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FLIP2G

Deliverable 2.1

Review of flipped classroom model

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Abstract:	**This report documents the work done towards the study of the flipped classroom pedagogical model and record all features that are important to be taken into consideration in an educational and training environment. It discusses the pedagogical foundations of the flipped learning model and its relations with problem-based learning, provides uses cases where this model was applied in various contexts, and discusses educational data creation in such cases. Finally, it discusses the state of the art in gamification for flipped classrooms.**
Keyword List:	**Flipped Classroom, Pedagogical Foundation, Educational Data, Gamification, Serious Games, Problem-Based Learning, Learning Analytics, Flipped Learning Model**

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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
F2F	Face to face
FC	Flipped Classroom
LA	Learning Analytics
LMS	Learning Management System
MCQ	Multiple-Choice Question
PBL	Problem-Based Learning
SDT	Self-Determination Theory
STEM	Science, Technology, Engineering & Mathematics
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 first deliverable of WP2, D2.1 – Review of flipped classroom model. Its purpose is to document the work done towards the study of the flipped classroom pedagogical model and record all features that are important to be taken into consideration in 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.

More specifically, this deliverable covers issues such as the definition and pedagogical underpinnings of the flipped classroom, different models for flipped learning, uses cases of flipped classroom implementation, and types of activities and technological tools employed in flipped classrooms. Moreover, it discusses the relation between flipped and problem-based learning, and educational data generation in flipped classrooms, since there are important topics for the FLIP2G project. This deliverable concludes with a review on game employment in flipped classroom, and on the application of gaming elements in the flipped classroom.

1 Introduction

The aim of this section is to introduce the background of the work pursued with Task 2.1 "State of the art on flipped classroom model". 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 2.1 "Review of flipped classroom model" (henceforth referred to as D2.1) of the FLIP2G project. The main objective of D2.1 is to document all work done towards the study of the flipped classroom pedagogical model and record all features that are important to be taken into consideration in an educational and training environment. These results will feed into the development of the FLIP2G educational approach.

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 conduct the literature review on the state of the art of the FC and its features.
- Section 3 defines the FC instruction model and comments on its pedagogical foundation and its relation to Problem-Based Learning. Then, it presents its main features and different models that were developed for representing flipped learning. It also presents implementations of FCs in various subjects and contexts and concludes with a discussion on the different types of learning activities and tools employed in such implementations.
- Section 4 discusses the educational data generation and the employment of learning analytics in the FC implementations reviewed. Since there a few cases of such implementations that focused on this aspect, the educational data generation and its potential use for learning analytics in one of the most used virtual learning environments for FCs is also discussed.
- Section 5 discusses gaming elements in the FC by first defining those elements and then presenting use cases where such elements were employed. These use cases are presented in a table in Annex A.
- Section 6 concludes this document by providing directions for future research on the discussed topics.

2 Methodology

In order to perform a thorough and in-depth review of the FC model, a collection and structured review of the relevant state-of-the-art was carried out. The review included the following research fields covered by FLIP2G in order to identify main terms, concepts and components of the FC domain that will guide the development of the FLIP2G educational approach. Such research fields include:

- FC terms and objectives;
- Flipped learning models;
- Games in FC
- Learning analytics in FC;
- Limitations;
- Existing approaches and practices of FC in educational and training settings;
- Existing approaches and practices of FC in PBL-designed educational and training settings.

We started by searching the major research databases of computer science, i.e. ACM Digital Library, IEEE Xplore, SpringerLink, ScienceDirect and Google Scholar using keywords such as flipped classroom, flipped learning, flipped learning model, flipped classroom problem based learning, game/gamification flipped classroom, flipped classroom learning analytics, learning analytics methods for flipped classroom etc. We preferred publications dated from 2011 (as according to Google Trends' search and news reference volume data the term 'flipped classroom' started becoming popular in January 2011) (Figure 1).

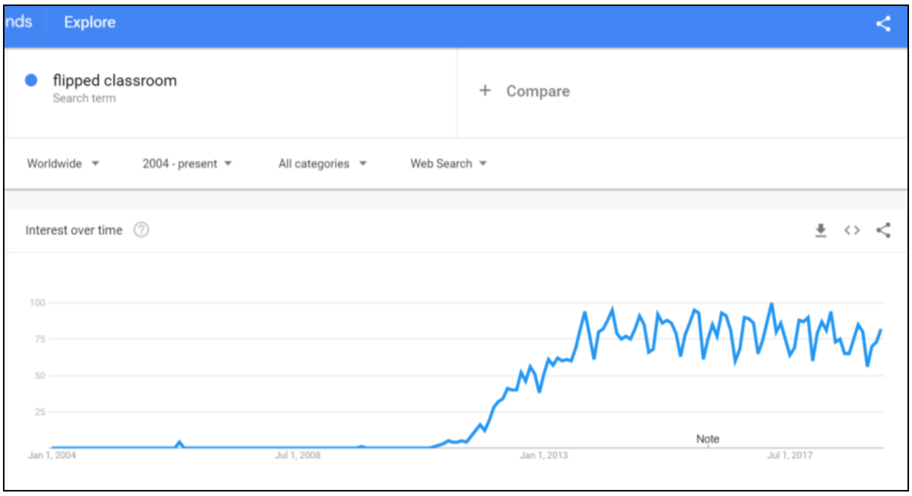

Figure 1. Google trends on the term "flipped classroom"

The references of the selected papers were checked and additional papers were found. Electronic articles written in blogs referring to FC were also reviewed, as they allowed to include empirical experiences from FC practitioners and direct testimonies from FC practitioners. Finally, initiatives coming from research institutes, universities, training organizations, companies and funded projects were also included in the survey, for similar reasons. Including non-academic sources allowed us to illustrate our overview with the widest range of testimonies and empirical experiences.

This resulted in a collection of more than 150 publications that included (a) conference, workshop and symposium papers, (b) journal articles, (c) electronic articles and (d) technical reports and educational guides. Around 100 publications were finally selected as the most relevant. Furthermore, a total of 35 sites were selected, which discuss initiatives on the FC from researching organizations/institutes, research communities, standardization bodies, consortia, and funded projects.

3 The Flipped Classroom Instruction Model

3.1 Definition

The flipped classroom (FC) is a teaching method, which has seen a surge in popularity due to the increased access to digital learning materials. Many different definitions have been given for FC. Lage, Platt, and Treglia (2000) defined FC as a teaching method where "events that have traditionally taken place inside the classroom now take place outside and vice versa". This is a broad description of FC, though implies that FC is simply a re-ordering of a traditional class model. This definition omits some key features of FC, which was addressed by Bishop and Verleger when they defined FC as "an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom" (Bishop & Verleger, 2013). Abeysekera and Dawson provide a "lowest common denominator" definition; they define FC as "a set of pedagogical approaches that (1) move most information-transmission teaching out of class, (2) use class time for learning activities that are active and social and (3) require students to complete pre- and/or post-class activities to fully benefit from in-class work." (Abeysekera & Dawson, 2015). While they claim FC is often characterized by "use of technology, especially video" (Abeysekera & Dawson, 2015), this definition makes no assumptions about technologies used for FC, if any at all. While most discussion of FC, particularly in this paper, is focused on its use of technology, it is worth acknowledging that technology is a useful tool for enabling FC as opposed to a requirement for FC to be implemented. As such, this paper will proceed with the definition provided by Abeysekera and Dawson, as it retains the broad applicability of Lage et al.'s definition, while still acknowledging key components of FC, as in Bishop and Verleger's definition.

3.2 Pedagogical foundation

As an educational model FC's foundation lie in active learning (AL), as it "shifts the focus of learning from passively receiving content information to diligently participating in learning activities" (Frey, 2018). AL helps student develop and nurture important skills such as "critical thinking, creativity, communication, and collaboration" and "promotes social interactions, allowing students to work collaboratively with their peers and teachers" (Frey, 2018).

In addition to aiding students to progress and learn, AL can help teachers too. Bonwell notes that he often felt discouraged by students' performances when using traditional teaching methods. However, with the use of AL methods, every class became an opportunity to assess whether the students had successfully comprehending the material, and whether he had been effective in transmitting the materials for the class (Bonwell, 1999). Furthermore, Bonwell suggests that perhaps the most important reason to use AL is that when "done well, [it] improves student motivation" (Bonwell, 1999), which can be one of the great challenges that teachers of any discipline face.

In their critical analysis of FC, Abeysekera and Dawson (2015) used self-determination theory (SDT) to examine FC in terms of student motivation (Figure 2). SDT is concerned with the psychological needs behind motivation and the social conditions that foster these processes (Ryan & Deci, 2000). SDT identifies two distinct types of motivation: *intrinsic* and *extrinsic*. Intrinsic motivation is the “manifestation of the human tendency toward learning and creativity” (Ryan & Deci, 2000). It is an inherent motivation, which exists without the need for rewards. SDT is less concerned about the causes of intrinsic motivation, but rather the “conditions which elicit and sustain, versus subdue and diminish” this type of motivation (Ryan & Deci, 2000). Extrinsic motivation on the other hand is a socially generated motivation, often occurring due to social expectations, or possible rewards for certain actions or behaviour. SDT argues that extrinsic motivation can be variably autonomous, as the reward can be something of self-determined value, or it could be something completely external. For example, some students may complete an assignment because they will improve their understanding of the subject and increase their chances of finding employment in the future. Other students may complete the same assignment because they were instructed to do so by their teacher. In both cases, the motivation was extrinsic, but the level of autonomy behind the motivation is different (Abeysekera & Dawson, 2015; Bonwell, 1999). In the first scenario, the student’s motivation, although extrinsic, is *self-determined,* and highly autonomous. SDT is particularly interested in extrinsic motivation with higher levels of autonomy, which has been “internalized and integrated” (Bonwell, 1999).

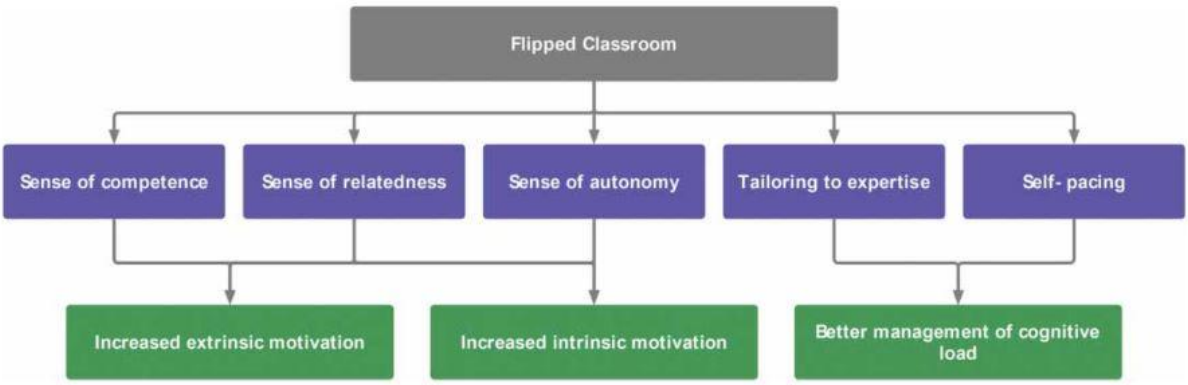

Figure 2. Theoretical framework on the potential of flipped classrooms to cater for motivation and cognitive load (Abeysekera & Dawson, 2015)

Abeysekera and Dawson propose that due to the active participation of students, “[learning] environments created by the FC approach are likely to satisfy student needs for competence, autonomy and relatedness and, thus, entice greater levels of intrinsic motivation” (Abeysekera & Dawson, 2015). However, they acknowledge that FC cannot create intrinsic motivation, but rather can nurture it where it is present. As students advance through higher levels of education, their levels of intrinsic motivation is often reduced, and they are often driven by extrinsic motivation "due to increasing social demands from their personal and work lives" (Abeysekera & Dawson, 2015; Leach & Zepke, 2011; Sheard, Carbone, & Hurst, 2010).

As with intrinsic motivation, extrinsic motivation requires autonomy, competence, and relatedness. The active participation required for FC is likely to satisfy the need for autonomy, and even in the absence of intrinsic motivation help internalize the rewards, thereby increasing the autonomy of the extrinsic motivation. FC also allows students to feel greater levels of competence through their participation and creation of knowledge, compared to their role as a passive recipient in a traditional classroom. Furthermore, the increased interaction between students and between students and instructor helps create an experience of increased relatedness. As such, Abeysekera and Dawson propose that FC is likely to "satisfy students' needs for [autonomy, competence, and relatedness] and, thus, entice greater levels of extrinsic motivation" (Abeysekera & Dawson, 2015).

Analysing FC with SDT shows how it could, from a theoretical standpoint, help increase and maintain student motivation. While motivation is of great importance, it is not the only factor to consider. Quoting Fulton (Fulton, 2012) and through findings of a survey of over 15,000 members of the National Centre for Case Study Teaching, Herreid and Schiller compiled the following list of advantages of FC over a traditional classroom structure (Fulton, 2012; Herreid & Schiller, 2013; Triantafyllou & Timcenko, 2014):

(1) Students can learn at their own pace

(2) Doing assignments in class gives teachers better insight into student difficulties

(3) Teachers can more easily customize and update the curriculum

(4) Classroom time can be used more effectively and creatively

(5) Teachers using the method report seeing increased levels of student achievement, interest, and engagement

(6) Learning theory supports the new approaches

(7) The use of technology is flexible and appropriate for "21st century learning"

(8) There is more time to spend with students on authentic research

(9) Students get more time working with scientific equipment that is only available in the classroom

(10) Students who are absent can still watch the lectures

(11) The method "promotes thinking inside and outside of the classroom"

(12) Students are more actively involved in the learning process

These reports show how FC can benefit both students and teachers in many ways, beyond simply increasing motivation. In addition to these survey responses, Herreid and Schiller note that studies support the anecdotal evidence from teachers of the effectiveness of FC, showing both a quantitative increase in grades, and an increase in student engagement and satisfaction with FC (Strayer, 2012; Zappe, Leicht, Messner, Litzginer, & Lee, 2009).

Herreid and Schiller also note some potential issues with FC. Firstly, students may be resistant to the new method, “because it requires that they do work at home rather than be first exposed to the subject matter in school” (Herreid & Schiller, 2013). As a result, students may come unprepared for the in-class portion of FC, and the effectiveness of FC will suffer as a result. Secondly, even when students do participate in the out of class preparation, the quality of that preparation is heavily dependent on the materials they are provided with. It can be difficult for teachers to create or find high quality videos, which meet the specific needs of their students and curriculum. Furthermore, creating these videos has a significant up-front time investment, which can be a large hurdle to overcome when introducing FC (Herreid & Schiller, 2013).

3.2.1 Problem-based learning and the flipped classroom

Within the range of broader in-class activities made possible by the FC, problem-solving activities come into focus in several case studies. Abeysekera and Dawson underline the fact that FC allows students to engage in a range of problem-solving activities using the knowledge they acquired in the pre-class process, and that these problem-solving activities can be carried in small groups, allowing for collaborative learning and the creation of communities of peer learners (Abeysekera & Dawson, 2015). Similarly, Song, Jong, Chang and Chen (2017) present the FC as a means to exploit the classroom time for appropriately designed interactive learning activities such as collaborative and problem-based learning activities.

Problem-based learning and student-centered design is grounded within the theoretical framework of socio-constructivist theory. Savery and Duffy (1995) define three fundamentals to constructivist theory: the notion that learning arises from interactions of the learners with their environment, that learning develops through cognitive conflicts which determine the organization and nature of the learning process and, finally, that learning evolves through social interactions and the evaluation, through collaborative work, of the viability of individual understanding.

Socio-constructivist theory is based on the same notion that learning occurs through the interactions of the learner with their environment, but with greater emphasis on the social and cultural frame where it appears. For example, educational researcher and pioneer Knud Illeris established in 1974 the key concepts of ‘problem formulation’ and ‘participant-directed learning’, tying them directly to Piaget’s theory that learning occurs through the interactions of the individual with his environment, and Dewey’s principle that learning processes should be based on the learners’ experience (Andersen & Kjeldsen, 2015). Vygotsky’s zone of proximal development (ZPD) theory is also essential to understand the interactions between learner, project and environment as part of the learning process (Harland, 2003). Freinet’s development of the natural method of education through the trial and error experimental procedure play a major part in the constitution of the socio-constructivist framework (Freinet, 1968) and supports the relevance of problem-solving activities in the FC method. Merrill, in his “first principles for education” also offers a problem-centered approach to education in application of socio-constructivist theory (Merrill, 2002). Figure 3 presents the theoretical framework of Merrill’s principles which is comprised of five principles as follows:

(1) Learning is promoted when learners are engaged in solving real-world problems
(2) Learning is promoted when existing knowledge is activated as a foundation for new knowledge.
(3) Learning is promoted when new knowledge is demonstrated by the learner
(4) Learning is promoted when new knowledge is applied by the learner
(5) Learning is promoted when new knowledge is integrated into the learner’s world.

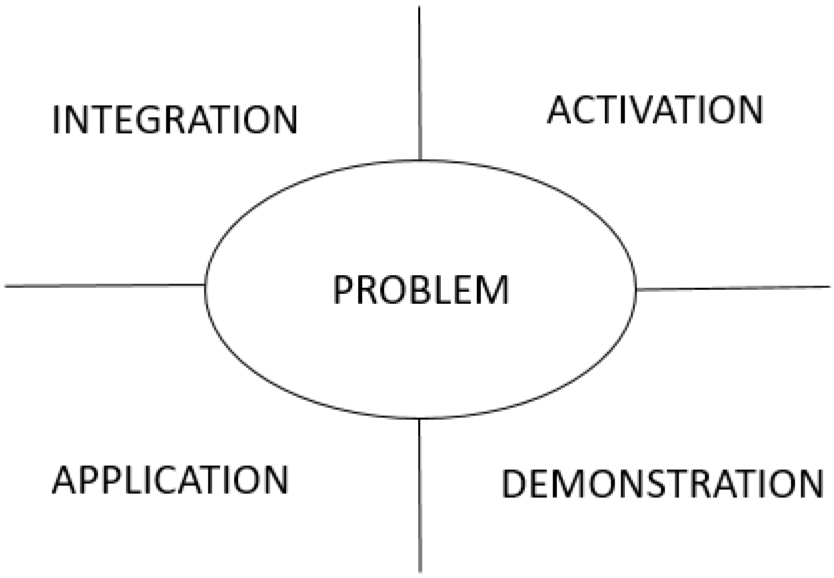

Figure 3: Merrill's model and phases for effective instruction (Marrill, 2012)

Problem-based learning has also been conceptualized as an essential form of student-centered learning. Adderley et al. (1975) laid out foundations to describe problem-based learning that decades in, still are relevant. Problem-based learning is therefore a method of learning based on the resolution of a set problem resulting in a final production, focused on group work and student initiative, where the teaching staff has an advisory rather than authoritarian role (Halle et al., 2006). Problem-based learning is thus based on a clear separation from a more traditional, ex cathedra, purely transmissive model, to be a new learning paradigm. It is also tied to Kolb’s model of experiential learning, where learning is a continuous process grounded in experience (Kolb, 2014). Figure 4 presents the pattern for Kolb’s model for experiential learning in which the learning process stems from a recursive loop between concrete experience, experimentation, reflexive observation, and abstract conceptualization. De Graaf & Kolmos (2003) illustrated some of these qualities as relevant to the Maastricht and Aalborg model of education, with a focus on collaborative group work.

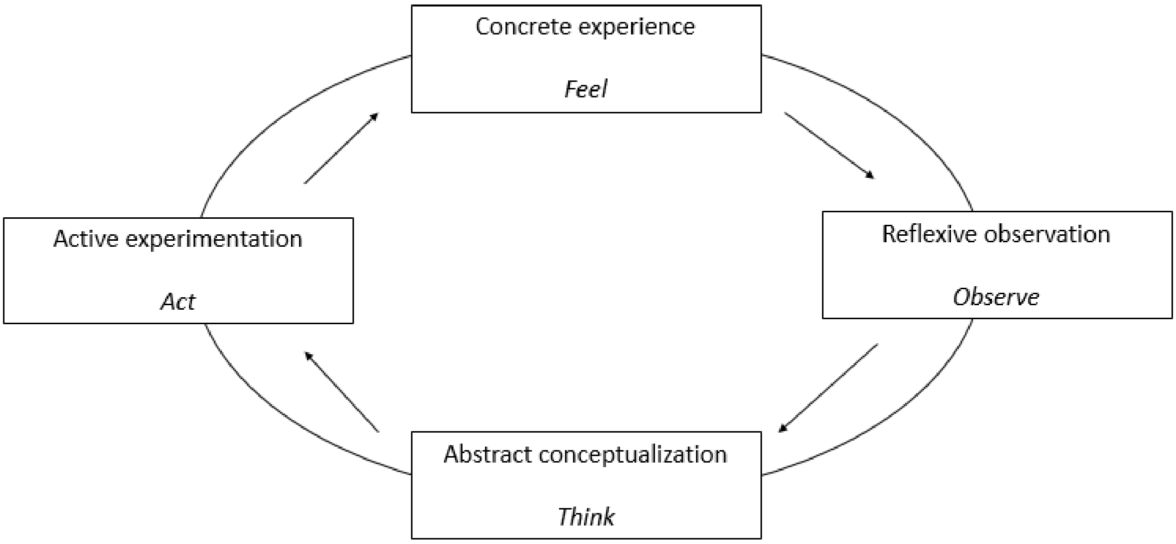

Figure 4: Kolb's model for experiential learning (Kolb, 2014)

The Problem-Based Learning (PBL) pedagogy has been applied at Aalborg University since its establishment in 1974 (Barge, 2010). Furthermore, research into blending problem-based learning and the FC has also been carried out successfully, through the evaluation of virtual learning environment (VLE), like Moodle (Triantafyllou, 2015) and the use of learning design methodology (Triantafyllou, Kofoed, Purwins, & Timcenko, 2016) to further educators' self-reflection in design and transmission of best practices. Research in problem-based learning at Aalborg University has also integrated the latest development in game-based learning through the use of game design and production as a core for the experiential learning experience (Schoenau-Fog, 2015).

Other case studies in the FC allow to observe successful blending of the FC methodology and problem-based learning. Çakiroglu and Özturk carried problem-based learning activities in FCs to promote self-regulation in learners. They gathered qualitative data from 30 undergraduate students in mechanical engineering class, through interviews with the students and teachers. They conclude that, in face to face (F2F) settings, goal setting and planning, task strategies and help seeking self-regulation skills were considerably high among the students, and that time-management, self-efficacy and self-evaluation were medium. In home sessions, goal planning and setting an environment structuring skill were high while time management and self-efficacy were medium and monitoring level was low (Çakiroglu & Öztürk, 2017).

Lo and Hew exploited Merril's model for effective instruction as a theoretical framework to design a secondary class mathematics flipped-classroom, and evaluated using a self-reported satisfaction survey before and after the implementation of the class and academic results of the students. Their results suggest that the use of Merril's First Principles of Instruction design theory to design the FC was effective in enhancing underperforming and high ability students' mathematical achievement. Students' self-reported feedback also suggests that they benefited from the FC approach (Lo & Hew, 2017).

Clark (2015) similarly used the FC methodology in secondary school to engage students in Mathematics in problem-solving activities. Observations made during the face-to-face classroom time suggest that students engage in problem solving activities on their own, without the teacher's assistance. Students expressed satisfaction in working with peers in collaborative problem learning and in sharing solutions. Clark concluded that students were more engaged in the FC than in the traditional delivery approach.

Research that tried blending the FC approach with other theoretical models already exists. Student-centered learning in constructivist theory provides a foundational theoretical background in this regard. Problem-based learning and problem-solving activities appeared evidently as a framework to develop meaningful in-class activities. These previous case studies offer a good insight in the development of the FC by incorporating other tried educational approaches.

3.3 The four pillars of F-L-I-P

According to the Flipped Classroom Network (FLN), there are four key features in flipped learning (FLN, 2014; Bergman & Sams, 2012):

(1) **F**lexible environment: A FC is flexible in several ways. Since classroom time is devoted on activities, the physical space should be flexible; educators should arrange the physical space and materials according to the type of activity. Furthermore, educators who flip their classes should be flexible in their expectations of student timelines for learning (when and how learning takes place), and in their assessments of student learning.

(2) **L**earning culture: A flipped learning environment is student-centered. A shift in learning culture and expectations is thus necessary for both the instructor and students. The instructor must deliberately construct meaningful knowledge construction activities that allow students to explore topics in greater depth and create rich learning opportunities. Students have greater responsibility in the learning process, and they are actively involved in knowledge construction as they participate in and evaluate their learning in a manner that is personally meaningful.

(3) **I**ntentional content: An instructor in a FC should consider how to use the flipped learning model to help students develop conceptual understanding and procedural fluency. To this end, some material needs to be directly taught, while other material can be introduced and learned through student exploration. Educators use intentional content to maximize class time in order to adopt methods of active learning strategies.

(4) **P**rofessional educator: Professional educators may be less visible in a FC than a traditional one, but they are more critical in this environment. They continually observe their students, providing them with feedback relevant in the moment and assessing their work. They are also are reflective in their practice, connect with each other to improve their instruction, accept constructive criticism, and tolerate controlled chaos in their classrooms.

These four pillars summarize the pedagogical and implementation features, which shall be employed when designing FCs.

3.4 Models for flipped learning

Regarding the learning in FCs, various representation models have been proposed andeach is based on different approaches to or aspects of learning. Some of them take as departure point Bloom's taxonomy and adjust it in order to compare the learning objectives in the traditional model in comparison to the learning objectives in the flipped model. Such models aim to highlight the fact that traditional models of instruction focus on the presentation of material during class-time (lower levels in Bloom's taxonomy), leaving students with little support for practice and reflection (higher levels in Bloom's taxonomy), while the flipped model simply refocuses course time and resources, as shown in Figure 5 (Nechodomu et al., 2016). In a FC, students are presented with material outside the classroom, and then collaborate with each other both outside and within the classroom, where they have support to perform higher cognitive tasks, as they discover, practice, apply, and reflect.

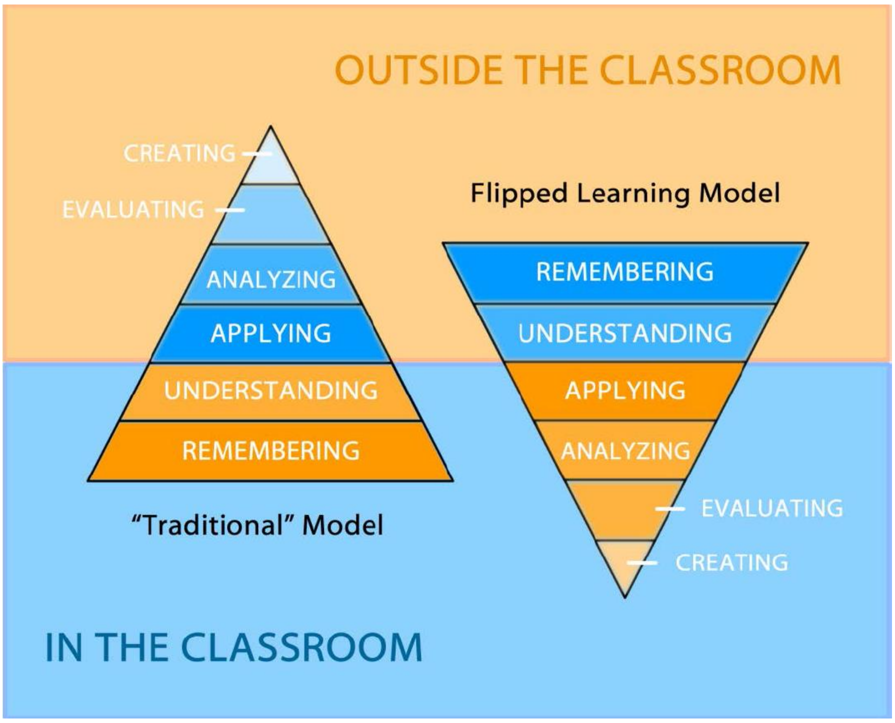

Figure 5. A flipped learning model employing Bloom's taxonomy (Nechodomu et al., 2016)

Nederveld and Berge (2015) have adapted Gerstein's Flipped Classroom Model (Gerstein, 2011) to Gilbert's suggestions (Gilbert, 2013) and produced the model shown in Figure 6. Gerstein (2011) has proposed a Flipped Classroom Model that is based on the Experiential Learning Cycle (Kolb, 2014), and Huitt's Cycle of Instruction (Huitt, 2009). It also corresponds well to Bloom's Taxonomy. There are four components/stages to this model. Gerstein (2011) suggests that the process starts with experiential engagement (upper right corner), which gets learners interested in the subject. Gilbert begins the process with concept exploration (lower right corner).

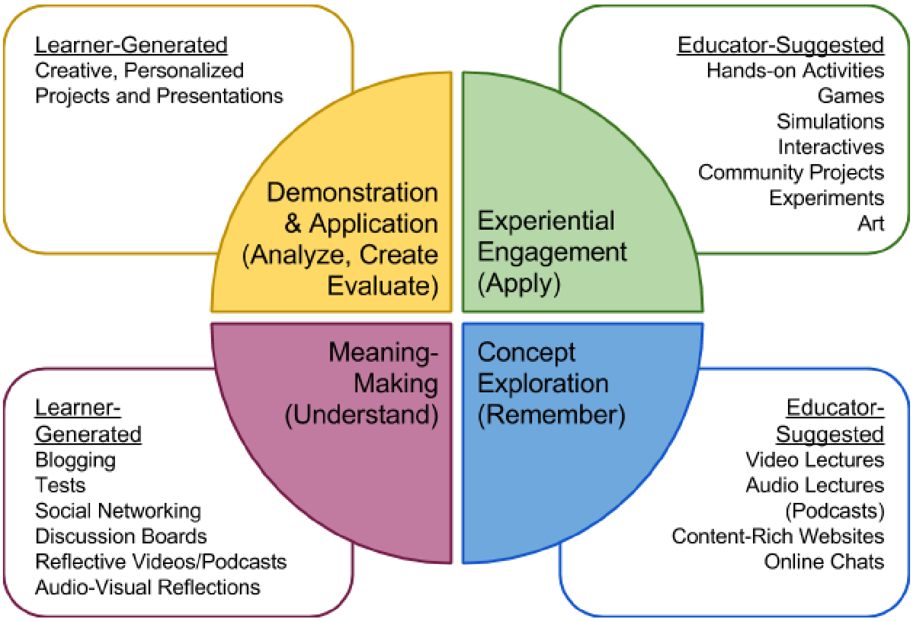

Figure 6. The Flipped Classroom Model as presented in (Nederveld & Berge, 2015)

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 (e.g. lectures). In a flipped learning environment, educators assign preparation material for students to study outside the classroom and allow them more control on when and where the preparation takes place. Learners then read, watch, and/or explore this material at their own pace and level. Educators may also allow learners to find and share resources (Gerstein, 2011; Gilbert, 2013). This phase does not need to be technology heavy. Media-rich technologies such as videos and podcasts are not essential for flipped learning. Students can also use printed material or any other low-tech resources to explore a topic. Looking back at Bloom's Taxonomy, these activities support remembering.

The "meaning-making" stage is also situated outside the classroom. After concept exploration, students make meaning out of the information they have been exposed to. There are more various activities to encourage meaning-making among learners. Some of them value peer-to-peer learning (e.g. discussion forum, social networking group, etc.), while others aim at ensuring that the students come to class prepared (e.g. quiz, comprehension check, etc.). In addition, reflection activities for students may be employed, such as posting on blogs, production of short videos or podcasts etc.

The “experiential engagement” stage occurs when the learner and instructor interact in a FC. It may 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 gauge student understanding, support correct application, assist students that are having difficulties and provide additional challenges to more advanced students.

The “demonstration and application” stage is the last of the Flipped Classroom Model. During this stage, students analyze, evaluate and create, while educators can evaluate for mastery and offer additional support where needed. Products of this stage may be personalized projects or presentations that occur in or outside of the classroom, but they should always be communicated to the educators and peers.

Blau and Shamir-Inbal (2017) have proposed a model, which offers a re-designed perspective on flipped learning in higher education based on the components of the traditional flipped model. This model addresses the role of different participators and components of the flipped learning, (i.e. instructors, students, technology use, and assessment process), and their manifestation in homework and in-class activities (Figure 7). This model merges the traditional FC model presented in the research literature (highlighted in gray rectangles) and the additional components of flipped learning revealed in a study conducted by Blau and Shamir-Inbal (2017) on students perceptions on the course components and learning processes (depicted as white rectangles in Fig. 7). Similarly to previous studies, the components of the model are analyzed separately for in- and out-of-classroom learning.

The traditional components of students' out-of-class learning include self-regulated learning, knowledge acquisition, learning on flexible time and place, etc. All these elements have been found to be relevant for FCs in the literature and in the study at hand. The components of traditional in-class learning activities reported both in the literature and by participants in this study include active and collaborative learning, inquiry and problem solving, knowledge scaffolding, and instructor facilitation.

The white rectangles in “at-home” part of the model present components that were revealed in the study by Blau and Shamir-Inbal and expand the traditional use of FC. Consistent with previous research, self-regulated learning was also manifested by Blau and Shamir-Inbal in the ability of students to monitor learning episodes, determine which strategies to use, assess whether the chosen strategies were effective in meeting learning goals or required adjusting, and evaluate their emerging understanding of the learning topics. In addition to self-regulation, their findings showed two types of group regulation: co-regulation, in which each student supports other team members in regulating their learning, and shared regulation, i.e. collective regulation of team learning. Ongoing evaluation, metacognitive thinking, monitoring learning strategies, and reflection on peers' learning and team learning were significant parts of the course assignments and activities. Furthermore, this study revealed that rich and active learning activities take also place out-of-class and also that the instructor may act as facilitator beyond class time.

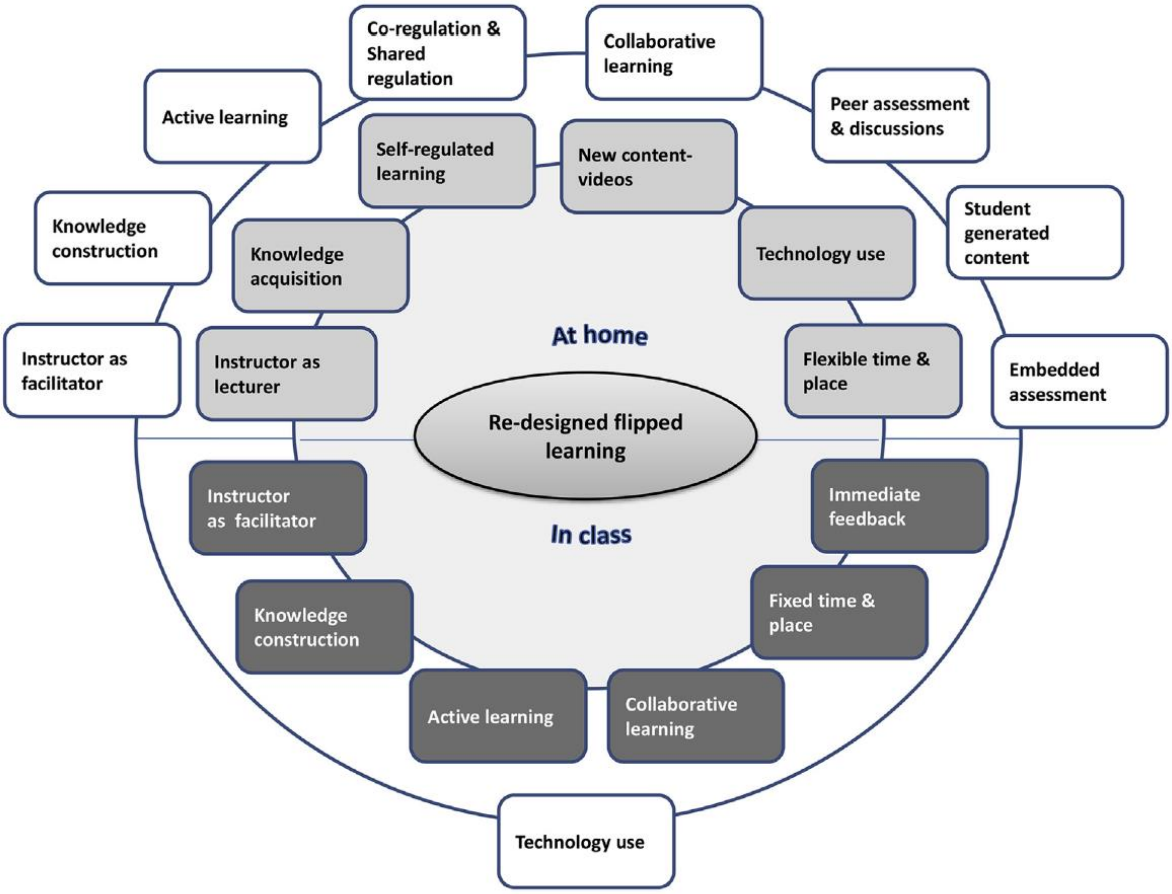

Figure 7. The re-designed model of flipped learning for higher education (Blau & Shamir-Inbal, 2017)

As for technology, the traditional model mostly uses technology for out-of-class sessions, in order to transmit information to students, while in the classroom it applies a constructivist pedagogy without using technology. In the re-designed model, the inclusion of technology at the bottom part for the in-class activities highlights the important role that digital tools played for such activities in this study. In other flipped learning models, technology is used in out-of-class learning to promote remembering and understanding according to Bloom’s taxonomy. In contrast, with in-class learning activities teachers are able to focus on the applying, analyzing, evaluating, or even creating levels, depending on the learning objective. However, in this study technology was used for supporting learning on all levels of Bloom's taxonomy. Students used one-to-one technology in both face-to-face lessons and synchronous videoconference sessions. The technology supported offline and online discussions; shared documents, spreadsheets, and presentation apps enabled technology-enhanced collaborative learning activities in- and out-of-class.

Finally, the re-designed model places a special emphasis on technology-enhanced embedded assessment, which combines individual reflection with peer feedback, collaboration, and co-creation of course content and learning outcomes by students in order to develop regulation strategies in both individual learning (i.e. self-regulation) and teamwork (i.e., co-regulation and shared regulation).

3.5 Use cases of the flipped classroom

In a 2018 meta-analysis of the effectiveness of FC across 55 studies, Cheng et al. (2018) found that there was a significant effect on cognitive learning outcomes, though the effect sizes "were significantly moderated by subject area". The meta-analysis showed that Arts and Humanities had the largest effect sizes, while all other subjects had a small but positive effect, except for engineering subjects, which had a negative effect size. Four of the subjects, including engineering were not found to be statistically significant. This suggests that FC has a positive effect on the cognitive learning outcomes of students in subjects such as Science, Social Sciences, Mathematics, and particularly Arts and Humanities while other subjects such as Health, Business and Engineering may not have the same impact.

This analysis of subjects as a mediating factor in FC is important, though limited in some ways. Firstly, the number of studies concerning each subject varied widely, with some subjects like Arts & Humanities, Engineering, and Business being represented by only a few studies (5, 5 and 3 studies, respectively), and others such as Science and Mathematics being examined by a larger number of studies (9 and 15 studies, respectively). The low number of Secondly, since the evaluation methods of each of these studies was different, much of the data could not be used in the meta-analysis. As such, this study only compared the cognitive effects of FC (i.e. test results) and overlooked data on the affective (i.e. student satisfaction, motivation, difficulties encountered etc.) and behavioural (i.e. retention) (Cheng et al., 2018). Furthermore, this meta-analysis lacks an overview of the specific approaches and methods used in the various studies. As such, this section will proceed to look at some cases of FC being implemented in both science, technology, engineering & maths (STEM), and in Arts & Humanities.

3.5.1 The flipped classroom in STEM

There are numerous examples of FC being used in STEM subjects. Kay and Kletskin (2012), for example, used problem-based podcasts in a pre-calculus course. Most students reportedly made frequent use of the podcasts, rated the teaching method highly, and reported significant knowledge gains in the subject area. Love, Hodge, Grandgenett, and Swift performed a comparison between a traditional classroom and FC for a linear algebra course at the University of Nebraska, Omaha.

Though the final exams yielded similar results for both classes, students from the FC showed a significant increase in results on sequential exams. Furthermore, students from the FC were very positive in reports of their experiences with FC and felt that the methods used helped both their attention and retention of information (Love, Hodge, Grandgenett, & Swift, 2014).

Bates and Galloway (2012) used FC for a large-enrolment introductory physics course at the University of Edinburgh. Students were given weekly reading assignments, accompanied by a quiz delivered through a Virtual Learning Environment (VLE). The final question in the quiz was an open-ended question where students could report what they do not understand after the reading assignment, so that the instructor may get a clearer idea of what needs to be focused on in-class. The in-class sessions were built around clicker questions, which were used to generate discussion among students. The use of FC in this course resulted in a pass rate of 89% and a high average grade.

The study showed a consistently high level of student engagement, indicated by the number of clicker responses during the in-class section. Once more, the students were very positive in their feedback on the class structure – there was a high level of overall satisfaction with the course, and students indicated a high level of preference towards FC over a traditional classroom at the end of the course (Bates & Galloway, 2012).

Enfield (2013) used FC in an undergraduate web design course, where students were asked to watch instructional videos prior to class, respond to a quiz, and then engage in discussions with other students and practice what they learned. Students once more responded favourably to this method, reporting that not only did it help them learn the content, but that also it helped them grow their ability to learn independently.

Triantafyllou and Timcenko (2014) implemented and evaluated FC in a statistics course at Aalborg University. The students took this class as part of a media technology course, and as such most had a poor mathematical foundation – less than 10% of students passed the pre-course evaluation, with an average score of 39.9%. The pre-class section of this FC used instructor-made video casts in combination with reading assignments and other online videos. In class, students took part in question round to clarify what they found challenging, followed by in-class assignments designed to reflect on, discuss, and practice what they learned. These assignments were mostly led by groups of students, rather than being led by the instructors. Once the FC section of the course concluded, students were given a post-test similar to the pre-test they initially took. This time, 62% of the students passed with an average score of 66.25% (Triantafyllou & Timcenko, 2014).

3.5.2 The flipped classroom in non-STEM subjects

In addition to the STEM subjects mentioned above, FC has also seen numerous implementations in the humanities, social sciences and business courses. Grossman et al. (2015) used FC in a VLE as part of a narrative-focused module to develop and encourage empathy in medical students. This consisted on video lectures from expects in different topics, along with discussions and exercises. Students evaluated this method with high levels of approval, and instructors found that "[the use of a VLE] promotes the sharing of ideas, teamwork and collective construction of knowledge [and thus] is an effective teaching strategy” (Grossman et al., 2015).

Kong (2014) found that FC had a positive effect on the development of information literacy and critical thinking skills on 107 secondary level students. This FC model used an e-learning platform, which supported three stages of FC, pre-class, in-class, and post-class, allowing the viewing of learning goals, and sharing of documents and workspaces. In addition, there was a discussion forum for students to allow group communication and discussion.

In a longer study, Kong (2015) also analysed the development of critical thinking skills over a three-year period, using FC to “engage learners in online pre-lesson learning preparation, in-class group discussion inside digital classroom and after-class extended learning using social learning platform”. This study showed that overall students showed good development of critical thinking skills, though some aspects such as hypothesis identification, induction and deduction were stronger than others, such as explanation and evaluation. In both of Kong’s studies, students and instructors alike perceived FC as highly effective, particularly the use of a digital classroom (Kong, 2014; Kong, 2015).

Zhonggen and Guifang (2016) used FC for a Business English Writing class for Chinese students. Students were asked to “learn and internalize” writing skills before class, while they could use online communication tools to communicate with their peers and instructors if any difficulty arose. They were also provided with lecture videos and notes for the pre-class segment of FC. The in-class segment was aided with a clicker, where students would answer questions through anonymous polling, which would then lead to in-class discussions and group exercises. The clicker system allowed instructors to quickly and easily see how many students were responding to questions correctly. If a high percentage was correct, then they could move on. If a low percentage was correct the instructor would cover the topic in more detail, while if it was split, then that would be a good opportunity to split into groups and discuss, followed by a new poll. This process would repeat until a high enough percentage of students were answering correctly on the polls (Zhonggen & Guifang, 2016).

Desai et al. (2018) used films as part of their implementation of FC in a Cross-Cultural Management course. . Students were provided with films relating to various cultures for viewing and analysing as a group as part of the pre-class section of FC. In-class the student presented and discussed the films and the cultures they represented. Student evaluations of the course were positive, with many students expressing that the use of in-class time gave them a chance to reflect and develop new ideas that would not have been possible in a traditional classroom.

Jong (2017) introduced FC to a Liberal Studies course, which traditionally uses the pedagogical approach of guided social inquiry learning. This method focuses on giving students a platform for reflection and open-ended discussion and argumentation about societal issues, using specific tasks to guide them in this discussion and reflection. Jong merged that pedagogic framework with FC for a proposed flipped social enquiry learning. A VLE was used to provide video and other materials for the out-of-class information transmission of this FC. In-class time was used for students to analyse texts and construct arguments, while the instructor would observe, and intervene when necessary. This study took place across three schools of differing academic bands, i.e. the students from school A had a high level of academic achievement, students from school C had a low level, and school B was in between. The results showed that FC had a "desirable pedagogic effect" on students in schools B and C, but not A, perhaps because the high-achieving students at school A were past a ceiling where FC would have an impact. However, qualitative data from all schools showed that the FC provided a more "advantageous learning experience both inside and outside the classroom" than the traditional model.

3.5.3 The flipped classroom in training

Nederveld and Berge (2015) conducted a literature review on the use of flipped learning in workplaces. They reported that flipped learning can be used for training professionals in the following cases:

- New hire onboarding. The flipped learning approach can be applied for new hire onboarding classes, where class participants are given access to printed material (manuals, technical documents, guidelines, etc.), and/or to training application with exercises to complete. Then, a face-to-face session can be conducted to emphasize key points, assess understanding and allow for questions. In this case, flipped learning can decrease training time and possibly retention.
- Product training. When employees need to be trained in new tools, the flipped model can be applied in order to give employees a chance to familiarize with the new product before the face-to-face training. Moreover, employees may be provided with reading material or instructional videos. During the face-to-face sessions, employees are better prepared to ask questions tailored to their needs and take therefore better advantage of the training session.
- Skills training. The flipped model can be also applied for skills training (e.g. sales training). In this case, employees are provided with instructional videos, answer questions and may also participate in online discussions. This leaves more time during the face-to-face session for practicing the skills at hand.
- Flipped webinar. The flipped webinar is more social in nature than a typical webinar. Instead of the traditional structure of an online presentation with a few minutes for questions by participants at the end, the flipped webinar provides participants with material to study beforehand, encourages them to explore the topic further if desired and leave feedback online. This feedback can be used to adjust the webinar content to the needs/questions of the participants.
- Conferences. Another application of the flipped model that is related to the corporate world is the flipped model for conferences. Flipped conferences or flipped sessions at conferences

ask the presenters to create short videos explaining what the session will cover. Then the actual session can be used for clarifications, discussions, and reflections becoming that way more interactive.

3.6 Types of activities in the flipped classroom

In FCs, different types of activities may take place depending on the session type (out-of-class or in-class), the learning objectives to fulfil, the type and size of the learners, the available infrastructure, the time available etc. Based on the literature review conducted for this deliverable, we attempt here to mention the type of activities employed in FCs. In order to categorize activities, we use a simplified FC model, which distinguishes activities based on chronological order (what occurs first, what then, etc.), and the session where the activity takes place (in-class or out-of-classroom) (Figure 8).

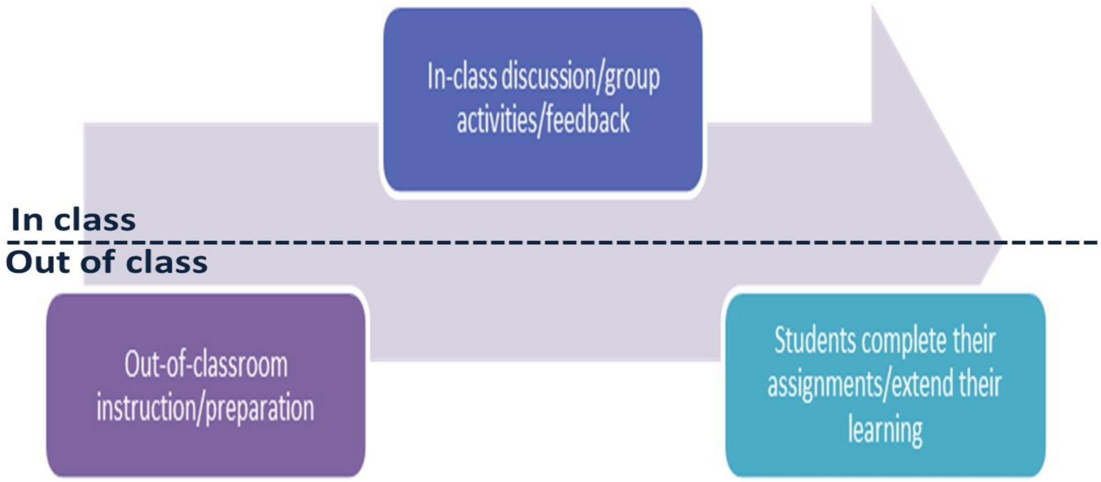

Figure 8: A simplified FC model for describing activities in FCs

While Cheng et al. (2018) saw that the effect size of the cognitive learning outcome on students was significantly moderated by subject area, based on the cases mentioned above, there seems to be little variability in the activities used.

3.6.1 Out-of-class

Almost all the cases presented in sections 3.5.1 and 3.5.2 used videos for the pre-class materials, often supplemented with additional reading materials (printed and/or online). These videos were often instructor-made, meaning that they can be tailored to the specific requirements of the course. Furthermore, despite a heavy initial time investment, these materials can be reused for the same curriculum. Videos were replaced or supplemented by podcasts, screencasts, or pencasts, while in some cases the instructors did not employ such media at all.

Quizzes or diagnostic tests were often used to motivate and assess the quality of the student's pre-class preparation and learning. This was sometimes done as part of the pre-class section through a VLE, and sometimes done at the beginning of the in-class section. This was a common approach for most cases, and these exercises gave the instructor a clear idea of what areas needed to be discussed in-class. In some cases, students were asked to provide feedback on the out-of-class session (e.g. what was the most challenging part, what was the easiest, etc.) either individually (e.g. by using feedback forms) or collectively (e.g. using a discussion forum, online chat, blog, etc.).

In some FC implementations, out-of-class activities included the so-called synchronous sessions. These are sessions were the learners can interact with the instructors and/or their peers. Such activities were used to alleviate the issue of learners lacking just-in-time explanations.

Out-of-class activities may also occur after classes. In such after-class sessions, the instructors required students to carry out supplementary activities. Post-class activities were either a continuation of what was done during class time (e.g. finalize in-class activities) or additional activities. In the latter case, activities were used in order for students to check their understanding and/or reflect over their own practice.

3.6.2 In-class

The in-class time was mostly student-led. Firstly, the choice of topic, while ultimately determined by the instructor, was chosen based on the student's apparent learning needs, as evaluated from either pre-class materials, or question sessions at the start of the in-class session. Activities and discussions in this topic were then often led by students while observed and moderated by the instructor. This same approach seemed to be present regardless of subject area. Even the nature of the activities changes very little among subjects. The exact content is of course different, but the in-class materials seem to focus on reflection, discussion, and argumentation, regardless of subject.

A key feature between in-class activities is group activities or activities that promote collaborative learning. The literature review has also shown that an important consideration for instructors was how to handle students who came to class unprepared. Ill-prepared students cannot participate meaningfully in class practice, and this can be very frustrating for their peers, especially when learning activities are carried out in groups. The solution to this problem depended heavily on the educational level where the flipped instruction model was applied, since there are different expectations depending on student age. Possible solutions included assigning different activities to ill-prepared students or requiring them to carry out the out-of-class preparation in class.

3.7 Technology Tools for Flipped Classrooms

In order to support the activities taking place in FCs, various technology tools have been employed by instructors. In the following table, we provide a list of such tools for supporting different types of activities in FCs. The list is a synthesis of the lists presented by Nederveld and Berge (2015) and Nechodomu et al.(2016).

Table 1. Technology tools to support FCs

Activity	Tool
Create a video lecture	Screenr, Screencast.com, Camtasia, Screen-o-matic (screencasting programs) Explain Everything, Screenchomp, ShowMe, Educreations (screencasting tablet apps) Powtoons (animated video creation) VoiceThread (interactive multimedia presentation)
Create an audio lecture	Audacity
Create an interactive video with knowledge checks	Articulate Studio or Storyline, Adobe Captivate or Presenter. Camtasia, Lectora
Create a pencast	Doceri, Livescribe, Camtasia
Create a presentation	Animoto, Google Slides, Keynote, Prezi Haiku Deck (table app)
Upload a video, audio lecture, podcast or other resources (books, articles, job aids)	YouTube, Vimeo (non-interactive video) iTunes (audio) Box, Dropbox, Google Drive LMS such as Moodle, Blackboard, etc.
Collect, curate and share a list of resources	Diigo, Padlet, Evernote
Create lessons with pre-made videos	TED-Ed, Khan Academy
Quiz or poll learners	Poll Everywhere, Google Forms, Survey Monkey Socrative, InfuseLearning, GoSoapBox (tablet apps) LMS such as Moodle, Blackboard, etc.
Encourage collaboration, communication or discussion; provide ongoing support	PBWorks, Wikispaces (wikis) Twitter, Facebook Celly, Podio
Collect student reflections	FlipGrid

	Padlet PBWorks, Wikispaces (wikis) WordPress, Blogger (blogs)
Integrate activities in a VLE	Moodle, Blackboard, ALEKS

The above list is of course not exhaustive and mentions the tools that have been often employed in FC implementations.

4 Educational data generation and learning analytics in the FC

The FLIP2G project aims at developing a pedagogical approach that will combine the FC model, serious games, and PBL, and will accommodate learning analytics (LA) features. Therefore, we review in the following sections cases from the literature where LA were employed in FCs. We use the model shown in Figure 8, in order to define in which session of the FC model LA were employed. Since most of the FCs cases we reviewed used a VLE to support the FC activities, and the cases of LA employment are few, we present in the last section the different type of educational data produced in a VLE (Moodle) as an inspiration for the future employment of LA in FCs.

4.1 Out-of-classroom

Gilliland (2017) used the pre-class section of FC for learning analytics (LA) in the Histology section of the organ-system curriculum at the University of Northern Carolina, School of Medicine. The Echo360 platform was used to create and distribute videos, though Gilliland does not accompany these videos with quizzes or other types of assessment. Rather, the Echo360 platform had a LA feature which "allows faculty to determine how many students are preparing for class, but more importantly […] enables the instructor to determine which segments of the module are causing difficulty for students based on how long they repeat/ replay those particular parts of the module" (Gilliland, 2017). This use of LA helped the instructor clearly see how many students had prepared for class, and with what areas they struggled and needed more support during the in-class section of FC.

Jovanovic et al. (2017) also used the pre-class section of a FC as an opportunity to collect LA. While Gilliland assessed student engagement and levels of participation, this study went further and tried to use LA to determine individual student learning strategies in their preparation. They argued that since FC is unfamiliar to most students, who are more accustomed to a traditional classroom model, it is important to "shed light on how students approach and manage [the FC environment], and how they regulate this process, [because] students often lack sufficient skills and proficiency to modify their learning strategies to better suit the specificities of newly encountered learning situations" (Jovanovic et al., 2017). Since self-reports on learning strategies can be unreliable for a multitude of reasons (Jamieson-Noel & Winne, 2002), they decided to gather and analyze trace data from the Learning Management System (LMS) used to deliver pre-class materials in the FC in order to determine student's learning strategies.

Students were provided with videos, which were followed by multiple-choice questions (MCQs) about their contents, documents with embedded MCQs, and a sequence of exercises to be completed before class. The trace data, which was collected from this, was a quadruple containing: event id, type of action (Table 2), anonymized student id, and timestamp. Furthermore, learning sessions were extracted from this data as "continuous sequences of events where any two consecutive events are within 30 min of one another" (Jovanovic et al., 2017).

Table 2. Types of Learning Actions Recorded (Jovanovic et al., 2017)

Action Code	Description
EXE_CO	a correctly solved summative assessment item (exercise)
EXE_IN	an incorrectly solved summative assessment item (exercise)
MCQ_CO	a correctly solved formative assessment item (MCQ)
MCQ_IN	an incorrectly solved formative assessment item (MCQ)
MCQ_SR	a solution requested for a formative assessment item (MCQ)
VIDEO_PLAY	activation of a course video
CONTENT_ACCESS	access to a page containing reading materials
MC_ACCESS	access to the dashboard; this is considered a metacognitive evaluation action
MC_ORIENT	access to the schedule and the learning objective pages; this is considered a metacognitive orientation action

When using trace data such as this, it is important to use "appropriate analytical methods and techniques that allow for the detection of strategies as latent constructs emerging from the observable student behaviour" (Jovanovic et al., 2017). In the case of this study, student learning sessions were encoded and sessions from students with exam scores above the 90th percentile and below the 25th percentile were examined with an exploratory sequence analysis. Clustering was then used firstly to group similar learning sequences and detect behaviour patterns, and secondly to group students based on these identified patterns and try detecting an association between these behaviours and performance.

In addition to showing levels of student engagement and preparation, methods of data collection and analysis like this can help instructors better understand how students prepare for classes. Additionally, the association between learning strategies and results (i.e., students with varied strategies generally out-performed students who focused on summative assessment) may help instructors identify students likely to underperform based on their learning strategies, as opposed to engagement. However, this data is not indicative of *why* students choose certain learning strategies. The addition of qualitative data may help build an understanding of student behaviour.

4.2 In class

The in-class section of FC has not seen as much attention for LA as the pre-class section. Since the pre-class section makes heavy use of digital tools it is often trivial to collect data for LA. In-class, however, is often student or instructor led activities and discussions and activities, which do not require use of a VLE (Blau & Shamir-Inbal, 2017). As such, it can be difficult to collect in-class data for LA. These systems could be integrated with in-class activities. For example, Bates and Galloway (2012) and Zhonggen and Guifang (2016) used clickers in class to assess student's knowledge of certain topics and guide the class and determine what areas needed focus. This use of technology could be expanded to put a heavier emphasis on the use of a VLE or other digital tools in order to gather data on student's in-class activities and engagement.

4.3 Educational data generation in Moodle

In the following section, we exemplify the educational data generation in a VLE, in order to present the potential data a LA algorithm could use for the evaluation of a FC. We use Moodle as an example because it is one of the most popular for FCs in the literature. The various components of Moodle allow for the collection and analysis of different types of data.

4.3.1 Student engagement and interaction with the VLE

Student engagement and interaction with Moodle data can be gathered and analysed using the standard functionality of Moodle (reports), and other LA-related plugins for Moodle (e.g. GISMO, Statistics, and Heatmap). This type of data is gathered as learners use the platform in order to shape an understanding of their overall engagement with the VLE.

By employing the logs for the specific Moodle page, an instructor is able to extract student action reports. Moodle distinguishes among the following actions on the various activities: create, view, update, and delete. The activity report provides the total number of views by number of users, and the date of the last access on each activity. Moreover, through the course participation reports, Moodle provides information on views and posts per activity. This information provides an overview of learner engagement with all activities.

The LA plugin GISMO can be used to better visualize and combine the data provided by the Moodle reports. GISMO is a graphical interactive monitoring tool that provides visualization of students' activities in Moodle. With GISMO, instructors can better visualize various aspects of student engagement, such as reading of materials, submission of assignments, engagement with forums etc. The added value of the GISMO graphs is that they are interactive and can be easily adjusted in time, or for individual students.

The Heatmap plugin is another tool that can be used for LA purposes. This tool overlays a heatmap onto a course to highlight activities with more or less activity in order to help teachers gain insight into the use of the various elements of their courses. The Heatmap paints each activity with a colour from pale orange to vivid red depending on the number of user views on this activity (pale orange being the less used, and vivid red being the most used activity). Under each activity, the tool provides specific numbers of user views and the number of users, who viewed the activity. Moreover, it adds a small block with a summary on total views and distinct user views for the whole module. This information is only visible to users with a Teacher role.

Furthermore, the Statistics plugin for Moodle can be used in order to have a quick overview of accesses to the platform per day. This plugin adds a graph in the Moodle page, where total connections per day are shown for the last 30 days.

4.3.2 Data from Moodle activities

Each Moodle activity generates data depending on the type of the activity. For example, a forum generates posts, which can be analysed using e.g. text mining techniques. The same applies for essay activities or any other activity producing pieces of text. Moreover, activities such as feedbacks when used as survey tools can be further analysed depending on the content of the activity (e.g. from Likert scales, multiple choice questions, etc.). Finally, data assessment activities (e.g. quizzes, hand-ins, choice, etc.) can be used to make conclusions on the level of student understanding.

5 Gaming elements in the FC

5.1 Definition of gaming elements

To understand gaming elements in the FC, you simply have to examine where they appear in the FC process. Observation of uses cases that combine gaming elements and the FC allows observing a wide variety of approaches. Figure 9 lets us observe several instances where gaming elements can be implemented: during the pre-class preparation process and engagement with the pre-class material, in-class games conducted as group activities, and post-class gaming elements supporting completion of the class and extension of the learning process. To understand gaming elements in the FC, we will also examine two fundamental approaches: gamification and game-based learning.

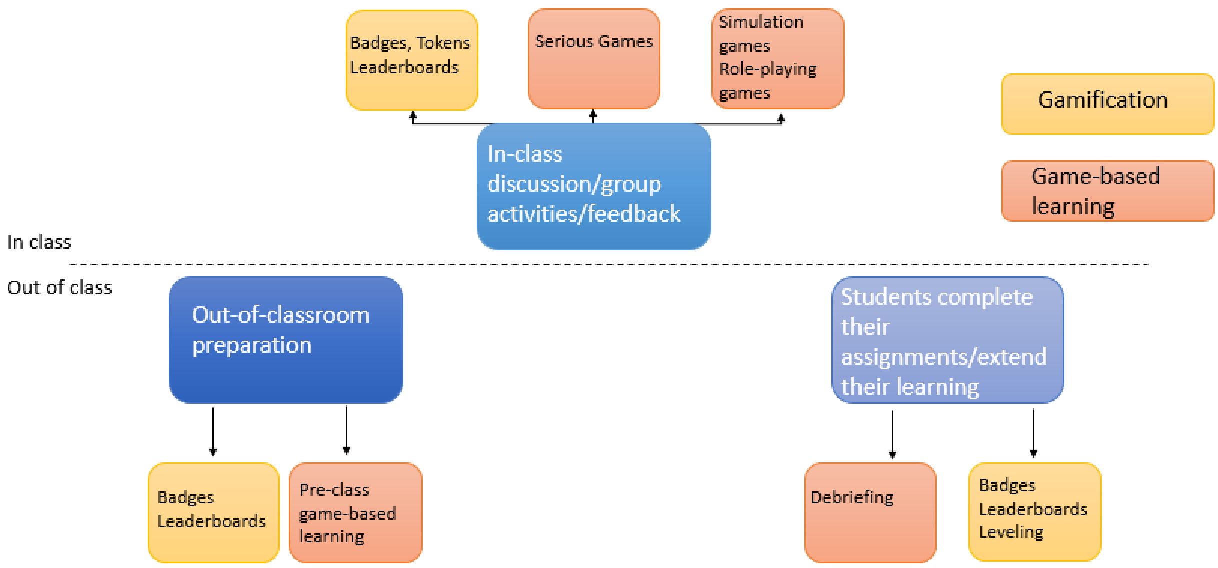

Figure 9: Gaming elements in the FC

Gamification is defined as an "umbrella term for the use of video game elements to improve user experience and user engagement in non-game services and applications" (Deterding et al., 2011). This definition refers to scoring and evaluation elements such as badges, achievements, levels and leaderboards. However, this early definition has been criticized as it focused on rewards and gratification which, under the frame of the Self-Determination Theory (Deci & Ryan, 1985) constitutes extrinsic motivation (Nicholson, 2012). In opposition to this idea, both the FC approach and problem-based learning can be connected to the fundamental needs for self-determination in individuals: need for competence, need for autonomy, and need for relatedness, as the fulfilment of these needs can sustain intrinsic motivation and high levels of self-determined motivation (Deci & Ryan, 2012).

Recent studies therefore make a distinction between reward-based gamification and meaningful gamification. Meaningful gamification is “the concept of using elements from games to help participants find a personal and meaningful connection within a specific context”, based on the idea that, instead of relying only on rewards, gamification should integrate concepts like player-created narratives, authentic player-based experiences, and reflection through debriefing (Becker & Nicholson, 2016).

The definition of game-based learning (GBL) on the other hand, is that learning materials are integrated into the gameplay to stimulate motivation and problem-solving skills in learners (Tao, Huang, and Tsai, 2016). Van Eck proposes three main applications of game-based learning: students building game from scratch, educators or developers building specific educational games to teach students, or integration of commercial off-the-shelf (COTS) games into the classroom (Van Eck, 2006). While commercial games can be used for educational purposes, game-based learning usually involve some form of a serious game, which is defined as “a game in which education (in its various forms) is the primary goal, rather than entertainment” (Michael & Chen, 2005). Both gamification and game-based learning have appeared in conjunction with use of the FC.

One of the challenges with the FC is ensuring that students will engage with the pre-class online learning materials and come prepared before coming to class (Matsumoto, 2016; Baksa-Haskó, 2016). This concern led to the implementation of gamification to track down the students’ progress and engage them with the material. The gamification aspect comes in the form of badges or accomplishment listing visible in the virtual learning environment, allowing students to monitor their progress and visualize their learning goals (Matsumoto, 2016; Aşıksoy, 2018; Tsay et al., 2018; Kanbul & Ozdamli, 2018).

Some research projects, however, go beyond the scope of points and leaderboards and integrate full games in the pre-class preparation (Zhamanov & Sakhiyeva, 2015; Ling, 2018; Ye, Hsiao, & Sun, 2018; Wang, 2019). An elementary approach consists in using games (including commercial games) to prepare the students for the class (Zhamanov & Sakhiyeva, 2015; Ye, Hsiao, & Sun, 2018). A more complex approach consists in embedding the learning material within an educational game and supporting student engagement with the material. In this approach, the students interact with the learning material either as they play the game or when they need to use the learning material to progress in the gameplay (Ling, 2018; Wang, 2019). For example, Lin (2018) developed a study based on the use of game-based learning in the pre-class process. The learning material of the FC was integrated to the Serious game *The Protégé* for the English communication class in the University of Singapore. The game being specifically developed for this class makes it a good exemple of game-based learning. However, Lin also considers the choice design a form of meaningful gamification. She considers meaningful gamification “as a catalyst in motivating students to read background material and grasp key concepts that in turn facilitate a flipped classroom” (Lin, 2018). The fact that engagement in the learning material is processed through the game and the playful engagement with the narration and not only through badges or scoring supports this assertion.

Gaming elements can also be integrated during the class time and as in-class activities, again both through gamification and game-based learning. Rewards-based gamification implemented in the pre-class process can be carried on in the classroom time. Latulipe, Long, and Seminario (2015) for example, used questions tokens to encourage their learners to try and find answers by themselves before asking the teachers (study groups retaining all their tokens would gain bonus points). Playful competition through beginning of class quizzes can also be favored, especially through the use of clickers and an online quiz system such as *Kahoot!* (Hung, 2016; Baksa-Haskó, 2016; Kanbul & Ozdamli, 2018).

The games that appear as in class activities can be varied in form, ranging from board games, digitally-enhanced board games and digital serious games. They also vary in usage, from short sessions at the beginning of the class meant to test the learners' preparation (Hattingh & Eybers, 2017; Hung, 2018) to class-length sessions of serious games incorporated as the main part of the class experience (Tao, Huang, & Tsai, 2016; Hung, Sun, & Liu, 2018; Lin, Hwang, Fu, & Chen, 2018). These uses are the clearest illustration of the implementation of game-based learning in the FC.

A last element related to gaming elements is the use of roleplaying or simulation games in the classroom. This last category is more difficult to define as the playful elements can be harder to characterize, and their inclusion in game-based learning is contented. Sauvé and Kaufman (2010) consider simulations as learning environments presenting a simplified reality that allow for learning without the risk of a real situation. They consider that "simulation games develop problem-solving skills such as decisiveness, creativity, and cognitive flexibility". This definition has allowed Wastiau, Kearney and Van den Berghe (2009) to consider educational role-playing simulations as an artificial dynamic environment in which learners can interact while playing specific roles, with defined objectives and in a specific scenario. On the opposite, Landriscina (2013) makes a specific distinction between simulations and games. Upon noting that "simulation" and "games" are often used interchangeably, especially owing to the fact that many serious games are developed as simulations, he considers that simulations are based on the imitation of the system or situation, whereas as game is not bound by that constraint. It is however noted that simulations and games do have some overlap (Landriscina, 2013, p5). Therefore, we will mention examples of FCs using either role-play or simulation elements in a constructed manner that is meant to engage fully the learners, beyond the scope of a case review.

Several case studies mention the use of role-playing games or simulations as an in-class activity in the form of cooperative learning. O'Flaherty and Phillips, in their scoping review of the FC in higher education, identify two instances where role-play is part of the in-class activity (O'Flaherty & Phillips, 2015). Other cases use the term "simulation" for similar activities, putting the learners in the position of professionals who need to perform in their future professional roles (Angelini, 2016; Liebert, Mazer, Merrell, Lin, & Lau, 2016; Angelini & Garcia-Carbonell, 2019; Watts, García-Carbonell

& Angelini, 2015; Olsen, Kevin & al., 2018). Angelini (2016) for example encourages future teachers to enter a simulation where they have to develop their own learning sequence based on English literature as if they were preparing to run a class activity on their own.

Finally, it can be noted that, while gaming elements are well-documented for the pre-class and in-class sequences, they tend to disappear in the studies that focus on post-class activities. With rewards-based gamification, it is implicit that the gamified elements of badges and leaderboards are a continuous structure that continues from a class to another, and only few cases explicitly use gamification as a way for the students to track their progress (Latulipe et al., 2015). Rewards-based gamification also allows some educators to refer specifically to the next class as “leveling” (Bergman & Sams, 2012, p. 66). Lameras and Moumoutzis developed a theoretical model of gamification in the flipped teaching in mathematics that would integrate both levels and learner-driven narration to give students a sense of ownership of the learning process (Lameras & Moumoutzis, 2015).

Similarly, debriefing is an essential part of the game-based learning process, both in simulation games (Petranek, 1992) and in educational role-playing games (Mariais, 2012). Becker and Richardson consider that “reflection through debriefing, to help build meaning for the student” is an essential part of meaningful gamification (Becker & Richardson, 2016, p66). Angelini also explicitly mentions the “Debriefing and qualitative analysis of students’ reflections” as part of her FC process in teacher training (Angelini, 2016) and discusses a three phases simulation anchored in the FC experience: briefing (pre-class preparation), action (in-class simulation), and debriefing (post-class reflection) (Angelini & Garcia-Carbonell, 2019). However, most case studies just evoke “in-class discussions” without specifically connecting the post-game processing of the game experience as part of the learning process (O'Flaherty & Phillips, 2015), which highlights the possibility that the efficiency of gaming elements could be improved with more focus on the post-class process.

5.2 Uses cases of flipped classrooms and games

Uses cases of combined use of FCs and games can be found for learners of all levels, from Elementary school to University, and a wide array of disciplines, especially language acquisition, STEM and medical professions. For this study, we have examined an early selection of 24 case studies coming from 10 different countries. A table summary of this study can be read in the table in Annex A: Uses cases of FCs and games.

Medical training appears as a specific domain in uses cases of FC and games, in the sense that, contrary to other fields which integrate varied forms of gamification or game-based learning in their approach, they appear to use almost exclusively simulations, barring other forms of gaming elements. Since it is possible to pinpoint the use of roleplay or simulation as an in-class activity in several studies (Liebert et al., 2016; Prober & Khan 2013; Critz & Wright 2013; Olsen, Kevin & al. 2018). These cases use simulation as a realistic representation that ties up to Landriscina’s definition of simulation as “an interactive representation of the system to be studied, based on a model (simplified representation) of the system” (Landriscina, 2018).

STEM subjects however start to offer a greater variety of games and gaming elements. Latulipe et al. (2015) developed a flipped and gamified classroom for a media computation class, in conjunction with “lightweight teams”, a system that allows cooperative work while detaching evaluation and grading from group performance. The gaming elements present are reward-based gamification: established goals, badges, leaderboard and tokens. The weekly workshop started with clicker quizzes challenges to allow peer instruction. The outcome of this class was seen as generally positive, with students praising the opportunity to learn in groups and presenting an average higher post-course performance as a non-flipped, non-gamified classroom. However, the gamification elements scored lower than teamwork in students’ feedback and their effectiveness was only marginally accepted for this analysis (Latulipe, Long, & Seminario, 2015). Similarly, Baksa-Haskó used the FC methodology and gamified elements to improve an e-learning course by integrating Moodle badges and in-class quizzes to test the learners’ knowledge of the learning material. The self-reported feedback from students and teachers was generally positive. Students appreciated the flexible time management and video supported lessons. Teachers appreciated taking a new role as mentors (Baksa-Haskó, 2016).

STEM classes also present several examples of integrated game-based learning in the FC. Zhamanov and Sakhiyeva used the Cisco Certified Network Associate (CCNA) course into a Computer Networks subject for 3rd and 4th level bachelor students. His team completed the online classroom with personal, custom-made instructional videos. The Cisco platform also allowed students to access a set of educational games as part of the pre-class time: *Binary Game*, a game inspired by Tetris that trains students in the binary language, and *Volunteer Game*, a game that educates about the security policies of a company (Zhamanov & Sakhiyeva 2015). Hattingh and Eybers (2017) created a custom-made “*Data Science Pursuit*” board game to train students in science. The questions of the game were structured according to Bloom’s Taxonomy, testing different competencies. The game was used in conjunction with the FC, especially to increase students’ engagement with the learning material at the start of the class. Although the students’ feedback was mixed, the class attained a never-before 100% pass (Hattingh & Eybers, 2017). Hung et al. (2018) developed a mathematical game of capture the flag with differentiated roles for middle high school students supported by a MOOC learning scenario. The variety of roles in the game allowed for heterogeneity groups in the classroom. The results of the experimentation showed an improvement in students’ motivation, especially students with low or moderate self-confidence in mathematics (Hung, Sun & Liu, 2018). Finally, Kanbul and Ozdamli (2018) provide an interesting example in game coding education, using both quizzes and badges as a reward-based gamification process through Moodle for the pre-class phase, and an in-class project development about coding in Gamification FC media. Students were distributed in groups of 3 or 4 and had to complete educational game improvement projects by the end of the semester. Using game fabrication as a learning environment by simulating students working as employees of a game development company has already resulted in positive outcomes for students learning and improved technical, analytical and project management skills (Schoenau-Fog, Reng, & Kofoed, 2015). The outcomes presented by Kanbul and Ozdamli were positive, both in terms of students' attitude towards coding learning. Students' eagerness towards coding was considered medium level before study and increased to high level after implementation of the gamification supported flipped classroom. (Kanbul & Ozdamli, 2018).

Language acquisition classes offer the same variety of approaches, from rewards-based gamification to in-class simulation. Mastumoto (2016) developed for junior high school learners in Japan the Super Rapid Accumulation of Lasting Abilities (Surala) system as an online educational system with gamification elements (e.g. visualization of progress and goals, competition, gradual leveling etc.). This study showed a positive perception of the methodology in learners who appreciated the detailed explanations and intelligibility in the gamification design for e-learning used in the project. Out of 105 responses, 95 used positive descriptors for the gamification design for e-learning (GDE) (Matsumoto, 2016). As mentioned earlier in Lin (2018), the educational game *The Protégé* was developed to support students' engagement with the online pre-class learning material for an English communication course in the University of Singapore. *The Protégé* runs a scenario where the professor is missing, and the protagonist's role is to find him by running an investigation that is based on the learning material. The game was designed with elements of scalability in mind and allowed instant feedback when the player engaged with the questions over the course of the game. The game was also designed to fulfil the conditions and components to intrinsic motivation by allowing autonomy in exploring the material and control over the actions of the protagonist of the game. The outcome of this study showed a marginally higher improvement in interest and autonomy in the students. Students' reflection and feedback were also largely positive (Ling, 2018). Angelini ran several experiments using a web based simulation as an in-class activity, both for students interested in designing courses as future teachers, and students that wanted to improve their English writing skills (Angelini, 2016; Watts, García-Carbonell & Angelini 2015; Angelini & Garcia-Carbonell, 2019). In the latter use case, the English writing skills of engineering students were trained using class simulation and a large web-based simulation in real time, and the outcomes were compared against a control group following a traditional English as a foreign language (EFL) course. This study concluded that the use of simulations improved students' written production in a 250 words timed essay, with a greater improvement being recorded for students who participated in the simulation-based instruction.

Several case studies have tried to analyze the effect of the combined use of the FC and games, with the majority of cases doing this by comparing a FC using games or gamified elements to a standard FC. An exception however can be found in the study run by Lin, Hwang, Fu, and Chen (2018) that compared an experimental group using a flipped game-based learning approach to a control group using a conventional game-based learning approach. Both groups were University students engaged in a Business class. They would learn in class with a story-based learning module in which they played as an obedient daughter building a beautiful castle for her father, and commerce knowledge and basic management principles in the process. It is worth noting that, to facilitate the learning process, the story elements were narrated in native Mandarin, but the practice module, questions and answers were presented in English for practice of the learned knowledge. In keeping with the FC methodology, students in the experimental group could access educational material provided by the course instructor (videos, guiding questions and written summaries). The authors concluded that the flipped contextual game-based learning approach offered an effective environment for students to engage with the context and fundamental management principles. Students engaged in the flipped game-based approach presented a better English business performance and fewer writing errors than students engaged in the conventional game-based learning approach (Hwang, Fu, & Chen, 2018).

Most case studies, however, compare a standard FC approach to a FC approach integrating gamification or game-based learning (Hung, 2016; Tao, Huang, Tsai, 2016; Ye, Hsiao, & Sun, 2018; Hung 2018; Aşıksoy, 2018; Tsay, Kofinas & Luo 2018; Wang, 2019) and illustrate instances where the integration of gaming elements reinforces the efficiency of the FC method. Tsay et al. (2018), similarly to Matsumoto (2016), Latulipe et al. (2015) and Baksa-Haskó (2016) introduce gamification to support engagement with the online material in the form of an "information technology-based gamified system with a range of online activity". Tsay and his team concluded that the course design based on gamification contributed to student-centered learning and enabled the use of the FC. Furthermore, they observed that the gamified platform supported the increase in engagement particularly in female students and students with a job (Tsay, Kofinas, Luo 2018). Aşıksoy (2018) also used a gamified approach in the pre-class preparation against a non-gamified FC and found a significantly increased motivation and learning achievements in the students following the gamified FC (Aşıksoy, 2018).

Two case studies present interesting examples of game-based learning integration to the FC by using games as a pre-class activity, with positive results on the pre-class learning outcomes. Ye et al. (2018) developed a flipped game-based learning strategy (FGBL) by using the commercial games *Ballance* and *Angry Birds* to introduce Newton's law of motion and mechanical energy conservation notions respectively. The FGBL strategy integrated the digital game before class and cooperative learning in the form of group discussion and practice in class. This strategy was compared against two control groups: one with the same pre-class game practice followed by a lecture-based instruction, and one with a traditional learning approach, with a lecture teaching and no pre-class content. The FGBL students, all in 8th grade level, achieved better overall learning outcomes than their lecture-based counterparts (Ye, Hsiao, & Sun, 2018). Wang (2019) used a similar pre-class game-based learning approach with high school students engaged in a classical Chinese language class. Wang developed an educational game whose script was cooperatively built with Chinese teachers. The pre-class material was two-fold: animated-story materials and game-based learning content. The game, adapted from a classical Chinese lesson and entitled *the Trip to Beitou Sulfur Caves*, tells the story of a person travelling from China to Taiwan in order to look for sulphur for the government. The students were encouraged to use the pre-class material: the animated story material targeted reading comprehension, whereas the game-based learning material – where they played as the Trip to Beitou protagonist Mr Yu – invited the learners to make choices and test their understanding of the classical Chinese context. The class activities presented are a blend of group activity and personal activity using learning worksheets, which tested how well they previewed the learning material. The experimentation tested both learning effectiveness and students' perceptions. The conclusion was that both groups gave positive feedback regarding the FC and, while there were no significant differences in terms of learning performance, learners with both game-based and animated-story material, and especially the low achievers, gave more positive feedback (Wang, 2019).

Finally, three case studies present further examples of games used in the classroom, as a way to test, exploit, or consolidate exposition to the learning material (Hung 2018; Tao, Huang, & Tsai, 2016; Hung, 2016). Hung (2016) used quizzes at the beginning of each class to test if university students had engaged with the FC learning material. The experimental group was tested on dynamic quizzes with clickers through the *Kahoot!* platform and following the bring your own device (BYOD) paradigm, while the control group had access to the same pre-class learning material, but was tested on a quiz presented on PowerPoint and students had to raise their hand to provide the answers. The students engaged in the dynamic quiz provided positive feedback and scored higher in interactivity with both peers and teachers, participation, motivation and attention (Hung, 2016). Subsequently, Hung (2018) used Technology-Enhanced Board Games (TEBGs) to support the FC approach. Participants were university students enrolled in English listening and speaking practice course. The pre-class preparation was self-study of an assigned video. Then, the students in the gamified FC would engage in a game-based learning activity while the students of the conventional FC would engage in a small group activity by answering and discussing the questions on printed worksheets. The game took the form of a board game with a game board, a set of player tokens, a dice and a deck of QR code cards. Those cards allowed students to access the learning material, one question at a time. A QR code cards triggered various responses and video-based questions that the players had to answer correctly in order to gain points. The overall results suggested that the TEBG gamified FC was more beneficial than regular FC by supporting an interactive environment which reduced their anxiety to speaking English and enhanced their motivation. Tao et al. (2016) used the digital game Adventures of an Astronaut, conceived for Elementary class learners in EFL, to support the FC learning. Their results suggested that the FC with game-based learning had the potential of motivating students better and providing better learning outcomes (Tao, Huang, & Tsai, 2016).

Uses cases where gaming elements are combined with the FC thus take many different forms:

- Gamification elements exploited to support e-learning and students' engagement with the pre-class material
- Gamification elements that support the whole FC process by using badges and leveling as a means for the students to track their progress
- Game-based learning supporting pre-class learning
- Game-based learning through in-class activity, especially to test students' pre-class preparation
- Simulation and role-playing games engaging students in active case studies or project learning

It can be also underlined that post-class reflection and consolidation of skills and knowledge still appears to be the weakest part of combination of the FC and gaming elements and should be the object of further examination and development.

Following similar observations, Lameras and Moumoutzis (2015) offer a conceptual model to combine inquiry-based learning and the FC model with gamification and game processes as a way to strengthen and improve learning. The GamifyMaths framework they propose, suggests the development of a holistic approach that utilises a personal learning environment (PLE), where students could be co-creators of content, processes, and assessment. This is further supported by a gamified Graphical User Interface (GUI) that adds motivation through standard gamification elements, such as points, badges and leaderboards. This theoretical model appears of interest as it opens to the possibility of incorporating both gamification and game-based learning to the FC, while suggesting the possibility of user-generated content that could support meaningful gamification.

Early examination of literature regarding gaming elements in the FC suggests that there is precedent for the efficiency of combining the FC model with gamification or game-based learning. Research suggests that “Game-based learning is an appropriate solution to extend the flipped learning experience” (Hattingh & Eybers, 2017) and “flipped classrooms integrated with MOOCs and game-based learning can enhance students’ learning motivation and outcomes” (Hung, Sun & Liu, 2018). Results also point to “the potential that meaningful gamification has in motivating and helping students in scaffolding reading material before their classes, and shows it to be not only a viable but also a worthwhile facility to invest in and develop—particularly for facilitating a flipped-classroom environment” (Ling, 2018). The process of combining gamification, game-based learning and the FC should however incorporate meaningful gamification and follow a holistic approach to develop a bespoke design that would encompass the whole learning experience, with special attention to the post-class learning progress, which seems to have been more neglected by research so far.

6 Conclusion

The purpose of this deliverable was to review and analyse FC and its main features. It also presented the derived information to deduce how the FC instruction model can be combined with problem-based learning and gamification elements to be transformed into a new educational paradigm that will also employ LA features. In this context, this deliverable has discussed:

- The definition of the FC instruction model, its pedagogical foundation, and how it relates to problem-based learning. Moreover, it presented its main features and models that have been developed to represent learning in FC (flipped learning). Such models compare how FC are different to traditional learning and teaching and highlight how FCs can support learners to perform learning tasks on higher cognitive levels with instructor guidance and support.
- A synthesis of various implementation of the FC model in various subjects and contexts. This synthesis made apparent that flipped learning has the potential to improve learning at different educational levels (e.g. primary, secondary, undergraduate) and contexts (training), and for different subjects (e.g. STEM, humanities, social sciences, etc.). By combining information from such implementations, a list of the commonly used learning activities and technology tools in FCs was developed in order to guide the FLIP2G development of an environment for problem-based and gamification activities for FCs.
- Based on a literature review, the educational data generation in various FC sessions (pre-class, in-class, after-class), as FLIP2G aims at integrating LA features into its learning environment. Only few use cases were found to employ LA features for FCs and this applied mainly to the pre-class sessions, where heavy technological tools and environments were used. The objective with the LA use was to monitor student engagement and activity during pre-class sessions. Since most of the cases use VLEs for such sessions, we have exemplified data generation in Moodle in order to provide directions for the employment of LA in FCs implemented in such environments.
- A definition of the concepts of gamification and gaming elements, and a synthesis of implementations of FCs, where these concepts were employed. It was found that such gamification and gaming elements have been employed in all three sessions of FCs serving different objectives (e.g. making sure students come to class prepared). This synthesis provides a framework for the introduction of serious games in the FLIP2G educational model.

Overall, this document has analysed the FC as a learning strategy and as a local implementation and has elaborated on its features that are important to be taken into consideration in an educational and training environment. From this analysis, it became obvious that problem-based activities, gaming elements, and LA features can greatly contribute to the improvement of the FC instruction model in terms of student engagement and motivation and with the aim to develop transversal skills and competencies among learners.

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Annex A – Uses cases of FCs and games

(Study) Author	Year	Location	Gaming elements in the FC	Study/ participants	Outcomes
(1) Latulipe, Long, & Seminario, 2015	2015	USA	Gamification design: stamps, token, leaderboards, tokens (in-class use)	University computer programming class, 1212 students over 2 semesters	Study showed better outcome with the use of gamification and the FC compared to a non-flipped class
(2) Matsumoto, 2016	2016	Japan	Gamification Design for e-learning (visualization of progress and goals, competition against other learners, gradual difficulty)	Junior High school EFL, 174 students over 9 months	95 out of 105 descriptive words used by students showed positive appreciation of e-learning with gamification elements
(3) Hung, 2016	2016	Taiwan	In-class quiz through Kahoot! Platform with clickers to evaluate students learning at the beginning of the class	University EFL 44 students during 3 flipped classes	Use of the flipped classroom with gamified quizzes using clickers rated better than a FC with non-gamified quizzes using the board and a raised-hand response
(4) Lameras & Moumoutzis 2015	2015	UK, Greece	Holistic approach using Gamified Graphical User Interface (GUI) associating levels, progress bars, points, badges in conjunction with user-generated content and digital storytelling	Conceptual model	Presentation of the GamifyMath conceptual environment

(5) Zhamanov & Sakhiyeva 2015	2015	Kazakhstan	Pre-class serious games (Binary, the Volunteer game) used for pre-class learning	University math classes for more than 100 students	Successful use of the Cisco Networking Academy online and plans to develop more qualitative video lessons
(6) Baksa-Haskó, 2016	2016	Hungary	Gamification design: moodle badges, in-class quizzes	University, Informatics for business and economics majors, more than 1000 students over three years	Gradual improvement of students' involvement and decrease in cheating attitudes
(7) Aşıksoy, 2018	2018	Turkey	Gamification design: goals, quizzes (bonus points for extra hard quizzes), time limits, badges, leader boards	University, Physics course, 61 students over 1 semester	Comparison to a non-gamified FC, self-reported students' opinions largely positive over the gamified elements
(8) Tsay, Kofinas, Luo 2018	2018	UK, Greece	Gamification design for pre-class: goals, differentiated level of activities, badges, leaderboards	University, Business Personal And Professional Development course, 136 students over 1 year	Comparison to a non-gamified student-centered learning showed a significantly better course performance in the gamified condition than in the non-gamified one. Engagement in online learning activities was positively related to course performance.

(9) Kanbul & Ozdamli, **20**18	2018	Turkey	In-class quiz through Kahoot! platform and project-based educational game development project	University, Computer project development, 35 students over 14 weeks	Self-reported students' opinion of the FC rated globally positive
(10) Ling, 2018	2018	Singapore	Pre-class serious Game The Protégé with reading material embedded in the game experience, scaling access to the reading material	University, English Communication, Women in Film module, 16 students	Meaningful gamification was successfully used as a catalyst to encourage students to engage with the reading material
(11) Angelini, 2016	2016	Spain	Simulation of designing a teaching sequence	University, English teacher training, 103 students	Students responded positively to the use of designing simulation as a means of learning
(12) Liebert, Mazer, Merrell, Lin, & Lau, 2016	2016	USA	Simulation based flipped classroom approach with in-class simulation backed by pre-class learning	University, surgery clerkship training, 89 students over 1 year	Medical students' response to the simulation based FC was overwhelmingly positive, reporting that the learning environment supported accountability and self-directed learning
(13) Prober & Khan 2013	2013	USA	Roleplaying used as an in-class activity	University, medical school, 141 students over the first and second year	Positive development of active learning strategies with the support of professionals in class

(14) Critz & Wright 2013	2013	USA	Roleplaying used as an in-class activity	University, nurse practitioners in training, 20 students, 11 weeks	High satisfaction response from students and faculty, students demonstrating increased autonomy with learning
(15) Hattingh & Eybers, 2017	2017	South Africa	In-class serious game: Data Science Pursuit, a trivial pursuit game built to support learning	University, science undergraduates, 34 students over 1 semester	Self-reported perception of the students gave a general positive feedback and a 100% pass rate to the class
(16) Tao, Huang, Tsai, 2016	2016	Taiwan	In-class serious game: Digital game Adventure of an Astronaut	Elementary school, English class, 26 students over 3 weeks	Comparison with a FC with no game indicated a greater learning effectiveness to the group working with the game
(17) Hung, Sun, Liu, 2018	2018	Taiwan	In-class serious game: Capture the flag type board game with differentiated roles allowing for heterogeneity group	Middle high school, math, 238 students over 2 weeks	Quantitative results showed positive learning motivation and outcomes7
(18) Hung, 2018	2018	Taiwan	In-class serious game: digitally enhanced board game at start of class. Cards with QR codes used to motivate students to answer questions.	University EFL students, 48 students over 3 weeks	Comparison with a non-gamified FC showed the gamified FC to support EFL learners by reducing their anxiety and supporting their motivation

(19) Ye, Hsiao, & Sun, 2018	2018	Taiwan	Pre-class games: use of commercial game (Balance and Angry birds) as a pre-class training	High School 8th grade physics, 87 students during 2 classes of 1-week duration each	Flipped game-based learning (FGBL) strategy compared to game-based learning with lecture and normal lecture classroom. Results suggest games have potential as pre-class learning tools to enhance motivation and give students understanding of physics concepts
(20) Wang, 2019	2019	Taiwan	Pre-class game: serious game A trip to Beitu used in conjunction to animated materials	High school classical Chinese, 75 students over 2 weeks	Comparison with a non-gamified FC showed equivalent learning results, but better motivation and willingness to engage with the material in the game-based group
(21) Lin, Hwang, Fu, & Chen, 2018	2018	Taiwan	In-class serious game: contextual educational game developed on RPG Maker, integrating a story-based module to learn about the business structure	University, English business writing, 68 students over 8 weeks	The flipped game based learning offers an effective environment to support students learning with more time to practice their business writing in-class
(22) Angelini & Garcia-Carbonell,	2019	Spain	Simulation: web-based simulation for English writing	University, EFL, 50 students over 4 months	The use of simulation effectively improved students written

2019					production compared to a traditional EFL course
(23) Watts, García-Carbonell & Angelini, 2015	2015	Spain	Simulation: designing a teaching sequence	University, EFL teaching training, 71 students	Learners underlined that simulation activity gave benefited them linguistically and gave them a better understanding of the subject they studied
(24) Olsen, Kevin & al., 2018	2018	USA	Simulation-based curriculum in medicine	University, medical school	Overall self-efficiency of interns improved following the curriculum