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FLIP2G

Deliverable 2.2

The FLIP2G flipped classroom pedagogical model

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Deliverable factsheet

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Abstract:	**This report presents the theoretical model for the FLIP2G project. It presents the key concepts to the project and the result of previous reviews of the flipped Classroom and educational theories. It presents a new pedagogical model based on the flipped classroom wheel model, and incorporating PBL and gaming elements. Finally, it discusses each step of the FC and analyses, for each step, the learning activities, data, analytics and interventions that applies to it. It exploits both scientific literature and partners' focus group interviews to present a full pedagogical model for the FLIP2G project.**
Keyword List:	**Flipped Classroom, Pedagogical Foundation, Educational Data, Gamification, Serious Games, Problem-Based Learning, Learning Analytics, Flipped Learning Model, Learning design**

Consortium

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Statement of originality:

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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List of Abbreviations

The following table presents the acronyms used in the deliverable in alphabetical order.

Abbreviation	*Description*
AL	Active Learning
GBL	Game-based learning
F2F	Face to face
FC	Flipped Classroom
LA	Learning Analytics
LMS	Learning Management System
PBL	Problem-Based Learning
SDT	Self-Determination Theory
VLE	Virtual Learning Environment

Executive Summary

The FLIP2G project aims to establish a Knowledge Alliance between higher education institutions, schools and private companies that will boost skills development and introduce novel, data-driven approaches to education and training. The consolidation of all efforts will provide a transnational set of results, as follows:

- a new pedagogical method that combines PBL and flipped classroom with game-based learning (FLIP2G educational approach)
- a simulation-based serious game that supports PBL-enhanced flipped classroom processes, adaptive pathways and educational data recording
- learning designs for higher education, schools and business that support the Flip2G paradigm
- Learning analytics features that produce informative insights on learning process.

The above results aim to produce engaging pedagogical models and novel technologies that can foster motivation, generate adaptive learning pathways and allow self-directed learning in education and training.

WP2 is responsible for: (a) carrying out a study on the flipped classroom learning strategy in order to record the features that support transversal and entrepreneurship skills development and active engagement in the learning process, (b) carrying out a study on the PBL model in order to identify the elements that can enrich the traditional flipped classroom model towards in depth knowledge acquisition and transversal skills development, and (c) constructing a learning model that will visualize how flipped classrooms should be applied in multiple sectors like higher education institutions, secondary schools and companies.

The present deliverable is the second deliverable of WP2, D2.2 – the FLIP2G educational model. Its purpose is to document all work done towards the creation of the flipped classroom pedagogical model and record all important features for an educational and training environment. Information that is included in this deliverable is valuable to all partners for ensuring the appropriate development of the FLIP2G educational approach, and the gaming features and LA modules that it will employ. The purpose of the FLIP2G pedagogical model is to present the educational orientation to the project and support further development and implementation by all partners within the objectives of the pedagogical model.

More specifically, this deliverable covers issues such as the insertion of core concepts (PBL, LA, Learning design, GBL) into the new pedagogical model. Moreover, it discusses the structure of the pedagogical model. For this model, we decided to integrate these core elements to the FC wheel. By approaching the FC as a cycle and not a linear process, we believe that we give to the model more flexibility and meaning, and that it will be a useful structure to support autonomous, self-directed

learning. Our objective is to create a new, extended approach to the FC that would make the FC a fully holistic and adaptive learning experience. Finally, this deliverable concludes with the potential applications of the pedagogical model, especially through the development of a gaming platform to support the FC.

1 Introduction

The aim of this section is to introduce the background of the work pursued with Task 2.2 "FLIP2G flipped classroom design". The scope and the objective that the current document has set out to achieve are presented in sub-section 1.1. The intended audience for this document is described in sub-section 1.2 while sub-section 1.3 outlines the structure of the rest of the document.

1.1 Scope

The present document is the Deliverable 2.2 "pedagogical model" (henceforth referred to as D2.2) of the FLIP2G project. The main objective of D2.2 is to present all preparatory work carried out in order to develop a high quality FLIP2G pedagogical model. Furthermore, the report will also present the features for the implementation of the FLIP2G model that can be implemented in secondary and higher education.

1.2 Audience

The intended audience for this document is the FLIP2G consortium, the European Commission, and the public interested in investigating the Flipped Classroom (FC) model.

1.3 Structure

The structure of the document is as follows:

- Section 2 presents the methodology followed in order to exploit the elements taken from the state-of-the-art review and incorporate them in a new pedagogical model
- Section 3 presents the core elements of the review and which elements are being built up inside the pedagogical model. Thus, it presents the main features of PBL, LA, Leaning Design and GBL and reflects on how these elements can be useful in a FC design.
- Section 4 presents the pedagogical model, starting with the FC wheel. It then presents the three-layer model incorporating learning activities, data generation, and learning analytics. Each section of the FC wheel in then detailed with an exploration of the type of learning activities, data generation, learning analytics and intervention to be implemented during that phase.
- Section 5 concludes on the pedagogical model and tries to discuss practical applications of the model to the development of a game platform to support the FC.

2 Methodology

The main goal of this report is to present an educational approach that will enhance and support the flipped classroom by incorporating PBL elements and games, both through GBL and gamification tools. Furthermore, the FLIP2G pedagogical model aims at exploiting the data that is generated towards improving the learning experience for both learners and educators.

Towards this end, we carried two separate literature reviews on the main topics covered by the FLIP2G approach, i.e. serious games for education and learning (D1.1) and the FC methodology (D2.1). Next, a thorough analysis of the main results from each deliverable was carried out. The study aimed to derive the main concepts from each topic that would be included in the FLIP2G approach.

The aforementioned research led to the construction of a generic framework that will guide the creation of the educational approach. To this end, the following steps on building a framework were followed:

- Selection of main topics: integration of the FC with PBL elements and LA, GBL and Gamification
- State-of-the-art review: FC analysis (D2.1), GBL in the FC (D2.1) analysis of PBL, analysis of LA
- Focus groups: brainstorming sessions with the FLIP2G partners focused on the PBL cycle, integration of learning tasks, data extraction, and intervention
- Development of the conceptual framework: development of the FLIP2G model

The last two steps were carried out through discussions and feedback among the consortium, which generated ideas regarding the type of games and learning activities that could be integrated related to the content and structure of the approach. Figure 1 illustrates the work done towards the creation of the FLIP2G education approach.

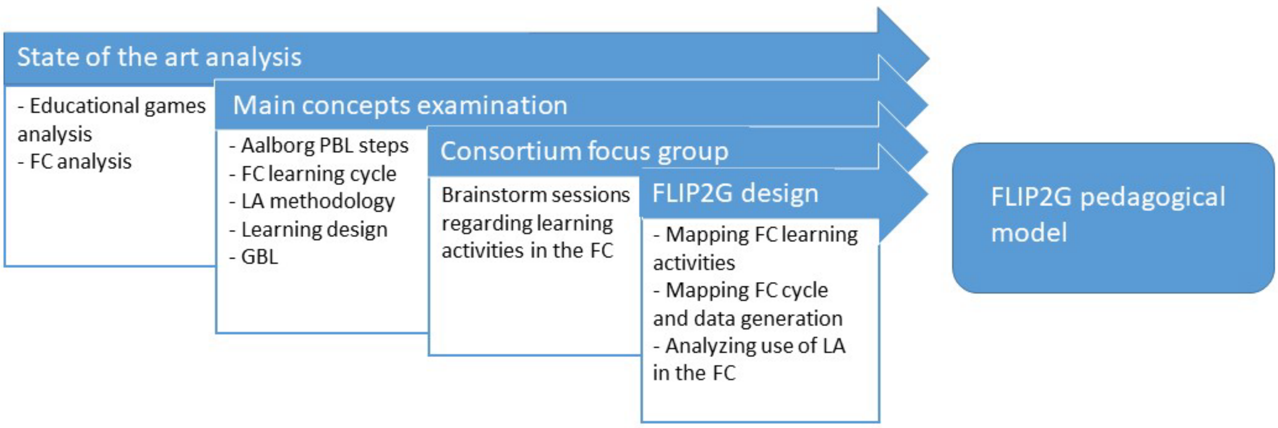

Figure 1 FLIP2G pedagogical model methodology

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3 Analysis of the main concepts

This chapter will include a brief overview of the main concepts identified during the literature review for the main topics in the deliverable, such as PBL, LA, learning design and game-based learning. The analysis of these notions aim at supporting the creation of a pedagogical approach that will combine these concepts to enhance teaching and training and support a bespoke learning experience in the FC. With this approach, educators will be able to use the FC methodology in a more efficient manner, support their students during the course, assess their performance and plan interventions to modify their curriculum as needed. Learners on the other hand will be more supported through the FC experience, get a better insight into their progression and benefit from a personalized flipped learning experience which will reinforce their capacity for self-directed learning.

3.1 PBL model steps

PBL is a student-centred pedagogy in which learners learn through the experience of problem solving (Neville, 2009). In Aalborg University, Denmark, all university programs have been based on PBL, also referred to as "PBL - The Aalborg model" (Barge, 2010). The PBL - Aalborg Model has become both nationally and internationally recognized and a trademark for Aalborg University. Figure 2 presents a simplified model on the PBL steps devised to highlight the PBL elements we will be using for our theoretical framework.

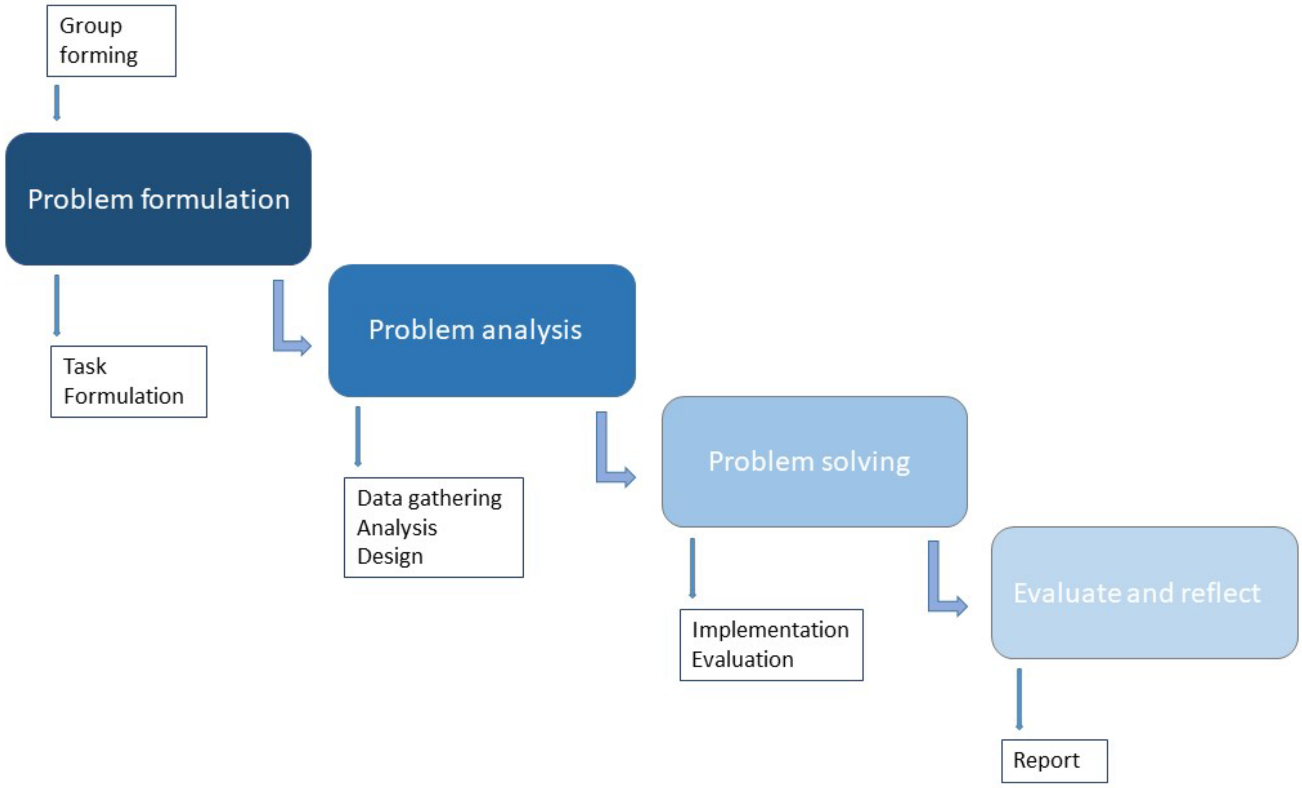

Figure 2 The PBL model simplified to its core elements

In this model, learners form groups in order to work towards solving a problem. Teamwork is an essential part of PBL, and the group environment's purpose is to support the learners' motivation and to produce succesful results.

Since our model only aims at integrating PBL elements in the FC model, it appears necessary to identify which aspects of the PBL method would be essential to our model. For that purpose, we have boiled down the PBL process to 4 core steps.

In the **problem formulation** phase, each group identifies issues that could be considered as a problem that need solving. The problem must be specific and straightforward so that it can be solved within an imparted timeframe. However, it should also be complicated enough to require all members to contribute in terms of language and skills. Finally, it must be complex enough for the solution to require a full process of analysis, design, implementation and evaluation.

In the **problem analysis** phase, the group gathers data on the problem they are investigating and analyse the information to make informed decisions that can lead to the design of a strategy for the resolution of the problem.

In the **problem solving** phase, after the students have designed an appropriate solution, they move towards the implementation of the solution. The implementation is then applied for validation and tested through different means such as user tests, technical tests or interviews. The results of the evaluation are recorded and are part of the assessment of their work.

Finally, the group submits the report on their project work where they formulate their conclusion and suggest future work on their problem. This phase is the "**Evaluate and reflect**" part of the PBL process. During this phase, the students consolidate their learning by reflecting on their work, but can also learn by evaluating and reflecting other groups' works. This latter option is part of the peer-learning part of the process.

There are precedents in incorporating problem-based learning elements to the FC cycle. For example, Chiang (2017) underlines that "it has become common for problem-solving strategies to be applied to learning, and these strategies have become a popular topic in educational research. Through problem-solving strategies, students are able to raise questions, collect information, discuss their findings, and share their conclusions. This improves and develops their ability to solve problems." Chiang (2017) uses problem-solving to frame online interactions in the FC for a computer science coding class. The discussion board interactions are distributed in five types of interactions, four of which fit the PBL model, the last one being an "other" loose category for unclassified elements. These interaction on the online forums were defined as such: *asking questions* (problem formulation), *provide information* (problem analysis), *compare, analyze and discuss* answers (problem solving), and *result in a conclusion* (evaluate and reflect). The evaluation of the course, taken by 44 undergraduate students, showed that the flipped classroom combined with the problem-solving strategy was more effective than the previous problem-solving sequence, as the introduction of the flipped model made students more willing to exchange and collaborate on the questions raised.

Similarly, Valdez et al. (2018) develop a curriculum for electrical engineering classes combining the FC and PBL in which the final objective was to present to solve a problem by implementing a lighting proposal and show. Evaluations of the new curriculum show increased students grades in average and positive evaluation by the students regarding the quality of the course, in spite of an increased workload.

Another example is provided by Ozer et al. (2018) which create a gamification supported FC with game development problem-based learning course in game development. Thirty-five students participated in the course and showed an increased interest towards coding learning activities and increased motivation over the course evaluation (through mixed methods).

Therefore, earlier examples show a positive impact in combining the FC with PBL. However, current literature only presents us with examples where the PBL aspects concern a specific section of the FC: either to support out-of-class preparation and discussion, or for in-class activities. Our perspective is to incorporate the entirety of the PBL methodology into the FC experience to create a fully integrated learning experience. The objective is to blend in the Aalborg model of PBL to the FC as a means to reinforce the educational benefits of each method.

3.2 LA analysis

"LA is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs." (Long & Siemens, 2011). Fig 3 shows the steps of LA in a course.

Figure 3 The LA cycle

Current literature suggests that LA in education have the potential to support and improve the learning experience. LA applied to education enables policy makers and administrators to adapt the curriculum to their students' needs, identify individual students' learning status or difficulties to deliver adaptive learning, and provide insight into the students' behaviors (Hwang et al., 2017).

Chen and al. (2016) suggest that the future of blended educational methods might rely on fully integrated smart learning environments that, through big data and learning analytics "could derive new and more effective learning models by analysing the data collections of various learners and further extract valuable learning patterns". These new systems could accompany the learning process over long periods of time and even through the entire career.

The literature also covers the type of data that can be collected and used in the FC methodology. Fernández and al. (2018) thus proposed several scenarios to implement LA in the FC. Their approach is to present a model that incorporates LA in the three steps of the FC. Fig 4 presents the model of LA in the FC according to Fernández and al. (2018)

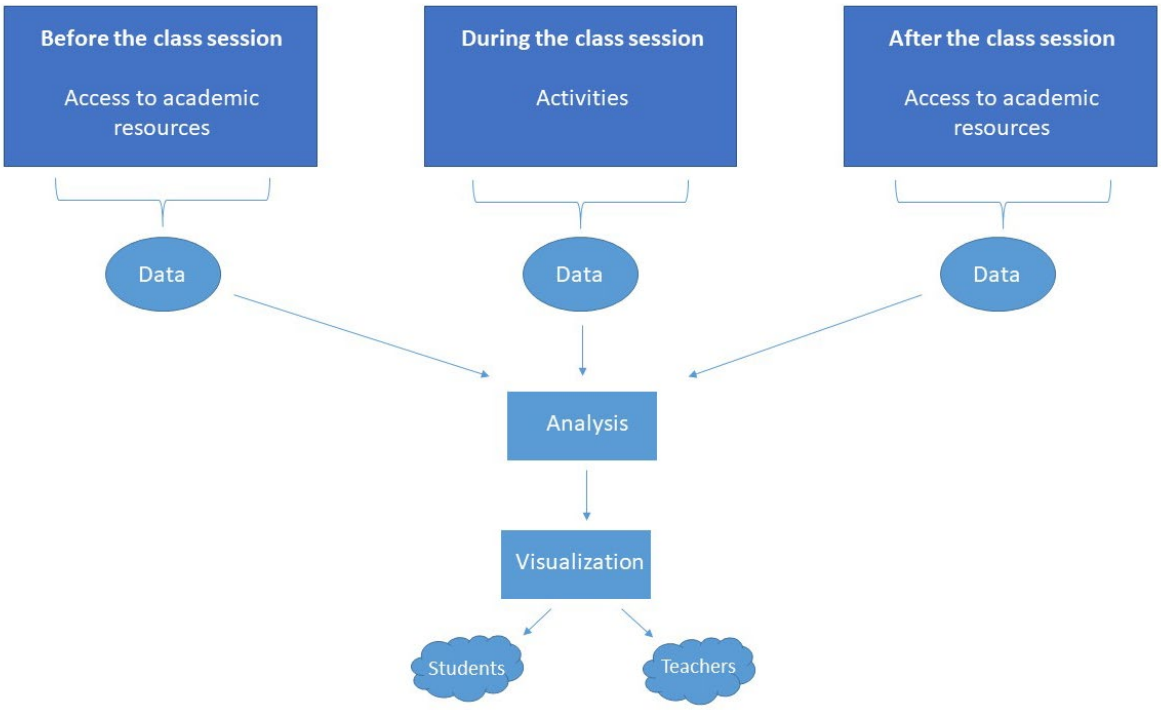

Figure 4 LA in the FC according to Fernández et al. (2018)

Taking scenario models from a collection of previous academic works, Fernández and al. (2018) suggests the following indicators:

- Amount of time invested in a video
- Amount of time invested in a specific time interval of the video
- Number of downloads of a PDF document
- Number of visualizations of a page of information (HTML page)
- Amount of time invested in a page of information (HTML page).
- Score obtained in the exercises.
- Number of times that an exercise has been attempted (number of attempts).
- Time used to complete an exercise.
- Number of written messages in the discussion forum of the class (an online forum).
- Type of written messages (e.g. questions, answers, or comments) in the discussion forum of the class.
- Evaluation of the resources provided (students evaluate the utility of the resources).

However, this model still follows a very linear approach to the FC and, although the analysis conducted by Fernández and al. (2018) stresses the importance of LA to adapt the learning process to the feedback given of the students' experience, their learning scenarios tend to neglect the post-class process and give almost nothing of the intervention process of LA.

Further literature provides methodologies for LA in the classroom (Hwang et al., 2017):

- Decision tree: modeling the relationships between data items in the form of a tree structure, which allows to predict dropout rates or student behaviour.

- Clustering: Grouping a set of data items with similar features, which can be used for recommendations of content or goals to individual students.

- Association rules: Finding occurrence relationships of content, behaviour and the layout of learner interface, which provide information to identify specific learning paths.

- Time sequence analysis: Finding the sequential relationships between learning behaviours and interactive content to analyse students' learning patterns to predict learning outcomes and issue recommendations.

- Visualization techniques: Presenting a data set in the form of graphs or images to help interpret the data, which is useful both to students and policy-makers.

Finally, relevant operations based on LA can be categorized into six categories:

- Predictions and interventions. This regards the operations that answer previously asked questions about possible outcomes. Examples of such actions include estimations of a learner's future scores, potential dropouts or at-risk learners, etc. These actions can be carried out through a number of LA methods such as statistical inference and machine learning.

- Recommendations and personalization. This regards the provision of suggestions to educators and learners based on specific learner-based LA information.

- Adaptations. This regards the tailoring of the course materials or learning activities based on a learner's progress in order to ensure maximum performance. The types and number of adaptive actions to be performed is a decision made by the educators depending on the learning context and the specific learner.

- Mentoring. This regards all the actions that are performed by the educators in their facilitating roles, especially in student-centred learning strategies. In these cases, educators study the LA outputs and provide guidance and advice based on the LA information.

- Assessment and feedback. This regards the support of formative and self-assessment actions during the learning process as well as the provision of informative feedback to both educators and learners regarding the ongoing progress. Continuous assessment is an essential objective of PBL3.0 and such mechanisms will be studied during the project.

- Reflection. This regards the provision of visualizations and information that show educators and learners the ongoing progress, current achievements and mistakes made, comparison between learners and groups, across courses etc.

We conclude therefore that our model will make a thorough use of LA and incorporate data collection, analysis and intervention to the whole FC process.

3.3 Learning design for the FC

While PBL and LA are the main concepts of the FLIP2G educational model, it also relies on learning design to optimise the integration of the pedagogical frame and learning activities.

Learning Design represents "the learning activities and the support activities that are performed by different persons (learners, teachers) in the context of a unit of learning (e.g., a course, a lesson or any other designed learning event)." (Koper, 2006). The most common framework for Learning Design is defined in the Larnaca Declaration on Learning Design (Dalziel et al., 2016) This declaration defines the core concepts of Learning Design (guidance, representation, sharing), and the development of a Learning Design teaching cycle by three central steps: **planning activity, design core-learning concepts,** and **implement activity**. Fig 5 presents the full teaching cycle as presented in the Larnaca Declaration Learning Design Conceptual Map.

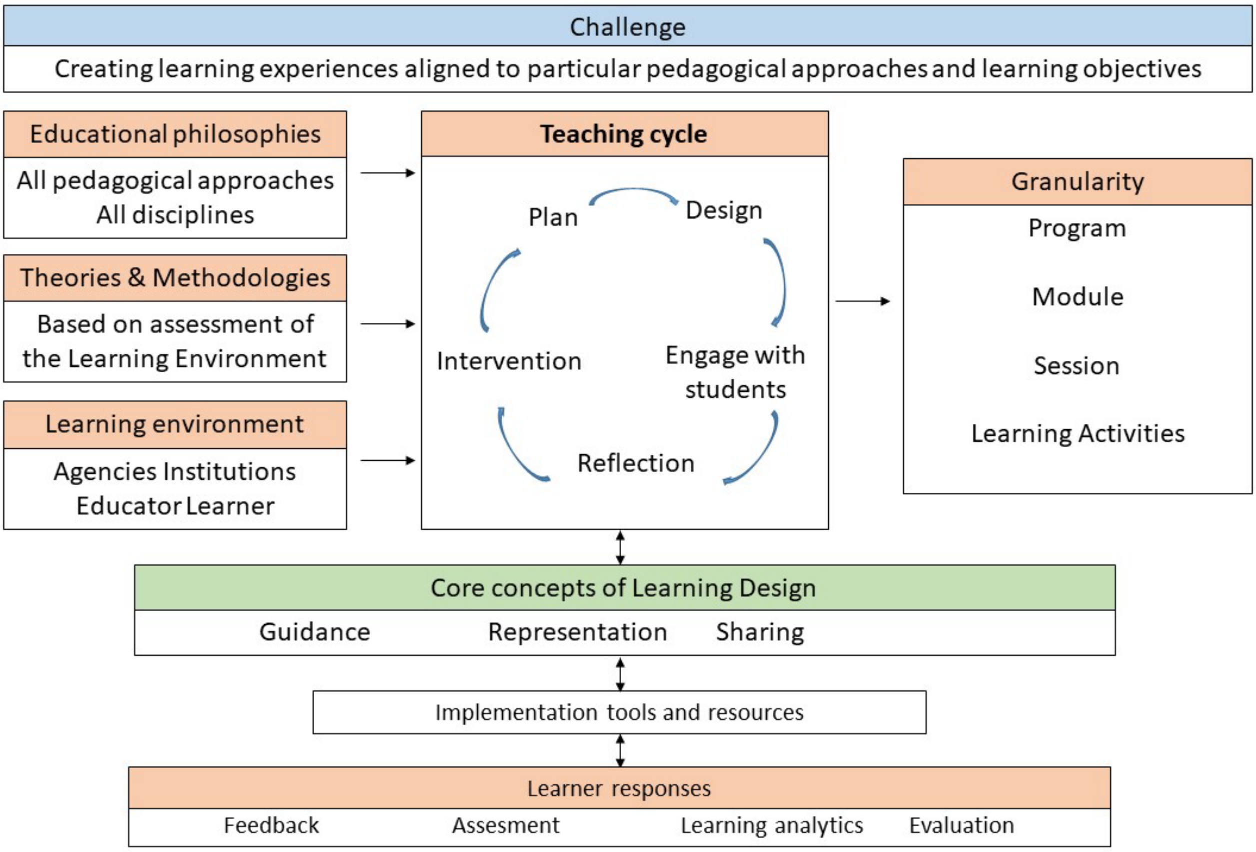

Figure 5 Learning design model based on the Larnaca Declaration Conceptual Map (Dalziel et al., 2016)

Successful application of Learning Design to the FC was studied in Triantafyllou et al. (2016). Their study shows that when Learning Design is used to describe a classroom setting, important decisions guided by this component and related to the structure of teaching and learning will follow the FC structure (as regard in and out-of-class sessions in particular). The application of this methodology over 3 semesters of statistics course for undergraduates revealed that it encouraged educators to reflect on their own practice, and that the FC enabled them to get valuable feedback from their students. In turn, they reflected on each flipped session and adjusted the next one throughout the semester.

Therefore, although learning design is not a core part of the pedagogical model, we consider that it should be used as a framework for the design of learning activities in the FC. Similarly, learning design will be featured in the first level of the pedagogical model that regards the designing of learning activities.

3.4 Gamification and game-based learning for the FC

Our previous literature review showed precedents of case uses of games in the FC. These forms could be variable, from gamification to use of educational games to complete simulations games that aim at reproducing closely the real situation. Our earlier review showed that using game elements or gamification in the FC yielded positive results in terms of student motivation, engagement, and academic results, compared to a standard non-gamified FC (cf D2.1, p 43 for examples)

Further literature, however, emphasizes the potential for further research into integrating games in the FC, or combining game elements and LA in the FC. These more recent examples show that gaming elements are relevant for a complete integration in the FC. Furthermore, they also reveal that there is potential for a more fully integration of gaming elements in the whole of the FC, and not only in a limited fashion, segregating in-class and out-of-class activities as two separate entities.

For example, Klemke and al. (2018) developed a flipped MOOC model integrating gamification and LA by assigning a selection of game elements to a group of 19 education professionals and asking them to analyse which of these would be the more effective for the design purpose. The participants formed four small groups covering a variety of subjects (from management to language acquisition). All groups selected “level indicators” and “goals” out of a selection of ten features, and three out of four groups “empowerment”, “smooth learning curve” and “communication channels”. Similarly, Lo and Hwang (2018), while developing a new conceptual framework to support research in the FC, consider integration of gamification one of the four priority research orientations into the FC. They argue that some research show that integration of game elements could enhance students’ learning achievements, but that further research is required to reach conclusive evidence to the fact.

Feedback loops, as a central component of GBL, appear a central point of work to integrate GBL in the FC model. Busch et al. (2015) uses mobile learning games as a support to the FC showing that GBL could be useful to the FC by supporting repetitive exercises implanted as modules. Since some elements of acquisition require repetition (e.g language fundamentals or numerical literacy), a playful experience with trial-and-error feedback loop can support the learning experience. Similarly, Yang (2017) analyses the most efficient design choices in terms of feedback efficiency, underlining the importance of corrective feedback inn the learning process. He argues, “Although all games contain feedback mechanisms (e.g. awarding points or completing levels) that inherently increase motivation, educational researchers place more value on instructive feedback that is more closely tied to learning and can provide information to students”. This element underlines the value of communication and information and can be tied to the potential value of LA in the FC.

Finally, Uskov and al. (2017) provide a list of arguments supporting, in the same manner, the integration of GBL and LA in smart learning environments for the FC. Their research relies on the analysis of more than 150 publications relative to smart pedagogy and smart learning environments. Their final list of learning strategies focused on adaptive teaching, learning analytics, collaborative and context-based learning, GBL and the FC. Their evaluation of this smart pedagogy used for 43 students showed significant interest and acceptation of the smart pedagogy components in Computer Science in Information System curricula.

As such, although the field is relatively recent, our background research indicated that there is potential to integrate the PBL model in the FC and support it with gaming elements. Our model aims to determine the most efficient way to integrate these elements.

4. The FLIP2G educational model

4.1 The flipped classroom wheel model

For the purpose of our educational model, we decided to steer away from a linear model and to focus on the circular model proposed in several writings about the FC. Nederveld and Berge (2015) have thus adapted Gerstein's Flipped Classroom Model (Gerstein, 2011) to Gilbert's suggestions (Gilbert, 2013). Fig 6 proposes a simplified version of the FC as designed by Gerstein (2011)

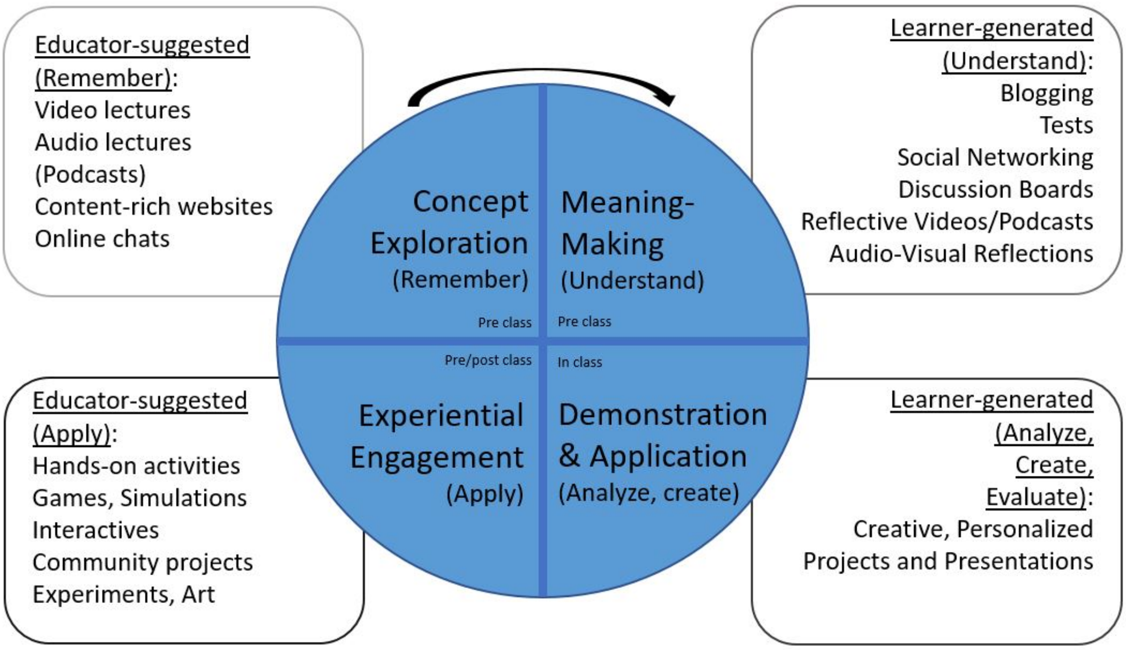

Figure 6 The FC wheel cycle and activities based on Gerstein (2011)

There are four components/stages to this model. Gerstein (2011) suggests that the process starts with experiential engagement (lower right corner), which gets learners interested in the subject. Gilbert begins the process with concept exploration (upper right corner). For the presentation of our model, we will start with concept exploration. However, we will also consider that the experiential engagement phase can work both as the end of a FC cycle and as the beginning of the new one.

According to this model, the FC process begins with concept exploration. The "concept exploration" stage is an educator-led part of the process that introduces learners to learning material. This is traditionally the presentation part of a course outside the classroom (by e.g. video lectures). After concept exploration, students make meaning out of the information they have been exposed to by engaging in various assessment or reflection activities. The “meaning-making” stage is also situated outside the classroom. Students show their mastery over the concept exploration content by producing their own content that reflects upon their acquisition in a meaningful way. The “demonstration and application” stage is the stage of the FC Model that occur in the classroom. During this stage, students analyse, evaluate and create and engage in peer learning activities or projects, while educators can evaluate and offer additional support where needed. Finally, the “experiential engagement” stage occurs after the class, or before a new class. This phase occurs when students consolidate their knowledge or explore further. It may thus occur before the concept exploration stage, when educators engage students in activities with the aim to pique their interest in a topic (e.g. play a game). It may also occur after the meaning-making stage, where students have to apply what they have learned (e.g. practice a skill, work on a project, etc.). At this stage, the educator has a chance to support students in applying their knowledge.

4.2 Model and layers

For the purpose of this educational model, we endeavoured to combine first this FC model with PBL elements, gamification and GBL activities, in order to better frame the learning activities in FCs. This model is presented in fig 7.

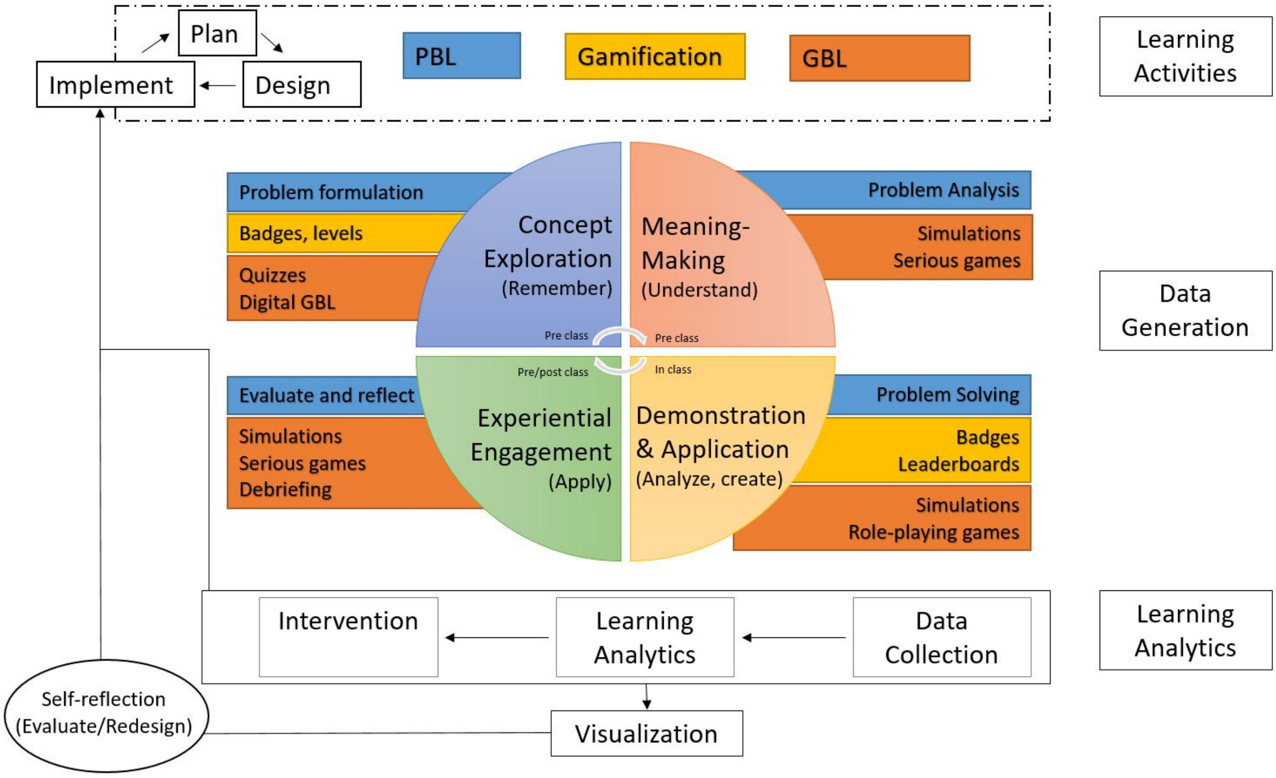

Figure 7 The FLIP2G pedagogical model

For this model, we concentrated the PBL process to four core stages: Problem formulation, problem analysis, problem solving, and to finish evaluation and reflection. Our purpose is not to transfer the full articulation of the PBL in the FC, or to model the FC around the PBL cycle, but to adjust the FC process based on the most important components of a PBL approach.

We also decided to analyse which elements of GBL and gamification fit better in the different stages of the FC cycle. This will allow for a greater understanding of why and how the integration of gaming elements has been successful in the FC, and how we can develop a more complete model from here.

Finally, we tried to analyse how LA and interventions could be incorporated to the model.

We ended up devising a 3-tiered layer model:

- On the upper level, the **learning activities**. The learning activities level contains the preparation and development of the curriculum. The learning activities level incorporates both PBL elements and gamin elements following the "plan-design-implement" cycle of the learning design model. The purpose of the learning activities level is to design the FC with an educational objective in mind, while approaching the FC as a bespoke adaptive holistic experience.
- The second level is the level of **data generation**. It concerns everything that happens before, during, and after each FC. The purpose of this model is to ensure that data is generated and collected in each phase of the FC, so that LA can be implemented in the most relevant and effective way.
- The last level is **Learning Analytics**. Learning Analytics also comes into three phases, from data collection, to analytics and then intervention. Learning analytics leads to visualization produced for both educators and learners. LA then allow students a phase of self-reflection on their learning, and for educators to intervene on the learning activities levels by adjusting the program as needed.

For a full presentation of the FLIP2G pedagogical model, we are going to detail each phase of the FC. For each phase, we will discuss which activities and learning processes can be implemented, starting with concept exploration. For each of these phases we will discuss learning activities, data generation, learning analytics and interventions.

4.3 Concept exploration

The concept exploration phase is the phase of the FC in which the learners start the learning process by being exposed to new content, knowledge and ideas and start to remember it. It occurs off-class, before the classroom activities. Learners are invited to engage with educator-suggested content. Such content can include video lectures, audio lectures, podcasts, but also written material and textbooks. Fig 8 presents the structure of the concept exploration phase.

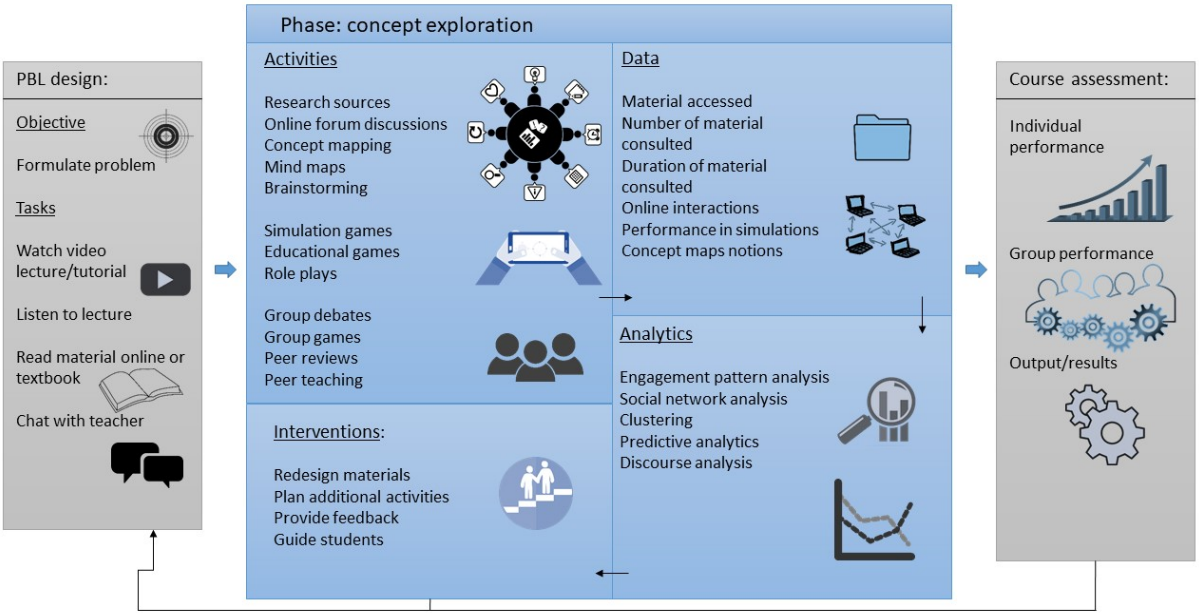

Figure 8 Conceptual map for the concept exploration phase of the FC

The concept exploration phase of the FC is associated to the problem formulation phase of the PBL model. The objective during this phase is to introduce students to the problem and allow them to decide where to focus their learning.

The ***learning activities*** for this phase must encourage the students to seek information and engage with content. They must be focus on academic or technical content while remaining engaging and allowing for active engagement with the learning material. They should also encourage peer learning, even though most of this phase will occur at home, in off-class learning moments.

For example, students can present the result of their exploration of the subject to their peers. In smaller classes, debates are also a tool to work with a new subject. Collective study sessions at the library to explore a subject can also be organized or encouraged. Another activity can be the Peer Theatre, where students share the text that they have to study between themselves and engage through a group performance. Peer learning can also be supported by online interactions such as online forums, or through peer reviews or mentoring activities.

Some fields lend themselves very well to exploration through games. For example, historical subjects can be studied through educational games that allow the exploration of different scenarios. A game can be used to support the introduction to the content material. For example, the game The Protégé (Ling, 2018) introduces a scaling approach to the reading material in the FC by inviting the student to explore the mystery of the teacher's disappearance. A video game can introduce different problems to be solved over the course of the gaming session. The game can even centre on the main problem that the educator needs to introduce, or support engagement with the learning material. For example, the game World without Oil (cf. D1.1) presents an issue tied to the real world and the different stakeholders' perspectives. Similarly, roleplaying games also have the potential to allow a first introduction to a specific problem: the focus on the role and collective storytelling can be an efficient way to introduce concept by relying on intrinsic motivation.

Concept mapping and mind maps are also efficient activities for the concept exploration phase. They can be performed individually or in groups. Students must identify the key concepts included in the given problem and highlight the links/relationships among them.

The **data** generation for the concept exploration phase is closely related to the type of activity and material. Since most of this phase occurs on line and pre-class, it can safely rely on already established forms of data gathering already used in VLE.

This data can consist for example of: type and number of materials seen, duration for each material, exchanges of messages or questions asked online, tests in reading comprehension and fluency. Peer learning activities can be more difficult to track in terms of data generation, but data can include work notes from participants, recording of performances, debates or work sessions, and peer review arguments and result. Finally, any production during the concept exploration phase such as mind maps or concept maps can also be part of the data gathering.

The **analytics** for the concept exploration phase are reliant on the data gathering method. The analytics include statistics about online engagement, individual and group performance and the difference between these two approaches. Online communication and peer learning can generate Social Network Analysis and Content Analysis through the number of connection, exchanges and the vocabulary used during those exchanges. Engagement patterns determine how students interact with the online material and clustering allow determining early learners' profiles. Finally, early predictive analysis can help identify which students are more likely to pass and more likely to fail.

Finally, **interventions** should address the issues observed in the early stages of the FC. They can consist in redesigning the less suitable material, providing adaptive material best suited to each student's personal interest, or provide additional material. LA also allow educators to plan target interventions towards the groups or individuals in need of assistance, e.g where the data shows a lack of language proficiency and/or where there are social insecurities within pupils. Interventions can also provide students with efficient means to review their peers without bias. The analytics can also provide pointers for home and time organization and reminders for tasks. Finally, cluster analysis can help devise the best pairings or support group formation for students of similar or complementary interests and abilities.

4.4 Meaning-making

The meaning-making phase is the phase of the FC where learners need to understand the academic or theoretical knowledge that was introduced during the concept exploration phase. The content during this phase is learner generated and must show students their mastery and assimilation of a given knowledge or technical information. This phase should therefore include activities targeted towards knowledge assessment. From a PBL perspective, it corresponds to the problem analysis phase. Content creation can consist in participating to discussion boards, creating written reports or online productions. It occurs off class, before the classroom activities. Fig 9 presents the mapping of the meaning-making phase of the FC.

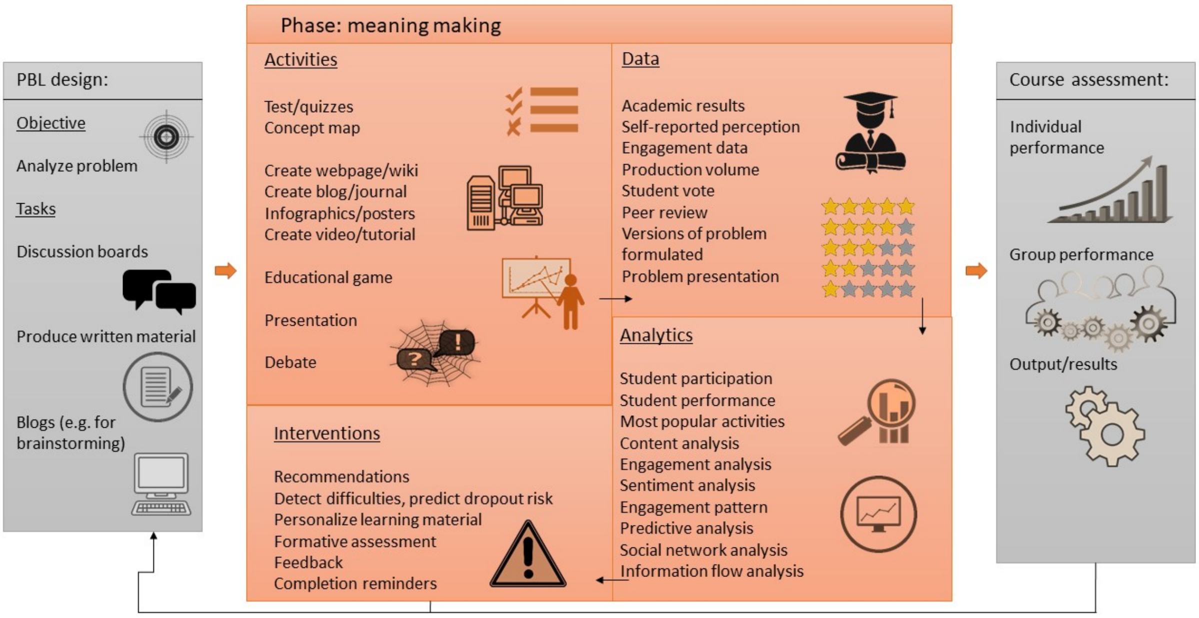

Figure 9 Conceptual map for the meaning-making phase of the FC

Activities for the meaning-making phase cover most production activities. Group activities such as debates, short presentations of essay, infographics or posters in front of other are possible. Individual activities can include simple knowledge assessment exercises such as quizzes, essay writing, creation of blog, webpage, wikis, tutorial or podcast, conceptual maps, etc.

Online systems for quizzes such as Kahoot! or Quizzlet very conveniently blend knowledge assessment and group activities (quiz taken in pairs or teams).

Finally, educational games are useful during the meaning-making phase if they directly exploit the knowledge or skills gathered in the previous phase. For example, the University of Taiwan used a digital game-based learning system for Unity programming for students to prepare during the pre-class phase of a Computer Science FC (Hsu & Lin, 2016).

During the meaning-making phase**, data** generation is first a direct outcome of learner-generated content and support observation of students' reflection. For example, evidence of pupils knowledge in the form of multimodal texts or webpage. Evaluation of the learner generated content through teacher assessment, peer review or students' votes for selected content is also central data.

Quizzes can generate data in form of time spent, number of correct answers, time necessary to answer etc. Educational game also generate their own data in terms of time spent, achievements unlocked, number of trial and error. Where serious games are used, the academic results of participants compared to non-participants should be observed, so that the game can be adjusted to improve the learning process.

Analytics for the meaning-making phase aim at supporting knowledge assimilation and consolidation in the students. Important statistics include percentage of students' participation in debate, statistics about performance and evaluation, about most popular activities. Content analysis evaluates what the students have remembered. Sentiment analysis can cover students' affective state towards learning. Analytics can also cover engagement patterns base on students' participation.

Based on these analytics, **interventions** for the meaning-making phase cover detection of the most common problems and difficulties and support through advice, reminders or personalized materials and activities, both for the class and the individual student. Formative assessment should also be a significant part of the meaning-making phase. Formative feedback should be given to support students and additional tasks where needed. Predictive analysis should continue during this phase and identify both over-performing students and students at the risk of dropping out. Support already given to students in the concept exploration phase to provide constructive feedback and peer review without bias should continue during the meaning-making phase.

4.5 Demonstration and application

The demonstration and application phase is also a phase for learner-generated content. However, the demonstration and application phase occur in-class and is the preferred time of the cycle for hands-on activities and collaborative learning. This phase follows the design and implement a solution part of the PBL process. Activities include group work, development and testing of a prototype, maintaining a journal or portfolio of the working process. Group engagement is supported by presentations, peer reviews on solutions, discussion boards and blogs. Fig 10 presents the demonstration and application phase of the FC.

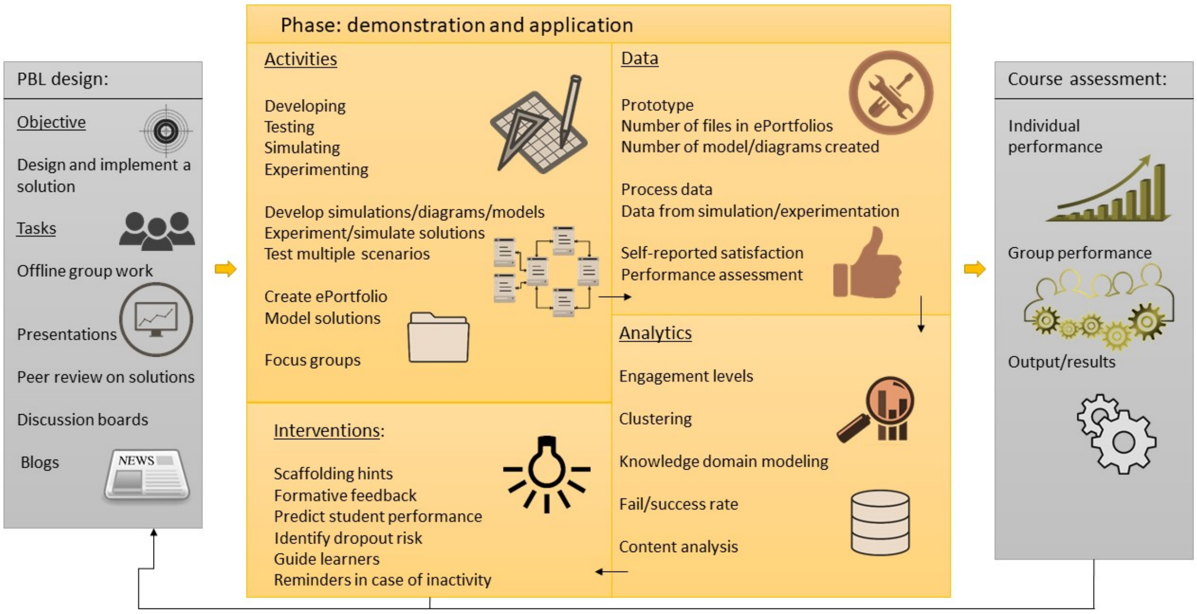

Figure 10 Conceptual map for the demonstration and application phase of the FC

Activities for the demonstration and application phase should be oriented towards a material activity and production of results. It can involve the development and test of a prototype, creation of an ePortfolio where students gather evidence of their work and learning process, creation of infographics and posters to solve a specific problem (e.g as part of a marketing campaign to solve a specific problem). Another approach is for students produce visualization of the solutions approached with diagrams of models. They can also simulate outcomes of the solution with online tools or online simulations. Within the same group, students can try to come up with solutions individually before coming together and confront their solution. Finally, activities can be based on abstraction of content, by asking the student to apply their solutions to a different case study or by modifying some parameters of the problem at hand.

Data generation in the demonstration and application phase comes from various sources such as students' performance assessment and academic results, their participation in online forum or in class presentations, the time taken for each phase of the prototype development. If the students provide an ePortfolio, the number of document uploaded or the assessment of the document can also generate data. If the students engage in modelling or simulation of their solution, data can come from their engagement in the simulation, number of trial and error, time spent on the simulation, etc. Finally, questionnaires about student satisfaction and motivation can be developed and implemented from that stage forward, to evaluate their perception of the learning process.

For the demonstration and application phase, **analytics** can cover statistics about participation, common mistakes, and students' academic results. Content analysis can be applied to the students' portfolios or written reports. Engagement pattern can determine students' participation and cluster analysis can refine students' or group profiles.

Interventions following learning analytics allow solving issues that happen during the testing and implementation of solution. They provide formative feedback on the solutions and prototypes. They support interventions towards students at risk of dropping out, through reminders or personalized tutoring. Educators can also evaluate or enforce milestones to the demonstration and application phase to support an iterative solving process and prevent student dispersion in non-constructive work.

4.6 Experiential engagement

The experiential engagement phase can occur after the class, or before the class as the introduction of a new FC cycle. Activities in the experiential engagement phase are also teacher-suggested but, if at the end of the cycle, the learners themselves can come up with activities to further their learning experience. If the experiential engagement phase starts the FC cycle, it introduces a new problem. It includes in that case similar activities to the concept exploration phase: watch video lectures, listen to audio lectures or podcast, read online material or textbooks and articles. However, in the final stage of the FC, the experiential engagement phase allows for deeper reflection on the demonstration and application phase and conceptualisation of the learning process. As a final stage of the FC, the experiential engagement phase can include peer-learning activities such as reviews and evaluation of other students' projects, engagement with educational games or extended online material. Therefore, in the final stage of the FC, the experiential engagement means both consolidation of existing knowledge and further exploration of the subject, which can lead to the next cycle of the FC. Fig 11 presents the experiential engagement phase of the FC.

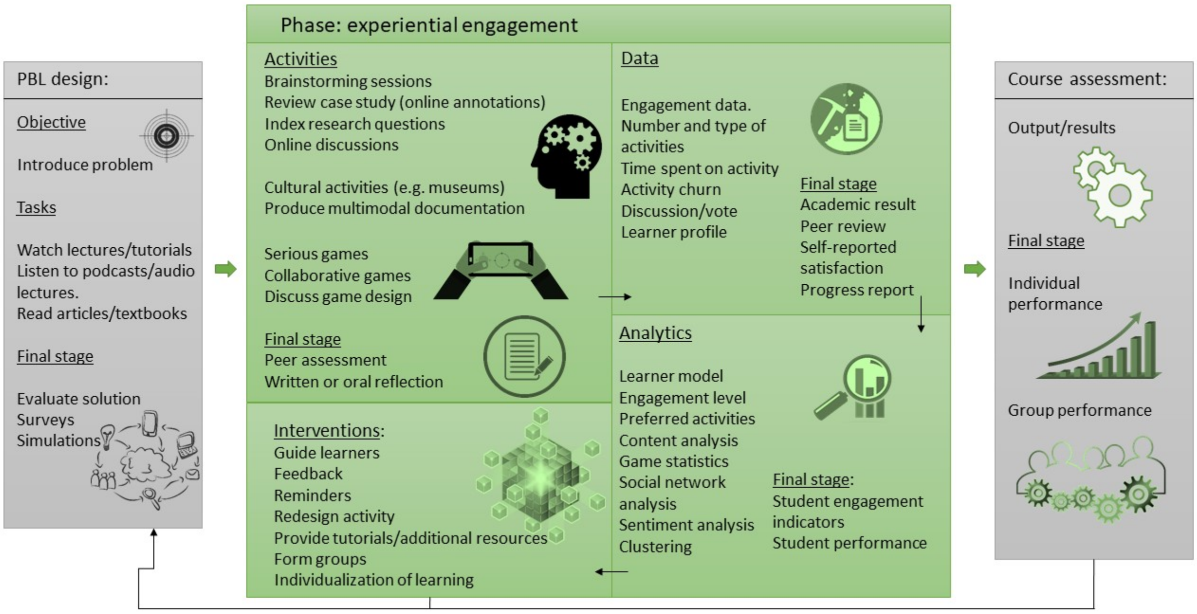

Figure 11 Conceptual map for the experiential engagement phase of the FC

Activities for the experiential engagement phase that introduce the subject can be brainstorming sessions, social annotation of existing work or articles (some platform allow online annotations), work in small groups on relevant sources. Annotation of scientific work is useful as both a reading comprehension training and a means to engage the students collaboratively since they can read others' annotation and discuss them online and in-group sessions. Students can also run in-group brainstorming sessions by creating index cards, shuffling them and then answering them at random. Fieldwork such as a visit to a museum, observation outside of school or in the city, laboratory observation are useful to contextualize the subject.

Games related to the topic at hand can be used during the experiential engagement phase. A game can be a tool to introduce a research question: students play in pairs, create a research question based on the game they are playing, and take notes to answer the questions. Alternatively, they can start by taking extensive notes to formulate a research question afterwards. With the notes, they can produce together and comment on both the research question and the game design. They can finalize the production in the form of a written article, a multimodal text, a video presentation or a podcast. Games used in the experiential engagement phase should also give learners the opportunity to shuffle between different scenarios.

In the experiential engagement phase, students should be encouraged to keep exchanging on the topic: online discussion board, dedicated twitter hashtags, or collective activities in the final stage of the FC.

If the experiential engagement phase coincide with the final stage of the FC, collaborative activities can also support reflection on the work done. Students can continue peer reviews and comment on the other groups' solutions. They can also try to present their work to outside observer, or to sign up to competitions with their project. They should also be able, individually, to reflect on their work by producing a written or oral final report on their learning process.

Data generation for the experiential engagement phase covers engagement data first: number and type of activities performed, type of activity, activity churn. Final projects evaluation can also generate data in terms of student performance, work contribution of students, participation and academic results. Peer review results and assessment also contribute to data on the finished projects. Participation in games can generate game statistics with scores, leaderboards, achievements, trial and errors. Participation in forums can generate data in number of connections, number of messages, time spent.

Finally, in the final stage of the FC, satisfaction questionnaires, interest and perception of the subject and motivation questionnaires can evaluate students' perception of the learning cycle. Qualitative data gathered through interviews can also document the students' experience.

Analytics for the experiential engagement phase first cover again clustering to identify students' profiles, engagement patterns and performance, both in educational games and in their own production. Statistics can also identify the most interesting activities for students.

In the last stages of the FC predictive analysis can identify the most influential factors for a successful project, and project quality as a function of all factors. Content analysis can assess students' production and correlate it to their understanding of the topic.

Online engagement allow Social Network Analysis to understand the links among the online users and identify the 'key' users with high density and centrality. We can use Content Analysis to understand communication pattern and responses and Sentiment Analysis to understand affective states towards the topic.

In the final stage of the FC, we can use student predictive statistics and decision trees to identify and display the variables for academic success and engagement in a given project.

Interventions for the experiential engagement phase include reminders to less active students, redesign of activities, and personalization of activities. In the final stage of the FC, educators can redesign the whole cycle. They can take into account both the predictions for students' success and risk of student dropout. They can provide formative feedback to the students regarding their learning process.

At the beginning of a new FC cycle educators can issue recommendations of learning materials through comments on students' notes and engagement, tutorial for educational games, recommendation for additional exercises.

Clustering can help form new study groups, and content analysis can help suggest new problems and studies for the next cycle of the FC.

Individualization of the learning process can be supported through personalized feedback, educators’ suggestions for topics and reading material, or online resources.

5 Conclusion

The present deliverable aimed at exploiting the results of the two previous deliverables and of our own literature review to present the FLIP2G pedagogical model.

The methodology followed in this deliverable included the study of the two previous deliverables (i.e. D1.1 "Serious games for education and training" and D1.2 "Review of the flipped classroom model"), and an extensive literature review on the core themes we were working with. It took in feedback and brainstorming from all partners on the FC cycle and learning design. We used this information to elaborate an abstract FLIP2G framework that includes a variety of inter-related concepts and that can be applied in any subject through data-driven adaptive systems.

The FLIP2G pedagogical model is comprised of three levels:

- The pedagogical level, which includes the development of learning activities and the implementation of the learning cycle based on the principles of the learning design methodology
- The data generation level, which includes all the activities carried out and all the data generated, whether learner-generated, educator-generated, or system-generated.
- The Learning Analytics level, which includes all LA methods that analyze educational data and provide meaningful information, visualization and interventions to improve learning and personalize the learning experience.

The pedagogical model framework was then elaborated following the FC wheel to determine the best strategies to incorporate PBL elements and LA in the FC. Nest, the approach consisted in selecting which PBL elements were the most relevant to our pedagogical model. Furthermore, we analysed previous successful incorporation of GBL and LA in the FC to determine which strategies would best fit our pedagogical model.

The FLIP2G pedagogical model was then detailed for each phase of the FC. We presented the most appropriate learning activities, learning analytics and interventions for each step of the FC. It is expected that learners engaged in the FLIP2G model of the FC will get better opportunities for self-directed learning through a fully holistic adaptive experience, while retaining the benefits of the FC approach in terms of collaborative learning and transversal skills (e.g. critical thinking, problem analysis, creativity, innovation, communication of ideas, organizational management etc.). Table 1 presents the final components selected for the FLIP2G model.

Table 1 The FLIP2G pedagogical model essentials

The FLIP2G pedagogical model essentials	
FC structure	4 part FC cycle: - Concept exploration - Meaning making - Demonstration and application - Experiential engagement
PBL elements	Problem formulation Problem analysis Problem solving Evaluate and reflect
Gaming elements	Problem-based or situated learning with rewards-based game mechanisms Collaborative learning Feedback-loop Guided-learning
Learning design concepts	Based on the Larnaca declaration principles of Learning Design (Dalziel et al., 2016) - Plan - Design - Implement - Reflect - Redesign
Layers of the pedagogical model	Learning activities Data generation Data analysis
Objectives and further research	⇒ Develop and adaptive learning platform ⇒ Support a fully holistic and adaptive FC experience ⇒ Exploit the best benefits of meaningful gamification and playful learning ⇒ Emphasis on self-directed learning and collaborative leanring

The purpose of the FLIP2G educational model is to guide further development in the model. The FLIP2G model is meant to be fully adaptable to different levels (both secondary and higher education) and a wide variety of subjects. The next step will be now to develop a simulation-based serious game platform, which will support PBL-enhanced flipped classroom processes, adaptive pathways, and educational data recording. This platform is going to be employed and evaluated for designing and implementing learning modules on secondary and higher education and in training. It will allow the implementation of adaptive pathways in order to adjust learning to individuals, and also to provide formative and summative feedback to learners and educators. The educators will then be able to use this feedback to adjust and redesign learning activities in order to better facilitate their teaching.

Further investigation in the FLIP2G model will have to take into account the learners' individual profile and measure its efficiency on different categories of students, as well as its implementation in different subject and type of studies.

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