Gamified Mobile Collaborative Location-Based Language Learning

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As design-based research, this study describes the development and analysis of two location-based augmented reality (AR) serious learning games (SLG) for French second language (FL2) learning. *Explorez* and *VdeUVic* are collaborative quest-based SLGs. At different locations on campus, players interact with characters that give them quests including clues or options to further the storyline. These interactions take place in the form of either written text, or audio and video recordings, encouraging students to develop language skills both written and oral. Students choose their own learning path and advance at their own pace. Three cohorts of FL2 university students play-tested the games, with 58 of the 77 students choosing to participate in the study. The design-based research framework for the development of the game iterations and subsequent testing was an iterative process with each stage producing output that became input for the next stage. The evaluation of the AR language tools was implemented by means of a mixed-method case study, collecting data of both a qualitative and quantitative nature, through pre and post-play questionnaires, interviews, and video recordings of student gameplay interactions for analysis. Informed by situated cognition, one of the goals was to provide a contextual and immersive learning experience. Additionally, this research drew on sociocultural theory and the social nature of language learning, emphasizing learner interactions as a principal learning force. This research examined the learners' perceptions of their learning experience, as well as the ways in which students collaborated to complete the tasks. Employing a situative approach framework informed by social regulation and content processing, student learning patterns were examined. Distinct types of learner interactions amongst teams during gameplay were shown. Patterns in the emergence of learners' high-level co-regulation during collaborative learning are indicated in the findings. Key elements for the development and implementation of location-based serious games to foster collaborative learning are highlighted.

Keywords: collaborative learning, location-based games, language learning, augmented reality, game-based learning, serious games, gamified learning environment

INTRODUCTION

Given the ubiquitous presence of mobile technologies, in an educational context mobile AR has acquired substantial attention in the past decade. Mobile devices such as smartphones or tablets can trigger digital information and/or game elements by means of the device's GPS or by utilizing camera recognition software. This provides students with technology-mediated immersive experiences,

blending the real world with virtual elements (Klopfer and Sheldon, 2010). One of the main affordances of these immersive environments is their potential to increase learner interaction and engagement (Dunleavy et al., 2009). However, as with any technology, the educational benefits of AR rely not only on the potential of the technology, but also on how the AR systems are designed and integrated into learning environments (Perry, 2018).

The present study entails the development and implementation of two location-based AR serious games for French second language (FL2) learning. *Explorez* and *VdeUVic* are collaborative quest-based SLGs. This paper is part of a larger study (see Perry, 2021) and will focus on collaborative learning in the gaming environments; specifically asking the question: How do second language (L2) learners socially regulate and process content during gameplay? The significance of "place" in the AR mobile learning games will also be broached. The present research entailed a case study, which included three cohorts of FL2 university students playtesting the games, with 58 of the 77 students choosing to participate in the study. The evaluation of the AR language games entailed a mixed-method case study, collecting data of both a qualitative and quantitative nature, through pre and post-play questionnaires, interviews, and video recordings of student gameplay interactions for analysis.

MOBILE AR AND COLLABORATIVE LANGUAGE LEARNING

In regards to mobile AR systems specifically for language learning, research is still emerging. Pegrum (2019) discusses the range of possible designs for AR mobile learning with students' roles varying from passive observers to active learners. On the passive end of the spectrum, some studies design AR systems that supply information in the target language (TL) at real-world locations, and then students later report on the locations visited (Liu and Tsai, 2013; Liu et al., 2014). These systems employ AR to supplement the real-world environment with relevant information, and as Pegrum (2019) describes are used "as lenses to make the invisible visible" (212).

The present research is motivated by the other end of Pegrum (2019) continuum for design in which students "interact with their settings and try out their developing knowledge and skills; or to collaborate with peers and others as they engage in problem-solving" (212). Relatedly, several studies entail AR games in which L2 learners engage in collaborative gameplay, interacting with each other, game content, and their environment (Holden and Sykes, 2011; Perry, 2015b; Berns et al., 2016). However, in these studies although collaboration is mentioned as part of the design processes of the learning tools, it is not the focus of the analyses. Perry (2015b) research entailed the SLG *Explorez*, designed for university FL2 students to play in teams. *Explorez* transforms the campus into a virtual francophone world where students interact with characters, items, and media as they develop their FL2 skills and discover their campus. The mixed-method case study explored the benefits and limitations of gamifying language learning by means of quest-based learning

and AR. Qualitative and quantitative data were gathered by means of questionnaires (pre and post), focus groups and audio recordings of gameplay for analysis. The study consisted of a small test group; however, findings supported prior studies, which showed that game-based mechanics can be positive motivators for learners. Additionally, findings indicated that the students found the intrinsic learning motivators of quest completion and collaborating with teammates to be *Explorez*'s more relevant game mechanics.

More recently, research on collaborative AR language learning has begun to emerge. Given the affordances of AR use within real-world contexts, much of the current research draws on contextual or situated learning theory (Pegrum, 2019). Several studies employed video data of *ChronoOps* team gameplay for their examination of language acquisition, and the significance of place-based learning in AR games (Hellermann et al., 2017; Thorne and Hellermann, 2017; Sydorenko et al., 2019; Thorne et al., 2015). In two of the studies, the researchers employed conversational analysis to examine collaborative patterns during gameplay of *ChronoOps* (Hellermann et al., 2017; Sydorenko et al., 2019). Hellermann et al. (2017) close analysis of one team of three participants described the complex interactions pertaining to collaborative reading aloud during gameplay. Findings showed that reading game text aloud resulted in diverse interactional practices, such as co-reading, turn taking, and paraphrasing. Additionally, the authors state that in contexts of collaborative action, reading can trigger and merge both social and embodied practices when students are wayfinding, seeking clarification, or additional information during gameplay.

As Reinhardt (2019) highlights, research on gamified L2 learning is still limited and there is much to be explored. The present research will contribute to this body of knowledge by exploring the collaborative patterns of students during gameplay of place-based AR L2 games; specifically, analyzing learners' social regulation and content processing during gameplay.

METHODOLOGY

The present research employed Peffers et al. (2007) Design Science framework in order to address the research questions, which entails an iterative process in that each stage produces output that becomes input for the next stage. This methodology consists of six activities to progress through the research process:

1. Problem identification and motivation
2. Definition of solution objectives
3. Design and development
4. Demonstration of artifact usage
5. Observation and measurement
6. Diffusion

Design-based research is an iterative process, and the process iteration affords the opportunity to return to prior stages (such as design and development) during and after evaluating the artifact. Although created for Information Systems, this methodology lends itself well to other research domains. This process also

correlates with the CSCL (Computer-supported collaborative learning) method of iterative design, which combines theory and informal observations via case studies in order to improve the artifacts, which mediate the learning and collaboration: "(d)esigners need to conduct microanalyses of collaborative learning with and through technology in order to identify the features of designed artifacts that seem to be correlated with effective learning" (Stahl et al., 2006). This study builds on Perry (2015a) case study analysis of *Explorez* which focused on the motivation and engagement potential of gamifying second language learning. A first step to the present research was therefore the development of the next iterations of both AR games, *Explorez* and *VdeUVic* incorporating student feedback from testing and applying the multi-game parameters from gaming research (Nasir et al., 2015).

Situated Learning Theory

One of the goals of the present study was to provide a contextual and immersive learning experience for the students. This theory posits that learning is socially constructed and naturally embedded within the culture, activity, and context in which it takes place (Dunleavy and Dede, 2014). Furthermore, this theory highlights the significance of authentic contexts for learning as well as communities of practice; therefore, developing authentic collaborative learning environments *via* AR is a pertinent option in regards to a required shift in pedagogy for FL2 learning. Herrington et al. (2003) define authentic activities as "tasks that have real world relevance and utility, that integrate across the curriculum, that provide appropriate levels of complexity, and that allow students to select appropriate levels of difficulty or involvement" (62). This reflects the aims of gamified learning, and in the context of language learning, highlights a need to add meaning to otherwise decontextualized facts and skills. Holden and Sykes addressed this challenge by incorporating AR into an authentic Spanish speaking neighborhood, engaging L2 students in local contexts. Fortunately, AR for L2 learning is also a means to create virtual language environments when authentic contexts are not possible, and research pertaining to AR L2 learning within these virtual environments is emerging (e.g., Perry, 2015a; Zheng et al., 2018; Sydorenko et al., 2019). Perry (2015b) findings supported that students found speaking French in real world locations (although only virtually French) aided in their understanding of how they may apply their French, subsequently giving more meaning to their learning.

AR Games

This study entails the development and analysis of two location-based AR SLGs for French L2 learning. Details regarding the development of the next iterations of the games are not included in this paper due to length restrictions, and scope, but a brief description of each game follows (see Perry, 2021 for design and development details).

Explorez

Explorez is a quest driven virtual narrative treasure hunt. The overarching gameplay narrative entails a francophone celebrity visiting the University of Victoria, and this individual is seeking an assistant to help them with certain tasks, which includes learning about the campus. At the designated game locations students interact with non-player characters (NPC) that direct them to certain locations, provide details about the quests (which involve specific tasks) or progress the gameplay narrative. Gameplay interactions take place in the form of written text or audio and video recordings, and create opportunities for increased language input and output production. Additionally, *Explorez* emphasizes oral production by means of an audio journal. The gamified system consists of three levels with four quests per level and several challenges allowing the learners to choose their own learning path. The quests were designed based on themes studied in the language laboratories of the Fran 160 course at the University of Victoria, such as food, entertainment, music, etc. Thus, the gameplay tasks are directly linked to the course content. **Figure 1** shows the first two NPCs encountered, and an example of the player map view.

VdeUVic

Visite normale de UVic (*VdeUVic*) is a French version of *UVic Normal Campus Tour* (*UNCT*). *UNCT* was developed and tested as a group project for a CSCW (Computer-supported collaborative work) course (Perry et al., 2015), and focused on extending collaborative potential in ARIS[1] games. *UNCT* was developed with the intention of generating situations which would entice teams at different locations to share information, *via* Twitter, to help each other solve a puzzle.

The premise of *UNCT*/*VdeUVic* is that three groups of students begin a routine tour of the campus that ends up taking an unexpected turn. The players follow their guide to escape the danger nipping at their heels and collect magical items along the way. When the three teams physically meet for the end scene, each arrives with two unique items collected during the tour. The three groups must collectively choose between two outcomes by combining a set of items.

The purpose of *VdeUVic* is not simply to function as a tour for the University, but also to serve as a team-building exercise, and therefore other objectives include collaboration and team cohesion. Game design drew from Nasir et al. (2015) study, entailing nine parameters of multiplayer video games from prior research: *complexity, user interface, difficulty, subject matter, participation, unique roles, social interaction, collaborative patterns, and synchronicity*. All of these parameters were considered and implemented in *VdeUVic* and *Explorez*. Additionally, in both games players used Twitter to document their gameplay or respond to specific tasks, such as answering questions *via* audio/video journal entries.

Participants

Participation in the study was voluntary with three cohorts of different levels of university French students playtesting both

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[1]ARIS is a free, open-source platform for creating AR games and interactive stories for players to experience on iOS devices. The platform is designed to be user-friendly to facilitate availability to a wide range of users and requires no programming knowledge.
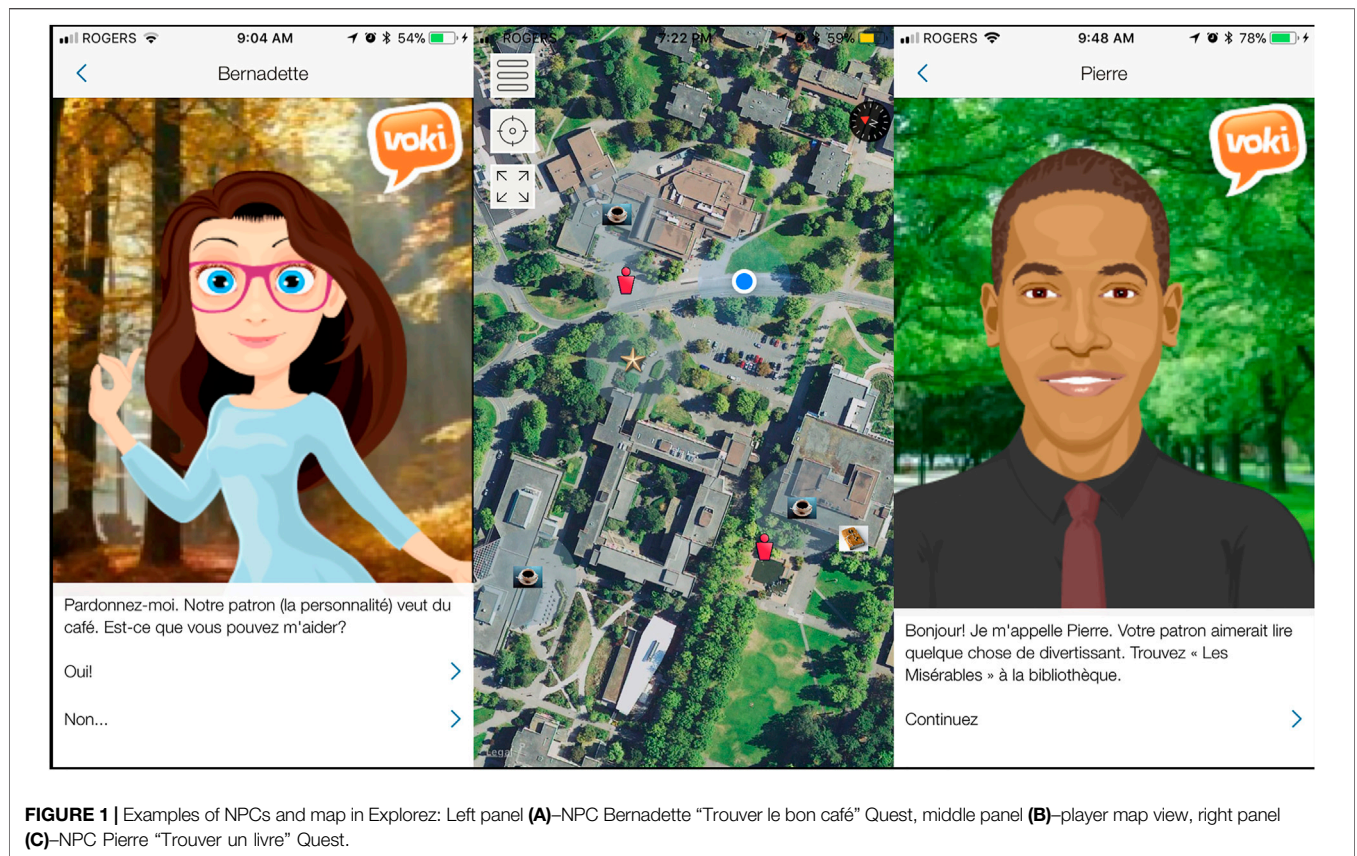
FIGURE 1 | Examples of NPCs and map in Explorez: Left panel **(A)**–NPC Bernadette "Trouver le bon café" Quest, middle panel **(B)**–player map view, right panel **(C)**–NPC Pierre "Trouver un livre" Quest.
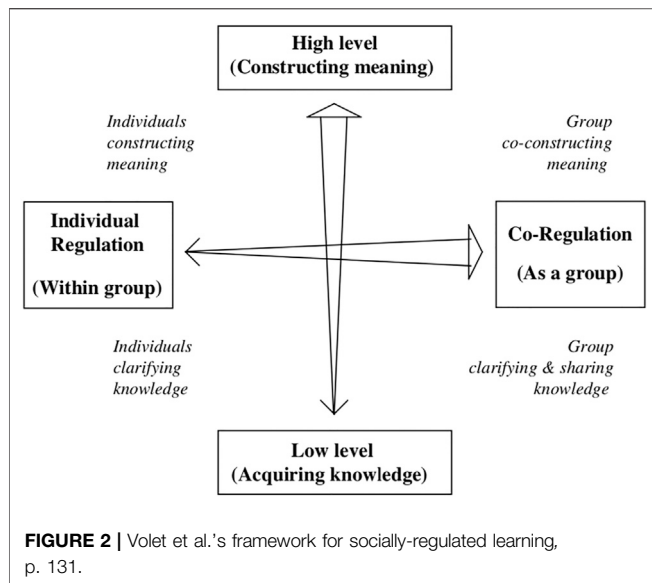
TABLE 1 | Detailed summary of data set information.

Data set	1	2	3
Term	Fall 2018	Spring 2019	Spring 2019
Level	Fran 160	Fran 120	Fran 100
# Of sessions	3	3	3
Length of each session	~80 min	50–60 min	~50 min
# Of students that participated in gameplay	41	28	9
# Of students that participated in study	33	17	8
# Of students that filled out both questionnaires	22	11	6
# Of students that participated in interview/focus group	13	6	3
# Of hours of gameplay video recordings	20	14	7.5

games (Fran100, Fran120, and Fran160). For each cohort, the researcher first approached the instructors, and after gaining permission, visited the students during class time to explain the research, and the L2 games. All students would participate in gameplay as a class activity, but the researcher invited volunteers to participate in the study, following the research ethics protocol[2]. Time constraints, and logistics resulted in the whole Fran 100 class playing *VdeUVic* during class time, and then only 9 out of 29 students (representing the one language lab cohort) also playing *Explorez*.

Data Collection

The evaluation of the AR language games and learner collaboration is implemented by means of a micro-analysis in order to collect data of both a qualitative and quantitative nature, through pre and post-play questionnaires, interviews and the gaming platform itself (quests completed, and badges collected). Additionally, gameplay interactions were video recorded for future analysis (a student from each team wore a head-mounted GoPro). The case study employed a hybrid method of analysis, but by no means sought to compare two different learning contexts. **Table 1** provides additional details regarding each data set: when it took place, the French course level, the length of each session, and the total number of students that played both games, and participated in the study, filled out both

FIGURE 2 | Volet et al.'s framework for socially-regulated learning, p. 131.

Volet et al.'s the present research coded episodes according to the following definitions:

> *High-level* content-processing episodes (individual or co-regulation) referred to engagement in elaborating, interpreting, reasoning, building on or linking ideas, or explaining in one's own words.
> *Low-level* content-processing episodes (individual or co-regulation) represent clarification of basic facts, from a written source or help seeking details.
> *Individual regulation* (high or low-level content processing) represented episodes featuring only one speaker, other than minor inclusions from others (e.g., "yep", "uh huh").
> *Co-regulation* (high or low-level content processing) represented episodes in which multiple group members made verbal contributions. p.132.

A pre-analysis of the data showed instances of all four quadrants during participant gameplay; therefore, the researcher continued the adaption of the framework to suit this different learning context. The next stage involved the selection process for inclusion/exclusion for the close analysis. The reviewing of Fran 100 playtesting videos showed that this cohort relied heavily on the accompanying language expert for game comprehension. The present research sought the close analysis of collaborative learning pertaining to the L2 students, therefore the data coding and analysis employing Volet et al.'s framework was restricted to data set 1 and 2 (Fran 160 and Fran 120); as these cohorts had either no accompanying language expert or limited interference from the accompanying researcher/ TA. Additionally, several team sessions were not recorded either due to human error or technical issues, and student absentees also affected team consistency. Therefore, to remain as consistent as possible for the close analysis, teams that had minimal or no changes, as well as all three sessions recorded were included. This resulted in three of six teams from Fran 160, and three of five teams from Fran 120 selected for the next phase of coding and analysis. The present paper will focus on data set 1 in the analysis of collaborative learning.

The adaptation of Volet et al. (2009) framework for a L2 gamified experience was an iterative process. Volet et al.'s study explored how high-level co-regulation in collaborative learning emerges and is subsequently sustained by employing video footage of veterinary science students during two meetings as they worked on a group assignment in the analysis of a clinical case. This research first coded the verbal interactions into two main categories: processing the clinical case, and other matters (such as task-related matters). For the present research, processing gameplay and other matters was therefore a logical first step. However, the present research entailed many additional elements, as the students were not only interacting with each other, but also with the learning tools. Volet et al.'s videos were coded solely on verbal interactions, however many player interactions during the present research were not verbal; especially when students were interacting with the tool. The added value of video footage offered the potential to code non-verbal instances of both low and high-level content

questionnaires, participated in an interview or focus group, as well as, the hours of video recordings for analysis.

In total, of the 58 volunteers that participated in the study 39 students filled out both questionnaires, and 22 of these volunteers also participated in an interview/focus group.

Procedure

This research took place on the University of Victoria campus. Each gameplay session began in the corresponding students' classroom and then players were directed by the gamified system to different campus locations for gameplay. Testing took place from October 2018 to April 2019 with nine testing sessions varying from 50 to 80 min each (three sessions per cohort).

Framework

This research sought a deeper examination of collaborative learning and thus a means of capturing this through video data analysis was employed through the adaptation of Volet et al. (2009) collaborative learning (CL) framework. This analysis examines the ways L2 learners socially regulate and process content during gameplay. As seen in **Figure 2**, the intersection of the two concepts creates four quadrants that indicate the principal dimension of social regulation (individual or group) and level of content processing (low or high) that can be observed while learners interact during the group activity. These four categories, which are identified in italics in **Figure 2** are: low-level individual regulation, low-level co-regulation, high-level individual regulation, and high-level co-regulation. Given that high-level co-regulation is the most effective means of collaborative learning (Volet et al., 2009), this is visually represented in **Figure 2** by the quadrant being intersected by the widest part of the arrows on the continuum.

Drawing on Volet et al.'s framework, coding at the episodic level was performed on sample videos from Fran 160. Similar to

TABLE 2 | Spreadsheet coding example Fran 160.

A	B	C	D	E	F
Time	Transcript	Code	Duration seconds	CO type	Notes
Time stamp documenting when an episode starts and finishes	Transcription of student gameplay	Markers for episodes: OT, EX, SR, SW, GP, IND LOW, IND HI, CO LOW, CO HI	Length of episode in seconds- minimum 10 s	Markers for type of collaboration: CO LANG, CO TECH, CO GP	Researcher notes from observing video
8:04–9:33	oui donc c'est un radio journal donc il faut considérer ton âge ton profession pas notre âge, il faut lui demander son âge **non non pour nous..parce que le célébrité francophone de uvic…il a.. il a besoin de notre information** oh *notre* oui en français oui	CO LOW	89	CO GP	Clarifying game instructions - IND HI episode less than 10 s

processing; for example, when students were using online dictionaries or creating a tweet. Additionally, gameplay is not stationary, students were physically moving to different locations; interacting with their surrounding environment, each other, the tools, or walking in silence. Thus, the categories for "other" emerged as recurring themes were marked within the data (Brinkman and Kvale, 2015). Given that the objective was not simply playing the game, but that of exploring the campus in the TL, small talk in English was coded as *off task* and not included under the combined evolving "other gameplay" category to gauge to what extent students remained *on task*. Additionally, other stand-alone themes within the "other breakdown" bracket emerged that would allow for a more in-depth examination of the data (e.g., students silently reading game content). This evolving analysis revealed the following empirically derived codes for the breakdown of content other than processing gameplay:

Other breakdown

- Off task–small talk in English
- Expert help–question posed to a TA, prof, librarian
- Silently reading game content
- Silent walking
- Other gameplay
  - small talk in French
  - not silent but also not enough content to code (less 10 s bursts)
  - interacting with gaming interface but no dialogue to code
  - Time posting and tagging tweet after it was created
  - Watching game content videos

The detailed coding of gameplay processing mirrored Volet et al.'s protocol in that episodes had to be a minimum of 10 ss in duration. If the episode was shorter than 10 ss it was categorized within the longer episode in which it took place. As seen in **Table 2** below, spreadsheets were employed for the coding and analysis. Time stamps were placed in column A of the spreadsheet. This documented the start and finish times of

TABLE 3 | Fran 160 team Bleu C's percentage of time per category for each session.

Bleu C	S1	S2	S3
Processing gameplay	85.7	72	65.9
Other breakdown			
Off task	11.1	0.7	7.8
Other gameplay	5.5	16.5	23.9
Expert help	1.2	5	2.7
Silently reading game content	0	0.8	0.4
Silent walking	5.2	9.8	4.7
Breakdown by dimension			
Content processing			
Total high-level	28.7	29.9	21.4
Total low-level	57	42.1	44.5
Social regulation			
Total individual regulation	28.8	11.5	20.6
Total co-regulation	56.9	60.5	45.3
Full breakdown			
High-level co-regulation	16.1	23.4	14.2
High-level individual regulation	12.6	6.5	7.2
Low-level co-regulation	40.8	37.1	31.1
Low-level individual regulation	16.2	5	13.4

each episode and was adjusted accordingly during the coding process. The transcript of student gameplay videos was copied and pasted into column B. Column C was used to insert the markers identifying each type of episode. This included the four gameplay processing codes, low-level individual regulation (INDLOW), low-level co-regulation (COLOW), high-level individual regulation (INDHI), and high-level co-regulation (COHI), as well as the additional markers mentioned above [off task (OT), expert help (EX), silent reading (SR), silent walking (SW), other gameplay (GP)]. In column D the researcher logged the duration of each episode in seconds.

Column E documented the collaboration type; language (COLANG), technology use (COTECH) or game interaction (COGP). Column F was used to record researcher notes.

Similar to Volet et al.'s research the demarcation of the episodes and the identification of the type of interaction observed in the episode were done simultaneously. The example for each column in **Table 2** shows an excerpt of the transcript for an episode from session 2 Fran 160 team Bleu C. The episode consists of the students clarifying the gaming instructions. One student has misunderstood the instructions, and displayed in bold text another team member explains the instructions again in his own words. Explaining in one's own words would fall under high-level content-processing; however, since this episode is shorter than 10 ss it is categorized within the longer episode (COLOW) in which it took place, as per Volet et al.'s protocol.

Once the video transcript had been coded, the researcher employed the spreadsheet filter function to column C to compile the episodes by category, and use the relevant data in column D to calculate the sum of the episode durations. The sum of each category was recorded and then divided by the total duration of gameplay for said team (also in seconds), in order to calculate and document the percentage of time spent on each category for each session and team. For example, **Table 3** shows Fran 160 team Bleu C's percentage of time per category for all three sessions.

As seen in **Table 3**, in session 1 (S1) Bleu C were processing gameplay 85.7% of the gameplay time. The *other breakdown* comprises 23.0% of the time. The analysis of video footage allowed the researcher to document overlapping episodes with team members participating in different categories at the same moment; therefore, the sum of these is not 100%, but instead 108.7%. For example, several overlapping episodes observed by the researcher during this team gameplay consisted of one team member composing tweets individually on camera while walking between locations (therefore high-level individual regulation), while the other two team members were casually conversing in French; however, since their small talk was not game related it was therefore coded as "other gameplay."

Data Illustrations

Presented in the form of excerpts, below are illustrations of each of the four categories: individual or co-regulation and high or low-level content processing. Each example is described in terms of consistency pertaining to the category for which it portrays. The vast majority of low-level individual regulation consisted of instances of one team member reading gaming content out loud to the rest of the team.

Excerpt 1: Low-level individual regulation

Kylie[3]: Vous utilisez le lien à la bibliothèque pour chercher le livre . . . ok . . . so it's PQ22681 . . . Ok . . . [verbatim continues]

In excerpt 1 Kylie is reading the onscreen gaming content to the rest of her team out loud. Such instances were coded as low-

level individual regulation, as they were all or mostly verbatim reading, and did not demonstrate clear evidence of meaning making or knowledge construction.

Low-level co-regulation instances included multiple speakers, and often pertained to clarifying gameplay content, making decisions prompted by the system or for gameplay progression. In excerpt 2, the participants from two teams (Rouge C and Vert C) are interacting while in the campus library.

Excerpt 2: Low-level co-regulation

Miles: Ok thank you very much! Merci!...Yeah, I totally know what this means . . . (All laugh)

Eva: Do you know where to go?

Alice: Yes

Sadie: This way! (points in direction of the stairs)

Eva: Ok we'll follow you.

Miles: Tricheur! (All laugh)

Lisa: You just asked the librarian!

Miles: Do you guys know how the library works?

Eva: Kind of . . . do you know what floor it's on and stuff?

Miles: It's on the third floor.

Tara: Ok over there then.

Eva: Yeah . . . I kinda know. . .

Tara: It's up there (points further up staircase)

Alice: There's a map up there we can look at.

Lisa: Yeah we'll look up there.

Miles: Also, we have to do an audio recording once we find it, so *that's* good! (All laugh)

Alice: Really?

Miles: Yeah, we'll take it to second floor then we'll like bring it back.

Eva: This way? (points to third floor door)

Sadie: Yes here!

In extract 2, Miles has just finished asking the librarian where to find the book *Les Misérables* for the quest *Trouver un livre*. As his team walks towards the staircase, Eva, a student from another team, asks if they know where to go. The group interactions as the two teams go find the book is not co-construction of knowledge, but clarifying facts, such as where to go, and sharing pre-existing knowledge (such as Alice sharing that there is a map on the third level). Therefore, it was coded as low-level content processing. The instance also illustrates interactions between multiple contributors, characterized by the speaker frequently changing, short turns, and similar amounts of contribution, indicators for the episode to be coded as co-regulation on the social spectrum.

High-level individual regulation instances often pertained to a team member creating a tweet individually (either orally or written) or a team member explaining the requirements of a task to their teammates. In the following excerpt 3, team Rouge A

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[3]All participant names have been changed to respect their anonymity.

has just read the directions for the task in the quest *Trouver des Services Françaises*.

Excerpt 3 High-level individual regulation

Julie: (reading information on door) C'est ouvert um . . . sept heures . . . trente à . . . trois heures trente . . . Est-ce qu'on a besoin de tweeter ça?..Est-ce que c'est le question? (rereads gaming prompt) puis quelles sont les services offert . . . ok oui (turns back to door looking for additional information) quelles sont les services . . . quelles services? Oh je ne sais pas.

The length of Julie's turn in excerpt 3 resulted in the instance being coded as individual. She is thinking out loud and attempting to understand what the task requires. When her teammates remain silent, she rereads the quest prompt and then subsequently answers her own question. She then returns to the door seeking additional information. This contribution was coded as high-level content processing given that the student is deducing what the task requires, reasoning out loud, and linking ideas. After her final comment "oh I don't know" her teammates then joined in, and the following instance was coded as high-level co-regulation as the students worked together figuring out the resources offered by the office and then creating the tweet.

High-level co-regulation instances illustrated co-construction of knowledge with multiple contributors. High-level co-regulation content processing episodes emerged when students responded to certain gaming prompts, as well as open ended questions. A large majority of instances arose during the task of creating a Twitter post in the TL, which often resulted in the students first discussing the content they should include, and then creating the tweet. In the following example, excerpt 4, team Bleu C is working on the Quest *Mystic Market*. The in-game character has informed the players that the French celebrity likes spicy food, and has asked them to order a starter, a main dish, and a dessert.

Excerpt 4 High-level co-regulation

Dave: Donc . . . on doit commander une entrée, un plat principal et un dessert . . . uhhh . . . Pour dessert (looking around at the kiosks)

Chris: les waffles?

Jade: Oui (All laugh)

Dave: Oui, il peut manger un waffle. . .

Chris: C'est pour petit déjeuner non?

Dave: . . . avec du syrup

Jade: . . .pas juste pour le petit déjeuner

Dave: Uh . . . et pour le premier cour . . . uh. . .

Chris: Quelque chose épicé?

Jade: Oui

Chris: C'est le le . . . (looking around at the kiosks) le . . . thaï le thaï c'est épicé

Jade: Oui le thaï ou. . .

Dave: Oui il peut manger la nourriture thaï

Jade: Il peut manger . . . un hamburger? (others laugh)

Chris: Un hamburger?

Jade: What?

Dave: Mais il aime les plats épicés, pas des hamburgers, ce n'est pas . . . umm ce n'est pas épicé. . .

Jade: Hmm?

Chris: Épicé . . . spicy

Jade: Oh! *Spicy* oh d'accord! D'accord! (All laugh). . .but you can make it spicy!

Dave: I mean you're not wrong!

Chris: Ou un hamburger très épicé? Oui?

Dave: Ok après le premier cours . . . il peut manger un hamburger avec beaucoup des épicé . . . (Laughter continues)

Jade: avec tabaco sauce

Dave:. . .le poivre et le sel

Jade: Non non pas sauce tabaco . . . sauce tabasco un sauce tabasco (Laughter continues)

Chris: *une* sauce

Jade: D'accord avec *une* sauce tabasco

Dave: . . .et pour un entrée? Umm on peut manger . . . (looks around at the kiosks) uhh . . . oh! Le soupe!

Chris: La soupe? Oui, c'est ça, ça marche

Dave: La soupe . . . uh le wild thai chicken?

Chris: Oui oui le poulet

Dave: Ah oui oui le poulet thaï d'accord. . .

Jade: It's so good

Dave: Yeah so good! Ok, C'est bon! (sic)

In excerpt 4, the students work together drawing from what they see in their environment around them to answer the task proposed by the system. They build on each other's ideas, and employ reasoning skills. The students also assist each other with several examples of corrective feedback. For example, Jade has not understood the meaning of épicé (spicy) and therefore at first does not understand why her teammates find her suggestion of a hamburger funny. Dave attempts to explain in the TL, but when Jade expresses she still does not understand, Chris offers the translation in English. Jade then joins her teammates in laughter, but follows up with the reasoning that they can make the hamburger spicy. Additionally, Chris offers corrective feedback to his teammates on several occasions, he suggests correct definite and indefinite articles (*une* sauce, *la* soupe), as well as the French word for chicken. In each instance the other student repeats back the correction, acknowledging that they have heard and understood the feedback. Furthermore, the episode illustrates the speaker frequently changing with short turns, and similar amounts of contribution by the participants. This is in correlation with Vauras et al. (2003) description of shared regulation with multiple team members involvement in a goal-oriented reasoning process.

TABLE 4 | Fran 160 cohort's focus and percentage of time on interactions by three groups in the three sessions.

	Session 1 (% time)			Session 2 (% time)			Session 3 (% time)		
	Bleu C	Rouge A	Rouge C	Bleu C	Rouge A	Rouge C	Bleu C	Rouge A	Rouge C
Focus of interactions									
Processing gameplay	85.7	60.2	59.8	72	60.4	59.3	65.9	78.7	56.2
Other breakdown	—	—	—	—	—	—	—	—	—
Off task	11.1	7.1	14.9	0.7	0.7	1.4	7.8	0	11.4
Other gameplay	5.5	13.2	1	16.5	23.5	18.8	23.9	19.9	17.4
Expert help	1.2	10	9.7	5	9.8	4.1	2.7	0	0
Silently reading game content	0	7.5	6.3	0.8	0	6.2	0.4	0.6	3.2
Silent walking	5.2	4.2	8.3	9.8	2.8	16.9	4.7	9.4	19.9
	—	—	—	—	Note 7.4*	—	—	—	—
Breakdown by dimension									
Content processing	—	—	—	—	—	—	—	—	—
Total high-level	28.7	13.1	14.5	29.9	15.9	18.4	21.4	37	23.5
Total low-level	57	47.1	45.3	42.1	44.5	40.9	44.5	41.7	32.7
Social regulation	—	—	—	—	—	—	—	—	—
Total individual regulation	28.8	11.4	11.8	11.5	24.2	26.4	20.6	23.3	20.5
Total co-regulation	56.9	48.8	48	60.5	36.2	32.9	45.3	55.4	35.7
Full breakdown									
High-level co- regulation	16.1	6.8	3.8	23.4	9.6	8.2	14.2	27	9.9
High-level individual regulation	12.6	6.3	10.7	6.5	6.3	10.2	7.2	10	13.6
Low-level co-regulation	40.8	42	44.2	37.1	26.6	24.7	31.1	28.4	25.8
Low-level individual regulation	16.2	5.1	1.1	5	17.9	16.2	13.4	13.3	6.9
*No recording due to assisting others	—	—	—	—	—	—	—	—	—

RESULTS

In order to employ the adapted framework and explore collaborative learning by means of tracking the emergence of high-level co-regulation during gameplay, the data was examined by three means: the focus of interactions during gameplay, patterns regarding the emergence of high-level co-regulation, and contributing factors to sustained high-level co-regulation.

Students Focus of Interactions During Gameplay

As in Volet et al.'s study the first step to exploring this framework is examining the focus of interactions across the groups and sessions. The first section in **Table 4**, lines one to seven, shows the breakdown of Fran 160 teams' focus of interactions. These teams' observable focus on content processing during *gameplay* was 56.2–85.7% of the time. *Other gameplay* constituted 1–23.9% of the time. Additionally, several *other gameplay* elements could be argued to also include content processing for L2 learners, such as conversing in the TL, watching French videos with the intent to understand the content, and interacting with the L2 gaming interface. When combining the two categories, gameplay processing and other gameplay, the potential for content processing increases from an average of 67–83% of the time per team per session.

Volet et al.'s results clearly showed that during five of the six meetings the students spent more time concentrating on organization and division of tasks than analyzing the case study; thus, not taking advantage of the opportunity for collaborative learning, but instead possibly choosing to learn the bulk of the content on their own and/or prioritizing tasks that required group consensus. However, this was a choice made by the participants on how to spend their time. The present research context is not as clear cut given that the nature of the activity was gameplay, and the overarching goal of the learning activity was to explore the campus in the TL. Therefore, in regards to learner choice, the amount of time students spent in small talk in English and thus *off task* is more relevant to the present research. Fran 160 teams spent 0–14.9% of the time *off task*, an average of 6% of the gameplay time per team per session. Therefore, overall the participants spent the vast majority of time on task.

In regards to the next section, the close analysis of content processing in *breakdown by dimension* the focus remained solely on the observable *gameplay processing* percentages, and was examined by each session in order to ascertain any variances between sessions and groups. The first three columns in **Table 4** displaying Session 1 of gameplay show high-level processing constituted 13.1–28.7% of the time, while low-level content processing constituted 45.3–57.0% of the total time. The substantially higher occurrence of low-level content processing was not unexpected given the nature of the activity. Additionally, research highlights the importance of low-level content processing in L2 learning (Nassaji, 2014). However, what is noteworthy is that the Bleu C team's high-content processing was close to double that of the Rouge A and Rouge C teams.

In regards to the dimension of social regulation, participant co-regulation (48.0–56.9%) engagement was substantially higher than individual regulation (11.4–28.8%) across all groups. Further divergence between groups and patterns emerged in the *full breakdown*. Video analysis details provided a more

holistic view given that different player/learner types affected the collaborative interactions of the teams. For example, teams Bleu C and Rouge C appeared to be on two ends of the spectrum; one team that collaborated very effectively, while the other one was much less effective in their collaboration. The Bleu C team were very engaged with each other, as well as the gaming content. The video data showed the iPhone often changing hands between team members as the students took turns reading game content, assisting each other with completing tasks, and discussing the content and next steps of gameplay. All three team members were involved in the discussion of what they wanted to post to Twitter before creating the post, and then for almost all recordings each student contributed, with each team member speaking on the recording. Pop-up questions were read out loud, and the students took the time to choose the answer together or at times debated which answer to choose. Most interactions coded for Bleu C were several consecutive turns between speakers.

In sharp contrast to the previous team's high level of collaboration, overall team Rouge C had 59% fewer collaborative instances in comparison to team Bleu C. The student from Rouge C that wore the GoPro for all three sessions held the device most of the time, and read most of the game content out loud. There were also several instances of team members gathered around the device reading content silently. When walking between locations the participant holding the phone at times read content silently, and push through without sharing the information with his team mates. In contrast to Bleu C which had many lengthy interactions with several consecutive turns between speakers, more than half of Rouge C team's interactions were quite brief (~10 s in duration). These were instances of a single turn between two students, such as a team member asking a question, and another teammate responding with a brief answer. This team did however show improvement in their collaborative interactions with each subsequent session. The two teammates that rarely read out loud did not appear unengaged, but rather timid, and thus appeared to gain confidence, as well as speak more in the TL with each subsequent session.

Volet et al. hypothesized that by the second meeting students would have made considerable progress regarding their knowledge of the case study, and thus the second meeting would allow for increased opportunities of collaborative learning. Volet et al.'s results partially supported this expectation. Given the nature of gameplay in the present research, and the additional fact that each session held new gaming content, it remained to be seen if within this learning context, subsequent sessions would afford greater opportunities for collaborative learning.

The complexity of gameplay in *Explorez* (sessions 2 and 3), in comparison to the first session with *VdeUVic* resulted in a substantially higher percentage of time spent on *other gameplay*. For example, time spent on tasks such as physically finding the correct book in the library, and watching the French movie trailers. All three groups had substantially less time *off task* in the second session. Additionally, in session 2 all three teams showed a slight increase in total high-level content processing and a decrease in low-level content processing. In regards to social

regulation, Bleu C team increased in co-regulation, while the other two teams' total co-regulation somewhat decreased. However, in the *full breakdown*, all three teams experienced an increase engaging in high-level co-regulation. This may have been due to a combination of both gameplay design, and student team dynamics.

In session 3, both Rouge A and Rouge C teams once again engaged in an increased amount of high-level content processing. Rouge A had a substantial increase in total high-level, over doubling from the previous session. For the first time Bleu C team saw a decrease in high-level content processing. Due to Session 3 taking place on the last day of class of the semester, at least one member from all three teams commented on this during gameplay. Team Bleu C participant Dave stated "it's so hard to speak in French today my brain is elsewhere I can't believe the semester is almost over!" *Off task* also increased for two of the three teams. In the full breakdown Bleu C's engagement in high-level co-regulation decreased, Rouge C's engagement increased, and Rouge A's engagement increased over three times from S2.

Similar to Volet et al. study, the present research partially supports that subsequent interventions allow for increased opportunities of collaborative learning. Team Rouge C engagement in high-level co-regulation more than doubled from S1 to S2, and increased again slightly for S3. Rouge A saw an increase in high-level co-regulation from S1 to S2 and then over tripled in S3. These teams also showed improvement in team dynamic and as such supports the potential of allowing for increased opportunities of collaborative learning.

Emergence of High-Level Co-Regulation

Similar to Volet et al.'s study, an additional potential benefit of employing the framework was to investigate if any relevant patterns regarding the emergence of high-level co-regulation could be identified. Despite the large difference in the types of learning activities (that of a gamified L2 activity in contrast to the analysis of a medical clinical case) the present research showed many parallel factors in the contribution to the emergence of high-level co-regulation to that of Volet et al.'s study: being that the emergence of high-level co-regulatory episodes were often initiated by a question-either direct or implied-or an explanatory statement or summary. In the present study all recorded teams from both cohorts showed these instances, following are some examples from cohort1: "Je ne comprends pas ... " (implied question, participant F18P16); "Qu'est-ce que vous savez de les Misérables?" (direct question participant F18P14); "Ok, on doit maintenant commander un repas en français ... " (explanatory statement participant F18P1). Worth noting is that within the gamified L2 context, the intentional design elements of task completion prompted the majority of the high-level co-regulation episodes. Students responding to gaming prompts, open ended questions, as well as the need to create a Twitter post in the TL resulted in the students discussing how to proceed, and what they should do, and hence the emergence of high-level co-regulation content processing.

Contributing Factors to Sustained High-Level Co-Regulation

The final step of the adapted framework was exploring potential contributing factors to sustained high-level co-regulation in group interactions during gameplay. Volet et al.'s study identified four possible factors to a group sustaining high-level co-regulation: asking questions, tentativeness of explanations, background knowledge, and shared positive emotions. These factors were also present in the following analysis of gameplay, although somewhat modified given the dissimilar learning context.

In the following excerpt all three students are gathered around the mobile device while creating a tweet in response to the task of informing the celebrity what services are available at the university SUB. Julie took the initiative to type the tweet on her device, while Mary held the device in use for gameplay, and Claire used her device to look up vocabulary during the excerpt. This multiple use of devices contributed to the division of tasks, and allowed all three students to be more actively involved compared to doing all tasks on one device.

Excerpt 5 Session 3 team Rouge A Fran 160

1. Julie: Ok, le Sub avoir le service . . . et obviousment . . . hmm, est-ce que c'est un mot?

2. Claire: Obviousement (all laugh)

3. Mary: Non

4. Julie: Peut tu umm.. le mot obviously? (still laughing points to other student's mobile)

5. Claire: Chercher le mot? Oui . . . (looks up the word on Google translate)

6. Julie: Oui, merci

7. Claire: Oh évidemment!

8. Julie: Évidemment! Oh that makes sense!

9. Mary: Oh, oui évidemment!

10. Julie: É . . . comment? é . . . non, comment est-ce qu'on . . . ?

11. Claire: E avec un (hand signal for accent) V . . . oui . . . I

12. Julie: é . . . vi..de . . . ment évide . . . évidemment . . . comme ça?

13. Claire: Oui

14. Julie: Avec un E? . . . à la fin? regarde (Comparing spelling on both screens)

15. Claire: Oui, évidemment. Ok j'ai utilise Google translate

16. Julie: le meilleur. . .

17. Claire: J'ai un peu . . . embarrassé pour umm . . . utiliser (Chuckles)

18. Julie: le meilleur café sur campus. . .

19. Mary: Non!

20. Claire: Non?

21. Mary: Non, ça ou aussi WordReference

22. Claire: Oui et WordReference c'est bonne

23. Mary: C'est bon!

24. Julie: At . . . à le? Avec un (inaudible)?

25. (All three students speak at once overlap unclear/indistinguishable)

26. Mary: Non, à le c'est *au* . . . je pense?...

27. Julie: avec un . . . comme ça?

28. Claire: Est le Sub masculin ou féminin?

29. Mary: c'est *le*, so I think it's *au*, je pense . . . A U . . . *at the* . . . je pense, donc *au*

30. Julie: Like the word at?

31. Mary: Yeah *at the* . . . or like what are you trying to say?

32. Julie: à Munchie Bar

33. Mary: oui, *at the*

34. Claire: At Munchie Bar

35. Mary: Yeah

36. Claire: so au Munchie Bar?

37. Mary: oui *au* Munchie Bar

38. Claire: Ok, probablement

39. Mary: je pense oui

40. Julie: Ok le Sub avoir le nourriture et oh non . . . *la* nourriture

41. Claire: Oui c'est la

42. Julie: Ok, la nourriture et évidemment le meilleur café sur campus au Munchie bar . . . quel . . . quoi d'autre? (looking around)

43. Claire: Peut-être Felicita's?

44. Julie: Ok, aussi . . . il y a ?

45. Claire: Oui, il y a

46. Julie: Il y a Felicita's . . . avec karaoke?

47. Claire: Oui . . . mais umm pretty sure it's kareoké (looking up word on Google translate)

48. Claire: yeah oui c'est [can't hear the rest over laughter]

49. Mary: Oui karaoké

50. Julie: K a r e o . . . ké? comme ça?

51. Claire: Oui karaoké . . . le karaoké sur jeudi? (Laughter continues)

52. Julie: Oui karaoké sur jeudi

53. Claire: les étudiants peut (inaudible) et boire beaucoup de bière (All laugh)

54. Mary: oui (Laughter continues)

55. Julie: mes mains sont froides et c'est difficile de tapper . . .

56. Claire: A étudiants?...(Inaudible)

57. Mary: Étudiants

58. Julie: Est-ce que c'est correct?

59. Claire: Ah étudiant? c'est. . .

60. Julie: C'est en anglais les . . . clés

61. Claire: Oh ok

62. Julie: Ou des étu. . .

63. Mary: Ou . . . the u has an accent (points to *ou* on screen)

64. Julie: Merci . . . Ok étudiants boire beaucoup de bière (All laugh) C'est un bon. . .

65. Claire: Une? C'est une bonne bière. . .

66. Julie: Quoi? Une bonne? I was gonna say c'est un bon hangout

67. Marie: Un quoi?

68. Claire: Oh (Laughter) umm une bonne

69. (All students speak overlap unclear/indistinguishable)

70. Claire: I E it's a great place

71. Julie: Le SUB avoir la nourriture et évidemment le meilleur café sur campus au Munchie bar.

72. Claire: Aussi il y a Felicita's avec karaoke . . . karaoké sur jeudi où des étudiants boire beaucoup de bière.

73. Julie: Et tweet

74. Claire: Mot cliquer (All laugh)

75. Mary: mot-*clic*

Similar to Volet et al.'s study question-asking contributed to sustaining group engagement in high-level co-regulation during gameplay. In the excerpt above the students collaborative learning is supported by their negotiation of meaning including requests for help and comprehension checks. Additionally, question asking was quite dominant throughout, with many requests for help (lines 1,4,10,12,14,24,28,42,44,50,58) pertaining to vocabulary, spelling, grammar, or content. For example: line 1 Julie asks "est-ce que c'est un mot? (is that a word?); line 12 Julie sounds out the word as she types it, then asks "comme ça?" (like this?); and line 24 begins a discussion on the correct preposition for translating *at* for a masculine noun (grammar). Additionally, three questions entailed comprehension checks (lines 30,31,65). In line 31 after the speaker changes several times discussing the translation of *at*, Mary clarifies she is understanding correctly and asks ". . .or like what are you trying to say?". As the students discuss and create the tweet content they illustrate high-level content processing, further supported by reasoning, building on each other's ideas, requests for help and comprehension checks.

A second factor Volet et al. identified in the possible sustainment of high-level co-regulation was a tentativeness of explanations. The authors elaborated specifying that students sharing content knowledge with some uncertainty or lacking assertiveness possibly encouraged the other group members to also contribute and expand the dialogue. This concept of tentativeness is seen throughout Excerpt 5 *via* the multiple requests for help, offering suggestions in the form of indirect questions, and also when the students are giving each other corrective feedback. For example, when Mary offers the correct translation of the preposition *at* to her teammates (lines 26,29), she explains then includes "je pense" (I think). This tentativeness is also apparent in the students' vocal tones, facial expressions, and body language in the video recording. Claire's content suggestions (lines 43,51) are put forth as indirect questions and her tone and body language further support a tentativeness. As Volet et al. highlight this tentativeness is paralleled in educational psychology literature as *openness* and *non-defensiveness*. Vauras et al. (2003) state that openness is a significant factor in successful peer collaboration. Therefore, the group dynamics must also allow for peer assistance, and the students themselves be open and willing to give and accept assistance. Throughout excerpt 5 student instances of tentativeness and the team's group dynamics were describable as open and non-defensive, supporting the sustainment of the students' high-level co-regulation.

The third factor Volet et al. identified for sustaining high-level co-regulation was student's background knowledge. Volet et al. argue that "(t)here is evidence that distributed task-relevant knowledge increases high-level contributions to constructing knowledge in student work groups" (p.140). This mirrors the sociocultural perspective, which focuses on the social nature of language learning and highlights learner interactions as a primary learning force. Additionally, it parallels the concept of scaffolding, which draws on Vygotsky (1978) Zone of proximal development, and is further adapted for language learning to define collaborative peer L2 learning, regardless of the skill levels of the learners (Lantolf and Thorne, 2006). The learners take the roles of experts and novices, and assist each other by means of scaffolding through peer interactions (Ohta, 2000). Thus, a learner is able to accomplish more via collaboration with peers, than what they could accomplish individually. In excerpt 5, this is supported by Mary's previous knowledge of the correct translation of *at* given that the noun is masculine. Julie asks her teammates about the translation (line 24) asking "à le?" and Mary responds with no, *à le* is *au*. After Claire asks if the SUB is masculine or feminine, Mary attempts again, trying to explain in her own words that *à le* is *au*. Lines 24–39 are the three student's interactions concerning this translation until all three concur with the translation *au*. Throughout excerpt 5 the students effectively collaborate to create the tweet employing requests for help, comprehension checks, and corrective feedback.

The fourth factor identified by Volet et al. for sustaining high-level co-regulation was shared positive emotions. The multiple occasions of laughter throughout excerpt 5 support positive shared emotions amongst the team members. Laughter is brought on when Julie adds the suffix *ment* to the English word *obvious*, by the pronunciation of *kareoké*, and later on the misstated *cliquer*. Overall their demeanors appear playful, open and non-defensive. Additionally, despite the humor and laughter, the students stay on task in the creation of the tweet. Laughter is believed to serve as an instrument to build social cohesion (Robinson and Smith-Lovin, 2001). Moreover, positive emotions can result in increased commitment to the group

(Lawler and Yoon, 1996). Similar to Volet et al.'s study, the positive emotions and laughter in excerpt 5 appear to potentially play a role in the student's engagement in sustaining the high-level knowledge construction.

DISCUSSION AND CONCLUSION

This research sought to examine the potential of collaborative learning in place-based AR L2 games. The proposed adapted framework, which examined how students socially regulate and process content, was found to be useful in identifying patterns of interaction during gameplay of the L2 games. The analysis showed prominent differences in patterns of collaborative learning across groups and sessions. Additionally, the analysis identified contributing factors to the emergence of high-level co-regulation, as well as potential factors that aid students in sustaining high-level co-regulation during gameplay. By means of identifying both high and low level co-regulated content processing, the findings highlight that students participating in active collaboration also rely heavily on low-level co-regulation during gameplay. Although research supports that high-level co-regulation is the most effective means of collaborative learning (Volet et al., 2009), in regards to language learning low-level content processing is also an important factor (Nassaji, 2014). Additionally, the highly interactive nature of the AR games, as well as, the collaborative potential during gameplay support a sociocultural theory lens, focusing on the social nature of language learning and emphasizing learner interactions as a principal learning force (Lantolf and Thorne, 2006).

Despite the very dissimilar learning context (that of a L2 mobile learning game in comparison to the group analysis of a medical clinical case) the present research paralleled Volet et al.'s study regarding the emergence of high-level co-regulation in that the majority of the time it was preceded by a question or explanatory statement. In the context of the place-based learning game, the game design played an important role. High-level co-regulation content processing episodes emerged when students responded to certain gaming prompts, as well as open ended questions. A large majority of instances arose during the task of creating a Twitter post in the TL, which often resulted in the students first discussing the content they should include, and then creating the tweet. This supports the learning potential of AR learning games, as well as the use of Twitter for gaming tasks and L2 learning. This also echoes the many potentials of Twitter as a tool for language learning for both input and output production, with interactions in the form of written text or audio and video recordings (Rosell-Aguilar, 2018). Employing Twitter can be an effective addition for gaming systems should the developer/instructor require a means for students to respond to questions and tasks, and such a tool is not included in the development platform. Future research could further examine the integration of Twitter or other social networking tools in learning games and their potential learning implications.

The qualitative close examination of a lengthy episode of high-level co-regulation highlighted four potential factors that appeared to contribute to the students sustaining the engagement of high-

level co-regulation: asking questions, tentativeness of explanations, background knowledge, and shared positive emotions. Again, despite the different learning context, this exploration of potential contributing factors to sustained high-level co-regulation in group interactions during gameplay mirrored Volet et al.'s previous research. Additionally, similar to Thorne (2008) research, the students in the present study illustrated that their negotiation of meaning during gameplay included requests for help, comprehension checks, and corrective feedback.

The findings supported that the place-based AR gaming environments create opportunities for students to engage in high-level co-regulation. Learner collaboration during gameplay is of course dependent on many factors, including but not limited to the students themselves, group cohesion, and game design. The findings also supported that place plays an important role in gameplay as students draw from the environment around them in response to the tasks at hand. As illustrated in all four excerpts (see *Data Illustrations*), the place-based component of the AR L2 games played a central role. These excerpts also highlight three emerging themes in regards to the significance of place-based learning in AR games: during wayfinding as students figured out the next gameplay location and how to get there, pre-planning discussions before creating a tweet, and both physical and verbal references to the immediate surroundings while answering questions and/or creating a tweet. These results mirror those of Thorne and Hellermann (2017) study, further supporting the importance of place in AR learning games.

Furthermore, in the interviews, participants were asked if "place" added to their learning experience. Twenty of the 22 students responded "yes" that being outside of the classroom, in real environments (although only virtually francophone) aided in making their learning more relevant or meaningful. The participants also elaborated discussing the benefits of being outside the classroom and practicing their French in real world environments:

It added a very real aspect to the learning . . . being able to conversationally bring it outside of the classroom to *very real events*, and to apply what we learned. (Fran 100 participant S19P18)

I didn't think I'd remember some of the new words, but because I kept reading them, and we were in real ... relevant places I *did* remember them. (Fran 120 participant S19P13)

I absolutely loved it! I think it makes it *really fun* . . . it also added a sense of *realism* to the game because we actually had to traverse real distances and go to real places . . . and being outside and going around definitely added to my *interactivity* and *immersion*. (Fran 160 participant F18P1)

The above excerpts highlight the students' reported added value of being out of the classroom, and the place-based component of the games which by incorporating real-world locations for their L2 learning, created an immersive, contextual, and engaging learning environment.

Findings also showed that all student teams engaged in collaborative episodes regarding language, technology and

gameplay. Overall gameplay collaboration had the highest number of occurrences. Designing the two games to create opportunities for students to work together and promote collaboration appeared to be successful. This supports that the design and development of place-based learning environments drawing from previous collaborative digital games research (e.g., Rocha et al., 2008; Seif El-Nasr et al., 2010) is a suitable option. However, further research into such collaborative design is necessary, as well as which design elements may further engage students less likely to collaborate. Findings in the present research showed the level of interaction and collaboration varied by team, and appeared to depend not only on game design, but also students' comfort level speaking the L2, group cohesion, as well as player types and learner styles. Additional iterative game design to further encourage collaboration, team cohesion, and students taking turns holding the device may assist in an increase of interactions.

Additionally, the development of SLGs must not only include sufficient learning content scaffolding, but also appropriate gameplay scaffolding. Well-developed video games provide sufficient guidance for beginners at the start of the game, and the level of difficulty gradually increases as players progress (Gee, 2007). Findings showed that participants with gaming experience found the two AR L2 games to be straightforward, and the gameplay scaffolding appropriate. However, other participants without digital gaming experience at times struggled with gameplay comprehension, which resulted in the researcher simplifying gameplay options and progression where necessary, inserting additional in-game hints, as well as the creation of tutorial videos. Testing groups 2 and 3 had substantial less technical issues, and less gameplay issues overall, supporting that the iterative development of the systems after each testing session appeared to improve gameplay comprehension and scaffolding. This highlights the importance of several iterations of playtesting, and the relevance of the Design Science framework, in which the process iteration affords the opportunity to return to prior stages (such as design and development) during and after evaluating the learning tools. However, further testing and iterative development would benefit both L2 games, given that the adjustments and additional gaming elements did not fix all comprehension issues for some players. Another design element to consider is the inclusion of hacks. The development of gamified learning environments is a highly iterative process, and requires many adjustments in the final stages, especially when elements are location-based, as is the case in *Explorez* and *VdeUvic*. For some gaming triggers in location-based systems the only way to verify updates and changes is to physically go to the locations and test all the elements. In *Explorez* an additional scene was created containing hacks for each quest, and the necessary gaming elements to trigger each quest (conversations or badges). When the system builds on previous gaming elements (quests, tasks) these type of hacks are essential so that the developer does not need to play through every quest to get to the one which needs testing. These

insights underline the necessity of also piloting gamified systems, preferably with individuals with different technical, gaming, and language abilities to assist in identifying any design issues before conducting the study and/or first official playtest session.

In conclusion, this study included a small sample size, and therefore does not represent L2 learners as a whole. Another limitation is the lack of a control group; however, the research goal was not to compare classroom learning to gameplay learning. The scope of the present paper focused on student collaborative learning within two place-based AR learning games. However, the adapted framework also contributes to research, and the detailed steps of adaptation and analysis may assist in modifying other methodologies examining SLGs. The framework could be used in future projects to examine collaborative learning in other SLGs or further adapted for other learning contexts. Place-based gaming design also impacts student engagement and motivation, as illustrated by positive responses from participants in this study. Further research on design, as well as, gaming elements to specific learning contexts, such as employing Twitter for gameplay tasks merit consideration. Continued research on place-based learning games will aid in the creation of immersive, engaging and contextual learning environments.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because Research Ethics Protocol does not allow the data to be shared. Requests to access the datasets should be directed to BP bernadet@uvic.ca.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Victoria Human Research Ethics Protocol Number 18-263. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

BP Researcher and Author; Conceived and designed the analysis; Collected the data; Performed the analysis; Wrote the paper.

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