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Measuring the knowledge convergence process in the collaborative game MetaVals

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Abstract

This paper aims to advance in the characterization and implementation of the students’ prior knowledge and knowledge convergence in the context of computer-supported collaborative game-based learning in a university context.

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1. Introduction

In this paper we aim to present a preliminary analysis on collaborative learning in the context of the computer-supported collaborative game MetaVals experience carried out in ESADE Universitat Ramon Llull. The main object of this research is to identify whether knowledge convergence occurs among peers working together along the computer-supported game, and if factors such as prior knowledge may influence the knowledge convergence outcome of peers playing together collaboratively. On this early stage of the research, a first analysis of the results is presented on this paper on the general performance in the individual and collaborative phases. Some further research is planned subsequently to deepen on the analysis.

In Computer-Supported Collaborative Learning (CSCL) the game activity is proposed to the students to promote cognitive and social constructivist approaches of learning, promoting students’ prior knowledge identification, social interaction between peers and the definition of a learning context promoting the knowledge elicitation [1]. Within this approach, we consider the relevance of prior knowledge characterization as a requirement to adapt to the end user of the GBL activity [2], and the knowledge convergence process, as an increase in common knowledge among peers following collaboration [3]. Bearing in mind that knowledge

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convergence among peers is not a topic that has been recently analyzed in learning sciences, and considering also that it has not been yet considered in depth in relation to computer-supported collaborative Game Based Learning (GBL), we focused our study on the research on the collaborative convergence process during a game-based learning activity. In this line, we aim to analyze whether the relation of prior knowledge equivalence among dyads affects the knowledge convergence outcome.

Taking into account the innovative research proposed, we firstly present in this paper the game dynamics of the MetaVals Game experience carried out in a post graduate context [4] [5]. Secondly, we present the methodology followed in order to gather data to be able to compare knowledge convergence outcomes among the different sets of peers in this collaborative game. Finally we discuss some early results and introduce future perspectives for further research.

Before describing the MetaVals game experience, we begin by introducing the theoretical background on knowledge convergence and include a brief outline on the state of the art to go through previous researches presented by several authors on the topic [3, 6, 7, 8].

2. Knowledge Convergence. Theoretical Background

2.1. Knowledge Convergence

In the context of collaborative learning, knowledge convergence is the process by which two or more people may reach mutual understanding after having interacted socially and cooperated on a task [3] and hence becoming more similar with respect to their knowledge [6]. Several authors agree that knowledge is exchanged and may converge through social interaction [7] [6]. Let us give an example of a knowledge convergence process. Imagine there are two people working and collaborating together on a task (Player 1 and Player 2 for the game MetaVals experience). Player 1 knows A & B and player 2 knows B & C. In this example B refers to the common knowledge they have in common on the domain they are working on. On the other hand A and C symbolize the knowledge each one has that the other does not prior to interacting and working together in relation to the domain. During the knowledge converging process, i.e. working collaboratively and interacting together to solve the task, their knowledge may converge and ultimately construct similar declarative knowledge. In this line, the outcome convergence outcome achieved after collaboration implies that, in the end, both Player 1 and 2 know A, B & C. In other words, an increased similarity in the cognitive representations among the group members is achieved [8] as collaborative learners may influence the learning outcomes of their peers [7]. If the amount of common knowledge grows after collaboration, knowledge convergence is meant to have taken place. Knowledge convergence could take place in different degrees depending on the amount of common knowledge that is produced at the end of the collaborative learning process. As a result of this influence on one another they may be able to apply the knowledge achieved to solve future problems in a more efficient manner [9].

In order to analyze properly the knowledge convergence process and outcomes, several factors need to be taken into account. One of them being prior knowledge. As represented in Figure 1, this indicator is the first element to bear in mind when analyzing the knowledge convergence outcome. Prior knowledge influences the learning process, but it may also determine the collaborative learning process within the peers due to the knowledge equivalences and the differences on the specific units of knowledge, considered by Beaton [10] as asymmetrical knowledge, that is, “knowledge that others do not have”. One of the most argued advantages of collaborative learning is the transfer of knowledge between those learners who have different levels or units of knowledge [11] [12]. In this respect, learning activities should take into account students’ prior knowledge, but also peers’ prior shared knowledge and their prior knowledge equivalence which will probably determine the outcome knowledge equivalence. By prior shared knowledge it is understood those same concepts that both
peers had before collaborating (exemplified in our previous example with the letter B, e.g., the shared knowledge that both players had before interacting to collaborate). On the other hand, prior knowledge equivalence refers to dyads having a similar level of knowledge concerning the domain prior to interacting to collaborate (exemplified in our previous example with the letter A & C, e.g., they both provide the same degree of knowledge). Continuing with this same example, the prior knowledge equivalence would be even in this case, as both dyads provide the same amount of knowledge on the domain to solve the task.

![Fig. 1. Representation of the knowledge convergence process](image)

2.2. Knowledge Convergence. State of the Art Outline

Even though there have been studies and researches on knowledge convergence among peers, we may state that it is yet a topic to be deeply analyzed as it entered in the learning sciences not that long ago [13] [14]. Earlier studies [8] [3] presented findings to corroborate that knowledge convergence did occur during collaborative learning and some evidences showed that collaborative interaction was responsible for the increase in common knowledge among peers working together [13] [15]. In one of these studies [13], there seemed to be a correlation between the amounts of shared knowledge and learning as seen from a first data analysis, although some more data would be required to get generalized.

However, research has not necessarily empirically shown that converging processes lead to better individual outcomes or that it guarantees all group members show the same learning outcomes after interaction and collaboration [16] or take similar benefits from working together. In this line a study [13] showed that that only a small portion of knowledge, constructed by one of the dyads during interaction and collaboration, was presented by both learners. Similarly, studies with undergraduate students in a Computer Science course [17] concluded that those participants with lower domain knowledge improved their learning performance in a higher degree than those with higher domain knowledge.

Prior studies could lead to expect a positive effect of prior knowledge on knowledge convergence. It must be borne in mind, though, that former research evidences referenced on this paper are centered on particular contexts and specific conditions. In this sense, it obviously may vary the results depending on what exactly is being assessed on each case. Some of the former research carried out on knowledge convergence is mainly focused, just to give some examples, on external representation tools in videoconference environments [14], hypermedia learning [17] or on text-based computer-mediated communication with and without script cooperation [18].
Furthermore, it may also affect the results not only the focus of assessment, but also how and when individual knowledge is being assessed. In other words, temporization of the assessment may condition the data gathered, that is, how prior to the task the pre-tests are distributed to participants, how posterior to the task the post tested are passed to participants subsequent to collaboration. It must also be borne in mind whether the prior knowledge assessment is developed independently of the main GBL learning activity as a pre-task assessment or whether the GBL activity includes a way to analyze the prior knowledge integrated on-task.

Hence, considering that there are few differences between studies done so far due to each specific focus of analyses and conditions, and the specific characteristics of the GBL MetaVals Game experience, we developed a methodology that would suit those specific characteristics. It should also be mentioned that there are not many studies so far that focus on analyzing knowledge convergence in GBL and present empirical results. Having said that, some experiences have been carried out to create entertaining approaches to increase motivation which, as stated by its author [19], may result in the construction of shared knowledge.

We hereafter introduce the MetaVals game dynamics before entering on describing the methodology developed and previous to presenting the discussion

3. The Metavals experience

Collaborative games play an important role as engaging learning environments [20] that could be designed to support prior knowledge characterization [21] and the process of knowledge converge. The MetaVals game design has evolved from an activity carried face-to-face in class to a CSCL game supported in a web based environment [4]. MetaVals can be currently played in different varieties and environments depending on the specific characteristics and needs of the course: fully online or face-to-face, from a space/flexibility point of view and synchronously or asynchronously, considering the temporal flexibility.

The CSCL MetaVals game basically aims to put into practice finance concepts among non-finance experts at the university context at ESADE Universitat Ramon Llull Business School. The computer-supported collaborative game has by now been played by 70 post-graduate participants enrolled in the introduction to finance course.

The game is played collaboratively by dyads (Player 1 & Player 2) although at the very first stage each dyad plays individually (see Figure 2). This first part of the game, played individually, consists on completing a screen where each player is presented 6 items that need to be classified either as assets or liabilities. When distributing the items, the player should also fill in the “Level of Certainty (LC) panel” next to each item, where s/he indicates her/his degree of certainty on the answer given (from 0 “not sure” to 10 “very sure”).
Fig 2 Individual decision on assets / liabilities and Level of Certainty declaration.

After this first individual part of the game, each dyad sees the screen with the different 6 items answered by his/her peer as well as his/her LC when distributing each item. It must be said that the items for Player 1 and Player 2 are different. Hence both players will go through 12 items all together in order to finish the game. On this second part of the game (see Figure 3), Player 1 must agree or disagree on Player 2 answers and vice versa. The aim is to reach consensus among both dyads to properly classify the 12 items. Player 1 and Player 2 work together and collaborate to get better results than other couples also playing.
The MetaVals game has been tested and carried out in different modalities depending on the course needs: fully online/face-to-face synchronous/asynchronous. Whereas in some cases the interaction among dyads was done face-to-face, in some others a chat tool was provided within game to interact on the collaborative part in order to reach final consensus. The competition dynamics with the other couples playing within the same class aims to challenge them to combine a dynamic of intragroup cooperation within the dyad, promoting knowledge convergence, and intergroup competition against other dyads [22], which aims to provide the “conflict, competition, challenge and opposition” components of the game proposed by Prensky [23].

4. Methodology. To measure the knowledge convergence process in the MetaVals experience

With the objective of gathering data to analyze knowledge convergence process and measure knowledge convergence outcomes along the MetaVals Game experience, several tools were designed in order to get data for three different key stages of the process: pre-task stage, on-task stage and post-task stage.
4.1. Pre-task stage. Assessing prior knowledge and prior knowledge equivalence

Before participants start playing together, they are asked to fill in a self-declared statement on their level of knowledge and expertise on the domain of finance within a scale from 0 to 10. This metacognitive reflection on one’s own knowledge may be influenced by the participant’s feeling of knowledge, which may vary depending on the individual’s own perception. Nevertheless, we will not deepen on this factor in this paper. Also, in this pre-task stage, participants are asked to answer an off-task questionnaire on finances which will help assessing and determining their “real” level on the domain.

This data collection aimed to be able to assess participants’ prior knowledge on finances and, hence, be able to compare prior knowledge equivalence among participants. Consequently, the data gathered at this stage, on each participant’s prior knowledge on the topic, helps organizers to be able to set the pairs to play together in a collaborative way. Hence organizers may set pairs of peers based on a similar knowledge equivalence (both players having similar degree of knowledge) or, on the contrary, to set pairs with peers with no prior knowledge equivalence (one dyad having higher degree of knowledge than the other). This learning activity conditions may help determining if, as evidenced presented on a research in an hypermedia tutorial carried out with undergraduate students on Computer Science course [17], peers with low prior knowledge equivalence achieve more knowledge after collaborating than peers with higher prior knowledge equivalence.

Results presented [17] evidenced that participants with lower domain knowledge showed a greater improvement in their learning performance than those with higher domain knowledge. In other words, it will help to identify whether knowledge convergence outcome may be affected by prior knowledge symmetry or asymmetry.

4.2. On-task stage. Assessing knowledge sharing/contribution during collaboration

During the actual MetaVals Game, both the individual performance and the collaborative performance data is collected in a database for all three stages of the game (individual, dyad correction and dyad common decision). To start with, peers work individually to go through the different screens of the game. In the collaborative stage, peers need to agree or disagree on the dyads’ performance and reach consensus and that is when knowledge sharing takes place. The fact of having the extra information through the LC panel of the other player on each concept, as well as knowing his/her initial self-declare statement on the general topic allows being aware of what the other dyad knows, does not know or is not sure about. Dillenbourg [16] refers to this as “mutual modeling”. The fact of being aware of the similarities on the knowledge is referred to as “common ground” [3] [6]. This cognitive awareness will probably help easing the process of reaching consensus on the final and collaborative panel as dyads are fully aware of how certain his/her peer is on each concept discussed and, in this sense, be able to compare it to one’s own.

In those cases where the MetaVals Game experience was carried out synchronously in a fully online environment, a chat tool was provided for participants to interact, share knowledge, discuss and reach consensus. The information shared in the chat among the peers was also important data for research to see how peers used the knowledge available to them to collaboratively construct new knowledge in discourse. In those cases where the MetaVals Game was played in an on-campus course, two different dynamics were tested: to provide nevertheless a chat tool for the interaction or allowing the interaction to be done live. The important thing was that interaction would take place, no matter what tool to be used for communication. Knowledge convergence makes fully sense when a collaborative or cooperative dynamics is implied as dyads share knowledge with the objective of reaching a common goal (in this case, distributing all 12 items as assets or liabilities). This negotiation process aims to approximate learners’ cognitive responses which as a result may lead to participants converging knowledge. Furthermore, the competition with the rest of players within the
class participating in the MetaVals game forced each couple to be better than the others by sharing their knowledge among the peer.

4.3. Post-task stage. Assessing outcome knowledge and knowledge contribution equivalence

Both the individual and the collaborative performance during the MetaVals game were gathered to compare the results among all couples and assess their learning achievement.

Besides, in some cases, with the same objective of assessing the learning achievement, a post-questionnaire was passed to participants after the MetaVals game experience in order to precisely assess their level on the domain after having played collaboratively with the peer and having shared knowledge on the topic worked.

5. Results

A first analysis on the general performance in the individual (M=4.7; SD=0.89) and collaborative phases lead to consider a knowledge improvement in the dyad correction (M=5.11; SD=0.86) and collaborative performance (M=5.21; SD=0.77). The Levene’s test for studying equality of variances was significant; F(4,65) = 1.48, p = 0.22. Results from the t-test showed a significant difference in the scores for individual and collaborative performance (t (69) = 44.53, p < 0.05).

![Fig 4. Dyads decision on assets and liabilities.](image)

6. Discussion

The very first results of the MetaVals experience lead to consider the support of the collaborative GBL to increase the initial general individual performances as results show an increase in common knowledge following collaboration, although more analysis is needed in order to present firmer findings. In further studies,
the increase of performance in collaborative performance will be analyzed in relation to students’ prior knowledge, and the prior knowledge equivalence among peers as its distribution within small groups may influence collaborative learning and hence it should be taken into account [6] when analyzing the results. In this line, some further research implies comparing results among peers with different levels of prior knowledge symmetry and asymmetry. Furthermore, other prospective studies include widening the analysis to not only the final general activity performance results but analyzing each item per user while taking into account his/her prior knowledge.

Considering these first results we should take into account the relevance of prior knowledge characterization as a way to adapt the GBL activity to the learners’ prior knowledge [21] and introduce the required external regulation (scaffolding, guidance) [24] but also to analyze its influence in the process of knowledge convergence and contribute to advance the research in the collaborative learning process in GBL.

Additionally, in future uses of MetaVals the researchers aim to invite all participants to pass a test right after the game experience and also to invite them to redo it a few months later so to analyze whether the knowledge acquired is a long-term one.

References