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A praxeological perspective for the design and implementation of a digital role-play game

Eric Sanchez[1] · **Réjane Monod-Ansaldi**[2] · **Caroline Vincent**[2] · **Sina Safadi-Katouzian**[3]

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Abstract This paper draws on an empirical work dedicated to discussing a theoretical model for design-based research. The context of our study is a research project for the design, the implementation and the analysis of Insectophagia, a digital role-play game implemented in secondary schools. The model presented in this paper aims at conceptualizing researchers' and practitioners' relationships with the notion that knowledge development takes place at a meta-didactical level when the participants develop a shared practice and a shared discourse on practice (a common praxeology). This is done through collaboration and teacher-centered design of innovative learning settings. This model emerges from a double approach: (1) a literature review on collaborative research in education and, (2) an analysis of the verbal interactions of practitioners and researchers involved in the project. The study emphasizes the development of knowledge among participants. It also emphasizes the importance of knowledge brokering for filling the gap between research and practice and thus, for the adoption of digital technology by practitioners.

✉ Eric Sanchez
eric.sanchez@unifr.ch

Réjane Monod-Ansaldi
rejane.monod-Ansaldi@ens-lyon.fr

Caroline Vincent
caroline.vincent@ens-lyon.fr

Sina Safadi-Katouzian
sina.safadi@ens-lyon.fr

[1] CERF, University of Fribourg (CH), Fribourg, Switzerland

[2] EducTice, Ecole Normale Supérieure de Lyon – Institut Français de l'Education, Lyon, France

[3] EducTice, Ecole Normale Supérieure de Lyon and Ecole des Hautes Etudes en Sciences Sociales, Paris, France

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1 Introduction

Despite the widespread rhetoric about the positive impact of digital technologies on education and proactive educational policies in many countries, school adoption of Information and Communication Technology (ICT) is less developed than expected by policy makers. In addition, "there has been no appreciable improvement in student achievement in reading, mathematics or science in the countries that have invested heavily in information and communication technologies for education" (OECD 2015). It has been advocated that one of the numerous reasons impeding technology adoption and technology efficacy is that, due to the gap between practice and research, teachers face difficulties to seize the opportunities offered by digital technology. Educational technology research is considered to be disconnected to the needs of practitioners and to offer little systematic advice (Amiel and Reeves 2008). Research is also considered to produce an increasing body of knowledge which does not address the complexity of educational contexts and the challenges faced by practitioners (Ibid.).

Within this context, design-based research (DBR) offers opportunities to address the complexity of learning with digital technologies. Indeed, in the field of educational technology, DBR promotes a new perspective for overcoming the dualism between practice and theory by merging pragmatic and theoretical issues. By taking a resolute concern for the value of educational research, DBR is therefore expected to connect education, research and technology.

Researchers have paid considerable attention to DBR as an emerging methodological paradigm. However, DBR still lacks theoretical assumptions about how it enables for knowledge development. Recent papers on DBR mainly focus on hand-on considerations and the description of frameworks aiming at guiding the research process. Nonetheless, few of them address the underlying theoretical models that explain how collaborative design and tests in ecological contexts foster knowledge development. In addition, systematic and empirical recordings of DBR processes are rare and we lack empirical evidences about how these processes are carried out. We also lack empirical evidences about their impact on knowledge development and teaching practices. We consider this issue to be particularly important for the design of digital educational resources adapted to their users (teachers and students).

This paper aims at contributing to the filling of this gap. We suggest a model dedicated to conceptualizing relationships between researchers and practitioners with the notion that knowledge development takes place at a meta-didactical level. Participants reach this level when they develop a common *praxeology* (a common discourse on a shared teaching practice) through collaboration, for the design and implementation of innovative learning settings based on digital technology. This paper also draws on an empirical work dedicated to recording and to analyzing researchers-practitioners interactions with two perspectives: the description of the participants' *praxeologies* (ie. practice and discourse on practice) and the analysis of the debate which enables for their evolution. Our work aims at testing the praxeological model. We want to know if the *praxeologie*s of the different participants to a DBR project (practitioners and

researchers) evolve and converge during the time dedicated to collaborative design and experimentation in real contexts. We also want to know to what extend this evolution participates in knowledge development.

In the first section of this paper we draw the theoretical foundations and paradigmatic questions of DBR. A literature review enables for the presentation of a model aiming at conceptualizing collaboration between researchers and practitioners. This model also conceptualizes the consequences of this collaboration in terms of knowledge development. The second section describes our research setting based on the recording of participants involved in a research project. This project aims at designing a digital learning game for secondary education. We discuss the data collected in the third part of this paper.

2 Design-based research

2.1 Design-based research, a collaborative research methodology

In a work published in a French Journal, Sanchez and Monod-Ansaldi (2015) state that *design-based research* inherits from a long tradition of collaborative research methodologies. The rise of *design-based research* in the early 2000 is associated with the development of ICT for educational purposes. For *design-based research* (DBR) practitioners are not considered to be "subjects" of a study or "performers" of pedagogical solutions developed by researchers. They are *stakeholders* involved in an entire research project. They participate in the formulation of research questions and hypothesis based on problems that emerged from their teaching experience. They collaborate for the design of a pedagogical solution based on theoretical models developed by researchers. They are responsible for the implementation of this solution and may be involved in gathering data. They also participate in workshops dedicated to discussing and to giving meaning to the data collected. The role of researchers is also slightly different than usual. They are themselves deeply involved in the design of an innovative solution and temporary focused on pragmatic issues, at least during the phases dedicated to design and implementation.

As a result, DBR was defined as a collaborative and finalized research methodology early on:

> "*We define design-based research as a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories. The five basic characteristics: (a) pragmatic; (b) grounded; (c) interactive, iterative, and flexible; (d) integrative; and (e) contextual*" *(Wang and Hannafin* 2005)

DBR differs from other approaches in the following main characteristics (Design-Based Research Collective 2003):

– Collaborative: participants develop a common view of educational objectives addressed by the project. They build an agreement for the design of innovative

tools and a common understanding of the theoretical background needed for the development of these tools.
- Iterative: the design of the application results from several steps that combine design and analysis for flexible design revisions.
- Experimentation in naturalistic contexts (Cobb et al. 2003) enabled by the participation of practitioners involved in the whole process.

Reeves (2006) also emphasized the complexity of the problems addressed and the strong link between DBR and design methodologies:

> "*[DBR aims at] addressing complex problems in real contexts in collaboration with practitioners; integrating known and hypothetical design principles with technological advances to render plausible solutions to these complex problems; and conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles" (p. 58).*"

Therefore, in the area of the uses of digital technology in education, DBR has close relationships with software design methodologies that aim to take into account end-users by integrating them in a development team at the early stages of a project. Agile methodologies (Highsmith 2002) and user-centered methodologies (Norman and Draper 1986) are two examples of methodologies aiming at improving the reliability of digital artefacts. Within the educational field, DBR consists of a teacher-centered design approach. However, different stakeholders may be involved depending on the objective of the study: experts of the knowledge that students are expected to learn, software developers, students themselves and any person who possesses knowledge that might be taken into consideration for the design process.

Nevertheless, DBR objectives are not limited to pragmatic issues such as the design of learning or learning materials. The experiments that are carried out aim to test or refine the theoretical models developed by the researchers and, possibly, to create new ones. Thus, in the field of education, DBR addresses theoretical problems with targeted research by carrying out empirical studies dedicated to testing hypotheses. This means that, research on development and theoretical research may not be opposed but rather articulated.

DBR inherits from a long tradition of collaborative researches since the 70s but also results from disruption from previous approaches in particular regarding the role played by teachers. DBR differs from *action research* (Lewin 1946, Corey 1953, Bargal 2006) since the objectives are focused more on theoretical issues and generalizable results. DBR also differs from *didactic engineering* (Chevallard 1982, Artigue 1992) and *design experiment* (Brown 1992) by the way relationships between practitioners and researchers are envisaged. For DBR, practitioners are considered to be co-designers and not only performers of a learning scenario designed by researchers. Similar approaches of DBR, with different designations, emerged at the same period: *design science research* (Hevner et al. 2004), *design research* (Cobb 2001), *design and developmental research* (Richey and Klein 2007; van den Akker 1999) and *formative research* (Reigeluth and Frick 1999). They aim at combining "what is effective." (design) and "what is true." (research) (Hevner et al. 2004).

Thus, DBR also results from disruption from previous approaches in particular regarding the role played by teachers. DBR is grounded on close collaboration between

practitioners and researchers. It aims at articulating research and practice and considers practice to be a condition but also a means for carrying out research. In the following, we advocate for a theoretical model to analyze its collaborative dimension and its effects on participants' knowledge.

2.2 Design-based research as shared praxeologies

In this section we present a theoretical model aiming at describing how new knowledge is produced by *design-based research*. In a recent article, Sanchez and Monod-Ansaldi (2015) proposed a collaborative model built on the meta-didactical transposition framework (Aldon et al. 2013). This model aims to conceptualize the relationships between researchers and practitioners with the notion that collaboration occurs through the sharing of *praxeologies* (Fig. 1), in other words through developing a common practice and a shared discourse on practice (Sensevy et al. 2013, Aldon et al. 2017). According to Chevallard (1999), a praxeology is organized in two levels

- The *know-how* (*praxis*) that explains practices (i.e. the tasks performed and the technique employed).
- The *know-why* or knowledge (*logos*) that describes explains and justifies practices from a technological and theoretical point of view.

According to this model, the collaboration between researchers and practitioners occurs at didactical and meta-didactical levels (i.e. assumptions, explanations and justification of the didactical level). For example, decisions are taken about the tasks performed by teachers and students. This collaboration encompasses agreements regarding (1) what (tasks) should be performed by the teacher or the students, (2) the way the tasks will be performed (techniques), (3) the justification about the selected techniques (technology) and (4) the theoretical background framing the whole practice and justification (theory). In terms of developed knowledge, the expected results are both:

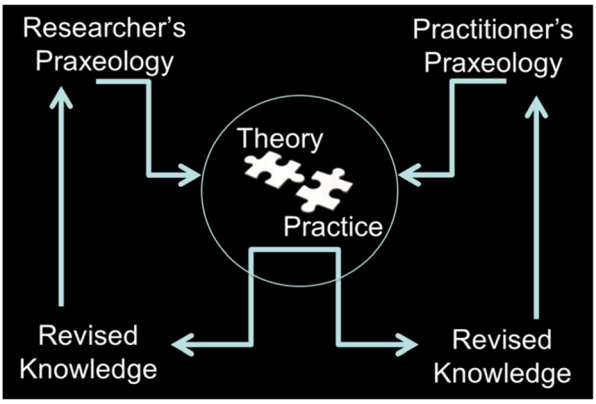

Fig. 1 DBR as sharing praxeology

– Pragmatic: new practices are developed, new tasks performed, new technology employed.
– Theoretical: the hypothesis embedded in the learning situations are confirmed or infirmed. The theoretical models are refined.

This knowledge might be incorporated into the participants' praxeologies. They are expected to evolve according to the knowledge shared during collaboration and gained through classroom experimentations. Collaboration between researchers and practitioners depends on the capacity to mobilize specific methodologies that foster this collaboration.

2.3 Context of the case study: Design and implementation of a digital role-play game

JEN.lab project aims to offer innovative perspectives for learning based on the design of *digital epistemic games* (JEN). *Digital epistemic games* intend to foster *epistemic interactions (*i.e. explanatory and argumentative interactions that play a role in the co-construction of scientific knowledge) that take place when players collaborate (Sanchez 2017). They are based on digital technology and simulate a real context in order to offer the learner/player the opportunity to deal with complex situations and ill-structured problems (Sanchez and Emin 2014; Shaffer 2006). JEN.lab project is founded by the French government and takes place in a specific school called AeP[1] (Associated educational Place).

During this 3 year project, workshops are dedicated to defining the learning objectives, to designing the game universe and the gameplay for a digital role-play game called *Insectophagia*. The workshops are also dedicated to discussing the analysis of the data collected during experimentations carried out in real school contexts and to iteratively revising the game. The methodology adopted for game-design is built on user-centered methods (Norman and Draper 1986) such as persona (drawing of an archetypal player) and brainstorming sessions. Tailored tools are also conceived for specific purposes. For example, the game scenario is collaboratively designed and described with a diagram called *Player-Flow* (Fig. 8). Researchers (from computer science and educational sciences) and secondary teachers participate in the workshops. *Insectophagia* is a game covering sustainable development principles. The game is based on the use of different digital artifacts (digital tablets for outdoor activities, computers in classroom) and paper-based activities. The game is designed for 15 to 17 years old students. The global objective, for each team (composed of 3 or 4 learners) is to create a start-up company, specialized in insect-based food production. The game lasts approximatively 7 weeks (18 h) depending on the school. Rewards (points, bonuses, badges…) depend on how the team of players manages to deal with environmental, social and economic issues. However, it is possible to make mistakes without real consequences. As a result, players are encouraged to continue trying and to find innovative solutions for insect farming and trading.

The project concentrates on three main objectives.

(1) A digital epistemic game is developed and tested within an ecological context with a large sample of participants. It is expected that the students will develop a

[1] http://ife.ens-lyon.fr/lea/lea-english-version

more complex and realistic view of sustainable development (the interplay between environmental, societal and economic issues).

(2) It is expected that a generic and theoretical model of digital epistemic games emerges from these empirical experimentations. This model is intended to serve as a basis for the design of digital epistemic games.

(3) A design-based research methodology is developed and tested. This methodology attempts to combine pragmatic (the design of the game) and heuristic issues (the analysis of the impact of the game).

The objectives of the project and the underlying theories have been explained to the different participants to the project during a quick-off meeting. It is expected that the game will be collaboratively designed by researchers and teachers.

In our study, DBR is both a means (the methodology adopted for the research project) and a research topic (we want to understand how this methodology can be implemented and what effects result from this implementation). Collaboration takes place in a specific place named "laboratory for digital innovation in education". This laboratory offers different amenities and methodologies to foster collaborative work and creativity.

2.4 Objectives of the study and research questions

Our work field-tests the meta-didactical model of collaborative research. We observe if the different participants' praxeologies converge during the workshops dedicated to designing learning settings and discuss the results that emerge from the classroom experimentations. We aim to identify *shared praxeologies,* i.e. a common point of view on what should be done and how it should be done (*praxis*) and also why it should be done this way (*logos*). Therefore, we analyze how the praxeologies of the participants evolve during the project and to what extent this evolution participates in the development of knowledge. As a result, our objectives and research questions are the following:

- Characterizing the praxeologies of the participants in the project i.e. identifying how researchers and practitioners envisage educational practices and their justification. What tasks do they want to implement? How do they justify these tasks?
- Identifying to what extend the participants manage to reach an agreement on *praxis* and its justification;
- Describing this process from an argumentative perspective and identifying the phases of bargaining sequences. How participants manage to develop common *praxeologies*?
- Linking the evolution of the participants' praxeologies to the research process in terms of new design principles, technology integration and new conceptualizations (knowledge development)

The purpose of this article is not to analyze the efficiency of the digital game developed during the project but to understand how it is possible to address the gap between researchers and practitioners during a design-based research project.

3 Methodology for the praxeologies analysis

3.1 Data collected

The data collected encompasses the videotaping of four workshops that arose for the first iteration of the project. The project started in June 2014 and, until December 2015, eleven workshops were dedicated to this first iteration. During spring 2015, 14 teachers in 4 secondary schools with 96 students implemented and tested the first version of the *Insectophagia* game. We videotaped two workshops before school experimentations in October and November 2014. We also videotaped two additional workshops in November and December 2015. The data analyzed for this paper comes from the October 2014 workshop and November 2015 workshops. We selected and transcribed two one hour excerpts. Thus, there is a one-year gap between these workshops and, during this year, teachers and researchers beneficiated from the opportunity to meet and to gain experience from experimentations carried out in different schools.

We selected the excerpts according to the following criteria:

- The different participants collaborate for the design or the re-design of the game.
- They can be considered as stakeholders. They are involved in school experimentations.
- The participants are focused on a common issue. For this paper, we selected discussions that relate to student assessment. Practitioners and researchers discuss how assessment might be taken into account for this specific game-based learning approach.

Among the contributors of this paper, one is the principal investigator of the project, another one did not participated in the first iteration, and two did not participate at all in the project.

3.2 Praxeologies analysis

We coded the transcriptions of the videotapes according to a 4 dimensional grid based on the praxeological model. The *praxis* relates to the (1) tasks performed both by the students (players' tasks) and by the teachers (game masters' tasks). The *praxis* also relates to the discussion about (2) how the tasks will be performed (workshops dedicated to game-design) as well as how the tasks were performed during school experimentations (workshops dedicated to discussing what happened and what should be changed). The *logos* relates to the justification of the *praxis* from (3) technological and (4) theoretical points of views.

The transcriptions were collaboratively coded by two researchers. A third researcher revised the first tagged version. The tagging is driven by the following questions:

- The task (what?): what should have been done in the classroom? What do we want to do? What will the students do?
- The technique used to perform the task (how?): how did the students and teachers performed the task? How did they want to perform the task? How did we want the students or the teachers to perform the task?

Participant	T	Task (what?)
	τ	Technique (how ?)
	θ	Technology (why should this task be performed this way?)
	Θ	Theory (why do we think that?)

Fig. 2 Different dimensions and questions of a praxeology

- The technology (*ie.* the justification of the technique) (why?): why did they choose this technique to perform the task? Why should this task be performed this way?
- The underlying theoretical assumptions (why do we think that?): Why do we think that this task had to be performed this way? Why do we think that they should use this way to perform the task?

A praxeology is summarized by the answers provided to 4 questions according to the scheme described by Fig. 2.

3.3 Negotiations analysis

To better understand how participants manage to develop shared praxeologies, we took an argumentative perspective. We also coded the transcriptions of the videotapes according to the interactional negotiation framework (Firth 1995; Kerbrat-Orecchioni 2005; Maynard 1984). Negotiation is considered to be a more or less local process, which may emerge when a disagreement appears between two participants about a particular issue of the interactions, and when the objective of the process aims at reducing this disagreement (Kerbrat-Orecchioni 2004).

According to Traverso (2005), negotiation starts at the third round of the discussion when the disagreement *crystallizes*: (1) Participant A made a proposal to participant B. (2) Participant B rejects the proposal and made a counter-proposal. In case of *disagreement crystallization* (3) participant A rejects the counter-proposal and then, the negotiation starts.

According to Maynard (2009), negotiation is embodied in bargaining sequences that consist of a proposal or offer plus a preferred response (acceptance), a next-preferred response (counterproposal), or a dispreferred response (rejection). Thus, a negotiation process encompasses (Kerbrat-Orecchioni 2004):

- At least two proponents involved in the disagreement. They may be assisted by a third person playing the role of a moderator,
- An object to be negotiated,
- Discursive procedures aiming at resolving the disagreement,
- A final state (success, in case of rallying opinion or compromise, failure in case of standstill or dispute).

Bargaining relates not only to facts and opinions but also to issues and ways for communicating, participants' identities, powers, and even their opinions about negotiation itself (Kerbrat-Orecchioni 2005). The analysis of the negotiation that takes place during the workshops allows understanding the participant's concerns (what topics are discussed?), their involvement, their positioning and their interactional roles (who

argues? Who does not discuss? Who opposes? Who is the mediator?). Furthermore, objects that are negotiated are also sources of information to measure the evolution of the different praxeologies: which objects stabilize? Which objects are abandoned? Negotiations are mainly implicit but may become explicit (becoming synonymous with bargaining) through discursive or meta-discursive interactions. As a result, negotiation analysis enables for understanding the processes that take place when participants' praxeologies evolve. In particular, we want to identify participants who play a key role in this regard.

The transcriptions are coded by a single researcher and tagged with the following categories: proposal, counter-proposal, bargaining sequence, acceptance, rejection, alignment and nonalignment of the sequence's ending (Maynard 2009).

4 Praxeologies and knowledge development

In this section the results of the study are reported and discussed according to our research objectives. The analysis focuses on three main results that emerged from the data collection: (1) the participants' praxeologies evolved during this first year of the project, this evolution consists of the development of brokered knowledge (Meyer 2010) regarding how digital technology enables for assessing the students. (2) Some participants play the role of *brokers* in this regard. (3) The teachers developed a more autonomous approach for their teaching practices and acquired freedom.

4.1 Toward shared praxeologies

How do the participants' praxeologies evolve during the project? Do teachers and researcher manage to find an agreement? And if so, how shared praxeologies participate to knowledge development? In the following, we compare the teachers' praxeologies for the November 2014 workshop (WN14) and December 2015 (WD15) workshop.

In November 2014 the participants to the workshop are 6 teachers (P2 to P6) and a well experienced in research on game-based learning (P1) secondary school teacher. Indeed, she already participated in international research projects and gave talks for international conferences. She shares her time partly in teaching geography and history in a secondary school and partly in participating in a regular research team. At the same time, she is also writing her second master degree thesis (supervised by a researcher involved in the project). She is responsible for the organization of the workshops dedicated to game design. She already met the teachers involved in the project during a teacher training course about game-based learning that she gave during the previous year. As a result, she occupies a pivotal position in the project. On the one hand, she is a well-experienced teacher with a concrete practice in implementing a play-based pedagogy. On the other hand she is experienced in research and she possesses knowledge in educational sciences. In addition, she has a specific background on game-based learning theories.

During this workshop dedicated to designing the game (WN2014), the participants discuss a specific task (question: what?). They discuss how assessment should be implemented and the negotiation starts with a disagreement. The main concern discussed during this excerpt is how and when grades should be assigned to students.

P1	T	Students' assessment
	τ	After the game session
	θ	Playing is a time dedicated to learn
	Θ	Frivolity of play

Fig. 3 Praxeology of participant P1 (WN14)

In response to the technique that should be implemented (question: how?) P1 considers that grades should be assigned after the game session when "you leave the game and then you assess the skills developed by the students" (proposal). The underlying theory (question "why?") comes from the literature on game-based learning: "Frivolity is considered to be a core characteristic of a game" (Brougère 2000). The learner/player can make mistakes without real consequences and he/she is encouraged to continue trying (Gee 2003). Assigning grades to students "is a bit tricky because it kills the game" (P1). She proposes that the students "will be not rated and the assessment of the skills developed during the game will take place later on". According to her opinion, the justification is that "they learn something and they develop specific skills […] that I will assess later on". In other words, there is a time dedicated to playing and to learning and a time dedicated to assessing students (after the game session). The praxeology of this participant is summarized by Fig. 3.

The discussed task (T) relates to students' assessment. The proposed technique (τ) for students' assessment consists of carrying assessment after the game session. From a technological perspective (θ) the justification is that playing is a time dedicated to learning and that assessment should not be carried out during game sessions. The underling theory (Θ) is that play should remain frivolous (i.e. without negative consequences).

Participant 2 proposes a different response to the question "how?". She rejects this proposal and makes a counter-proposal. There is a disagreement crystallization about when and why assessment should be carried out differently. P2 considers that the game booklet is useful "for assigning grades to students or whatever… it is really easier" and proposes to collect data from the booklet. She justifies her opinion with an argument: for teachers, it is compulsory to assess the "learning outcomes". The praxeology of participant P2 is summarized by Fig. 4.

Other participants are less involved in the negotiation process. However, the transcription shows that they share praxeologies with P2. For example, P3 considers that "We need to be clear regarding this issue" [how students will be assessed]". She tries to find a compromise and suggests to alternate time dedicated to playing and time dedicated to assigning grades to the students "with periods dedicated to assessing the learning outcomes but not during the game sessions". In response, P4 emphasizes that "for a long time, the students will not have any grades. In respect to the parents and for

P2	T	Students' assessment
	τ	During the time dedicated to play
	θ	The most convenient way: with the booklet
	Θ	Assessment of learning outcomes is compulsory (grades)

Fig. 4 Praxeology of participant P2 (WN14)

R1	T	Players' assessment
	τ	Feedbacks - teacher (via the platform)
	θ	Formative assessment
	Θ	Games are assessment systems

Fig. 5 Praxeology of participant R1 (WD15)

the class councils, na na euh: :: (she breathes air by moving her face backwards). We will have to argue!"

At the beginning of the excerpt, P1 provides arguments from a theoretical level (why do we think that?). She underlines the needed frivolity of the game. However, she quickly moves to arguments that consist in suitable techniques for overcoming the difficulties that the teachers may encounter. By doing this, she demonstrates that she has some knowledge from real-school conditions. The debate ends with a proposal expressed by P1: "We will provide information to parents and there will be something to ratify: your students won't be rated during the time dedicated to game sessions and assessment will be carried out afterward". Two teachers, P4 and P7 (but not P2), expressed their agreement (alignment). However, it is not clear to what extent they agree with P1's proposal.

The second excerpt was recorded one year later after 9 additional workshops and school experimentations of the first version of the game. During this workshop the same issue emerged: "When and how students will be assessed?" The work aims at designing the next version of the game by taking into account the experience gained during school experimentations. The workshop consists of completing the *player-flow*. A player-flow is a diagram indicating the different missions assigned to the players, the tasks performed by the players, the resources needed to perform the tasks and the feedback provided by the game. In October 2015, the participants of the workshop are two researchers (R1 and R2), 5 teachers (P2 to P5) and the same well experienced in research on game-based learning (P1) secondary school teacher.

R1 expresses that it is important that, thanks to the feedbacks provided by the game, "the player has the feeling to make progress or not, that he or she gets the opportunity for self-assessment regarding the progress he or she made within the game". R1 explains that a new online platform should be designed because "it is an efficient way [for the teachers] to reward the players with points and bonuses" (proposal). The underlying theory consists of the fact that games are assessment systems adapted to formative assessment (Gee and Shaffer 2010). The praxeology of this participant is summarized by Fig. 5.

P1 expresses opinions that are explicitly agreed by P3. She considers that it is important to take into consideration the "feedback issue" and that this task should be performed by the teachers (acceptance and bargaining sequence). She also states that a "scenario might be designed". Figure 6 describes P1 and P3 praxeologies.

P1-P3	T	Players' assessment
	τ	Feedbacks provided by the teachers
	θ	Formative assessment
	Θ	Educational scenario

Fig. 6 Praxeology of participants P1 and P3 (WD15)

P2	T	Players' assessment
	τ	Feedbacks provided by the teachers (bookmark)
	θ	Formative assessment
	Θ	Grades are not so important

Fig. 7 Praxeology of participant P2 (WD15)

During this workshop, P2 expresses a totally different opinion than one year before. Based on the experience gained from school experimentations, she underlines that "rating the students is not so important; however they [the players] were eager to win!" She also emphasizes that assessment "should not be arbitrary" (i.e. based on "players' achievements"). She proposes a technique for assessing players: "there is an easy way, the bookmark". She means that, at a specific level, the players are asked to bookmark information and that, based on the relevance of these bookmarks, the teacher might provide feedbacks to the students. Figure 7 summarizes P2 praxeologies.

Based on the data recorded during the workshops, there are too few data collected from R2 and other teachers to give a precise description of their praxeologies. However, they mainly participated in agreeing to the proposed solutions (alignment). The different participants reached a consensus for formative assessment. Everyone seems to consider that the autonomy of the player results from the feedbacks provided by the game so that he/she can assess his/her way of thinking and behaving. The theories that support teachers' decisions evolved during the first year of the project and, though they enable for a consensus for the design of the game, they still differ from the researchers' theory.

4.2 Classroom practices and academic publications

The evolution of teachers' and researchers' praxeologies is confirmed by the examination of the teachers' practices during school experimentations and the analysis of the game material designed by the team. This is also confirmed by the ideas expressed by the researchers in the papers published during the project.

From a research perspective, a major result of the project is a complete revision of one of the main objectives. The collaboration between researchers and secondary teachers made apparent that the difficulties faced by the teachers to implement a game were not a matter of game-design but merely a matter of play-orchestration, a similar issue to classroom orchestration (Dillenbourg 2013). Thus, the research team operated a shift from a game-based to a play-based perspective and a theoretical model of a digital epistemic game emerged. This global and dramatic change observed at a macro-level analysis is also visible at a micro-level through the analysis of the voicing of the participants during the workshops. After the 2 year project, a position paper on a platform called *Play Management System* (PMS) (Sanchez et al. 2016) was published. Indeed, the shift from a game-based to a play-based perspective enabled for the conceptualization of an "integrated system designed to support both players and teachers to deliver, use, manage and track play situations" (Ibid.).

From the teachers' perspective, a major result of the project is a renewed point of view about game-based learning. They moved from the idea that game-based learning consists of implementing a game into their teaching practice to the notion that they have to play the role of a game master. Indeed, they define assessment as rewarding players

with points, bonuses and badges. Thus, during the project, theoretical results have been produced. They consist of a renewed approach about game-based learning. This approach is more focused on the player and on the interactions that emerge during play. They also consist of a better understanding of the roles played by the teachers.

The first version of the PMS is a paper-based version called *game booklet*. This booklet encompasses the information needed to play. Assignments and resources required for the different levels of the game are provided. This booklet also specifies the criteria that are used to reward the players. The criteria take into consideration students' achievements (quality of insect farming and trading project) and how sustainable development is taken into consideration (environmental, societal and economic consequences of the decisions taken by the players). A page of the booklet is dedicated to collecting points, bonuses and badges earned by the team. The students are not rated during game sessions. However, the booklet enables the teachers to integrate students' formative assessment into the game scenario. Rather than assigning grades to students, the teachers reward the successful players with points, bonuses and badges.

The *Player Flow* collaboratively drawn during the workshops (Fig. 8) illustrates that players' assessment is now integrated into the game scenario. Assessment consists of specific feedbacks provided by the teachers ("game master") to the students ("team").

These observations confirm the data collected from the workshops. The praxeologies of the different participants about students' assessment evolved during the first year of the project. First, this issue was dramatically reframed. The issue is not a matter of rating students anymore but a matter of designing specific feedbacks. These feedbacks are considered to be useful for self and formative assessment. In addition, some common features emerge. It becomes evident that the teachers are responsible for providing feedbacks and that these feedbacks enable for implementing formative assessment.

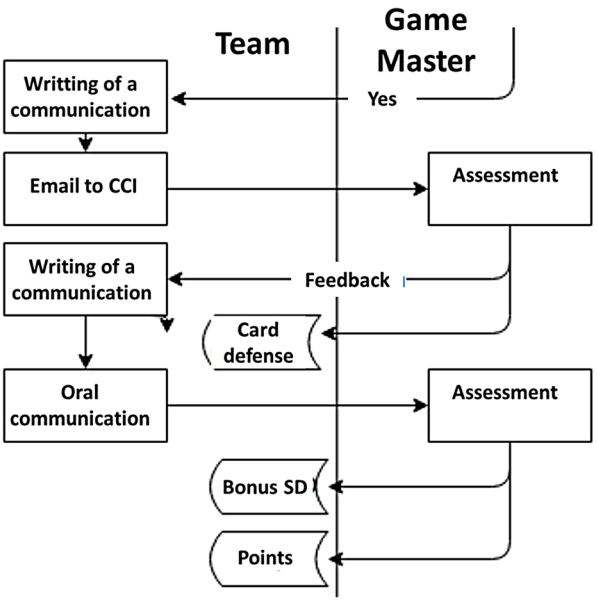

Fig. 8 Excerpt of the Player-Flow (level 1 of the game) (Translated from Jouneau-Sion 2015)

4.3 The crucial role of the broker

The analysis of the participant *praxeologies* and the negotiation process makes it apparent that P1 played a crucial role during the workshops. She is in charge of the knowledge that ought to be taken into account for the design process and she is engaged into a bargaining sequence aiming at finding a consensus. The selected excerpt shows that she first tries to convince with arguments at a theoretical level: "[assessment] kills the game". However, later on, during the negotiation, she moves to arguments at a technical level and explains how, concretely, the issue should be addressed. In other words, she makes it possible for a knowledge transfer from the academic field to the practitioners involved in the design and the implementation of the game to exist. This knowledge transfer is bidirectional. By fostering teachers-researchers interactions she also makes it possible for academics to get a better understanding of the constraints faced by teachers.

This transfer encompasses a *disagreement crystallization* (Traverso 2005) about a specific task and discursive procedures dedicated to resolving the disagreement. This transfer also encompasses reformulation and translation. P1 is aware that practitioners face institutional constraints (i.e. grades are compulsory). She does not deny this issue. She knows that it is an important issue for teachers and she proposes an alternative option (i.e. a message for parents). So, she is able to be focused on pragmatic issues and to propose concrete solutions. In addition, during the WN14 workshop, she expresses the theoretical background (i.e. frivolity of play) in terms of concrete decisions that should be taken for game design "time dedicated to playing separated from time dedicated to assigning grades to the students" (P1). She also reformulates the ideas expressed by teachers so that the researchers will understand the teachers' needs. For example (excerpt from WN14 workshop), she translates ideas expressed by teachers into theoretical concepts: "P3 needs to link the business creation [a specific phase of the game] to *collaborative learning*". As a result, the circulating knowledge between researchers and teachers can be named brokered knowledge (Meyer 2010). For this author, "brokered knowledge is knowledge made more robust, more accountable, more usable; knowledge that "serves locally" at a given time; knowledge that has been de- and reassembled." (p. 123). Indeed, this knowledge results from a complex process which encompasses the deconstruction of the knowledge owned by the participants and the emergence of a new knowledge which takes the form of *praxeologies* shared by researchers and practitioners.

The analysis of the debate devoted to discuss how and when students will be assessed enlightens another dimension of P1's role during the workshop. She is in charge of the organization and the animation of the workshop. During the first workshop (WN14), the teachers try to decide what skills will be developed by the students when they will play the game. They use a specific card game devoted to game design. At the beginning of the excerpt, 3 researchers form a group separated from the teachers.

P1 comes close to the group of researchers and asks:

> P1: "What are you doing? Do you want to participate?"
> R2: "It is what we were asking ourselves? Is there a risk that we introduce a bias in the…" [R2 is used to implement UX design methodologies and she seems to consider that she should not intervene during the design process.]

P1: "Especially that we are not enough teachers to be a driving force!"
R2: "Well, yes"
P1: "We need more brains for thinking… external brains for thinking! For example for a specific skill I take a card 'skill' and you, you will say "no, I don't see that like that" and you will bring an external point of view."
R2: "Yes, yes, but we need somebody [*i.e.* a teacher with us], because we will have an interpretation but maybe not a proper interpretation."
P1: "Alone… it is not possible for sure. As we are 3 teachers we have to form 3 groups"
R2: "Right"
P1: "And we will take 3 skills".

This short excerpt illustrates how P1 manages to foster interactions between practitioners and researchers. She organizes the workshop and takes into consideration that each participant has a role to play. She organizes the workplace so that they get the opportunity to negotiate the decisions taken during the design process and thus, to challenge their *praxeologies*.

The role played by P1 has already been well documented in different contexts. Different terms have been used to name people who are responsible for the transfer of knowledge between two communities but we consider that the term *broker* is the most appropriate. For Rasmussen et al. (2009), brokers belong to more than one community. They "are able to make new connections across communities of practice, enable coordination, and – if they are good brokers – open new possibilities for meaning" (p.109). Following Rasmussen et al., Aldon et al. (2013) explain, within the context of teachers training sessions carried out by researchers, how brokering mediates the meta-didactical transposition. According to these authors, "brokering is a common habit and researchers frequently play the role of brokers between the two communities who inhabit the process". In our context, this role is played by P1. Indeed, due to her twofold competences and her specific status, she takes the responsibility for ensuring the transfer of knowledge between the two communities. She is both a secondary school teacher and a Master student supervised by a researcher who participates in the project. As a result, she occupies a pivotal place for the transfer of knowledge between teachers and researchers. Further analysis of the corpus shows that different members of this research group can also take this brokering role. It is the case of one of the researchers who is also a former secondary school teacher.

In sum, the *broker* fosters the sharing of praxeologies within a community of researchers and practitioners by:

- *Organizing and animating* workshops so that the two communities, teachers and researchers, manage to collaborate. Due to her double status, academic scholar and teacher, P1 occupies a specific place in between the two communities. She organizes the workplace so that interactions take place.
- *Challenging* participants' *praxeologies* through the implementation of bargaining sequences. These bargaining sequences offer the participants the opportunity to make their *praxeologies* visible and to develop proposals and counter-proposals for a specific issue.

- *Transferring* the knowledge owned by each community. P1 plays the role of a *broker* who is responsible for the transfer of knowledge between 2 communities by solving misunderstandings and disagreements.
- *Translation and reformulation* of this knowledge so that the circulation of the knowledge becomes possible and that a new *brokered knowledge* emerges from the interactions that take place at technical and technological levels. As a result, *brokered knowledge* enables for theoretical improvements or revisions.

5 Conclusion

The analysis of the discourses recorded during the workshops enabled us to characterize the praxeologies of the participants to the project. This analysis showed a gap between practitioners and researchers about *how* to perform student's assessment and also about the justifications provided (*why?*). Though this result emerges from a specific and limited study, we think that it might be relevant to consider that the gap between practitioners and researchers should be addressed at different levels when they are expected to collaborate. Do they manage to reach an agreement on the use of digital technology (praxis) and how to implement these artifacts (technique)? Do they manage to develop a common view on why digital technology should be implemented this way (technology) and do they share a common theoretical background (theory) about this implementation? We think that this praxeological perspective for the design and implementation of digital technology offers a framework to addressing the gap between theory and practice.

For our study, during the first year of the project, practitioners and researchers managed to reach an agreement. The data collected shows that bargaining sequences lead by a broker played an important role in this regard. As a result, though our work has been carried out for a specific context and focused topic, it underlines the crucial role of the broker in making the knowledge transfer possible. This role encompasses the challenging of participant's praxeologies and the translation and reformulation of the knowledge owned by each community. Future studies should focus on a more precise description of this role. We need to understand what competencies should be mastered by people who can bridge the gap between researchers and practitioners.

This case study also illustrates how a community composed of researchers and teachers involved in design-based research is a *performative group* (Latour 2005). The group is built through the efforts made by the participants to solve concrete problems and to give meaning to the solutions adopted. Based on this case study, different hypothesis emerge:

- Within a community composed of researchers and teachers, cohesion and enrolment result from the circulation and reformulation of knowledge and the *broker* play a key role regarding this issue.
- At a meta-didactical level, the sharing of *praxeologies* results from the brokering of knowledge within the group. The emerging *brokered knowledge* enables for pragmatic and theoretical improvements:

- Teachers become able to envisage new perspectives for the implementation of digital technologies;
- Researchers improve their understanding of the complexity of the context and become able to develop or review their theoretical models according to this complexity.

Within the context of this project, it was particularly impressive to observe the shift, operated by researchers, from a game-based to a play-based perspective. We were also impressed by the capacity of the teachers to innovate and to revise their teaching practices. These results are in line with previous studies: design-based research fosters teachers and researchers professional development (Aldon et al. 2017).

Therefore, we think that the connection between digital technologies and learning can be reached if teachers are not considered to be technicians who apply ready-made solutions. Teachers should merely be considered as engineers who develop their own solutions based on relevant theoretical knowledge but also as researchers, responsible for the development of the knowledge needed for the design of innovative teaching approaches. Design-based research enables to design artefact that embody the knowledge built collaboratively by teachers and researchers. Therefore, they might be better adapted to the complexity of educational contexts and the challenges faced by practitioners. They also might take into account recent scientific advances. As a result, it is expected that they are more efficient.

At a meso-level, we consider that the *laboratory for digital innovation in education* offers the needed area of freedom to design innovative approaches for digital technology integration. It provides the tools and methodologies needed to foster collaboration. At a macro-level, it is probably important to take into account institutional security. In this regard, AeP, which institutionalizes the collaboration between practitioners and researchers and offers a room for non-conventional teaching practices, seems to have played a crucial role. During the first meeting, the teachers mentioned different constraints that explain their reluctance to change their teaching practices. These constraints relate to their professional identity (i.e. the way they assign grades to their students) and also about the expectations from other stakeholders (school director, colleagues, parents…). One year later, these constraints are still mentioned, they still exist. However, they seem to be regarded as external. The institutional context offered by AeP and the success that results from the school experimentations enable to overcome these constraints.

New models are needed for connecting research and practice for innovation. From this study, we learnt that the praxeological perspective for the design and implementation of digital technology offers such opportunity. In sum, we formulate the hypothesis that the laboratory and its institutionalization through AeP offer the teachers the opportunity to make their *praxeologies* move forward and make it possible for new practices and new theoretical perspectives for the adoption of digital technologies to emerge.

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References

Aldon, G., Arzarello, F., Cusi, A., Garuti, R., Martignone, F., Robutti, O., Soury-Lavergne, S. (2013). The meta-didactical transposition: A model for analysing teachers education programs. Paper presented at the 37th conference of the international group for the psychology of mathematics education. - mathematics learning across the life span, Kiel, Germany.

Aldon, G., Cusi, A., Morselli, F., Panero, M., Sabena, C. (2017). Formative assessment and technology: Reflections developed through the collaboration between teachers and researchers. In G. Aldon, F. Hitt, L. Bazzini, & U. Gellert (Eds.), Mathematics and Technology A C.I.E.A.E.M. Sourcebook (pp. 551-578): Springer.

Amiel, T., & Reeves, T. (2008). Design-based research and educational technology: Rethinking technology and the research agenda. *Educational Technology & Society, 11*(4), 29–40.

Artigue, M. (1992). Didactic engineering. In R. Douady & A. Mercier (Eds.), *Research in Didactique of mathematics. Selected papers* (pp. 41–66). Paris: La Pensée Sauvage Editions.

Bargal, D. (2006). Personal and intellectual influences leading to Lewin's paradigm of action research. *SAGE Publications*, (4), 367–388. doi:10.1177/1476750306070101.

Brougère, G. (2000). Jeu et éducation. Paris: L'Harmattan.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of the Learning Sciences, 2*(2), 141–178.

Chevallard, Y. (1982). *Sur L'ingénierie Didactique*. Paper presented at the 2e école d'été de didactique des mathématiques Olivet.

Chevallard, Y. (1999). L'analyse des pratiques enseignantes en théorie anthropologique du didactique. *Recherches en didactique des mathématiques, 2*(19), 221–266.

Cobb, P. (2001). Supporting the improvement of learning and teaching in social and institutional context. In S. Carver & D. Klahr (Eds.), *Cognition and instruction: 25 years of progress* (pp. 455–478). Mahwah, NJ: Lawrence Erlbaum Associates, Inc..

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher, 32*, 9–13.

Corey, S. (1953). Action research education. *Journal of Educational Research, 47*, 375–380.

Dillenbourg, P. (2013). Design for Classroom Orchestration. *Journal of Computers in Education., 69*, 485–492.

Firth, A. (Ed.). (1995). *The discourse of negotiation. Studies of language in the workplace*. Oxford: Pergamon Press.

Gee, J. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave Macmillan.

Gee, J., & Shaffer, D. (2010). Looking where the light is bad; video games and the future of assessment. *Edge, 6*(1), 3–19.

Hevner, A., March, S., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly, 28*(1), 75–105.

Highsmith, J. (2002). *Agile software development ecosystems*. Boston, MA: Addison-Wesley Professional.

Jouneau-Sion, C. (2015). *Une plateforme collaborative pour le jeu Insectophagia*. Ecole Normale Supérieure de Lyon, Lyon: Master Thesis.

Kerbrat-Orecchioni, C. (2004). Analyse des conversations et négociations conversationnelles. In M. Grosjean & L. Mondada (Eds.), *La négociation au travail* (pp. 17–41). Lyon: Presses Universitaires de Lyon.

Kerbrat-Orecchioni, C. (2005). *Le discours en interaction*. Paris: A. Colin.

Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. New York: Oxford University Press.

Lewin, K. (1946). Action research and minority problems. *Journal of Social Issues, 2*, 34–46.

Maynard, D. (1984). *Inside plea bargaining. The language of negotiation*. New York/London: Plenum Press.

Maynard, D. (2009). Demur, defer, and deter: Concrete actual practices for negotiation in interaction. *Negotiation Journal*(26), 125-143.

Meyer, M. (2010). The rise of the knowledge broker. *Science Communication, 32*(1), 118-127

Norman, D., Draper, S. (1986). *User Centered System Design: New Perspectives in Human-Computer Interaction*. Hillsdale, N.J: Lawrence Erlbaum associates.

OECD. (2015). Students, Computers and Learning*: Making the Connection,* Retrieved from doi:10.1787/9789264239555-en.

Rasmussen, C., Zandieh, M., & Wawro, M. (2009). How do you know which way the arrows go? The emergence and brokering of a classroom mathematics practice. In W. Roth (Ed.), *Mathematical*

representations at the interface of the body and culture (pp. 171–218). Charlotte, NC: Information Age Publishing.

Reeves, T. (2006). Design research from a technology perspective. In J. Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational design research* (pp. 52–66). New York: Routledge.

Reigeluth, C., & Frick, T. W. (1999). Formative research: A methodology for creating and improving design theories. In C. Reigeluth (Ed.), *Instructional-design theories and models* (Vol. Vol. II, pp. 633-651). Mahwah, NJ: Lawrence Erlbaum.

Richey, R., & Klein, J. (2007). Design and development research: Methods, strategies and issues. Mahwah, NJ: L. Erlbaum Associates.

Sanchez, E. (2017). Competition and collaboration for game-based learning: a case study. In P. Wouters, & H. van Oostendorp (Eds.), *Instructional Techniques to Facilitate Learning and Motivation of Serious Games* (pp. 161–184). Heidelberg: Springer.

Sanchez, E., Emin, V. (2014). Toward a model of play: an empirical study. In C. Busch (Ed.), The 8th European Conference on Games Based Learning, (Vol 2, pp. 503-512). Berlin: Germany.

Sanchez, E., & Monod-Ansaldi, R. (2015). Recherche collaborative orientée par la conception. Un paradigme méthodologique pour prendre en compte la complexité des situations d'enseignement-apprentissage. *Education & Didactique, 9*(2), 73–94.

Sanchez, E., Piau-Toffolon, C., Oubahssi, L., Serna, A., Marfisi-Schottman, I., Loup, G., George, S. (2016). Toward a play management system for game-based learning. *Lecture Notes in Computer Science series, 9891*, 484–489.

Sensevy, G., Forest, D., Quilio, S., & Morales, G. (2013). Cooperative engineering as a specific design-based research. *ZDM, the International Journal of Mathematics Education, 45*(7), 1031–1043.

Shaffer, D. (2006). Epistemic frames for epistemic games. *Computers and Education, 46*(3), 223–234.

Traverso, V. (2005). Cristallisation des désaccords et mise en place de négociations dans l'interaction : des variations situationnelles. In M. Grosjean & L. Mondada (Eds.), *Les négociations au travail* (pp. 43–68). Lyon: Presses Universitaires de Lyon.

Van den Akker, J. (1999). Principles and methods of development research. In J. van den Akker, N. Nieveen, R. Branch, K. Gustafson, & T. Plomp (Eds.), *Design methodology and developmental research in education and training* (pp. 1–14). The Netherlands: Kluwer Academic Publishers.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development, 53*(4), 5–23.