Chapter 15
Flipped Learning

Introduction

Flipped learning is a pedagogical teaching approach in which the conventional notion of classroom-based learning is inverted, so that students are introduced to the learning material before class, with classroom time then being used to deepen understanding through discussion with peers and problem-solving activities facilitated by teachers [1]. The same concept was applied later in the andragogical learning.

In the early mid-2000s, in the shadow of Colorado's Pikes Peak, veteran Woodland Park High School chemistry teachers Jonathan Bergmann and Aaron Sams stumbled onto an idea. Struggling to find the time to reteach lessons for absent students, they plunked down $50, bought software that allowed them to record and annotate lessons and posted them online. Absent students appreciated the opportunity to see what they missed. But, surprisingly, so did students who hadn't missed class. They, too, used the online material, mostly to review and reinforce classroom lessons. And, soon, Bergmann and Sams realized they had the opportunity to radically rethink how they used class time. Chemistry teachers Jon Bergman and Aaron Sams [2] and the founder of the Khan Academy, Salman Khan [3], were the first to popularize the phrase "flipped learning" into general use.

The concept of flipped learning, however, goes back much earlier than this. In the 1990s, a model of "peer instruction" was developed by Harvard Professor Eric Mazur, in which he provided material for students to prepare and reflect on before class. The class time was then used to encourage deeper cognitive thinking via peer interaction and instructor challenge. He called this "just in time teaching" [4]. This model was later expanded to include technological elements. At the International Conference on College Teaching and Learning in 2000, a presentation was delivered on "The Classroom Flip: Using Web Course Management Tools to Become a Guide by the Side" [5]. It was the first time the "flip" concept was introduced with emphasis on the learning management systems' role in delivering materials to

Y. El Miedany, *Rheumatology Teaching*,
https://doi.org/10.1007/978-3-319-98213-7_15

students before class. Significantly, the role of the teacher was amended and called facilitator and coach or "guide on the side". Subsequent research focused on the notion of "inverting the classroom" as a means of providing an inclusive learning environment in which personalized coaching and mentoring were the norm [6].

Fast forward to the current and the dramatic growth of online content which provided practitioners with an access to ample toolkits as well as resources for delivering flipped learning. Video creation (e.g. Screenr and Webinaria) and distribution tools (e.g. YouTube and Vimeo) provide the opportunity to create flipped content with ease [7]. Alternatively, there is a wealth of pre-existing media available for reuse (e.g. iTunes, Khan Academy and Open Yale Courses). While technology is not a prerequisite (flipped text-based content is just as valuable as video content), there is no doubt that the intersection of web 2.0 technology and learning theory has enabled flipped learning to become a valuable addition to the spectrum of blended learning. This chapter will discuss how the flipped learning model can be used to bring medical education into the twenty-first century. It will start with presenting the science of flipped learning, followed by "What should we know before flipping?", subsequently, flipped learning models will be summarized then the art of flipping. The chapter will conclude with discussing flipped learning in medical education and rheumatology and lastly challenges to flipped learning.

The Science of Flipped Learning

According to the constructivist, inquiry-based, learning cycle model [8–10], teaching consists of two phases (Fig. 15.1): a phase in which students are gaining conceptual understanding (hereafter referred to as the content attainment phase) and a phase in which students learn to apply and/or evaluate those concepts in novel situations in order to broaden their conceptual understanding beyond the context in

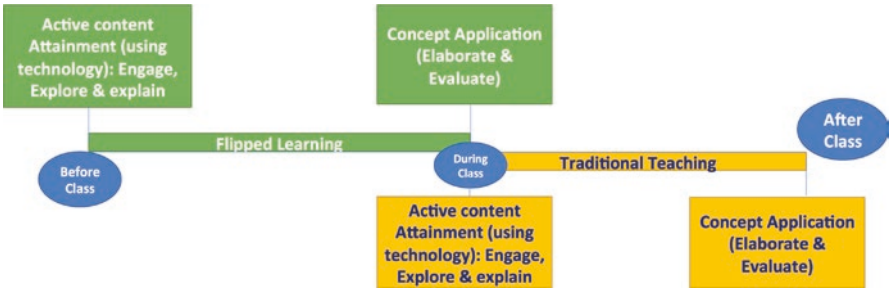

Fig. 15.1 Teaching phases: comparison between flipped and traditional learning. Teaching consists of two phases: (1) content attainment (a phase in which students are gaining conceptual understanding) and (2) concept application phase (a phase in which students learn to apply and/or evaluate those concepts in novel situations in order to broaden their conceptual understanding beyond the context in which they learned it)

which they learned it (hereafter referred to as the concept application phase). In a traditional teaching model, the instructor facilitates content attainment through various means in a classroom setting. Students are then given the responsibility of applying the concepts, generally in the form of homework assignments. In a flipped model, the roles are reversed, with students being responsible for attaining the content before coming to class, at which time the instructor facilitates the application process. It appears that the main difference between these models is the role of the instructor: to facilitate content attainment or concept application. Does it matter where you place instructor and student responsibilities?

While often defined simplistically as "school work at home and home work at school", flipped learning is an approach that allows teachers to implement a methodology, or various methodologies, in their classrooms. To counter some of the misconceptions about this term, the governing board and key leaders of the Flipped Learning Network (FLN) have composed a formal definition of flipped learning: "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" [8]. Defining the term helped also to distinguish between a flipped classroom and flipped learning. These terms are not interchangeable. Flipping a class can, but does not necessarily, lead to flipped learning. Many teachers may already flip their classes by having students read text outside of class, watch supplemental videos or solve additional problems; but to engage in flipped learning, there are four pillars which teachers should incorporate into their practice (Fig. 15.2).

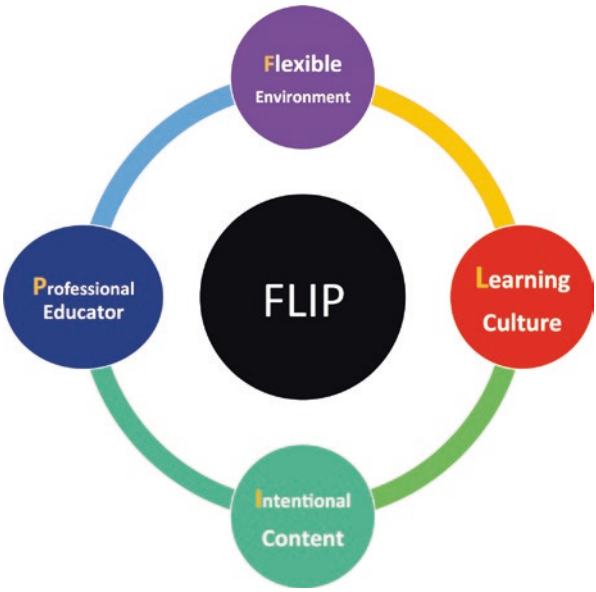

Fig. 15.2 The four pillars of flipped learning: flexible environment, learning culture, intentional content and professional educator

Flexible Environment

In contrast to the traditional learning style, flipped learning allows for implementation of a variety of learning modes. Physical rearrangement of the learning spaces is required to support either group work or independent study or accommodate a lesson or unit. Educators may require also to create flexible spaces in which students are able to choose when and where they learn. Furthermore, educators who flip their classes should be flexible in their expectations of student timelines for learning and in their assessments of student learning.

Learning Culture

In contrast to the traditional teacher-centred model, where the teacher is the primary source of information, in the flipped learning model, there is a fundamental shift of the educational model to a learner-centred approach, where in-class time is dedicated to exploring topics in greater depth and creating rich learning opportunities. Consequently, students are actively involved in knowledge construction as they participate in and evaluate their learning in a manner that is personally meaningful. As the year progresses, the educators should be able to see their students asking better questions and thinking more deeply about the content.

Intentional Content

Flipped classroom teachers almost universally agree that it's not the instructional videos on their own but how they are integrated into an overall approach that makes the difference. Flipped learning educators should constantly revise and consider how they can implement the flipped learning model. During class time flipped learning model can be implemented in standard teaching practice to help students develop conceptual understanding, as well as procedural fluency. They determine what materials students should explore on their own and what they need to teach. Students cannot just "watch the video and be done with it". Educators should use intentional content to maximize classroom time in order to adopt methods of student-centred, active learning strategies, depending on the subject matter and grade level.

Professional Educator

In contrast to the standard teaching style, in flipped classroom, the role of a professional educator is even more important and often more demanding. As it usually takes a little while for students to get used to the system, educators are expected to

continually observe their students, providing them with feedback relevant in the moment, supervising and assessing their work. Professional educators are reflective in their practice, accept constructive criticism, connect with each other to improve their instruction and tolerate controlled chaos in their classrooms. All aspects of instruction should be rethought to best maximize the scarcest learning resource. While professional educators take on less visibly prominent roles in a flipped classroom, they remain the essential ingredient that enables flipped learning to occur [11].

The main advantage of flipped teaching model is that it enables the educator to work individually with students. Classically, in the traditional classroom, the most outgoing and engaged students ask questions, while struggling students may act out. The flipped learning allows the educator to spend more time with struggling students, who may require help through challenging problems in the class. Advanced students have more freedom to learn independently. And, while students may occasionally lapse on their homework assignments, the new arrangement endorses better relationships between the educator and the student with greater student engagement and higher levels of motivation.

Concerning the video presentation which lies in the core of the out-of-class learning component (content attainment), cognitive theory of multimedia learning should be used to guide the video production process [12]. It is important to keep the students engaged while watching these instructional videos. Mayer [13] proposed 12 design principles to enhance the multimedia instructions. For example, segmenting principle stresses that a long presentation should be divided into a series of short videos. Specifically, empirical findings suggested that students' median engagement time of watching instructional videos was 6 min [14]. Thus, the desirable length of each video should be within 6 min. Also, personalization principle suggests that the presentation in videos should be spoken in a conversational style. Teachers should use an informal conversation with students (e.g. "I" and "you"), instead of a non-personalized style speaking in a third-person formal monologue. In addition, signaling principle states that learning is enhanced when essential materials are highlighted. Teachers may consider using PowerPoint-embedded presentation such as screencasts [15–17]. It can offer a step-by-step instruction to guide students' video watching [15] and assist students in note-taking [17].

What Should We Know Before Flipping?

Flipped learning can be an excitement for both educators and students alike. Enthusiasm for flipped learning is not limited to a certain education level or age. With the concept gaining more mainstream attention, a growing number of education faculty started implementing flipped learning. Lectures that were once held live in large halls are now recorded, searchable and viewable from anywhere and anytime, opening up new ways to interact, learn and share during the "in-class" time [18].

Proper implementation of flipped learning has been reported to be associated with several benefits [19]. It can lead to increased and better interaction between teachers and students and reduced student stress concomitant with higher student achievement scores. In addition, it can facilitate individualized teaching tailored to the student's requirements. Moreover, flipped learning helps teachers personalize lessons and assessments to target students' individual learning styles and abilities. For this reason, it is largely expected that the less clever students are, particularly, expected to benefit from flipped classrooms which offer multiple ways to absorb and learn content.

Simple movement of the course material from the classroom to the home will not improve learning outcomes. A successful flipped classroom is expected to offer a carefully designed learning experience that caters to each learner's own experiences and ideas. The educator can also use powerful analytics to see trends in students' understanding to prepare for class. In addition, teachers who use flipped learning approaches should continue to apply varied teaching strategies and good pedagogy/andragogy as they would with traditional models of learning. Teachers still need to ensure that students are able to transfer their learning to new situations. When starting to use a flipped classroom approach, teachers should start small so that students have time to develop an understanding of the model. Selecting what information to read or the instructional videos to watch at home is also crucial for the flipped learning model. Its content, accuracy and whether it fulfils the required teaching aims play a vital role in the success of the flipped learning experience. As the online tools will continue to multiply, this will offer both the educator and the learner the opportunity to learn and know different views of the same topic.

Flipped Learning Models

While there is no one model, the core idea is to flip the common instructional approach: With the instruction that used to occur "in class" is now accessed at home, in advance of the lesson time in the class. Class becomes the place to work through problems, advance concepts and engage in collaborative learning. At first, the flipped classroom sounds fairly straight forward. Having a closer look, however, it becomes clear that from this basic concept emerge several unique and interesting forms of how a teacher can invert their class. Educators can implement one or more of such flipped concepts which they feel right for their classrooms. Applying such a dynamic strategy of teaching will keep the students attracted and educators excited with the experience. Models of flipped learning include:

- *The standard inverted classroom*: Students are assigned the "homework" of watching video lectures and reading any materials relevant to the next day's class. During class time, students practise what they've learned through traditional schoolwork, with their teachers freed up for additional one-on-one time.

- *The discussion-oriented flipped classroom*: Teachers assign lecture videos, as well as any other video or reading related to the day's subject (e.g. TED Talks, YouTube videos and other resources). Class time is then devoted to discussion and exploration of the subject. This can be an especially useful approach in subjects where context is everything (e.g. history, art or English).
- *The demonstration-focused flipped classroom*: Especially for those subjects that require students to remember and repeat activities exactly (e.g. chemistry, physics and math). It is most helpful to have a video demonstration to be able to rewind and rewatch. In this model, the teacher uses screen recording software to demonstrate the activity in a way that allows students to follow along at their own pace.
- *The faux-flipped classroom*: This is perfect for younger students for whom actual homework might not yet be appropriate. This flipped classroom model instead has those students watch lecture video in class – giving them the opportunity to review materials at their own pace. After watching, the students can start problem-solving either individually or in groups, with the teacher is able to move from student to student to offer whatever individual support each young learner needs.
- *The group-based flipped classroom*: This model adds a new element to help students learn from each other. The class starts the same way others do, with lecture videos and other resources shared before class. The shift happens when students come to class, teaming up to work together on that day's assignment. This format encourages students to learn from one another and helps students to not only learn what the right answers are but also how to actually explain to a peer why those answers are right.
- *The virtual flipped classroom*: For older students and in some courses, the flipped classroom can eliminate the need for classroom time at all. Some college and university professors now share lecture videos for student viewing, assign and collect work via online learning management systems and simply require students to attend office hours or other regularly scheduled time for brief one-on-one instruction based on that individual student's needs.
- *Flipping the teacher*: All the videos created for a flipped learning do not have to begin and end with the teacher. Students too can make use of video to better demonstrate proficiency. Assign students to their record practice role-play activities to show competency or ask each to film themselves presenting a new subject or skill as a means to "teach the teacher" [20].

While it can be a challenge to choose which flipped learning model to use, the facility of using different models gives it a special taste and adds to its excitement. Mark Frydenberg of the Huffington Post noted that "It is not a 'one size fits all' model". He points out that every classroom is different, with different levels of access to technology, different levels of motivation on the part of the students and different technological know-how on the part of the instructors. Additionally, teachers must relearn how to act as the "guide on the side" rather than the "sage on the stage", and that takes time [21].

However, whenever the shift does occur, many experts believe the benefits are well worth the effort. According to ASCD.org, of 453 teachers who flipped their classrooms, 67% reported increased test scores, with particular benefits for students in advanced placement classes and students with special needs; 80% reported improved student attitudes, and 99% said they would flip their classrooms again next year [22].

The Art of Flipped Learning

Ideas and opinions about flipped learning environments vary. Some consider it simply another way of presenting the student-centred learning approach. Others view flipped classrooms as the most cutting-edge approach to learning. Still others see flipping as just another fad that will eventually run its course.

In many definitions and models, flipped learning means students watch a video of pre-recorded lectures before class. Then, when they arrive to class, they work through assignments or activities with their peers and the instructor. However, flipped learning teachers almost universally agree that it is not the instructional videos on their own but how they are integrated into an overall approach that makes the difference. After all, a video of a lecture is still a lecture. Expanding the definition of a flipped learning environment was discussed in an editorial by Barbi Honeycutt and Jennifer Garrett [22].

The essential goals of the flipped classroom are to move beyond the lecture as the primary way to deliver information and structure class time. In this approach the in-class time is "repurposed" for inquiry, application and assessment in order to better meet the needs of individual learners. While a well-developed lecture can be effective in the traditional teaching, the educators rely on it too heavily and often to the exclusion of other more meaningful teaching and learning approaches. Flipped learning enables educators to introduce new strategies of doing things. Yet adding something new generally requires letting go of something old. In the flipped learning, educators need to let go of their reliance on the lecture and focus on other ways to enhance learning by introducing active learning approaches that put students in the centre of the learning experience.

There are other ways to describe the flip. It can be defined as moving from an educator-centred to a student-centred learning environment. It could also be defined as shifting from individual to collaborative strategy. However, it is possible to flip a class using individual activities such as worksheets, quizzes, reflective writing prompts and problem-solving assignments. The key is to complete these activities during class time.

Flipping may or may not include technology. Bergmann and Sams [2] explain, "Ultimately, flipping a classroom involves shifting the energy away from the educator toward the students and then leveraging educational tools to enhance the learning environment". Bearing in mind that educational tools vary and are not confined to technology, the true essence of the flipping is principally to focus on the student.

Therefore, while videos and other technological tools can be effective in a flipped classroom, they are not essential. The true essence of the flipping is principally to focus on the student.

Putting a framework for comparing the lecture-centred style to the flipping approach, the cornerstone will be the "in-class" achievement. In general educators focus on higher-level learning outcomes during class time, whereas lower-level outcomes are expected outside of the class. This means the flipping could be as simple as watching a video before class and then attending class for more in-depth discussions that involve judging, creating and analysing. In contrast to the traditional teaching where the students are not prepared for applying the taught subject, in flipping where students work with the fundamental material before class, they are better prepared to apply the information and engage in higher-level discussions with their peers and the educator.

Another way to think about the flipped classroom is the student role in the process of learning during class. Dr. Honeycutt and Garret put the student in the core of the learning process and referred to the flip as focusing on the learners by incorporating them in the process. This allows students to spend ample time on "in-class" practising with their peers and educator. This adds a new level of complexity to the classroom.

Regardless of the definition or framework used to define flipped learning, the main outcome is a dynamic learning environment. Flipped classrooms are interactive; however, it can sometimes be even "messy", as students, instead of sitting passively listening to the lecture, are working together and solving problems. Flipped learning might also be risky. Educators relinquish a degree of control when the energy in the classroom shifts to the students. Similarly, while some flipped strategies may work, others may not. Educators using any flipping model need to be aware of these challenges when integrating active learning strategies into their classrooms. However, some of these challenges can be mitigated by careful planning. For example, starting with a flipped lesson plan helps determine the appropriate tools and most effective strategies which can help educators maintain control of the flipped classroom and ensure achieving the targeted learning outcomes.

One of the best approaches for educators to start with is by rethinking their role in the teaching room. When considering using new approaches, tools and strategies for teaching, it is expected that the lesson planning process and the assessment process will also change. In several cases, there are mini-lectures that need to be presented, but the majority of class time is spent on active learning. When planning for a flipped lesson, an educator should begin with the question, "what the learning outcomes are and what do the students need to do to achieve them?" This change in perspective will instantly flip the lesson focus since the question highlights the learners' efforts, not the educator. Consequently, the educators plan learning experiences based on what the students need to do and not what the educators are going to talk about. The instructor may give a presentation or a lecture, but any teaching activity must be designed to help students achieve what they need to do with the

information or material to accomplish the desired learning outcomes, not just to disseminate information [22].

Flipped Learning in Medical Education

Over the past few years, there has been growing interest in the use of flipped learning in the field of health science education. However, the majority of this work was carried out in pharmacy and nursing [2, 23–34]. O'Flaherty and Phillip [35] published a review of the literature, in 2015, on the use of flipped learning in higher education. Out of 12 studies identified from health science education, only 3 studies were conducted on medical education, none of which used a rigorous design to examine the effect of the flipped learning approach on learning outcomes (i.e. performance indicator or patient care outcomes) [36–38].

Recent review of the literature [39] highlighted four key findings on the current status of research on flipped learning in medical education. First, flipped learning in medical education has gained momentum as there have been a growing number of publication rate in this field over the past few years. Second, the effects of the flipping on learning are inconsistent, with some purported benefits and some reports of negligible improvement over traditional teaching methods. Third, students like the flipped learning teaching approach. Overall, the flipped learning seems a promising teaching strategy in medical education, particularly when the intent is to increase students' motivation, task value and engagement. However, most of the controlled studies focused on learners' perceptions of the intervention and changes in their knowledge and skills, whereas limited outcomes were reported on the higher level of Kirkpatrick's classification (i.e. changes in behaviour, professional practice and patient outcome). The studies published prior to 2015 were largely commentaries, action research, the before and after design without control groups or precourse survey design. In 2016, research on the flipped learning in medical education shifted to more rigorous designs, with almost half of the studies conducted using a controlled design. This suggests that the body of literature on the flipped learning in medical education is not only continuing to grow but is also being conducted using more rigorous research designs. This trajectory must continue in order to develop a strong empirical basis for (or against) the use of the flipped learning in medical education. The majority of work in this area has been carried out in undergraduate medical education. It is unclear if these findings would be generalizable to graduate medical education. This especially holds true for the research carried out in the preclinical years of medical school as this period tends to focus on classroom- and laboratory-based foundational science education. Although the clinical years of medical school are more similar to graduate medical education with regard to clinical learning in the context of a patient care environment, there are still significant differences between the learners (patient responsibilities, hours spent performing clinical work, depth and application of knowledge needed, etc.). Thus, more studies aimed at graduate medical education are needed.

Gain in knowledge and skill sets, when utilizing the flipped learning, was examined in a number of studies, compared with traditional learning methods. Only four studies provided sufficient statistics for effect sizes to be calculated. However, the effects of the flipped learning were generally mixed and inconclusive. One factor that might need to be taken into account in future research in this area is students' compliance with the flipped learning requirements (i.e. did the students complete the assigned preparatory work before the in-class session). This is linked to Heitz et al. note [40] which highlighted that the non-compliant group in their study was quite substantial (31%). Ultimately, students' compliance with flipped learning requirements might drastically affect differential gains in knowledge and skill sets compared with the traditional classroom.

Multiple studies reported positive students' perceptions of and attitudes towards the flipped learning. The students reported benefit were in favour of online modules as a learning resource [41]; and in in-class quizzes as well as follow-up homework as motivation for in-class participation [42]. Students learning through flipped learning methodology also reported greater task value, increased enjoyment and decreased boredom compared with those learning in a traditional classroom. In view of the positive attitudes towards the flipped learning demonstrated by the students, and the data depicting that flipped learning was, at least, as successful as traditional learning methods with regard to knowledge and skill set acquisition, it was concluded that the flipped learning could be considered as a component of medical education.

In order to more firmly support (or refute) the use of the flipped learning in medical education, future studies should be carried out to evaluate the higher levels of Kirkpatrick's framework. The effects of the flipping on learning have been examined across three of Kirkpatrick's classification measures: perception, attitude and change in knowledge and skill sets. Future studies should continue to focus on change in knowledge but should examine potential differential effects of the flipped learning on knowledge requiring different levels of cognitive processes, as highlighted in Morton and Colbert-Getz [43]. Changes in attitudes, as an independent variable and moderator of change in student knowledge, could be worthy of examination. Much of the work on change in knowledge has examined knowledge acquisition. Ultimately, it would be helpful to look at knowledge retention and transfer of this knowledge to professional practice and patient care (the highest two levels of Kirkpatrick's measures).

Flipped Learning in Rheumatology Education

It is important to state that the flipped classroom cannot be the only form of education. Medicine is still a very hands-on practice, and nothing can replace that experience. There must be clinical time in medical school as nothing will replace seeing a patient. Clinical experience and human interaction are too important to the practice of medicine. Thus, the flipped classroom and case-based instruction cannot be the

only form of instruction. However, this model represents a potential future as a means for improved instructional efficiency. The flipped classroom enable the students to be better prepared for the clinical experience so they can go further in their training, rather than catching up to where they're supposed to be [44].

Considering rheumatology teaching, earlier studies [45, 46] carried out to assess for educational deficiencies in musculoskeletal medicine revealed that a large majority of recent medical school graduates failed to demonstrate basic competency in musculoskeletal medicine on the clinical skills and examination front. It is therefore reasonable to conclude that medical school preparation in musculoskeletal medicine is inadequate and is in need to fundamental changes. Furthermore, several challenges have been reported, and it is believed that there is room for improvement to enhance the learning curve. Initially, and unfortunately, there is a general perception that the rheumatology curriculum and musculoskeletal learning come in the second place to a number of other specialities [47, 48]. This assertion is made, not only on personal observation, as rheumatology cases are not routinely included in the formal or summative OSCE exams for medical students, but also as an outcome of cross-sectional surveys to assess medical students' knowledge and clinical confidence in musculoskeletal medicine [45]. Furthermore, in contrast with the high prevalence of musculoskeletal conditions in the community, the time devoted to rheumatology teaching within the undergraduate curriculum remains inadequate and relies mainly on the availability of a rheumatologist with special interest in medical education.

Rheumatology can serve as a good model leading the way in changing medical education. Rheumatology is robust in both the basic science as well as clinical applications. This creates an opportunity for rheumatologists to be actively involved in the development of modern teaching approaches and the dissemination of the musculoskeletal knowledge in medical schools. Instead of giving lectures to teach the basic concepts and principles, students learn the basic materials in their own time and then come to class prepared to discuss the clinical applications of that knowledge. This agrees with the findings reported by Dr. Jonas, (Director of the Rheumatology Fellowship Training Program at the University of North Carolina at Chapel Hill School of Medicine), in the ACR conference 2016 [49]. She noted that "New concepts and new technologies are changing what medical school and medical education looks like, and rheumatologists are in the forefront". Considering the unique mix of basic sciences and clinical applications make the rheumatologists some of the best-positioned clinician–educators to guide and lead the shift in medical education.

A recent study was carried out aiming at implementing flipped classroom rheumatology teaching for undergraduate education and to evaluate outcomes of teaching using OSCE assessment and student perceived effectiveness and satisfaction survey [50]. Results of this work revealed that considering both clinical and academic outcomes, there was a compelling evidence to support the claim that students in the flipped learning course were overwhelmingly satisfied and confident. Students indicated high satisfaction levels reflecting that flipped learning was effective and gave them clear ideas of what is expected from them. Also, this approach did enable

the students to retain their knowledge (examples, recognition of clinical symptoms and signs of diseases, better ability to perform necessary tasks in a clinical practice). In turn, these knowledge attainment abilities have consequently improved their self-confidence. The result of this study is congruent with other studies done on the use of flipped learning in medical teaching; where results indicated high learners' satisfaction and confidence in their skills with clinical flipped learning [32, 51, 52]. The students' feedback reported in earlier studies comes also in agreement with the outcomes of this work reflecting their satisfaction with this teaching model and its learning outcomes.

Flipped Learning and the Learners' Views

Flipped instruction is gaining popularity in medical schools, but there remain some unanswered questions and items that should be addressed. These include queries regarding the learner beliefs and preferences [53]. Also, the optimum amount of the curriculum to flip and whether flipped sessions should be mandatory.

New media literacy research [54, 55] indicated that the current Internet generation student population is fully engaged in electronic media and audio-visual stimulation. Therefore, it would be logical to use interactive, technology-enhanced instruction as a tool to enhance the students' attention, participation and collaboration, even in small groups' clinical case practice. A study revealed significant improvement of educational outcomes when technology enhanced teaching was implemented [56]. Furthermore, results confirmed that embedding online video clips in the education process enhanced students' interaction and engagement. The tutor and independent observer scores revealed that the students' engagement has improved significantly in three dimensions: flow, interest and relevance, reflecting better understanding and attainment. This agreed with the outcomes of an earlier study which depicted that during a flipped learning setting, students were focused on the task at hand, enthusiastic and willing to finish the assessment task [12].

Demonstrating students how to learn through flipped classroom is vital for the success of the educational approach. Kirvan et al. [57] shared their experience in preparing the students gradually before full implementation of their flipped classroom. Students were asked to view a video lecture during class time. At the same time, they introduced students with some cognitive skills such as making their own notes while watching the video lectures. Providing instructor brief notes to accompany the videos is another useful technique to guide student learning during video lectures [15, 16]. For the in-class activities, students may not be accustomed to the change especially regarding the group learning process [15]. Teachers should provide clear instructions to ensure better communication and efficiency in group activities. For example, Clark [58] would split his students into three groups according to their ability. Each group of students had a clear lesson objective and completed their corresponding learning tasks. The high ability students worked on

practice problems in groups without the teacher's assistance, whereas the average students first reviewed the contents with the teacher before doing in-class exercises. As for the underperforming students, they would revisit the instructional videos in groups and gain a better understanding of the materials. In this example, every student in Clark's [58] flipped classroom knew their own learning objective and what to be discussed with their group members.

On another front, the issue of ensuring that the students have watched the video has been raised by Chao et al. [59] who pointed out that "it is difficult to ensure that students had truly previewed the video". In this regard, they designed follow-up quizzes on instructional videos to ensure students had previewed the learning materials. A learning management system (LMS) is therefore required to monitor and record the data of student learning. However, there is still a possibility that students complete the quizzes casually without being well prepared from video lectures. So how can we engage students in learning tasks? Another solution is to create an online discussion forum for students to post their questions and discuss with peers [60]. This will help in extending the learning community outside the classroom.

Outside the contexts of flipped classroom approach, gamification has been recently used in the education field to engage student in learning [61]. Hew et al. [62] found that digital game elements such as points, badges and leaderboard could produce a positive effect on student motivation and engagement. In a gamified environment, they found that students would be more active online (e.g. contribute more on discussion forum) and engage in more difficult tasks. Some learning management systems such as Moodle enable the use of game elements. To motivate student learning, teachers may consider flipping and gamifying their course by using these systems.

Challenges to Flipped Learning

Given education's long history of fascination with new educational approaches which are abandoned later, there's a real challenge that flipping, a seemingly simple idea that is profound in practice, may be reduced into the latest educational fad. And, in today's highly polarized political environment, it also runs the risk of being falsely pigeonholed into one of education's many false dichotomies, such as the age-old pedagogical debate between content knowledge and skills acquisition.

Before flipping the entire course, teachers can start small and proceed at a reasonable pace [15, 17]. Experiment in small ways also enables teachers to gain experiences of using flipped classroom approach. Teachers can cumulate the flipped learning materials by working on two to three topics every year. Grypp and Luebeck [15] further recommended teachers flipping their courses in team. In other words, teachers can share their experiences of implementing flipped classrooms as well as their teaching resources. However, in DeSantis et al.'s [63] experience, the materials created by others may not feature the host teacher. Discussion and agreement on the materials designed are thus necessary if teachers intend to develop a flipped course collaboratively.

While technology plays a big part in a successful flipped learning experience, the challenge remains of getting a fair access to it. It is not just the access but the download speed and the facility to view the educational content. While the majority of elite university students are more likely able to have a smartphone or a laptop with a decent Internet access for at-home lecture listening, this may not be the rule at all universities. This is also highly applicable in public high/secondary schools. This was one of the reasons critics pointed to the digital divide as a strike against flipping. Therefore, supporting the students who have limited access to technology resources is mandatory to the success of the flipped learning strategy. Teachers should consider students' socio-economic status and make IT supports available for them. For example, teachers can extend the use of computer facilities in school to support the implementation of flipped classrooms [16]. Also, teachers can prepare a few additional copies of flipped learning materials in flash drives or DVDs for the students who do not have Internet connection at home [58].

Many students need an incentive to watch videos at home just like they need to be motivated to read their textbooks and do their homework. Students' disengagement in the out-of-class learning is a real challenge to the flipped learning strategy as not all students are motivated to learn on their own. If students are not prepared, it makes it much harder to have a successful in-class experience. It has been suggested, in such cases, that the incentive can be the implementation of a short quiz at the start of class. As mentioned earlier, gamification can also be used in the education field to engage student in learning [61].

On another front, teachers need the knowledge and the time to create or provide targeted informative educational videos. The videos themselves should be focused, clear and relatively short (in average 5 min each). However, it takes time to get such videos right which represent an extra burden for the university/college tutors. Some faculty resort to the available free online videos. On another aspect, some educators need to put their egos aside as they shift from being the "sage on the stage" to becoming the "guide on side". So, instead of the traditional face-to-face time with long lectures, to relay information; interaction with students would be the best approach, as they grapple with course concepts. Furthermore, enriching teachers' knowledge of flipped classroom approach is important to keep the momentum and enthusiasm among the teachers. Institutes can create opportunities for teachers to share their experiences of implementing flipped classrooms as well as to receive feedback from colleagues or other professionals [63]. In Kirvan et al.'s study [57], a student teacher joined the teaching team of their flipped classroom. By enacting the flipped course, the student teacher gained experiences in both video production and lesson design. Kirvan et al. [57] concluded that their intervention could be a critical component of teacher preparation and "may be important for making education theory come alive for new teachers". Therefore, institutes may consider strengthening their teacher training and professional development on flipped classroom approach.

Though thoughtful curriculum or course redesigns may help to improve learning, there is no magic wand to achieve this target. Redesigning the traditional educational approach is a hard job which requires time, effort, support as well as enforcement. It might be quite not realistic to assume that good percentage of the students

would love doing homework. However educational strategy redesign presents an opportunity to re-engage students and improve their learning motivation. This is quite achievable with proper use of the technology to set proper expectations and monitoring of their students' performance [12].

The layout of the traditional classrooms is another challenge to flipped learning. Collaboration, communication and creativity are at the heart of this method, but fostering these skills is almost impossible with pupils inactive in rows of desks all day. With a little imagination, savvy teachers can implement a more flexible classroom with the minimum amount of fuss, resource and disruption, boosting student engagement and helping pupils to learn more effectively. Video-conferencing technologies, screen-casting tools and cloud-based platforms that let teachers create and deliver lessons all help to create the flipped classroom. However, with poor-quality, faulty and out-of-date ICT equipment, one of the main reasons for teachers not using technology in the classroom, this can be a barrier to success [21].

There is also another challenge that the flipped classroom could be seen as another front in a false battle between teachers and technology. Bergmann and Sams [2] emphasize that the "only magic bullet is the recruiting, training, and supporting of quality teachers". They reported that instructional videos are powerful tools for teachers to create content, share resources and improve practice. It seems almost certain that instructional videos, interactive simulations and yet-to-be-dreamed-up online tools will continue to multiply. But who will control these tools and whether they will fulfil their potential remains to be seen. Content is vital to creating a successful flipped classroom. However, a new approach often requires fresh resources. With spare time the one thing few teachers have in excess, the thought of designing and creating new content can be enough to turn even the most enthusiastic of teachers off.

Lastly, institutes may consider allocating additional manpower to support the implementation of flipped classrooms. In this way, teachers can develop their flipped learning materials collaboratively [15] and administer the flipped course in team [57, 64]. For example, Kirvan et al. [57] split their students into two groups (reteaching group and exploration group) by referring to their daily assessment results. One teacher provided remedial help for students who need further understanding of the materials (reteaching group), while another teacher helped more capable students explore the materials more deeply (exploration group). Once the re-teaching group was ready to proceed, they would join the exploration group to engage in the advanced learning activities.

In conclusion, flipped learning is a step forward educational approach which incorporates technology in the standard teaching process to enhance the students' learning curve. When compared the learning outcomes with traditional teaching, the previous reviews suggest that flipped classroom approach can improve student performance. However, rather than being viewed as the ultimate solution to improved teaching and learning, flipped classrooms should be used as one of many pedagogical/andragogical educational tools. Flipped learning seems to have great potential but is not the holy grail and needs to evolve beyond a one-size-fits-all solution. Only time will tell whether flipped learning permanently rewrites the classroom script

that has been used for thousands of years, but the results to date suggest that flipped classrooms allow us to begin to tackle the biggest barriers preventing learners from succeeding in the classroom.

References

1. Flipped learning. Higher Education Academy. https://www.heacademy.ac.uk/knowledge-hub/flipped-learning-0. Accessed 6 May 2018.
2. Bergmann J, Sams A. Flip your classroom: reach every student in every class every day. Washington, DC: International Society for Technology in Education; 2012.
3. TED. Salman Khan: let's use video to reinvent education. [Internet]. 2011. Available from: https://www.ted.com/talks/salman_khan_let_s_use_video_to_reinvent_education.
4. Crouch CH, Mazur E. Peer instruction: ten years of experience and results. Am J Phys. 2001;69:970–7.
5. Baker JW. The "Classroom Flip": using web course management tools to become the guide on the side. In: The 11th international conference on college teaching and learning. Jacksonville; 2000.
6. Lage MJ, Platt GJ, Treglia M. Inverting the classroom: a gateway to creating an inclusive learning environment. J Econ Educ. 2000;31:30–43.
7. El Miedany Y, El Aroussy N, Youssef S, Almedany S, Palmer D. Teaching the millennials: using youtube for teaching rheumatology in the standard educational setting. Ann Rheum Dis. 2018;77:1782.
8. Heiss ED, Obourn ES, Hoffman CW. Modern science teaching. New York: Macmillan; 1950.
9. Bybee R. An instructional model for science education: developing biological literacy. Colorado Springs: Biological Sciences Curriculum Studies; 1993.
10. Lawson AE. Science teaching and development of thinking. Belmont: Wadsworth/Thompson Learning; 2002.
11. Flipped Learning Network (FLN). The four pillars of F-L-I-P. 2014. https://flippedlearning.org/wp-content/uploads/2016/07/FLIP_handout_FNL_Web.pdf. Accessed 6 May 2018.
12. Lo CK, Hew KF. A critical review of flipped classroom challenges in K-12 education: possible solutions and recommendations for future research. Res Pract Technol Enhanc Learn. 2017;12:4. https://doi.org/10.1186/s41039-016-0044-2.
13. Mayer RE. The Cambridge handbook of multimedia learning. New York: Cambridge University Press; 2014.
14. Guo PJ, Kim J, Rubin R. How video production affects student engagement: an empirical study of MOOC videos. In: Proceedings of the first ACM conference on learning@ scale conference. New York: ACM; 2014. p. 41–50.
15. Grypp L, Luebeck J. Rotating solids and flipping instruction. Math Teach. 2015;109(3):186–93.
16. Schultz D, Duffield S, Rasmussen SC, Wageman J. Effects of the flipped classroom model on student performance for advanced placement high school chemistry students. J Chem Educ. 2014;91(9):1334–9.
17. Snyder C, Paska LM, Besozzi D. Cast from the past: using screencasting in the social studies classroom. Soc Stud. 2014;105(6):310–4.
18. King's Undergraduate Medical Education in the Community (KUMEC). 2016. https://www.kcl.ac.uk/lsm/research/divisions/hscr/study/undergradops/kumec/MBBS-2020.aspx. Accessed 22 Apr 2018.
19. Kurshan B. What you should know before flipping for flipped learning. Forbes: education /#change the world. https://www.forbes.com/sites/barbarakurshan/2017/04/26/what-you-should-know-before-flipping-for-flipped-learning/#1f97e80f23cc. Accessed 6 May 2018.

20. Riddle R. In 7 unique flipped classroom models – which is right for you? https://www.panopto.com/blog/7-unique-flipped-classroom-models-right/.
21. Frydenberg M. The flipped classroom: it's got to be done right. Huffpost. The blog. https://www.huffingtonpost.com/mark-frydenberg/the-flipped-classroom-its_b_2300988.html.
22. Honeycutt B, Garrett J. Expanding the definition of a flipped learning environment. Faculty Focus. 2014. https://www.facultyfocus.com/articles/blended-flipped-learning/expanding-definition-flipped-learning-environment/.
23. Muzyk AJ, Fuller S, Jiroutek MR, Grochowski CO, Butler AC, Byron May D. Implementation of a flipped classroom model to teach psychopharmacotherapy to third-year doctor of pharmacy (PharmD) students. Pharm Educ. 2015;15(1):44–53.
24. Critz CM, Knight D. Using the flipped classroom in graduate nursing education. Nurse Educ. 2013;38(5):210–3.
25. Ferreri SP, O'Connor SK. Redesign of a large lecture course into a small-group learning course. Am J Pharm Educ. 2013;77(1):13.
26. Hawks SJ. The flipped classroom: now or never? AANA J. 2014;82(4):264–9.
27. McGowan BS, Balmer JT, Chappell K. Flipping the classroom: a data-driven model for nursing education. J Contin Educ Nurs. 2014;45(11):477–8.
28. McLaughlin JE, Griffin LM, Esserman DA, Davidson CA, Glatt DM, Roth MT, Gharkholonarehe N, Mumper RJ. Pharmacy student engagement, performance, and perception in a flipped satellite classroom. Am J Pharm Educ. 2013;77(9):196.
29. McLaughlin JE, Roth MT, Glatt DM, Gharkholonarehe N, Davidson CA, Griffin LM, Esserman DA, Mumper RJ. The flipped classroom: a course redesign to foster learning and engagement in a health professions school. Acad Med. 2014;89(2):236–43.
30. McLaughlin JE, Rhoney DH. Comparison of an interactive e-learning preparatory tool and a conventional downloadable handout used within a flipped neurologic pharmacotherapy lecture. Curr Pharm Teach Learn. 2015;7(1):12–9.
31. Simpson V, Richards E. Flipping the classroom to teach population health: increasing the relevance. Nurse Educ Pract. 2015;15(3):162–7.
32. Pierce R, Fox J. Vodcasts and active-learning exercises in a "flipped classroom" model of a renal pharmacotherapy module. Am J Pharm Educ. 2012;76(10):196.
33. Singleton JA, Nissen LM. Teaching pharmacy student show to manage effectively in a highly competitive environment. Pharm Educ. 2014;14(1):21–5.
34. Wong TH, Ip EJ, Lopes I, Rajagopalan V. Pharmacy students' performance and perceptions in a flipped teaching pilot on cardiac arrhythmias. Am J Pharm Educ. 2014;78(10):185.
35. O'Flaherty J, Phillips C. The use of flipped classrooms in higher education: a scoping review. Internet High Educ. 2015;25:85–95.
36. Young TP, Bailey CJ, Guptill M, Thorp AW, Thomas TL. The flipped classroom: a modality for mixed asynchronous and synchronous learning in a residency program. West J Emerg Med. 2014;15(7):938–44.
37. Prober CG, Khan S. Medical education reimagined: a call to action. Acad Med. 2013;88(10):1407–10.
38. Kurup V, Hersey D. The changing landscape of anesthesia education: is flipped classroom the answer? Curr Opin Anaesthesiol. 2013;26(6):726–31.
39. Chen F, Lui A, Martinelli S. A systematic review of the effectiveness of flipped classrooms in medical education. Med Educ. 2017;51:585–97.
40. Heitz C, Prusakowski M, Willis G, Franck C. Does the concept of the flipped classroom extend to the emergency medicine clinical clerkship? West J Emerg Med. 2015;16(6):851–5.
41. Belfi LM, Bartolotta RJ, Giambrone AE, Davi C, Min RJ. "Flipping" the introductory clerkship in radiology: impact on medical student performance and perceptions. Acad Radiol. 2015;22(6):794–801.
42. Tune JD, Sturek M, Basile DP. Flipped classroom model improves graduate student performance in cardiovascular, respiratory, and renal physiology. A J P Adv Physiol Educ. 2013;37(4):316–20.

43. Morton DA, Colbert-Getz JM. Measuring the impact of the flipped anatomy classroom: the importance of categorizing an assessment by Bloom's taxonomy. Anat Sci Educ. 2016. https://doi.org/10.1002/ase.1635..
44. Williams DE. The future of medical education: flipping the classroom and education technology. Ochsner J. 2016;16:14–5.
45. Freedman K, Bernstein J. Educational deficiencies in musculoskeletal medicine. J Bone Joint Surg Am. 2002;84(4):604–8.
46. Truntzer J, Lynch A, Kruse D, Prislin M. Musculoskeletal education: an assessment of the clinical confidence of medical students. Perspect Med Educ. 2014;3:238–44.
47. Goh L, Samanta A, Cavendish S, Heaney D. Rheumatology curriculum: passport to the future successful handling of the musculoskeletal burden? Rheumatology. 2004;43:1468–72.
48. Day C, Yeh A, Franko O, Ramirez M, Krupat E. Musculoskeletal medicine: an assessment of the attitudes and knowledge of medical students at Harvard Medical School. Acad Med. 2007;82(5):452–7.
49. Jonas B. Rheumatology leads the way in changing medical education. ACR conference 2016 daily news. http://www.acrdailynewslive.org/rheumatology-leads-the-way-in-changing-medical-education/.
50. El Miedany Y, El Gaafary M, El Aroussy N, Youssef S. Flipped learning: can rheumatology lead the shift in medical education? Curr Rheumatol Rev. 2018. https://doi.org/10.2174/1573397114666180416170156.
51. de Fátima Wardenski R, de Espíndola MB, Struchiner M, Giannella TR. Blended learning in biochemistry education: analysis of medical students' perceptions. Biochem Mol Biol Educ. 2012;40(4):222–8.
52. Veeramani R, Madhugiri VS, Chand P. Perception of MBBS students to "flipped class room" approach in neuroanatomy module. Anat Cell Biol. 2015;48(2):138–43.
53. Pettit RK, McCoy L, Kinney M. What millennial medical students say about flipped learning. Adv Med Educ Pract. 2017;8:487–97.
54. Johnson L. The sea change before us. Educ Rev. 2006;41:72–3.
55. Oblinger G, Oblinger J, editors. Educating the net generation. Washington, DC: Educause; 2005.
56. Admiraal W, Huizenga J, Akkerman S, Dam G. The concept of flow in collaborative game-based learning. Comput Hum Behav. 2011;27(3):1185–94.
57. Kirvan R, Rakes CR, Zamora R. Flipping an algebra classroom: analyzing, modeling, and solving systems of linear equations. Comput Sch. 2015;32(3–4):201–23.
58. Clark KR. The effects of the flipped model of instruction on student engagement and performance in the secondary mathematics classroom. J Educ Online. 2015;12(1):91–115.
59. Chao CY, Chen YT, Chuang KY. Exploring students' learning attitude and achievement in flipped learning supported computer aided design curriculum: a study in high school engineering education. Comput Appl Eng Educ. 2015;23(4):514–26.
60. Bhagat V, Haque M, Bin Abu Kakar YI, et al. Emotional maturity of medical students impacting their adult learning skills in a newly established public medical school at the east coast of Malaysian Peninsula. Adv Med Educ Pract. 2016;7:575–84.
61. Hamari J, Koivisto J, Sarsa H. Does gamification work? A literature review of empirical studies on gamification. In: 2014 47th Hawaii international conference on system sciences. IEEE; 2014. p. 3025–34.
62. Hew KF, Huang B, Chu KWS, Chiu DK. Engaging Asian students through game mechanics: findings from two experiment studies. Comput Educ. 2016;92:221–36.
63. DeSantis J, Van Curen R, Putsch J, Metzger J. Do students learn more from a flip? An exploration of the efficacy of flipped and traditional lessons. J Interact Learn Res. 2015;26(1):39–63.
64. Mazur AD, Brown B, Jacobsen M. Learning designs using flipped classroom instruction. Can J Learn Technol. 2015;41(2):1–26.