels. Students give an individual answer for a given problem (option submission level). Then small groups of students are randomly formed (first group level). In the small groups, students examine the answers submitted by other students individually (rating). Students then take part in a discussion at the small group level and improve existing options collaboratively (improving). Larger groups are formed automatically by merging small groups (second group level). In the larger groups, students participate in an individual rating of the answers selected from the previous level (rating) and then collaboratively improve the selected answers (improving). Teacher can orchestrate collaboration at all levels through the PyramidApp dashboard. A screenshot of the PyramidApp dashboard is presented in Fig. 3.

The students were given training on how to use the PyramidApp for collaboration prior to the experimental session reported in this study.

3.3 Debriefing in Pyramid Scripts

After the Pyramid activity a debriefing was conducted by the teacher based on answers produced during the Pyramid activity and adding concepts for filling gaps if needed. The students' intervention during the debriefing guided the direction of the discussions. The debriefing lasted around 15 min.

Following the seven common structural elements involved in the debriefing process [9], the debriefer is the teacher that will conduct the debriefing and the participants are the students. The experience is the collaborative activity in the PyramidApp and the impact of the experience depends on the relevance of the experience for the students and should clarify the facts, concepts, and principles. The students participate with the recollection of their experience and report the experience in a verbal manner. The time is post-event debriefing.

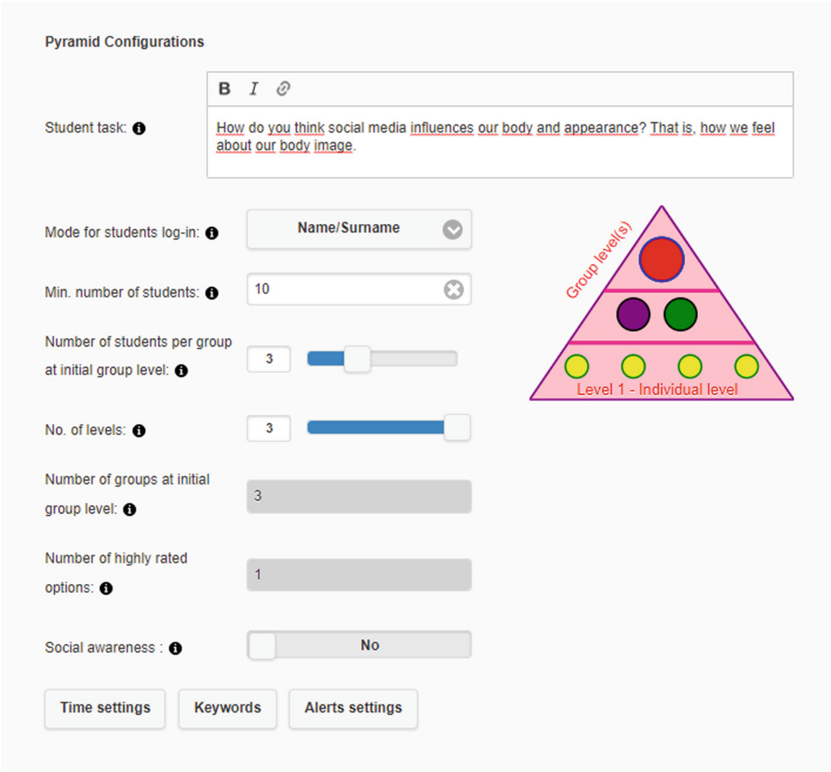


Fig. 2. PyramidApp user interface.

The main objective of debriefing is to promote a reflective process. For this, the teacher used the same strategy for all groups. The debriefing starts from the group answer provided by students in the Pyramid dashboard, i.e., the winning answer developed for the group. If this answer has some gaps, the missing concepts are added by the teacher. But, different from feedback, that is one way intervention, the debriefing process allows interaction and reflective discussions. For this, the teacher asks some questions to students, addressing missing or confusing topics. The students can explain their ideas and the teacher can guide them to reflection. The conversation evolves and confusion and doubts are solved by the teacher as it appears. Finally, the teacher summarized the conversation, highlighting the points discussed for the group.

Following debriefing, the students were asked to respond to a final questionnaire which asked them to write an answer to the same Pyramid task.

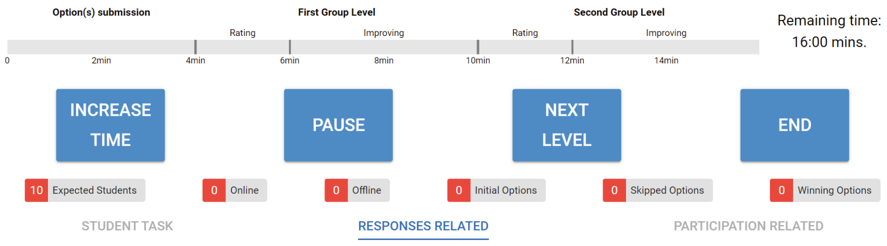


Fig. 3. PyramidApp dashboard: option submission, first group level and second group level.

3.4 Data Collection and Measurement

In this study the data was collected in three moments: an individual answer at first level of Pyramid, an individual answer after Pyramid and an individual answer after debriefing. Figure 4 summarizes the data collection.

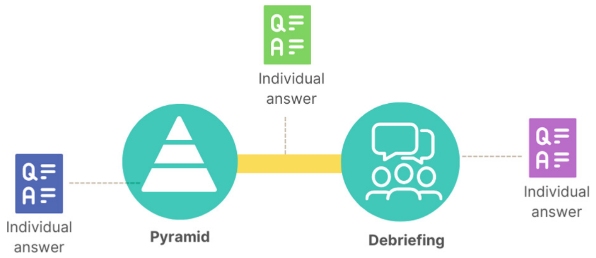


Fig. 4. Data collection.

In order to analyze the outcomes of collaboration, the student's learning gains can be measured in terms of an increased level of precision and a decreased level of confusion associated with an answer. Levels of precision can range from 0 (not precise) to 3 (student's response matches teacher's response). Levels of confusion can range from 0 (None) to 3 (high) [1].

4 Results

The students' answers were evaluated by the teacher grading the levels of precision and confusion. In Fig. 5 it is possible to see the learning gains in terms of average precision for pre, middle and post answers, which refers to the following, respectively, individual answers submitted to Pyramid activity, answers after the collaborative Pyramid activity and after debriefing. The results from Fig. 5 are similar to [2] in terms of decreased precision after Pyramid activity and increased precision after debriefing. In these sessions, there was no confusion in the answers.

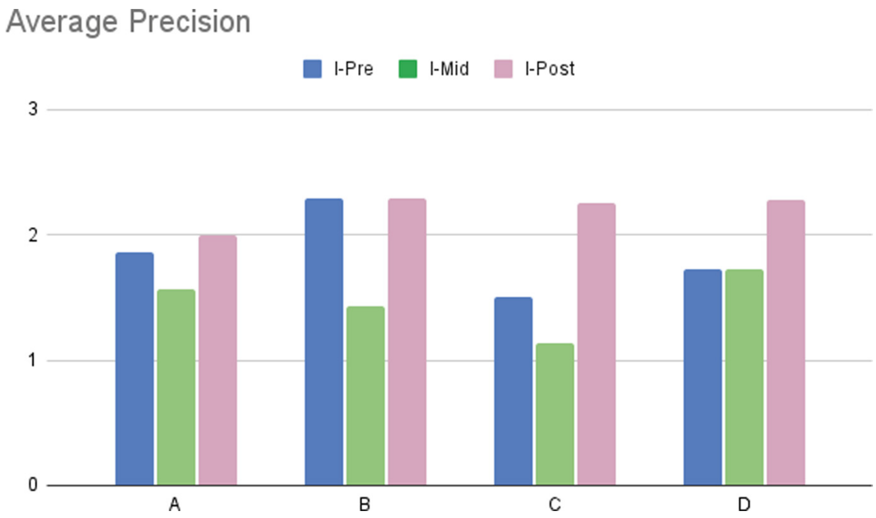


Fig. 5. Average precision in students' answers from A, B, C and D in I-Pre (individual Pyramid answer), I-Mid (individual, after Pyramid task) and I-Post (individual, after debriefing).

As shown in Fig. 5 in all sessions the precision of individual students' answers have decreased after participating in the Pyramid activity. For all sessions, the precision of individual students' answers has increased after debriefing. For sessions A, C and D the precision increased from the pre to the post, i.e., the students presented learning gain in terms of precision. Despite that, in session B the precision of students' answers increased after debriefing, but it was the same as the prior answers, i.e., the students did not present learning gains from the initial to the end of the session.

In order to illustrate the differences from pre to post, we can look at the answer from one student: Pre: *Can influence positively or negatively, according to the profiles we follow.* Mid: *It influences a lot.* Post: *Social media can affect positively or negatively, as they require many beauty and body standards, standing out as "healthy" standards of living.* In this example it is possible to note that from pre to post the student added concepts and explanations in his/her answer.

A qualitative analysis of the answers presented by the students was carried out to better understand the results of Fig. 5. The answers were coded considering the concepts treated by students. We followed an inductive data coding approach [14]. Firstly, the initial codes are extracted based on a preliminary read of the answers. In a second reading, the codes are refined and the answers are marked with the codes found. Following that, a new reading of the answers was conducted to review the codes extracted from the answers. The final coding scheme consisted of the following codes: comparison, pattern, false, unreal, negative and adapt. The codes, their meanings and an example in the answer are presented in Table 2.

Table 2. Coding scheme.

Code	Meaning	Context
Comparison	Student mentions that he/she makes comparisons when looking at body images in social media	*"you can see body images and compare yourself"*
Pattern	Student is aware of the idealized body images presented as patterns in social media	*"social media demand many standards of beauty and body,"*
False	Student is aware of false and manipulated images in social media	*"(body images) has several changes with effects and edits"*
Unreal	Student is aware that body images shown on social media are unreal and unattainable bodies	*"on social media, many people have the image of a perfect body, something that does not exist"*
Negative	Student reports negative emotions like envy, depression or sadness	*"can make you feel extremely bad about yourself", "putting us down", "we envy"*
Adapt	Student declares that he/she needs to change his/her body to adapt to the body pattern presented in social media	*"wanting to follow a pattern that are posted by influencers on the social media"*

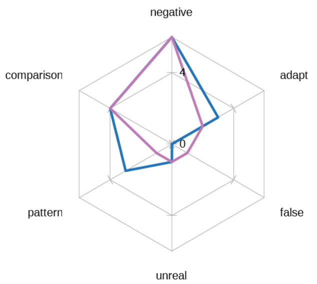
Figure 6 illustrates the frequency of codes appearing in students' individual Pyramid answers (pre) and after debriefing answers (post) for the 4 sessions for the codes comparison, pattern, false, unreal, negative and adapt.

For session A it is possible to note that students mentioned false/manipulated images more times after debriefing. However, comparison and negative emotions remained in the same frequency, but idealized body image patterns and the need to change to adapt to the pattern decreased.

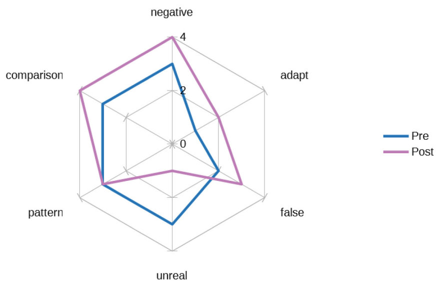
For session B it is possible to note that students mentioned comparison, negative emotions and false/manipulated images more times after debriefing. However, the need to change to adapt to the pattern remained in the same frequency, but unreal/unattainable body image decreased.

Session C presented the most difference from pre to post. It is possible to note that students mentioned four of five terms more times after debriefing.

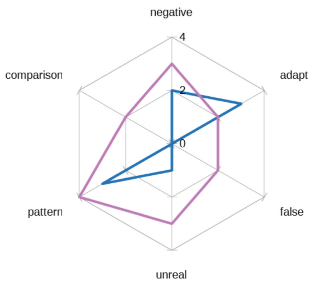
In session D it is possible to note that students mentioned the need to change to adapt to the pattern, unreal/unattainable body image and false/manipulated images more times after debriefing. However, false/manipulated images remained in the same frequency, but comparison and negative emotions decreased.



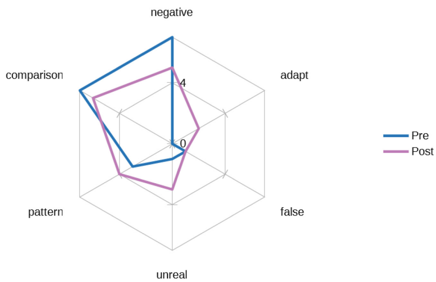
(a) Session A



(b) Session B



(c) Session C



(d) Session D

Fig. 6. Chart code frequencies for sessions A, B, C and D.

From all sessions, the knowledge of the topic was explored by the students and it was strengthened after debriefing.

Besides code frequency, we also explored the relations among concepts presented in students' answers. A network graph allows analyzing elements that stand in pairwise relations [11]. The relations may be qualitative, present or not; they may also be directed (from one element to another, but not the other way); and they may also be quantitative, i.e., they may possess weights. The network analysis begins by defining a specific corpus of texts, in this study, the students' answers for the task. From the students' answers, it was extracted the codes as shown in Table 2. The codes are the elements of the network. The relations between elements are extracted from the answers. If a student reports that "*I compare myself with edited body image in social media and it makes me feel depressed.*", this answer has 3 codes: false, comparison and negative. For this answer the codes false, comparison and negative are related, representing 3 edges at the network: false with comparison, false with negative and negative with comparison. The network graphs for the 4 sessions are presented in Fig. 7.

In Fig. 7 it is possible to see the relations among codes for the 4 sessions in two moments: pre, before group Pyramid activity and post, after debriefing. In session A it was added the code for false images from pre to post and it changed the relations they did. For sessions B, C and D it is possible to note that students were able to relate more codes at the end, visually represented by more links between nodes. And, the stronger the link, the more times the same relation was found in students' answers.

The students reported the relationships among idealized body image patterns presented in social media images, which are false/manipulated images, showing unreal and unattainable bodies, when compared to real bodies, can lead to negative emotions such as envy, anxiety, and depression.

The relations between concepts can be represented by the degree of a node, i.e., the number of its neighbors [11]. For example, in Fig. 7, session D - pre, the code comparison has 4 relations and the code false has only one. Considering we have 6 codes, a fully connected network or a complete network would have all nodes with 5 relations each. In this manner, if students articulated all concepts in the same answer it would result in a complete network. From Table 3 it is possible to see the sum of the degrees of all nodes for the 4 sessions. If we consider that the sum of the degrees of all nodes for a complete network is 30, we can see that sessions B, C and D enriched their connections after debriefing, approximating from a complete network. Session A did not increase the number of relations, however, it increased the concepts considered, that was 5 before the activity and 6 in the post debriefing.

Table 3. Sum of the degrees of all nodes in the networks from Fig. 7.

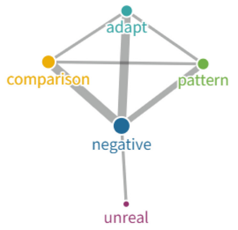
Sessions	Pre	Post
A	13	10
B	20	26
C	12	24
D	14	26

5 Discussion

From the learning activity conducted, the open-ended task resulted in similar levels of learning gains for the 4 sessions studied, which corroborate with previous works [1,2]. The results are decreased precision after Pyramid activity and increased precision after debriefing, as shown in Fig. 5.

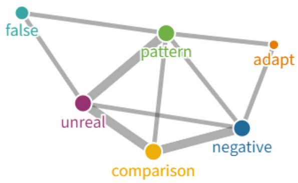
We can not observe explicit (individual) learning gains when comparing individuals' answers prior to the Pyramid with individuals' answers after Pyramid. In a detailed look at the answers, we could note that most of the answers after Pyramid are incomplete, with only one word or small phrases. The answers after debriefing are complete answers, allowing students to explain their knowledge. To this extent, we argue that students do not decrease knowledge after Pyramid activity.

From the learning design (open-ended task and workshop session) we derived three assumptions about the process (Pyramid and debriefing) and outcomes

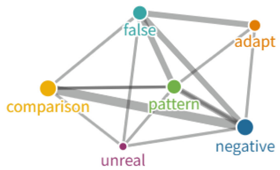


(a) Session A - pre

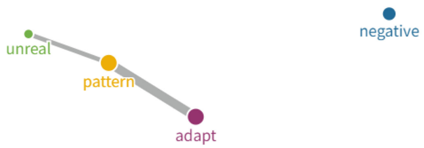
(b) Session A - post



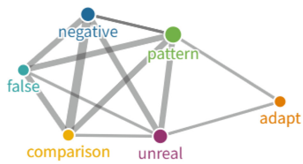
(c) Session B - pre



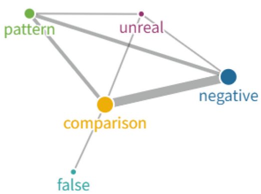
(d) Session B - post



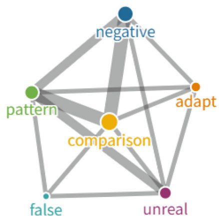
(e) Session C - pre



(f) Session C - post



(g) Session D - pre



(h) Session D - post

Fig. 7. Network graphs from sessions A, B, C and D in pre: individual Pyramid answer and post: after debriefing.

(students' answers): (1) students are less inclined to give complete answers after Pyramid, so we indicate a future motivation inspection at Pyramid activity; (2) the open-ended task does not have a right/wrong answer, so students can provide incomplete answers that could be partially correct. It is more difficult to occur at a closed-ended task that has a correct answer; (3) the intervention was conducted in a workshop and was an informal, non-curricular activity so that students were free to participate or not.

During a Pyramid activity based on an open-ended task, students have the opportunity to discuss multiple possible solutions for the task and can express personal opinions or beliefs. This type of task is aligned with Pyramid activity as it allows developing knowledge collaboratively, considering the individual initial beliefs and constructing agreements for a refined solution. On the other hand, this type of question can propagate confusion and some students can not be persuaded by the group, once they can remain with their prior beliefs, even if it is a misconception. Otherwise, the students can work on partial solutions, missing some concepts or relations between concepts. In these particular cases, debriefing is a highly recommended practice after the Pyramid activity to fill gaps and correct misconceptions. At the same time debriefing contributes to deriving useful insights through a discussion of the experience.

Returning to the question: How do open-ended tasks affect collaborative experience with Pyramid activity and post debriefing?

Our qualitative analysis of concepts and relations in the students' answers to an open-ended task confirm that the process of Pyramid activity followed by a teacher-led debriefing impacts the learning outcomes. The concepts represented by the codes extracted from the students' answers reveal that students expanded the concepts they mention from individual Pyramid answers to answers after debriefing (Fig. 6). More than that, students increased the relation of concepts from prior to post, making more relations between concepts (Fig. 7).

From social media workshop perspective, students could articulate the main concepts related to social media body image, referring to idealized body image patterns presented in social media images, which are mostly false or manipulated images, showing unreal and unattainable bodies, when compared to real ones can lead to negative emotions such as envy, anxiety, and depression. These answers are strongly connected with the studies in the area [7,15].

Considering an open-ended task, the debriefing can take different ways, depending on the students' contributions. The conversation is always enriched by the students' personal opinions or beliefs. An important part of debriefing is to guarantee a safe psychological place for students to share their beliefs, as stated by [13]. That is crucial for a successful debriefing because if students do not talk about their misconceptions, the teacher is not able to discuss them and promote a productive reflection.

Finally, the debriefing was conducted for the same teacher at all sessions. It is worth noting that the debriefer experience can impact the debriefing results. In this way, having a teacher use a debriefing script may improve the ability of facilitators to effectively lead the debriefing conversation, as suggested by [13].

6 Conclusions and Future Work

In this study we investigate collaborative learning in the case of a Pyramid CSCL script addressing an open-ended task and teacher-led debriefing. Prior preliminary research indicates that a Pyramid activity with open-ended tasks followed by debriefing impacts learning gains. This work contributes with additional evidence that corroborates and extends this previous work. The novelty is related to the context and learning design used for the data collection as well as to the methodology used to analyze the learning outcomes. The context is an informal learning setting involving teenage students, aged 16 and 18. In terms of the learning design, the task is open-ended and of a nature that leads students to express personal opinions based on previous experiences and institutions. Regarding the methodology, we have analyzed the evolution of concepts and relations in the evolution of students' expressed knowledge from a perspective of the learning outcomes.

Study findings support the importance of debriefing to learning gains achieved during scripted CSCL activities with open-ended tasks as it summarizes learning experience, fills gaps and corrects mistakes. The students were able to state more concepts and articulate them in more relations after the debriefing. Promising results about debriefing encourage future work on how debriefing influences teachers' orchestration load.

There are several limitations to this study. The number of cases we considered is low and the number of students participating in each activity is relatively low. These limitations can have an impact on the obtained results. However, as exploratory research there is no attempt to generalize the findings to a wider population, but to gain insights into collaborative learning. Another limitation is that only one teacher participates in the sessions, which means that the debriefing could have other results with a different teacher. For future work we plan to investigate the debriefing scripts that could guide teachers to structured debriefing. It is also relevant to explore debriefing time, i.e., the differences between post-event debriefing and within-event debriefing. Considering the cases in which confusion is propagated in the group, an earlier intervention by the teacher, within-event debriefing, could address mistakes as they appear and improve learning.

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