Development and use of a Playful Learning Observation Tool (PLOT) for Active Game-based Learning in Physical Classroom Situations

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Abstract: Purpose – This study presents the development and implementation of a qualitative observation tool for in-class observation of courses employing game-based learning (GBL), and playful learning situations. Methodology – The design of the observation model exploits a literature review of classroom observation models, of cognitive psychology motivation scales, and of GBL evaluation models. It integrates relevant elements from these domains to offer an observation model for GBL implementation. In this model, in-class observations are coded and analysed for GBL effectiveness and potential to support intrinsic motivation in students. The model was then used in two courses using different forms of GBL (one digital cooperative multiplayer game, one analog board game). Observations were coded using NVivo and distributed according to type of motivation and type of motivated learning tasks. Due to Covid19 restrictions and the difficulties of finding in-person classes, only two courses were examined using the model. Findings – the model appeared efficient in both observational situations, and the coding confirmed previous studies to the potential of GBL to sustain students' intrinsic motivation. The observations also showed that preparedness of students to the specific contents of the game reduced risk of amotivation and disengagement in students. Practical implication – The study allows us to reflect on best practices for GBL implementation and evaluation and how better understanding of in-class interactions during playful learning could enable educators and teachers to make better informed choices to implementing GBL. Interest – While there are many templates for classroom observation and GBL evaluation, there is a lack of dedicated observation models, that offer clear guidelines for qualitative data gathering in live, in-person classroom situations. This study aims at providing a specific tool to that purpose.

Keywords: game-based learning, qualitative data, observation, evaluation tool, motivation

1. Introduction

Using games and simulations in education is a common approach to increase quality of study through active learning. Active learning enables students with 21st century skills such as learning and innovation skills, media and technology proficiency and lifelong learning capacity (Soranastaporn et al., 2017). Several meta-studies have pointed to the effectiveness of games for cognitive, affective, and psychomotor learning (Sauvé, 2010). There is currently sustained interest in the field of playful learning,

However, evaluation of curriculums integrating game-based learning (GBL) has proved challenging owing to the wide range of technical, material, and human components that intervene in playful learning. Effectiveness of GBL has often been questioned due to this difficulty, but over the past decades empirical research has solidified interest in the playful learning approach, a recently coined umbrella term that tries to encompass various approaches, from gamification to digital GBL, educational escape games, board games and roleplaying games (Whitton, 2018). Common evaluation practices include students' performances through grades, pass rates, knowledge in pre- and post-tests, as well as students' perception of the learning process, through their self-reported appreciation of the method, interest in the studied subject, and evaluation of the technology. (Algayres et Triantafyllou, 2019). To fully understand the application and elements of GBL, though, prolonged time and extensive observation are necessary for gaining an in-depth understanding of a classroom proceedings. This task necessitates qualitative methodology (Fasse and Kolodner, 2013).

Classroom observation has always been part of the qualitative methodology toolbox. It has yet always seemed to play an auxiliary role to other methods such as interviews or text analysis. Among the challenges that Classroom observation presents many challenges (time, organization, ethics, impact of the researcher's physical presence on the teaching process), especially in finding a relevant model to frame the observation and get a clear understanding of what is happening in the classroom. It appears that there is a lack of observation models for GBL in the classroom.

Indeed, there are many teaching observation models (American Association for the Advancement of Science, 2013), as well as models to evaluate serious games efficiency for engagement and educational purposes. GBL

has often been studied through comprehensive methods of evaluation (e.g., Emmerich et Bockholt, 2016), but few or no models are specifically dedicated to observation of GBL in the classroom.

In this article, we try to bring an answer to this issue by designing PLOT (Playful Learning Observation Tool), a scale and analysis model for implementing GBL in physical classrooms. Our objective will be 1) to determine how we can build an observation tool for GBL in the classroom focusing on student motivation to participate in the learning process, and 2) if we can implement this tool in different classroom situations with different types of games. The structure of the article is as follows: we will present the literature background, the methodology for the design of the tool, the implementation of the tool, the results of the observations, and discuss the potential and limitation of our tool.

2. Background literature

We approached this study by examining the main topics relevant to the design of a GBL observation tool: classroom observation tools, GBL evaluation patterns, and student motivation models. We reviewed each topic to identify the most relevant elements to build our dedicated observation tool.

2.1 Classroom observation tools

Our first element of inquiry was classroom observation tools. While it was not possible to make an exhaustive recension of such tools, we investigated various examples both from manuals on qualitative data and case studies of observation tools development.

The objective of an observation tool is to support fieldwork research, which necessitates both long-term participation in a field setting, "careful recording" of what happens and "subsequent analytic reflection on the documentary record" (Erickson, 1985). Erickson (1985) thus recommends looking into specific structure of occurrences, and the way they can illustrate perspectives of specific actors for specific contexts. Wragg (2012) introduces a similar point through the critical event technique, with the idea that "the observer looks for specific instances of classroom behaviour which are judged to be illustrative of some salient aspect of the teachers' style or strategies: an element of class management, for example, a rule being established, followed or being broken". The American Association for the Advancement of Science (2013) published an extensive documentation focused on describing and measuring teaching practices in STEM. They recommend distinguishing descriptive and evaluative perspective (the first one centered around as objective as possible reporting, and the second trying to pin it against best practices or models). They also present several use cases of classroom observation tools.

With these points in mind, we analysed several observation tools. The results of this analysis can be read in table 1.

These case studies shared some elements that guided us for our own design and implementation. First, they would clearly identify the object of the observation, whether focusing on teacher, students, interactions between any of the two, engagement in each activity or manifest signs of engagement (e.g., questioning, sustained interactions). Secondly, they would provide a detailed list of relevant items to observe so that the tool could be applicable even in situations where the observer is not knowledgeable in the curriculum. Finally, all case studies acknowledged the limits and challenges of observation while trying to answer these issues. A very relevant point is that observation alone can be limited by lack of training in a designated model, by the nature of what is or is not observable, and the given number of sessions (AAAS, 2013). Therefore, while we focus in this paper on a designated model, we underline that qualitative observation should always be used in conjunction with other data, such as surveys or assessments (Holbrook, Gray and Fasse, 1999), or with other qualitative data taken from text documentation and interviews.

Table 1: Summary of classroom observation tools

Name of model	Focus of observation	Items described	Reference
PORTAAL Practical Observation Rubric to Assess Active Learning	Teacher and student behaviour	Four dimensions with focus on teacher's implementation on good practices (practice, logic development, accountability, reducing student apprehension). Some observations on students' engaging with teachers, manifesting support to their peers	Eddy, Converse and Wenderoth, 2015
Teacher–Pupil Observation Tool (T-POT)	Student and teacher interactions	Teacher-child and child-child interactions, coded for positive and negative interactions	Martin et al., 2010
STROBE Classroom Observation Tool	Student behaviour and engagement	Description of activity, proportion of active students, learners' behaviour (listening, writing), direction of attention	Adam Kelly et al., 2005
Flanders Interaction Analysis System (FIAS)	Student behaviour and engagement	Affect, engagement, and misbehaviours during class	Yang and Moskovsky, 2021
Observation Tool of Active Gaming and Movement (OTGAM)	Children's movements (strike, throw, roll)	Items describing children movement and activity (On/Off) engaged/disengaged	Rosa, Ridgers and Barnett, 2013
Observational Prompt Tool (OPT)	Students' activities and behaviours in class	Detailed activities or specific goals showing engagement (generating questions, group collaboration)	Holbrook, Gray and Fasse, 1999

Our objective in designing an observation tool is therefore threefold:

- A tool for a defined element, here interactions during the GBL experience.
- A tool presented as a list of items relevant to GBL.
- A tool that would enable both descriptive and evaluative perspective and be accessible even to observers with no GBL experience.

2.2 GBL evaluation tools

Our second main topic regards GBL efficiency in terms of student engagement, and evaluation grids to measure it. Integration of game mechanics (or *gamification*) has been typically used to enhance the teaching-learning process through the improvement of the students' motivation (Klock, Gasparini, and Pimenta, 2019). Similarly, GBL aims to stimulate motivation and problem-solving skills in learners by integrating learning materials into the gameplay (Tao, Huang et Tsai, 2016).

We examined several models of GBL evaluation tools, and how they defined categories to frame the user experience. Not all categories apply to in-class observation, but they provide guidance to the elements to examine in physical classrooms situations. The approach by Oprins et al. (2015) followed a linear temporal structure based on input, process, and output. Process includes game design, motivational and cognitive elements, and output focuses on learning objectives and outcomes (Oprins et al., 2015). Klock and Pimenta (2019) developed the 5W2H framework by focusing on material implementation of gamification, under the thematic question marks who, what, why, when, how, where, and how much. These categories cover a wide range of elements from type of players to interactions, playing goals, type of interface and educational outcomes. Similarly, Aubert, Medema, and Wals (2019) proposed a model based on three poles of evaluation: game design and technical aspects, people and processes, and purpose and outcomes. Tahir et al. (2018) presented in their model six parameters for evaluation: learning/pedagogical, game factors, affective cognitive reactions, usability, user, environment. Finally, in perhaps the most comprehensive analysis, Sanchez (2013) determined seven key criteria for game design, three motivational (based on competence, autonomy, and relatedness), as well as content, rules and feedback, mistakes and emotional aspects, and game integration.

We derived from this analysis the necessity to integrate in our model both elements of game design, user experiences and affects, as well as the connection to the importance of motivation in GBL experiences.

2.3 Motivation scales

Finally, we researched specific motivation scales. Indeed, for our model to be both descriptive and evaluative, we wanted to connect classroom observation with the potential to support motivation in students. Previous research has indicated that educational games have the potential to sustain motivation in students (Algayres, 2019).

The development of the model thus relied on fundamental principles in active pedagogies and students' motivation in cognitive psychology. Viau (1997) established three aspects in students' motivation: a sense of competence, an understanding the finality of the learning task, and control of the activity. Self-determination theory (SDT) as formulated by Deci et Ryan (1985) established both a continuum of motivation, as well as the idea that self-determined motivation depends on the satisfaction of three fundamental psychological needs: need of autonomy, need of competence, need of relatedness. These fundamentals have been reprised in many studies on GBL and active learning such as Minnaert and Boekarts (2007) or Sanchez (2013). Deci and Ryan (2000) further establish intrinsic motivation as "the inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn (…) The construct of intrinsic motivation describes this natural inclination toward assimilation, mastery, spontaneous interest, and exploration that is so essential to cognitive and social development". Figure 1 presents a synthesis of SDT used for our model.

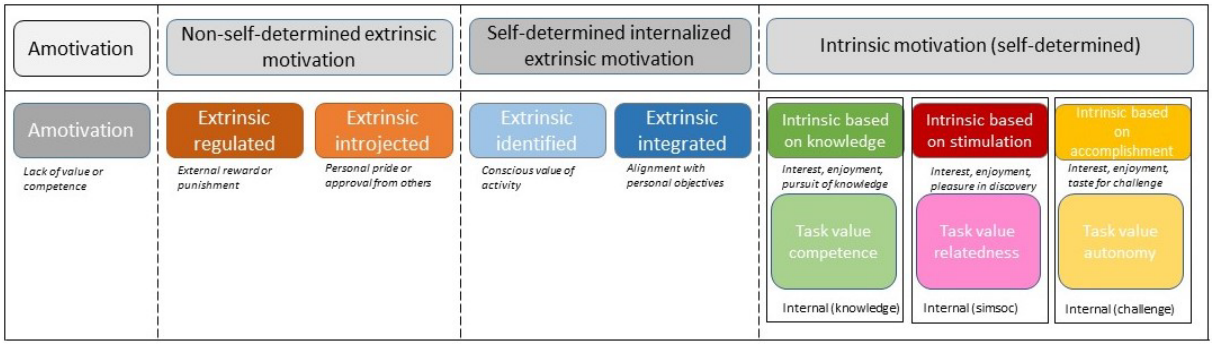

Figure 1: Synthetic representation of motivational constructs

This figure represents the continuum of motivation as well as the three fundamental psychological needs assigned to the task value. We distinguish in this repartition:

- amotivation (complete lack of value)
- non-self-determined extrinsic motivation (regrouping regulated and introjected extrinsic motivation, covering external factors from rewards, punishment to peer or teacher approval)
- self-determined internalized extrinsic motivation (grouping identified and integrated extrinsic motivation, situations where the task is not enjoyable but aligns with the students' perception of its value or align with their interests, in obtaining a degree in their chosen field for example)
- intrinsic motivation which, based on interest, enjoyment, and inherent sense accomplishment, is the most desirable to ensure long-term positive educational outcomes. Intrinsic motivation has three subcategories which we have tied to specific task values and fundamental needs. We grouped sense of competence with intrinsic value based on knowledge in the internal (knowledge) category. The internal (simsoc for stimulation and social) category groups motivation based on stimulation and need for relatedness. Finally, the intrinsic motivation based on accomplishment and need for autonomy for the internal (challenge) category.

3. Methodology

3.1 Design of the Playful Learning Observation Tool (PLOT) and analysis scale

From the elements studied in the literature review, we devised the PLOT tables and scales. The most prominent influences in this design were from:

- Holbrook, Gray and Fasse (1999) observation prompt tool, due to the clarity of their item list and focus on active learning through their Learning by Design methodology,
- Deci and Ryan (1985) self-determination theory and motivation scale, and
- Sanchez (2013) key criteria for game design as well as Klock and Pimenta (2019) 5W2H framework.

The PLOT table is comprised of two parts: the first part records the practical information of the course observed (date, place, number of students, subject), as well material conditions of the course (physical and social environment, type of learning tasks, discipline), while the second part, the PLOT table, focuses on the GBL experience. We decided to present this table under the appellation "playful learning" since its focus is on practical activities and interactions over the course of a GBL session, whatever the type of game considered.

The PLOT table lists 51 items regrouped in four categories: Who? (Players' profile, preferences, game culture), What? (Tasks, interface, communication, performance), Why? (Fun, engagement (cognitive, behavioural, emotional), play dynamics), and How? (Mechanics, dynamics, components, player journey, reinforcement). Each item takes the form of closed statements that leads to a yes/no perception, allowing the observer to simply list what happens (or not) during each playful learning session. Examples of such statements are, e.g., "Students play in teams"; "Students have a clear victory goal"; "Students make active use of their knowledge during the game"; "Students get immediate feedback from the game", but also negative outcomes such as "Some Students appear uninterested and disengaged"; "Some Students ignore the rules or cheat". Figure 2 shows the table in its original form.

Question	Who?	What?
Focus	*Players' profile, preferences, game culture*	*Tasks, interaction (interface), communication forms, performance (evaluation)*
Notes	• Most S have experience playing similar games • Most S have no or little game experience • S play solo • S play in teams • S play as themselves • S are given a specific role (alibi) • S prepared for the game before the session • S went through the game session on the spot • Some S express discomfort with GBL	• The game has been designed for a specific curriculum • S have a specific and functioning interface/material • Problems with the interface/material (explain _____) • S communicate directly with each other during the game session • S communicate online during the game session • S have a clear victory goal • S are given a loose set of objectives • S get a specific summative evaluation after the game • S participation in the game is not evaluated • S understand easily the objectives and tasks of the game • S self-regulate their progression objectives • S require a lot of T guidance to get started with the game • T frequently intervenes to reframe the game experience • S express frustration with the difficulty of the game tasks

Question	Why?	How?
Focus	*Fun, engagement (cognitive, behavioral, emotional), play dynamics*	*Mechanics, dynamics, components, player journey, reinforcement*
Notes	• S accomplish clearly identified challenges/tasks • S accomplish tasks that have equivalences IRL • S follow the game rules to accomplish their objectives • S make active use of their knowledge during the game • S can interact within a simulation of a different context • S follow a specific narrative • S engage in discussion often, pleasantly and/or humorously • S can change their objectives during the game session • S appear active and engaged • Some S engage only when actively solicited (by T or other S) • Some S appear uninterested and disengaged • Some S ignore the rules or cheat • Some S actively voice discontent with the game	• S engage in collaborative play • S engage in competitive play • S hear the learning objectives clearly (T or material or interface) • S show clear understanding of the mechanics and progression • S "level up" over the course of the game • S know their score and/or level at all times • S can see their level compared to others • S get immediate feedback from the game • S get a reward after each action/objective • S have possibilities of retry and error • S can customize their character/avatar • S can advance/influence the story/narrative during the game • S can support each other during the game • S get a debrief session after the game • S manifest low motivation and/or disengagement

Figure 2: Excerpt of the PLOT table

Each item of the PLOT table was listed in a dedicated analysis table and coded according to the motivational elements presented in Figure 1. These elements were listed both in Excel and NVivo. The choice of NVivo as a coding tool was made because of its speed and reliability, and easy to code nodes (i.e., codes that ensure monitoring of what is being observed. NVivo as a software tool has proven its efficiency to process data from various sources, among others classroom observations and field notes (Ozkan, 2004).

This structure allows the PLOT table to be used first for descriptive purposes, listing elements of interactions that can be easily observed even by observers without gaming experience. The PLOT analysis scale allows for an evaluative observation, by assessing which motivational elements are the most present in the observed experience. We express these elements in percentages of the total of items observed to evaluate the relative weight of each motivational construct.

3.2 Implementation

We tested the model in two different courses, for two different games, over four play sessions each. Table 2 presents the main characteristics of each game.

Table 2: Summary of games used in the study

Game	Type of game	Level	Number of students	Student per playing teams	Main game mechanic
Game 1	Digital multiplayer quiz	Undergraduate	10-12	2 students	Players team up to answer questions
Game 2	Non-digital strategic boardgame	High School	12	4 students	Players win tokens by performing learning tasks that they can spend on the game board

The first course involved undergraduate students in Aalborg University, Denmark, enrolled in the Medialogy curriculum, during a course entitled "programming of complex software systems". Since the course was delivered in a hybrid format due to partial resuming of classes after the Covid lockdown, only a group of 12 students took part in the game sessions. Game 1 was a multiplayer digital quiz like the one found in the popular educational application Quizlet: students are paired randomly, one student gets a series of questions while the other gats a set of responses, and they need to work together to pair the correct question and answer. Figure 3 presents a screen capture from the players' dashboards in this game, and a picture of the students sitting in playing pairs in the classroom. The students moved to sit in pairs or in small groups formed of several player teams. However, the classroom configuration did not allow for much flexibility.

Figure 3: Dashboard and classroom configuration for Game 1

The second course involved a group of 12 students at high school level (grade 10) enrolled in Østerskov Efterskole during Danish language and History lessons. Østerskov Efterskole is boarding school in Denmark where the entire process of learning revolves around GBL. A new game is designed and played by students each week, and courses are organized around the theme of that game. This method has been studied by Gjedde (2013) who concluded that students were highly motivated by GBL, and their results were equal, if not superior for some special needs students, to those of their peers in the same age group. We observed four classes based on a game entitled "Peace in our time". Game 2 was a board game where groups of four students would represent fictional countries engaged in diplomatic strife. As students do more conventional learning tasks

(worksheets, group discussions), they earn resources that can be spend for the progression of their nation on the game board. Figure 4 presents the boardgame and students during a play session.

Figure 4: Board game and classroom configuration for Game 2. Some students regroup around the boardgame table while others are busy at their learning tasks.

For each of these two games we ran four observation sessions. Each class was observed during 90 minutes under teacher supervision. The undergraduate students in Game 1 also had an autonomous group working time that was not observed. Due to COVID-19 restrictions there was only one observer, who noted items through all the session, and revised the whole grid at the end of each session.. We believe that a two-observer framework, if possible, would improve the accuracy of observation. Since items in the model describe general behaviours in the playful learning experience, they are only listed once per session, regardless of how many occurrences happen in a single session. We ended up with a total of 71 items for Game 1, 74 items for Game 2, and coded them both in Excel and NVivo.

4. Results

We sorted our list of observed items based on motivational constructs both in Excel and NVivo. The data can be both read as number of occurrences per item, and items listed by session. Each game was then evaluated with the number of items for each motivational construct in proportion of the total. Figure 5 presents an excerpt of the coded table in NVivo.

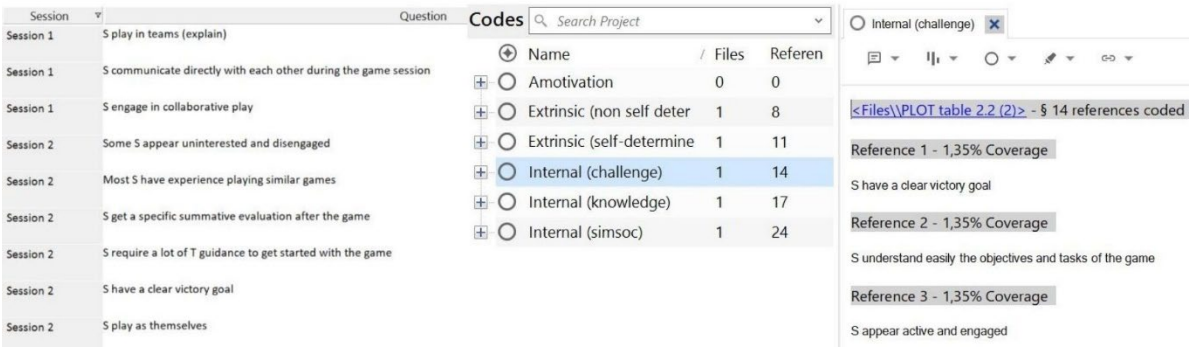

Figure 5: Excerpts of the coded table. Each item is listed by its code in the initial list, by session observed and by motivational construct associated with it.

Table 3 presents the item score and percentage for each construct and each game. Figure 5 presents the visualization of this data for game 1 and game 2. This allows for an easy descriptive and evaluative photography of each game session.

Table 3: List of motivational constructs and proportion of total for each label

	Intrinsic (knowledge)		Intrinsic (simsoc)		Intrinsic (challenge)		Extrinsic (SD)	Extrinsic (NSD)		Amo
Category	IMK	TVC	IMS	TVR	IMA	TVA	Einter	Eintr	Ereg	AMO
Items Game 1	7	4	4	12	15	10	6	0	8	5
Percentage Game 1	9,86	5,63	5,63	16,90	21,13	14,08	8,45	0,00	11,27	7,04
Items Game 2	6	11	11	13	6	8	11	7	1	0
Percentage Game 2	8,11	14,86	14,86	17,57	8,11	10,81	14,86	9,46	1,35	0,00

Definitions: IMK: intrinsic motivation based on knowledge; TVC: task value based on competence; IMS: intrinsic motivation based on stimulation; TVR: task value based on relatedness; IMA: intrinsic motivation based on accomplishment; TVA: task value based on autonomy; Einter: extrinsic motivation internalized; Eintr: extrinsic motivation introjected; Ereg: extrinsic motivation regulated; SD: self-determined; NSD: non-self-determined; AMO: amotivation.

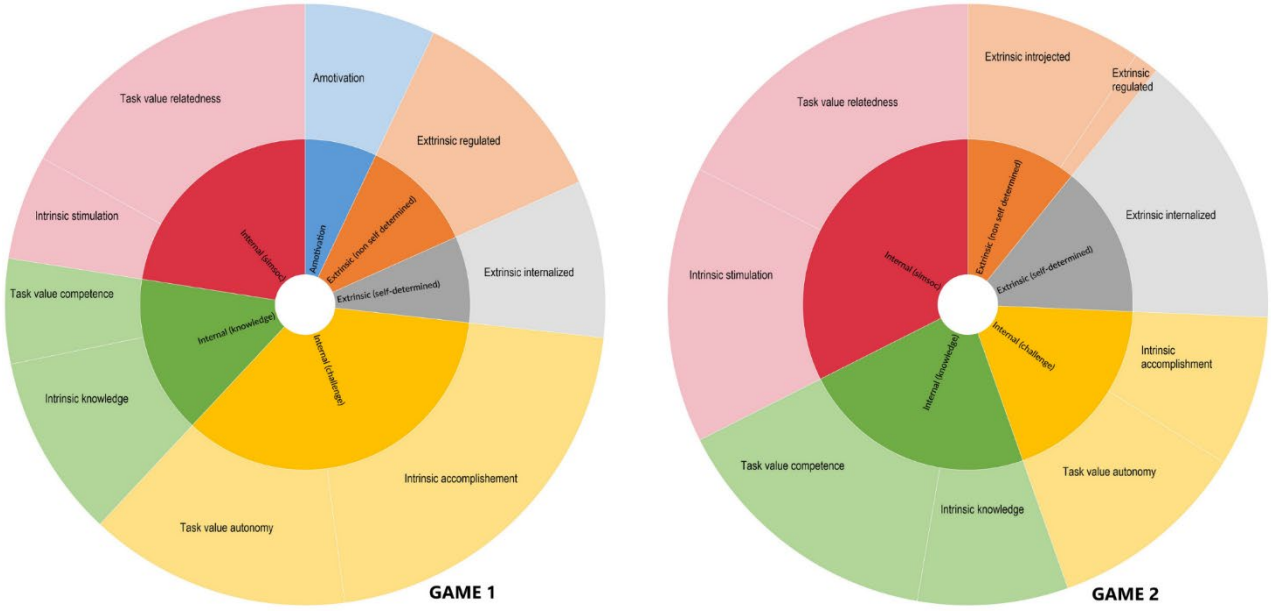

Figure 6: Pie charts for Game 1 and Game 2 sorted by categories and motivational constructs

The scores and visualization in terms of motivational constructs on both games are consistent with previous research (Algayres, 2019) that indicates that GBL can support intrinsic motivation in students. In our early research in GBL, the tested roleplaying game had shown improvement in intrinsic motivation based on stimulation and accomplishment. Game 1 presents its most salient features in the intrinsic (challenge) category, with high representation of accomplishment and task value autonomy, and scores also high in task value relatedness. This is consistent with the game being a multiplayer quiz, played in total autonomy, focusing on straightforward testing of knowledge with an immediate and quick victory goal, and necessitating a lot of student interaction. On the other hand, Game 1 presents higher scores in regulated extrinsic motivation and amotivation, which aligned with observations of a game that needed more teacher coaching to start, and where some students appeared averse to the GBL approach, and some did not prepare before class.

In comparison, Game 2 presents its higher features in intrinsic motivation based on stimulation and relatedness, as well as task value based on competence. This is also consistent with a game that emphasized group identities with students building their own fictional nation and flags and earning victory points doing learning tasks. The approach for the game was more holistic, leading in better motivational points for stimulation. Furthermore, Game 2 presents a significant score in internalized (self-determined) extrinsic motivation. This is also consistent with a student group, where GBL has been fully integrated as a valid method of education since it is part of their daily routine, and with students who were better prepared for the game.

5. Discussion

We observed that we managed to conduct observation sessions with our model for two very different type of games. By focusing on student-student and student-teacher interactions, as well as specific gameplay dynamics, the model could be applied to both groups equally. The repartition of the observable items in four delimited categories also made it easy to fill out. We consider that the observation model could easily be applicable in other curriculums or modes of GBL. The PLOT table and scale has therefore the potential to be an easily usable and replicable tool, to map both the student and teacher experience in a GBL situation, and to determine which motivational constructs are at play.

However, there are clear limitations to this approach. The first one is that due to ongoing Covid-19 limitations in terms of class reopening and external contact, we could only test our model with two games with a single observer in the room. More testing will be necessary to establish its pertinence in the long term. Furthermore, as stated earlier we strongly consider that observation is but one tool and aligned with Yazan (2015), we consider that qualitative data deriving from class observation should always be used in conjunction with other methods, both qualitative (interviews, textual and photographic analysis), and quantitative (surveys). However, owing to our initial purpose of trying to remedy the secondary role and poor documentation of classroom observation, we believe our tool to be appropriate to try and support valid and quality observation sessions in the classroom.

6. Conclusion

This paper presents the playful learning observation tool PLOT, aiming at facilitating qualitative data gathering in classroom situations. It was developed through a literature review of classroom observation best practices, GBL evaluation criteria and cognitive psychology theories of motivation. Particular attention was given to making the tool appropriate for various types of playful learning activity and accessible even to non-gaming observers.

Coding was made by learning session, by type of observation (who, what, why and how) and by motivational construct. This choice allowed for a descriptive and evaluative approach. We tested the table in two different classes with two different games and the results were consistent with the type of game and implementation.

More testing will obviously be required to consolidate the validity of the model, table, and scale but we hope that this tool will provide some opportunities for better use of classroom observation, or inspiration to develop such tools in the future.

Acknowledgements

This research was funded by the FLIP2G project. This project has been funded with the support of the Erasmus+ programme of the European Union. This paper reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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