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ARTICLE

A field guide for implementing a flipped classroom

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Abstract

The way flipped classrooms are perceived and even practiced by teachers is sometimes approximate. For instance, while the Covid-19 pandemic has pushed many universities to adopt distance learning, flipped classrooms have often been mentioned as a solution in that context. This inducement maintains a confusion between flipped classrooms and distance learning that might be detrimental for students and teachers. Moreover, embarking on a new pedagogical practice such as flipped classroom could be intimidating and time-consuming for the newcomer teacher. For these reasons, this article aims to share some tips for implementing a flipped classroom, with examples from biology and biochemistry. Based on our experiences but also on the current scientific literature, we structured these advice around three phases: preparation, implementation, and follow-up. In the preparation phase, we advise planning early to invert time in class and outside the classroom, but also to say it explicitly, as well as to identify (or optionally create) resources for students to learn in autonomy. In the implementation phase, we suggest to (i) be explicit in the acquisition of knowledge and foster students' autonomy; (ii) explore active learning in class; (iii) develop cooperation and sharing skills; and (iv) differentiate teaching practices to adapt to student needs. Lastly, in the follow-up phase, we propose to (i) evaluate both student learning and the pedagogical setting; (ii) take care of the logistics and the teacher's posture; (iii) document the flipped classroom, and (iv) share the teaching experience.

KEYWORDS

field guide, flipped classroom, pedagogy

1 | INTRODUCTION

This article aims to share some tips for implementing a flipped classroom, with examples from biology and biochemistry. The original idea of the flipped classroom involves reconsidering the type of work done by students autonomously (e.g., at home or in a library) and in class with the teacher, to provide a more active and effective learning experience for students.^{1,2} Many different practices are associated with the generic term 'flipped classroom' and are described in comprehensive

articles such as references by Bishop and Verleger³ and Lebrun et al.⁴

Performing an overall assessment of flipped classrooms is difficult, because the term 'flipped classroom' refers to many widely differing practices. However, studies have shown positive effects with some protocols,^{5–8} including for students facing difficulties.⁹ In addition, a series of meta-analyses by John Hattie^{10,11} suggest the substantial efficiency of flipped classrooms.^{12–15} A recent second-order meta-analysis has confirmed this conclusion and shown that flipped classrooms, compared with

conventional classrooms, significantly improve students' cognitive and behavioral learning.¹⁶ Although these studies argue toward a positive effect of flipped classrooms on student learnings, research on this topic is still ongoing and several articles have called for more studies to assess flipped classrooms.^{3,16–18}

The advises presented below are inspired by the French national conference on flipped classrooms, called CLIC, which has taken place in Paris since 2015. On the basis of the presentation of one of the authors (MB) at CLIC 2018, together with the audience's remarks during the presentation and the recommendations from one of the references,¹⁸ we have re-analyzed these advises from our practitioner's point of view and the perspective of the current literature. These advises have also been presented and discussed with the French education community during the 2020 CLIC conference (CLIC 2020).

2 | PREPARATION

2.1 | Invert time and say it

The basic principle of the flipped classroom involves considering the articulation of teaching and learning time.^{1,2} Whereas schools and universities have long worked on a transmissive model, teaching no longer involves solely frontally led courses.⁶

The spread of this practice has been accompanied by reflections on the nature of the tasks self-directed by learners. The goal is not giving more¹⁸ but moving away from lower cognitive level classroom activities, and performing in-class tasks that require greater support from the teacher^{4,19–21} (Table 1). With this model, the transmission of knowledge occurs remotely, but knowledge assimilation can occur face-to-face, via active pedagogy sessions.²² The inverted class then enables maximization of the 'active' time in the classroom by moving the discovery of knowledge outside the classroom, without decreasing efficiency.²³

TABLE 1 Activities performed autonomously and in the classroom with the teacher (left and middle columns) in relation to Bloom's taxonomy^{19,20} (right column).

Traditional classroom	Flipped classroom	Bloom's taxonomy
In the classroom	Autonomous	Remember
In the classroom/ autonomous	Autonomous / in the classroom	Understand
Autonomous	In the classroom	Apply, evaluate, and analyze

When preparing a flipped course, the teacher must design activities that can support the acquisition of elements of knowledge by autonomous students. For instance:

1. at the beginning of a course, prerequisites can be reactivated, or introductory concepts can be addressed.
2. before a class, activities engage students with the material that they need to study. Activities can also prepare learners to confront a complex task.
3. throughout the course, the teacher can also provide learners with a synthesis of the knowledge (through cheat sheets, quick reference cards or mnemonic devices), which can later be used to address complex tasks.
4. at the end of the course, students could work on a summary of the course.

Flipped classrooms modify how teaching is traditionally performed. To support learners in this pedagogy, teachers must explain how the course is organized, such as through providing detailed instructions in their syllabi.²⁴ One way to explicitly enforce what students are expected to do autonomously (e.g., at home or in a library) and in class is clearly defining pedagogical objectives, also termed 'learning outcomes'. While defining pedagogical objectives for flipped classrooms, teachers must keep in mind that activities performed autonomously by students should be related to the cognitive categories 'remember', 'understand' or 'apply', as presented in Table 1. Eventually, teachers should also clearly state how the course assessments are conducted and specify the learning material.

2.2 | Identify (or create) resources for learning in autonomy

That students have tasks to do autonomously mean that they need some material to read, watch, or even interact with. Most teachers will first try to generate their own media. This process may be time consuming and sometimes discouraging, especially if the teacher aims to produce high-quality video content regularly. We advocate for the reuse of resources openly available online or in the physical world. These resources may be, for example, textbooks, books, web-documentaries, handouts, video clips, MOOC excerpts, or Wikipedia articles. The choice is made according to students' needs and the pedagogical objectives defined by the teacher. Some selection criteria may include the resource's trustworthiness, author's level of expertise, chapter or video length, presence of a detailed plan, or presence of companion exercises.

However, after careful assessment, the teacher will need to appropriate the selected material and, if needed, comment on or expand it. That is, teachers must integrate this resource into their pedagogical mindset.

For video resources specifically, Guo et al.²⁵ have recommended choosing or creating short videos of 6 min or less, with a ‘Khan academy’ style, in which the teacher draws explanations on the screen. Other detailed recommendations are available on this subject.²⁶ Many video resources are freely available online, from YouTube to open education resources. Again, we advise teachers to spend some time browsing these resources before considering creating their own.

If the teacher decides to create her or his own resources, he or she should try to implement the change gradually.¹⁸ Instead of creating something new *from scratch*, she or he could start with something that has worked elsewhere and use resources, protocols, or lesson plans shared by others.

After the teaching material has been selected, there are many ways to share it with students:

1. In a closed face-to-face system (for example, a hand-out distributed in class); no digital tool is required.
2. In a closed remote online system, for example with a learning management system (LMS) such as Moodle, Blackboard, or Canvas, or shared cloud drives.
3. In a remote open system for example, a class blog or a website.

Regarding digital means to distribute teaching materials, some aspects should be emphasized:

1. Ensuring access for all students is crucial.¹⁸ Students must have the right equipment at home (internet connection, computer, or tablet) or access to a properly equipped library.
2. Learners must also be guided and supervised when using new material and tool.¹⁸
3. Although sharing material through an open system is not imperative, several positive effects can result. Resources are made available to other colleagues and teachers, and feedbacks from the community become possible.

3 | IMPLEMENTATION

3.1 | Be explicit in the acquisition of knowledge, and foster students' autonomy

At the start of the course, the teacher should be explicit about how the students will work autonomously

(Section 2.1). In addition to making a detailed syllabus, it is recommended to dedicate the first session to the setup and practical organization of the flipped classroom. During this session, students can become acquainted with the teaching material and online tools with the help from the teacher or teaching assistants. Teachers also should be patient during the first weeks, so that the students become confident about the method and the tools.

Before class, teachers must ensure that the resources made available have been consulted,¹⁸ and the required tasks have been performed. Even if the activity performed autonomously by students is of a relatively low cognitive level, support is required to limit the socio-academic inequalities associated with work done outside the classroom.²⁷ This outside-of-class support also provides indications that can be used by the teacher to adapt in-class sessions.²⁸ Students can complete several types of activities to support their acquisition of knowledge:

1. Take quizzes (possibly self-corrected) on the proposed material. Tools such as traditional LMS, Learning Apps, or Google Forms could be useful here.
2. Write down open questions on paper or through digital means.
3. Participate in question and answer sessions through LMS or messaging applications (e.g., Slack, Mattermost, and Messenger).
4. Write a summary of the studied material. The produced summary can later be reviewed by the students' peers and even used during exams.
5. Have students each list one thing that they found interesting and another that they want clarification on.
6. Collectively enrich a course trail or share the results of research on a given topic in a collaborative writing document. This activity is, however, subject to limited support and therefore must be followed by a class exchange session to make sure the main elements are well understood.

The introduction of a flipped classroom is likely to be destabilizing for students or associated with misunderstandings about the objectives or about the methods used. Therefore, effective communication¹⁸ and implementation of the advice ‘Invert time, and say it’ are crucial. Teachers require support from an efficient communication system (e-mail, social networks, or LMS). A forum could allow students to ask questions whose answers can then be provided by peers or the teacher, before, during, or even after class. Defining an interaction protocol (who answers to whom, and when) can also be useful. Office hours, as implemented in the English-speaking academic world, could be highly helpful toward this goal.

3.2 | Explore active learning in class

One key idea in flipping a class is making room for active learning during lectures.²³ In active learning, students are involved and engage with the course content in a large range of activities, such as discussions, quizzes, or problem-solving. Active learning, compared with traditional lecture-based teaching, has been found to improve student achievement,²² and some researchers have suggested that the performance of flipped classrooms could actually be explained by the use of active learning.²⁹

Many types of active learning strategies can be explored, from summarizing book chapters to teaching part of the course.³⁰ Among the activities that can be recommended in class, a review by Delozier and Thodes²³ suggests the following:

1. Quizzes with systems such as hands up, Plickers cards, clickers, or online voting systems (e.g., WooClap, Mentimeter, Kahoot, or Socrative).
2. Group discussions.
3. Student presentations or teaching.

More original methods can also be used, such as simulation games³¹ or team-based projects on research questions.³²

Note that active learning is not limited to in-class activities. Time outside the class does not have to be left passive, however, since any activity can be adapted in a more active manner.³³ In Table 1, we highlighted the types of tasks students could perform in the course of their learning. Most challenging tasks should be conducted in class with the guidance of the lecturer and through active learning. In the field of computational biology for instance, learning a programming language and performing research projects are typical examples of learning objectives that are difficult to reach via traditional lecturing but strongly benefit from active learning. Interactive material such as Jupyter notebooks,^{34–37} the Rosalind auto-correcting exercise collection³⁸ or code review of scientific software source codes^{39,40} are valuable resources and practices for learning how to program and discovering bioinformatics algorithms. One key aspect is to center the active learning activities around key competencies to be acquired by the students. For example, information literacy is essential to biochemistry students.⁴¹ To work on this competency students need to find their bearings in a scientific paper. They also need learn how to get information from both text and figures,⁴² and activities around figure descriptions can therefore be proposed.⁴³ Engaging teams of students in open research challenges is also a unique opportunity for students to learn what a research project is about.⁴⁴

The number of pedagogical strategies proposed could be overwhelming for a teacher willing to try flipped classrooms. However, teachers should keep in mind that errors are acceptable. Many iterations may be necessary to obtain an acceptable pedagogical scenario.⁴⁵ In that regard, an interesting and encouraging observation is the ‘teacher effect’ that is, that enthusiastic teachers have a positive effect just through trying.¹⁰ We interpret this observation as a right for teachers to tinker.

3.3 | Develop skills of cooperation and sharing

A potential advantage of flipped classrooms is that they can develop cooperation skills among students.⁴⁶ Cooperation has been observed to be an important asset allowing the efficiency of flipped classrooms.⁴⁷

Typical examples of activities that can be performed in teams are editing shared documents, creating videos, or editing Wikipedia pages.⁴⁸ From this perspective, many on-line tools now offer a ‘collaborative’ feature to promote team production (e.g., Framapad, Prezi, Quizizz, Google Docs, and wikis).

To the extent that cooperation could be a pedagogical objective, collaborative work can be proposed, for example with poster sessions in biology, chemistry or biochemistry curricula.^{49–55} In addition to preparing students for the design and presentation of posters per se, poster sessions favor and develop communication skills and statistical reasoning.⁵⁶ Interestingly, the use of a poster session as an alternative evaluation method, could facilitate the inclusion of underrepresented students.^{49,50} For example, we used a poster session in a biology course on model organisms, with each group of students presenting a different organism and discussions exploring the pros and cons of the model organisms studied.

3.4 | Differentiate

Lo and Hew have recommended individualized learning objectives.¹⁸ Although flipped classrooms alone are not sufficient to perform differentiation, they can facilitate its implementation. All tasks and activities performed by a student may provide a record of learning and progress. This tracking of learning enables problems to be identified and facilitates differentiation and remediation.

Regular assessments are essential for the success of flipped classrooms. Assessment of the knowledge acquired during preparatory activities (i.e., autonomously) is useful not only to ensure that the activities have actually been achieved by students but also to identify problems and

address them in a targeted and immediate fashion. In class, voting systems provide instant feedback on the knowledge acquired by students.

Flipped classrooms require teachers to be explicit (see Section 3.1) regarding the organization of the course (learning outcomes, assessments, teaching strategies, and learning materials). We believe that this aspect could benefit students with special needs. In addition, given that the transmissive portion of learning is studied individually and autonomously by students, this framework could in principle be adapted to student needs (e.g., by using different fonts or color schemes, or by enabling subtitles on videos). For example, we mentioned above an exercise of scientific figure description that revealed to be relatively easy to adapt for a blind student with the help of an accessibility assistant who described the figures of the studied research article.⁵⁷ Noteworthy, adaptation learning material or teaching activity, using the concept of accessibility assistant, proved to be effective in deciphering cognitive tasks, which ultimately led to a better learning experience for the whole class.⁴³

4 | FOLLOW-UP

4.1 | Evaluate

Beyond the assessment of student learnings, evaluating the pedagogical protocols used is important. Among the indicators for evaluating a flipped classroom, it is worth considering not only the grades obtained by students but also broader criteria, such as absenteeism, autonomy, students self-confidence on the subject, and cooperation.⁵⁸ Course evaluation surveys completed by students provide valuable feedback in this regard.

Because of the important need for further research in this field,^{3,17,18} studies conducted by teachers could provide a basis for participatory research on flipped classrooms.

4.2 | Take care of the logistics and the teacher's posture

Engaging students to work on teaching material outside the classroom requires teachers to anticipate broad, inclusive, and seamless access to their material. Some technical solutions have already been provided above.

In class, material such as flipcharts and sticky notes will be needed to ease teamwork. To support learning situations in teams, reorganizing the space in the classroom could quickly become necessary. This arrangement aims to facilitate exchanges between students but also

illustrates changes in the posture of the teacher. Adoption of the flipped classroom approach is usually accompanied by the teacher's reflection on the classroom layout, such that the teacher is no longer in front of or behind the students, but instead is close to or even in the middle of the students.

The teacher then shifts 'from sage on the stage to guide on the side'.⁵⁹ This organization often results in the establishment of work islands within which each team is invited to have an empty chair to allow the teacher to be 'beside the students'.

4.3 | Document the flipped classroom

One advantage of a flipped classroom is bringing experiment and discovery back into the classroom. All trials and errors should be documented and written down, not only to track them but also to allow for retrospective analysis of the pedagogical approach used.

We advise teachers after each class to take a few minutes to write down what happened during the class, including both positive and negative points, and what could be improved upon in the next class. The students can be involved in that process, for instance by leaving their comments on a post-it note or by filling a quick online survey. We usually ask our students to leave comment with one thing they learnt or enjoyed during the class and one thing they did not understand or would like more explanations on. In our experience, adjustments proposed by students are often useful. Moreover, the process of consulting students helps nurture their intrinsic motivation.^{60,61}

4.4 | Share the teaching experience

As stated in the introduction, there is not one but many flipped classrooms. The flipped classroom a teacher experienced will probably not be like someone else's flipped classroom. After a couple of iterations, the teacher experience of flipped classroom will be highly valuable and we advise the teacher to share it.

A teacher can publish her or his feedback as tweets, blog posts, or even research articles.^{31,44} To foster sharing and exchange, we advise to follow the FAIR principles,⁶² to make the media Findable, Accessible, Interoperable and Reusable.⁶³ In particular, we encourage teachers to share their experiences in documents under open licenses such as Creative Commons Attribution (CC BY) or Creative Commons Attribution Share Alike (CC BY-SA) that will ease reuse of resources while guaranteeing the citation of the original author.

Students' productions can also be shared or published in portfolios⁶⁴ that will document and prove their competencies.

5 | CONCLUSION

This article aims to gather some field tips for implementing a flipped classroom. In addition to changing the teacher's posture ('from sage on the stage to guide on the side'⁵⁹), the flipped classroom approach changes the atmosphere and working conditions for both teachers and students.

Designing and setting up a flipped classroom is often accompanied by an increased teacher workload, which could be limited by adopting several strategies mentioned above: use of resources produced by others, automated corrections, or peer assignments.⁶⁵ Working in pedagogical teams or communities of practice^{66,67} is also a way of sharing the burden of work and of getting support from others.

One aspect that we also highlighted is the need for more research on flipped classrooms.¹⁶ Therefore, enabling participatory research on the subject will be important to evaluate and document the multiple forms of flipped classrooms.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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