Franqueira, Virginia N.L. and Tunnicliffe, Peter (2015) *To Flip or Not to Flip: A Critical Interpretive Synthesis of Flipped Teaching.* In: Smart Education and Smart e-Learning. Smart Innovation, Systems and Technologies . Springer, Cham, Switzerland, pp. 57-67. ISBN 978-3-319-19874-3.

To Flip or Not To Flip: A Critical Interpretive Synthesis of Flipped Teaching

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Abstract. It became almost fashionable to refer to the term "flipped" in higher education. Expressions like flipped learning and flipped classroom are often used interchangeably as an indication of innovation, flexibility, creativity and pedagogical evolution. We performed an exploratory study on this topic following the Critical Interpretive Synthesis methodology for analysis of the literature. Our findings indicated that the term "Flipped Learning" is misleading and that, in fact, the synthetic concept behind it is "Flipped Teaching". We derived a synthesising argument, in the format of two synthesis models, of the potential benefits promoted by flipped teaching and the potential issues which affect its success in practice. Those models allow STEM course tutors not only to make informed decisions about whether to flip teaching or not, but also to better prepare for flipping.

Keywords: Flipped Learning, Teaching, Pedagogy, Higher Education

1 Introduction

"Flipped" has become the pedagogical buzzword of the day: flipped learning, flipped classroom, flipped course, and even flipped university currently seem to be the preferred terminology to demonstrate that educators are up-to-date with latest developments, have a vision for the future and embrace changes. It is gaining incredible visibility and being subject of numerous debates not only within academia but also in the media. However, lots of questions remain unanswered about its novelty and effectiveness in practice. This paper reports on an exploratory study of flipped learning in higher education using Critical Interpretive Synthesis (CIS) [14]. This methodology, popular in the domains of Social Science and Health research, aims at analysing evidence collected from the literature reviewed to develop concepts and theories using induction and critical thinking [14]. Interpretive approaches, such as CIS, contrast with integrative approaches aimed at aggregation and summarization of evidence [13]. The former is interrogative and iterative in nature, thus, suitable for exploratory research starting from a broad topic without a specific research question [27] – these were reasons why CIS was selected as the methodological backbone for this study about flipped learning.

1.1 Methodology

CIS [14] is a methodology which uses literature as primary source of evidence of different kinds; e.g., qualitative and qualitative evidence collected from multi-disciplinary or multi-method sources [3]. It incorporates some elements of Meta-ethnography (i.e., Lines-Of-Arguments as analysis strategy) and Grounded Theory (i.e., inductive approach for emergent theory generation). As such, CIS aims at the development of *synthetic constructs* which derive from new interpretations of existing concepts and constructs directly collected from the literature, and of a *synthesising argument* which relates existing and emerging concepts/constructs [14]. Table 1 summarises the key characteristics of CIS.

Table 1. Key characteristics of Critical Interpretive Synthesis (CIS) [14, 15, 3, 27]

Purpose	CIS is a process of review; it aims to explore a topic and develop a synthesising argument which critically integrates the literature reviewed.
Process	CIS follows a cyclic approach where iteration, reflexivity and refinement coexist. Searching, sampling and analysis happen in parallel within iterations.
Procedure	There are no pre-defined procedures and CIS recognises the "authorial voice" for the development of a synthesising argument grounded in evidence collected from sources critically analysed – reproducibility is not a requirement.
Search	Search of literature is flexible and draws from both keyword search in databases, and researchers' awareness of relevant material. Exhaustive searches are outside the scope of CIS.
Sampling	CIS uses a purpose-based sampling where sources are chosen according to the emergent theoretical framework allowing the selection criteria to evolve. Sampling saturation establishes coverage.
Analysis	Interrogation rather than aggregation drives the analysis of sources; what is included in the review derives from a critical approach to the material selected.
Results	Analysis allow the development of a synthesising argument which connects existing constructs & concepts to new ones derived from synthesis – synthetic constructs.

We followed several iterations starting from the broad intent of understanding flipped learning and its foundations up to the more specific intent of analysing experiences with flipped learning compared to the traditional approach. Along the process, we restricted our review to empirical studies evaluating the implementation of a same STEM (Science, Technology, Engineering, and Mathematics) course in both modalities – flipped and traditional.

2 Concept & Foundation of Flipped Learning

The idea of class flipping is attributed to Baker [2] and Lage et al. [24]. The former focused on Web-based tools as an essential enabler of flipped classrooms, and the latter focused on inverted classrooms as a promoter of *inclusion* [9] better accommodating different learners' styles and abilities. Lage et al. [24, Page 32] describes the idea as: "Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa". Such early definitions were too fuzzy, and allowed false interpretations [7]. For example, distance learning, empowered by the advent of MOOCs (Massive Open Online Courses), could be considered as a flipped approach but is not since "classroom" is completely redundant in this case.

The foundation of flipped learning is *Active Learning* [18, 32]. Active learning builds over constructivism – a student-centred approach which emphasises "learning by doing" [20]. It is anchored on the principles of (i) intentional learner, i.e., students are actively responsible for and owners of their learning, (ii) reciprocal teaching, i.e., learning is a collaborative process where students benefit from social interactions with peers and tutor, and (iii) anchored instruction, i.e., learning requires the application of knowledge to complex, contextualised, and real problems, case-studies or scenarios [10].

Although flipped learning draws from active learning practices, it goes further and completely moves passive and individual activities, such as assimilation of content and concepts, to outside contact time. In fact, flipped learning shifts learning activities which fall on lower levels of the Bloom Taxonomy [8] (e.g., knowledge and comprehension) to outside the classroom and focuses on higher levels activities (e.g., application, analysis, evaluation and synthesis) inside the classroom [21].

Although there is no consensus on a definition of Flipped Learning, the following recent definition seems to capture its essence [38, Page 5]:

> Flipped Learning is a "pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter."

This definition exposes an intrinsic issue with recent definitions of flipped learning – they do not refer to *learning* but rather to *teaching*. Teaching facilitates student learning [6]; learning being the delta between what a student knows/understands prior and after a teaching intervention. Therefore, the synthetic construct which emerges from this study is **Flipped Teaching** defined as above.

2.1 Implementation of Flipped Teaching

Advances in technology and the open source movement have largely enabled the flip in teaching from a traditional approach, based on live lectures, to an online approach, based on video-lectures and Web assessments [7].

The Flipped Learning Network [16] has published what they consider as the Four Pillars (F-L-I-P) of the flipped approach [21]. Chen et al. [12] criticise this F-L-I-P model in terms of its comprehensiveness for application to higher education. They based their critique in three aspects. First, F-L-I-P focuses more on content planning than on delivery, providing poor insights on types of activities and how they should be conveyed. Second, it focuses on the educators' perspective leaving the students' perspective unaccounted for. Finally, it lacks guidance for the individual learning space. To address those gaps, they proposed three additional pillars (P-E-D). All these seven pillars are reviewed next.

1. **F**lexible environments. Flipped teaching requires flexible environments to meet students' needs of studying content anywhere, anytime, and their expectations of flexibility in relation to assessment and to learning curve.
2. **L**earning Culture. Flipped teaching requires a shift from a instructor-centred approach, where students are passive, to a student-centred approach, where students are active and owners of their learning. This aims to promote deep learning [26], and cooperative learning targeted at the *Zone of Proximal Development* [37]; this means that tutors should assist and challenge students up to the limit of their capacity, but not beyond since it would demotivate them [21].
3. **I**ntentional Content. Flipped teaching requires that tutors evaluate (and prepare) content and activities appropriate for the individual learning space, and for the group learning space. They can draw from constructivist techniques such as problem-based learning [4] and peer-based learning [36].
4. **P**rofessional Educators. Flipped teaching demands more from tutors than traditional teaching. They have to be constantly reflecting on how to maximise contact time and how to assess students understanding of content absorbed on their own.
5. **P**rogressive Networking Learning Activities. This feature emphasises the social ingredient of active learning delivery, i.e., the need for "learning by networking", achieved by activities centred in collaboration and teamwork, complementing "learning by doing". It also suggests the adoption of a progressive strategy of low-to-high-risk activities to gradually allow students to adapt. Low-risk activities tend to have short duration, be considerably planned, structured, not controversial, and familiar to students and tutors [12].
6. **E**ngaging and Effective Learning Experience. This feature expands the role of "professional educators" and proposes the monitoring of *transactional distance* to improve learning. Transaction distance is the psychological or communication distance – disconnected from physical distance – between students and tutors [30]. It fluctuates in a flipped setting, therefore, should be managed by tutors with the purpose of decreasing the distance. Chen et al. [12] propose two ways to achieve that: increment dialogue and reduce

preset structure. For example, learners' autonomous activities (like watching video-lectures) increase the distance and should be balanced with activities which enhance student-tutor communication and allow tutors to monitor learning (like quizzes or personalised formative feedback via email or learning platform).
7. **D**iversified and Seamless Learning Platforms. This feature extends "flexible environments" and regards the need of digital platforms to fulfil requirements of individualization, differentiation, personalization, reliability and consistence [12].

3 Empirical Evaluations of Flipped Teaching

Empirical evidence were collected from the literature comparing STEM courses delivered via both traditional and flipped teaching. Traditional teaching is an approach where tutors present new content (concepts, facts, theories) in class while students take notes; practical sessions exercise the content to some extent, students consolidate their knowledge through homework, and address challenges via assessments. This section discusses findings.

Content coverage. Experience with a same course delivered in traditional and in flipped mode (e.g., [29, 41, 39]) indicates that the latter tends to run in a faster pace compared to the former. Flipped teaching allows more topics to be covered by students on their own, and more individual feedback and guidance to be provided in class.

An interesting aspect of flipped teaching is the possibility to cover and assess more learning outcomes [39]. This is achievable in part because it "increases [opportunity] levels of problem solving structure and practice" [1, Page 229]. It is also partially achievable because in-class group activities make it very convenient to assess learning outcomes related to teamwork, communication, and students' ability not only to solve but also to identify and formulate problems [7]. These are all soft skills regarded as valuable in industry.

Perception from tutors. Benefits of self-paced, asynchronous learning outside the classroom is a strong point often recognised by students who experienced flipped teaching [25, 29]. They can follow their own schedule to cover content at home or on the move, and can watch video-lecture passages repeatedly.

Increased motivation and student engagement were also observed when flipped teaching was compared to traditional teaching [39]. For example, students perceived in-class active learning as fun, and easier to remain focused [25]. Many students also perceived that intensive hands-on activities they were experiencing extensively in every class would allow them to acquire practical skills sought by the industry [28]. Students felt more at easy to ask questions and participate in the less structured and more cooperative flipped environment [24, 29, 11].

On the other hand, tutors reported that flipped teaching translated into an increased interest on the course subject area because students engaged into a variety of realistic problems and case studies [25, 39]. Kim et al. [23] observed significant better rates of students retention in their flipped version of an engineering course. They believe this is the result of the cooperative learning component of flipped teaching, and better performance decreasing the number of students who abandoned the course due to the lack of hope in a “pass” grade.

Academic performance. Empirical evidence from flipped teaching indicates an improved performance of students in assessments, compared to traditional teaching. Yarbro et al. [38] refer to examples where it either incurred in a significant or a marginal improvement in students' performance, but never the opposite. In addition, experience suggests that flipped teaching enables the acquisition of a richer skills set, such as higher-order thinking, innovation in problem-solving, cooperation, independence, collaboration and creativity [35, 39, 33, 41]. Cooperative learning and active learning, both embedded into flipped teaching, enable deeper understanding of concepts [39], therefore, promoting deep learning [6]. Love et al. [25, Page 322] provide insights in this respect: “over 70% [of students] agreed that explaining a problem or idea to their partner helped them to develop a deeper understanding of it”.

Time & effort for preparation. Often authors who engaged in flipped teaching mention a substantial effort for the transition from traditional mode. In particular, they refer to preparation of video-lectures. For example, 100 hours to generate and edit 45 video-lectures of 5-15 minutes [29]; 35 hours of recording to produce 48 video-lectures of 30-60 minutes [41]. The bright side of this substantial preparation effort is the possibility of reuse, and the shorter preparation required before each flipped class [11, 29]. The recommendation of short video-lectures (30 minutes or less) is echoed by many [40, 7, 28] – in this case, students would watch one or more videos per week. However, this strategy creates challenges. From the perspective of tutors, it creates the challenge of selecting and organising material in really small chunks [29]. From the perspective of students, it creates challenges regarding a lack of a clear module structure.

An alternative to avoid the dangers of poor quality teacher-created videos [22], and cut down on preparation investment, is to adopt off-the-shelf video-lectures[41]. A variety of educational videos is available (e.g., Khan Academy, MIT OpenCourseware, TED Talks, and YouTube), although quality may remain an issue.

Perception from students. Although the majority of students tend to be positive about flipped teaching, there seems to be always a consistent minority (15-25%) who remain negative about it. For example, Butt [11] reported 25% of students not seeing value in flipped teaching; Bates & Galloway's findings [5] showed that 8% of students slightly/strongly preferred traditional teaching while 10% were neutral; Kim et al. [23] obtained similar results: 15% of students disliked or declared to be neutral.

Paradigm shift. STEM students throughout their academic life have been mainly exposed to traditional teaching. When the approach is turned up-side-down by flipped teaching, some students find it hard to adapt because they are required to leave their comfort zone to become active learners [34]. While some students succeed to adapt after a short transition period, some do not [12]. This also depends on students' readiness to self-directed learning [19]. Moreover, Gajewski & Jaczewski [17] suggest that attitude towards flipped teaching may be affected by cultural differences since some cultures may be more open to changes and innovations than others.

Pre-class preparation. Preparation for class assumes a more vital importance in flipped teaching; unprepared students reportedly feel strongly behind [12]. Therefore, preparation represents a point for adjustment required from students. Mason et al. [29, Page 434] observed that in the first weeks of their flipped course, students reported to be "frustrated" in class. However, "by the fourth week, students seemed to have realized that they would learn more during class time if they came prepared". This perception is corroborated by other authors (e.g., [39]). The lack of pre-class preparation, if substantial, may cause a burden for those who prepared and may feel demotivated [11]. It also causes a burden for tutors in terms of extra assistance required by those unprepared and the need of keeping the whole class busy. Despite the stereotype that learning in flipped mode is more demanding in terms of study time, preliminary results indicate that this is not the case [29].

Learning management. One crucial aspect of asynchronous content delivered outside class, as in flipped teaching, is learning management. Tutors need to specifically check students understanding of the material *before each class*. This allows formative feedback to be provided to all or to individuals in the next class or remotely before it. Quizzes seem to be the most commonly used method of input for that monitoring – the majority of authors report the use of pre-class quizzes [7, 40, 23], while others prescribe pre-class *and* post-class quizzes [39]. An alternative approach for learning management is Just-In-Time-Teaching (JITT) [31]. In JITT, class activities and scope are adapted depending on results from assessment of students understanding [25, 40]. One way to implement that is to pose questions at the beginning of each class and collect answers via clickers. Depending on the results, the tutor uses micro-lectures and adjusts peer activities to solve misconceptions and gaps. Therefore, learning management in flipped teaching runs the risk of becoming a 24/7 task [12].

4 Reflection and Synthesising Argument

Flipped teaching is not really a new pedagogy. In fact, it leverages from practices anchored on existing, well known, educational models such as Active Learning, Problem-based Learning and Peer-assisted Learning. The element of novelty which can be attributed to Flipped Teaching is the *flip* of content delivery away from the classroom (replacing face-to-face lectures by video-lectures) and 100% use of classroom time for "learning by doing" and "learning by networking" activities. However, this delivery shift seems confusing even for authors reporting flipped experiences. For example, Marwedel and Engel [28, Section III] argue that flipped teaching is a novelty for Engineering but not for Social Sciences. They regard seminar-style lectures, popular in the latter sciences, as flipped teaching – maybe because it is a student-centred approach. Our study indicates, however, that this is a misconception since the delivery of content prepared by students as homework and its delivery as seminar in class, although promoting independent learning, remains a traditional setting. In flipped teaching, lectures content and delivery remain as a responsibility of the tutor. Fig.1 synthesises potential benefits promoted by flipped teaching when compared with traditional teaching.

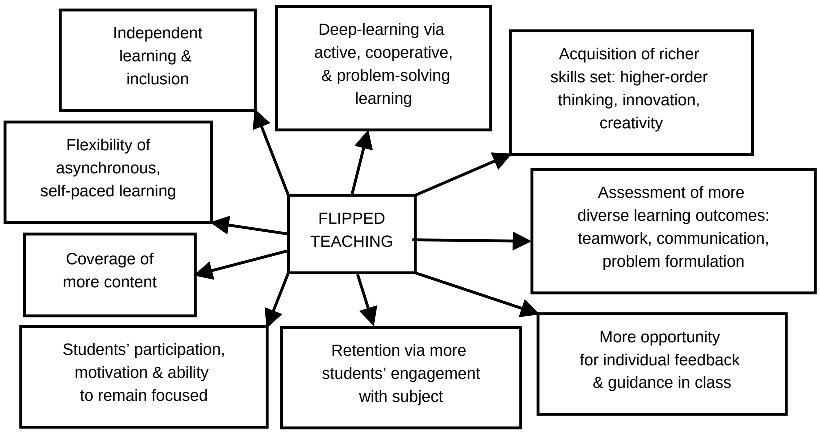

Fig. 1. Synthesis of potential benefits promoted by flipped vs. traditional teaching.

The implementation of flipped teaching involves investment and raises challenges. Fig.2 synthesises factors that affect the success of flipped teaching in practice. One such factor is the effort-consuming preparation of high quality video-lectures to convey pre-class content. An alternative is to use off-the-shelf videos, but poll results among teachers [22, Page 63] suggest that finding those videos is rather a difficult task. Herreid and Schiller [22] propose standardisation and sharing of videos and case studies on a centralised repository such as the National Center for Case Study Teaching in Sciences[3] – a form of collaborative teaching – as a way forward.

According to Chen et al. [12], it typically takes 3 years to fine-tune a flipped course and achieve its maximum benefits. Questions remain unanswered regarding the return on investment of flipped teaching in a diversity of courses and cohorts. For example, there are STEM courses with stable content (e.g., "Foundations of Computer Sciences") while there are others with rather dynamic content (e.g., "Advances in Digital Forensics Research"). There has been no opportunity for longitudinal and realistic studies to answer such questions yet.

There is a paradox in flipped teaching. Some authors (such as [24]) claim that it accommodates well different learning styles, promoting inclusion through a variety of teaching methods which can be used. Others (such as [40]), however, raise the question about how different learning styles, different cultures [17] and

[3] `http://sciencecases.lib.buffalo.edu`

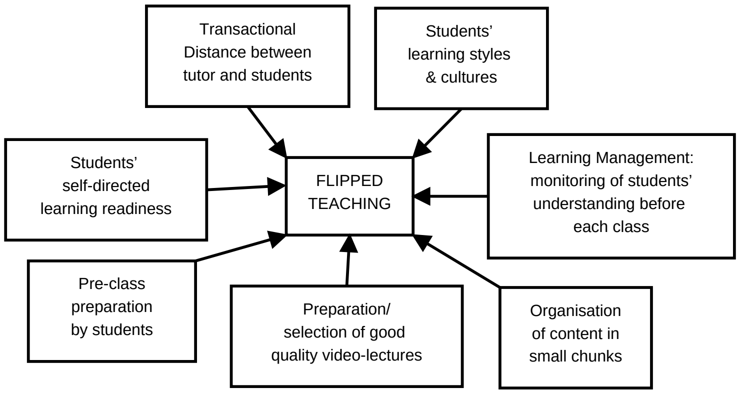

Fig. 2. Synthesis of potential issues that affect the success of flipped teaching.

different levels of students' readiness for self-study [19] adapt differently to it. The former's perception [40] is that active learners may fit best with flipped teaching although, in the end, students with other learning styles may also benefit by developing skills via active-engaging tasks. Deeper and broader studies on factors affecting flipped teaching remains a gap which calls for empirical research.

5 Conclusion

This paper used Critical Interpretive Synthesis to review terminology, foundation, implementation and empirical evaluations of flipped teaching in STEM courses. "Flipped Learning", a widespread terminology, is misleading since it refers to a teaching strategy rather than to a learning strategy per se. Findings from this study allowed us to build a synthesising argument in the format of two models showing what flipped teaching promotes (i.e., potential benefits) and what affects its success (i.e. potential issues). Tutors considering to adopt flipped teaching should invest to minimise the latter to maximise the former. The paper also pointed to research directions needed to further improve our understanding of flipped teaching in practice.

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