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THE FLIPPED CLASSROOM: MEDIA HYPE OR EMPIRICALLY BASED EFFECTIVENESS?

Lars-Frederik Weiß, Gunnar Friege
Leibniz University Hannover, Germany
E-mail: weiss@idmp.uni-hannover.de, friege@idmp.uni-hannover.de

Abstract

Few teaching concepts have received as much attention in recent years as the Flipped Classroom (FC). This is clearly linked to media attention on the concept, which is currently being intensified by the Corona pandemic. In this research, the media rise of the concept is explained and the discrepancy between popularity and empirically validated research results is clarified. While the literature basis for the FC has grown enormously over the last decade, reviews and initial meta-analyses have shown, through their filter criteria, that not many of studies can meet scientific standards. The comparison of individual studies is particularly difficult, because there is no uniformly accepted framework and no uniform definition of the concept. For this reason, one of the goals of this research was to give an overview of the variety of FC definitions, discuss its most controversial characteristics, and to provide the key elements for a definition of the FC. A comparison of selected studies and reviews shows an assessment of the effectiveness of the teaching concept. The findings shed light on potential problems and challenges, and provide directions for future research.

Keywords: *active learning, digitalization of education, e-learning, flipped classroom*

Introduction

The Flipped Classroom (FC) method, as a vehicle for the digitalization of education, has become a focus of digital teaching methods. Traditional learning by means of books and notes can be supplemented and supported by digital media, such as learning videos and simulations, and this is especially true for the Flipped Classroom concept. "Learning is increasingly taking place virtually, whether as e-lecture, free online course, in an inverted classroom or through learning apps" (Schmid et al., 2017, p. 5). Universities see the digitalization and implementation of "innovative" didactic concepts as solutions for problems such as heterogeneous student populations and individualized learning (Zervakis & Mooraj, 2014). With an increasing digitalized society, teaching at schools and universities is also becoming more and more digital through new didactic concepts such as the Flipped Classroom (Schmid et al., 2017, p. 50), not to mention the worldwide increase of digital learning material and methodologies in home-schooling settings and online university courses due to the Covid-19 pandemic (see Figure 1 for an increase in search interest after the recent Covid-19 outbreak). "The Flipped Classroom method (Inverted Classroom or, much less frequently, reversed teaching) has been very much present in public and scientific discussion about modern forms of teaching, including the use of digital media, for some years now" (Werner et al. 2018, p.13). Despite its increasing popularity and media attention, the effectiveness of the Flipped Classroom as a teaching concept remains debatable. In addition to this, research on the FC is still in its early stages. The present study is intended to provide an overview of the current state of research. The development and definition of the FC is discussed in detail and the related media hype is highlighted. The FC is realized in universities and in school teaching, i.e., under different organizational and curricular conditions. The differences between realizations of the FC in schools and universities is explicitly discussed. An analysis and comparison of meta-analyses

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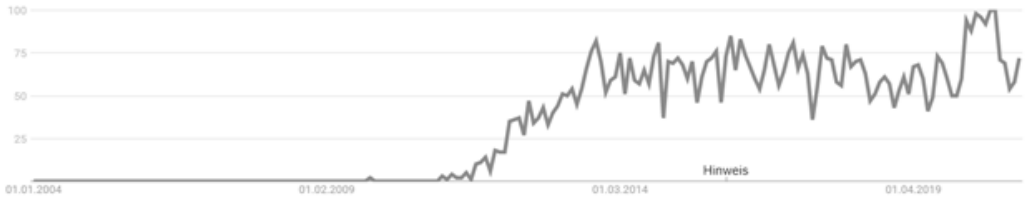
and reviews, as well as frequently cited peer-reviewed articles, provide the basis for drawing implications and conclusions for further research, teaching, and educational policies. Previous misconceptions and misunderstandings of the concepts are addressed.

Development of the Flipped Classroom – a Media Hype?

Media interest in the FC has been growing worldwide since 2012, and can be easily visualized using, for example, Google Trends (Fig.1). Google Trends is only used here to show public interest in the FC, not as a scientific method of analysis. The context in which the term was searched for remains unknown.

Figure 1
Temporal Interest in the Search Term "Flipped Classroom



Note: created with Google Trends (www.google.com/trends), status: 26.02.2021
(value 100 indicating the highest popularity)

In line with the strong growth in FC media interest, it is increasingly becoming the focus of research. "The flipped classroom is a phenomenon that is spread rapidly at schools and universities around the world, also attracting a growing body of the research" (Zupanec et al., 2018, p.136). A more scientific picture emerges from the analysis of publication figures on the subject of FC. The Web of Science lists 5292 publications on the Flipped Classroom for the period 2000-2020. The strong increase in published articles from around 2012 is striking (Table 1).

Table 1
Number of Articles Published per Year

Publication Years	Number of Records
2020	844
2019	964
2018	961
2017	997
2016	719
2015	553
2014	268
2013	90
2012	18

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Interest in the FC is substantially impacted by video portals and learning platforms, whose users multiplied from 2010 onwards. In general, there is a clear dominance of North American literature on the topic of FC. "While much of the U.S. dominance in publications could be accounted for by a general Anglo-American dominance in academic publishing, it should also be noted that the flipped classroom approach was first popularized in secondary education by two teachers, Bergmann and Sams, both of whom are active within the U.S. educational context" (Lundin et al., 2018, p. 9). A search of the Web of Science literature database confirms this, with over 1300 publications from the U.S. (https://wcs.webofknowledge.com/). The large number of newly published articles is partly due to the fact that the implementation of and research on the FC is largely based on the initiative of single lecturers and teachers. As a result, many publications are experience reports and recommendations for action, but rarely structured empirical studies with hard evidence for teaching and learning. First meta-analyses confirm the limited study situation of empirically valid research. Wagner et al. (2020) found only 33 empirical studies from 1054 on the FC that met scientific standards (period Jan. 2012 - Jan 2018). The large number of studies that have been conducted does not allow a generalizable conclusion to be drawn about the effectiveness of FC, as there is a lack of information about the control groups and the design of conventional instructions.

The concept began in 1997 with Eric Mazur's “Peer-Instruction". Walvoord and Anderson published "Effective Grading” in 1998, and the article "Inverting the Classroom: A Gateway to Creating an inclusive Learning Environment" was published in 2000 by Lage, Platt and Treglia. Broad research on the concept started 15 years later. While Mazur (1997), Walvoord and Anderson (1998) and Lage et al. (2000) focused only on university teaching, the implementation of the FC in schools started in 2007 with Bergman and Sams (in the Anglo-American sphere) (Bergmann & Sams, 2012). While the Inverted Classroom has its origins in American universities, the FC was initially established at schools. Consequently, both terms are frequently used in literature. However, the FC is the most common term for referring to concepts used in schools and universities. Regardless of the taxonomy of the concept, the rapid increase in media and research interest is striking, though as the FC is often thought of as part of the digitalization of education, this is not surprising. The boom in free video and teaching material portals (such as YouTube or Khan Academy) and the availability of digital playback devices (especially smartphones) have been making significant contributions to the popularization of the concept. According to the *Jugend, Information, (Multi-) Media* (JIM) study (2018), which examined the media usage of young people between the ages of 12 and 19, 99% of German households own smartphones, 98% own a computer/laptop, and 98% have internet access. These results are most likely comparable to other industrialized countries. However, simply watching instructional videos does not automatically mean that something fits the FC concept. Nevertheless, easy access to a large number of such videos will promote the popularity of the concept.

The FC is also being discussed intensively outside of scientific publications, using striking headlines, strong terms and claims of successful teaching (for example: *teaching innovation*). The German daily newspaper *Süddeutsche Zeitung* reported that: "Professor Bonnet abolished his lectures. Since then, his students have been performing better in exams." One of the most popular weekly magazines, Der Spiegel, states: "Cologne professor is a YouTube star", “Cologne professor of mechanical engineering uploads his lectures on YouTube. Since doing so, more people have been passing their exams." However, the daily Frankfurter Allgemeine Zeitung speaks of an "[...] online attack on teaching". The New York Times proclaims “The virtual teacher has arrived […] turning traditional education on its head.” In addition to reports in various newspapers, the personal experiences of teachers, consultants and FC coaches have been published in various internet blogs and magazines, which offer recommendations for action and often provide free video material. For example, the human resource magazine Best of

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HR-Berufsbilder reports: "How the Flipped Classroom improves learning: teaching and digital media belong together." The FC teaching innovation and similar or synonymous concepts (like Inverted Classroom or reversed teaching) are of increasing interest, and obviously associated with high expectations for scientific communities, teaching settings and in public. Although teaching settings are quite different, particularly for schools and universities, there is still a striking lack of differentiated views on these highly diverse settings.

Clarification of the FC Concept

Even if the basic concept seems easy to understand at first - outsourcing the traditional lecture content to a self-learning phase and working on cognitively demanding tasks in a presence phase instead of as homework - a look at the literature reveals a lack of clear distinction between the FC approach and traditional teaching (O'Flaherty & Phillips, 2015; Tucker, 2012).

As O'Flaherty & Phillips (2015) and Tucker (2012) state, definitions of the FC concept differ greatly. "While published research at times refers to teaching and learning approaches which could potentially be classified as FC approaches, they rarely label it as such" (Abeysekera & Dawson, 2014, p. 5). For this reason, an overview of the most common definitions was created in chronological order, providing a simple overview (see Table 2). The selected definitions are taken from review articles or peer reviewed, frequently cited articles.

Table 2
Definitions of the Flipped Classroom Concept

Definition	Reference
"An inverted (or flipped) classroom is a specific type of blended learning design that uses technology to move lectures outside the classroom and uses learning activities to move practice with concepts inside the classroom."	Strayer (2012, p.171)
"Recording in-class activities to convey a course: Students watch the video before the class and use the class time to solve complex concepts, answer questions, and students are encouraged to learn actively as well as create bonds with daily lives."	Stone (2012, p. 405)
"We define the flipped classroom as an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom."	Bishop & Verleger (2013, p.9)
"pedagogical approaches that: 1. move most information-transmission teaching out of class; 2. use class time for learning activities that are active and social; and 3. require students to complete pre- and/or post-class activities to fully benefit from in class work."	Abeysekera & Dawson (2014, p.4)
"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."	Association of Flipped Learning Network (2014, p.1); Bergmann & Sams (2014, p.14)
"In short, the flipped classroom is a pedagogical approach which moves the learning contents taught by teachers' direct instruction to the time before class in order to increase the chances for the students and teacher to interact. Therefore, teachers would have more time to guide the learning activities and solve students' problems in order to promote the learning effects."	Hwang et al. (2015, p.452)
"Flipped Learning is a framework that enables educators to reach every student. The Flipped approach inverts the traditional classroom model by introducing course concepts before class, allowing educators to use class time to guide each student through active, practical, innovative applications of the course principles."	ALAAS (2018)

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While all the definitions suggest that knowledge transfer should be separated from the actual classroom into self-learning phases, and that the time which has now been freed up should be used for active learning, opinions are divided on the use of media for knowledge transfer: "Although some definitions of the flipped classroom approach require video lectures [...], others provide a broader approach" (Wood et al., 2016, p. 4). Bishop and Verleger (2013) exclude articles in their review that do not use video as a medium for imparting knowledge during the self-learning phase and instead make use of other media, emphasizing how videos are a dominant component of the FC. "We restrict this definition by excluding designs that do not employ videos as an outside of the classroom activity. While a broad conception of the FC may be useful, definitions that become too broad suggest that assigning reading outside of class and having discussions in class constitutes the flipped classroom" (Bishop & Verleger, 2013, p. 5). They legitimize the restrictions of their definition, among other things, by learners rarely reading texts conscientiously. This means that the effectiveness of reading tasks for preparation would not reflect their FC definition (see Table 2). However, it should be noted that the absorption of information from videos would often be superficial or incidental. "Thus, self-study in the non-school classroom runs the risk of being ineffective" (Fischer & Spannagel, 2012, p. 238). The digitalization of knowledge transfer through videos could therefore lead to teachers focusing on the selection and creation of videos - which should certainly be done to a certain extent - but neglecting the actual planning of classroom teaching, with its activating elements.

> "Use of video as the prime means of direct instruction has resulted in an emphasis on the effectiveness of video production and delivery, with the teacher or school selecting videos rather than considering the broader range of direct teaching methods in a traditional classroom." (Sharples, 2014, p. 16)

Werner et al. (2018) also point out that learners need guidance in working with videos as learning tools, ensuring an active and sustainable use of the material provided. They further state that "[...] the fact that children and young people use digital devices on a daily basis in their leisure time does not mean that they use digital media in learning contexts without problems" (Werner et al., 2018, p. 61).

At this point, it does not seem conclusive to delimit the FC primarily by means of the medium used during the self-learning phase. Such a definition excludes all teaching approaches which do not use videos but in principle correspond to the core FC concept. Consequently, there are definitions that are restrictive to varying degrees. Some definitions define the FC through technology and video lectures, and thus propagate the FC as new and innovative. On the other hand, there are more open definitions that allow teaching concepts that may have been practiced for several decades to be considered FC. According to Strayer (2012), the FC belongs to the super-category of e-learning, i.e. electronically supported learning. It can be seen as a special form of blended learning. Unlike traditional blended learning, conceptual knowledge and facts are almost exclusively learned in a self-learning phase, which precedes the application of what has been learned in the presence phase in an FC setting. In traditional blended learning, knowledge transfer takes place both through e-learning and in traditional lectures (O'Flaherty & Phillips, 2015; Baumgartner, 2011). Unlike Strayer (2012), both Ozdamli and Asiksoy (2016) and He (2016) stressed that the FC was not to be understood as simply watching online videos. The focus is much more on interactive activities during lessons and face-to-face time with teachers. It is noticeable that early definitions regard the FC as e-learning (Bishop & Verleger, 2013; Stone, 2012; Strayer, 2012) while later ones (Abeysekera & Dawson, 2014) have expanded upon this, making e-learning no longer a necessary prerequisite for the FC concept. In an attempt to summarize the various definitions into an overview of core constituents, Lo (2018) has assumed the following elements to be essential for the FC:

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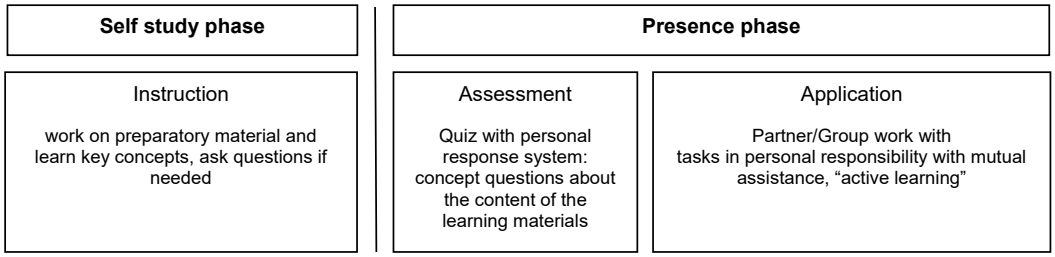
1. Out-of-class, individualized, computer-based instruction, focusing on information-transmission teaching.
2. In-class, interactive group learning activities that emphasize peer-assisted learning and problem solving.

In accordance with Lo (2018), Finkenberg (2018) visualizes a basic form of the FC, which is to be understood as the "lowest common denominator" of various forms of implementation. The presence phase is divided into assessment and application.

Figure 2
Adapted Basic Form of the Flipped Classroom, in the Style of Finkenberg (2018)



While Lo (2018) has focused on computer-based instruction, a more open approach like Finkenberg's (2018) - though restricted by an assessment phase – seems to be the most appropriate. The concept of the FC should not be defined by the supporting medium, but by the phasing of teaching and learner activation, as well as by the role shift of teachers and learners away from traditional teaching. The FC concept can thus be seen as a synthesis of various pedagogical approaches that shift the transfer of knowledge from classroom to self-learning phases, shape classroom time through active learning and require students to work independently or in a self-regulated manner (Abeysekera & Dawson, 2014; Al-Zahrani, 2015; Strayer, 2012).

Based on the discussion and theory of FC, the following definition is proposed: The Flipped Classroom is a form of teaching in which students prepare for the actual lesson asynchronously and independently in a self-study phase, using materials provided by the teacher. The self-learning phase is supplemented by a subsequent presence phase, in which the acquired knowledge is examined, applied and developed in a student-centered manner. The teacher acts as a learning guide, who creates the learning environment for the successful consolidation of knowledge.

Differences between the FC and Conventional Teaching

> “A judgement about the learning effectiveness of the Flipped Classroom must be based on the lessons it is compared to. The term "traditional teaching" is diffuse and in many studies it refers to different forms of teaching - from the classical lecture without any activity of the learners to question-developing lessons that can be designed with a high degree of student activity.” (Finkenberg, 2018, p. 24)

In the FC literature, traditional teaching (if described at all) is primarily understood as the passive reception of knowledge during a teaching period (cf. Bishop & Verleger, 2013). The passive reception of knowledge describes a frequently held idea about learning. Pupils "[...] generally see learning as the simple transfer and storage of knowledge [...]. Their learning behavior in class is correspondingly 'passive'" (Kircher, 2015). Likewise, a similar manner of thinking can be observed in many teachers: "[...] the view that knowledge can be passed on

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(transported to the student) dominates" (Kircher, 2015, p. 662). Furthermore, the independent processing of exercises outside of class, mostly in the form of homework, is a typical component in teaching defined as traditional. The same applies to teaching at universities. In such settings, traditional teaching is understood as the passive acquisition of knowledge within the framework of lectures. Exercise groups, in which tasks that were typically worked on at home before being checked in class, are another passive element of traditional university teaching, especially in physics and mathematics.

The role of the teacher also differs between the FC approach and teaching with other concepts that are not structured according to the basic FC concept (see Figure 2). This means that they do not distinguish between an asynchronous self-learning phase and a synchronous presence phase. While a fear of the FC making the physical presence of teachers superficial exists – since students would eventually acquire the knowledge without the presence of a teacher – this fear is countered by a shift in the role of the teacher during a presence phase of the FC concept.

> "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." (Jensen et al., 2015, p. 2)

The role of the lecturer is changing dramatically, especially in the university environment. While the conventional role of the lecturer is characterized mainly by lectures with little student activity, the presence phase of the FC now demands a more complex didactic embedding of the teaching content, in which the focus is on student activity. Content knowledge and the knowledge of methodology and didactics are required to facilitate a suitable learning environment. The transfer of knowledge and its application and consolidation now play a crucial role for the lecturer. Intensive and broad preparation is also necessary on the part of the lecturers, as the presence phase invites students to ask questions, even beyond the core content of the individual subject areas.

A change in roles can also be observed in school contexts, albeit less drastically than in university settings. In the FC concept, the teacher is responsible for providing materials that allow students to prepare for the actual lesson in a self-regulated manner, since the mere transfer of knowledge is outsourced from the classroom (Lankford, 2013). As before, the teacher must design a learning environment in which knowledge can be applied and developed, and on a more individual basis in the FC. The activities of students and the use of cooperative forms of learning require the teacher to carefully examine the learning group and the learning situation. Here, the importance of the teacher in the FC concept again becomes clear. "This may be contrary to the belief of many that the teacher becomes less important when introducing videos as a lecturing component" (Fredriksen, 2020, p. 393). The teacher accompanies the learners as they work with more complex tasks, while the students carry out the less cognitively demanding acquisition of the largely declarative knowledge in a self-organized, individual, and asynchronous manner (Gilboy et al., 2015).

Not only are the roles of university lecturers and teachers changing, but also those of students and learners. While university students should already be well-trained to acquire knowledge in a self-regulated fashion and to adapt it to their individual learning behavior, this poses a far greater challenge for students — again, it becomes clear how central the role of the teacher in the selection and provision of materials is. In the presence phases, students are now confronted with cooperative forms of learning and a good number of activities. In the STEM

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subjects, traditional teaching instead relies on the independent calculation of exercises without didactic and methodological embedding. This can make working with fellow students in group work and different and new student-centered methods a challenge. Furthermore, the modular and more flexible structure of courses can also lead to difficulties in organizing learning.

As can be seen from the overview of definitions (Table 2), the definition of the seemingly simple structure of the FC is anything but trivial. A change to a more open definition, where an FC concept is possible without an e-learning component, is considered reasonable. A differentiation to conventional teaching is difficult to make, because conventional teaching varies greatly between teachers, lecturers, schools and universities. Nevertheless, a differentiation through role shifts of teachers and students seems to be a good and concise distinguishing feature.

Research Methodology

There have already been some meta-analyses and reviews on the topic of FC, with different focuses following strict guidelines (such as PRISMA). Instead of a further meta-analysis according to these guidelines, existing meta-analyses and reviews will be used to form the foundation of the present literature review. As mentioned earlier, only a few articles have met scientific standards, since most of the extensive literature on FC is based on individual reports and recommendations for action. In this study, the reviews and meta-analyses were used to contrast frequently cited studies. Field reports, recommendations for action and non-peer-reviewed articles were not included in the discussion of the current state of research. The citation index, impact factors and cross referencing were consulted, in order to identify frequently cited and popular studies that have significantly shaped the state of research and opinions on FC. The Web of Science and Google Scholar were mostly used to screen and filter studies. As a prerequisite for inclusion in the research findings (Table 3), studies must compare the FC approach to a non-FC approach and must have been conducted in a STEM subject. The 26 articles listed were read and analyzed in detail. Information about the test instruments, the subject area of the study, the constructs examined and the effect sizes of significant results were highlighted.

Research Results

Apart from a contradictory definitions of the FC, previous research has also provided mixed results and has largely been limited to research based on the initiative of individual lecturers, using questionnaires to evaluate students' attitudes towards the new concept or to compare it to the traditional teaching format (Blair et al., 2016; Mason et al., 2013; Newmann et al., 2016; Strayer, 2012; Teo et al., 2014; Thai et al., 2017). Research on the FC is almost exclusively limited to university teaching, with research in the Anglo-American sphere dominating. Despite an enormous growth in literature (especially in the last two years and even outside the USA), "the Flipped Classroom still has exotic status in the German university system, but especially in the German school system" (Finkenberg, 2018, p.40). According to this, didactic research on the FC is the exception in the German (and, most probably, the whole European) language area. One such example is "Flip your Class!", which examines the implementation of the FC at three schools in Berlin, and another is the "Flipped Classroom" project, with 28 pilot schools in the state of Schleswig-Holstein. The studies suggest that the integration of digital videos in the classroom is suitable for learning with students. However, the study's approaches do not represent an FC in accordance with the definitions presented. The evaluation of the "Flipped Classroom" project is limited to written feedback from individual schools, which report on the increased motivation of learners (Ministry of Education and Vocational Training, 2017). The accompanying research is to include a survey of learners and

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teachers, but a more detailed evaluation of the project has not yet been published. The results of the data collection by means of expert interviews, student observations and surveys of the "Flip your Class!" in Werner et al. (2018) must be critically questioned. Especially since the implementations do not correspond to the common definitions of the FC, no conclusions should be drawn about its effect at this point. Furthermore, the data collection and evaluation in the Flipped Classroom project is not transparent. A further investigation of the FC in schools was conducted by Finkenberg (2018). A study examining the FC in the physics lessons of an upper secondary school of 151 students found a significantly better learning performance in the FC group, with medium strength effects (see Table 3). Furthermore, a significant increase in the physics-related self-concept in the treatment group (FC) was observed. Finkenberg's study can be seen as evidence of the effectiveness of the FC in school physics lessons.

A large number of previous studies have been conducted in the STEM field. Because the processing of authentic, practice-oriented problems requires knowledge of a multitude of laws and concepts which must be mastered before they can be applied to such problems, "many STEM subjects contain an abundance of principles and (seemingly) abstract concepts which students need to 'know' before being able to move on to more practical, authentic applications" (Huber & Werner, 2016, p.267). These concepts and laws, which form a basis for practical applications and problems, could be transferred particularly well into the self-learning phases of the FC concept.

In the following, an in-depth overview of publications from the STEM sector will be given. Only studies that have been published in peer-reviewed sources that meet scientific standards and were published after 2012 are listed. Furthermore, the selected articles meet the Flipped Learning Network's definition of the FC (Table 2). For this reason, conference proceedings and conference contributions were not included in the overview. A review of previously published studies - also from the field of medicine - can be found in the review by Bishop and Verleger (2013), which is discussed later. In addition to the constructs examined, the overview also lists the effect size and any significant results. In some cases, no effect sizes were published. In such cases they were calculated retrospectively, provided that sufficient parameters were available for the calculation and underlined in Table 3. The test instrument used for data collection was also listed. Test results from self-developed tests were compared. These are marked as "self-developed". All the studies compared the FC approach to conventional teaching and were classed as effective, making no difference, or less effective. The vast majority of these studies examined the learning gains after implementing the FC approach. Few of the studies examined any other affective constructs of the study participants.

Table 3

*Findings of Peer-Reviewed Studies Comparing the Flipped Classroom and Traditional Teaching in the STEM-Field (*marks statistical significance, __ marks calculation by authors)*

Findings	Source	IC	ES	Field of Teaching	Test Instrument
FC more effektive	Amresh, Carberry &Femiani (2013)	Learning gain Computing self-efficacy*	d=1.12	University Engineering (introductory programming course)	Pre-Post surveys, Exam Scores (self-developed)
	Mason, Shuman, and Cook (2013)	Learning gain* (only on certain items)	NA	University Engineering (mechanical engineering)	Exam scores (self-developed)
	McGivney-Burelle and Xue (2013)	Student's perception on teaching	NA	University Physics (calculus)	Surveys and Interviews

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	Wilson (2013)	Learning gain*	d=.57	University Statistics course	Exam scores (self-developed)
	Talbert (2014)	Student's perception (>70% preferred FC)	NA	University Math (Linear Algebra I)	Case Studies
	Beapler, Walker & Driessen (2014)	Engagement* Flexibility* Confidence* Learning outcomes* Effective use*	d=1.05 d=.38 d=.78 d=.38 d=.41	University Chemistry	Perception surveys (Whiteside et al 2010; Walker et al 2011)
	Chao, Chen & Chuang (2015)	Learning gain* learning attitudes, motivation and self-evaluation	d=.79	High School (11th grade Engineering)	Pre-Post Tests (self-developed)
	Chiang & Wang (2015)	interest in cooperative learning, engagement, self-directed, self-regulating, and self-determined skills	NA	University Engineering	College and University Classroom Environment Inventory (CUCEI)
	Wassermann et al. (2015)	Learning gains* In-class communication*	η_p=.04 d=1.39	University Math (Calculus III)	Exam Scores and survey (self-developed)
	Atwa, Rosseni & Hussin (2016)	Learning gains*	d=.47	High-School Physics (11th grade)	Physics Achievement Test (PAT) (self-developed)
	Sun & Wu (2016)	Learning gains*, Student-teacher interactions	η_p=.06	University Physics	Exam scores Survey (Sun, Shih & Wang (2007)
	Şengel (2016)	Learning gains*	d=0.57	University Physics	Exam scores (self-developed) Exam scores (self-developed
	Heuett (2017)	Learning gains*	NA	University Math (non-math majors)	Exam scores (self-developed)
	Adams & Dove (2017)	Learning gains*, Perception of learning	r=.5	University Math (Calculus and Analytic Geometry I)	Pre-Post Tests (self-developed)
	Finkenberg (2018)	Learning gains* Self-concept in Physics*	η_p=.06 η_p=.03	High School Physics (11th grade)	Pisa-2015 Items (ST130)
	Eldy, Elnetthra (2019)	Learning gains*	NA	Pre-University (Mechanics and	Pre-Post Tests (self-developed)
	Tolks et al. (2016)	Learning gains*	η_p=.06	Thermal Physics) University Physics	Pre-Post Tests (self-developed)
	Wei et al. (2020)	Learning performance*	NA	Middle School Math	Pre-Post Tests (self-developed)
No difference	Mason, Shuman, and Cook (2013)	Student's perception of teaching	NA	University Engineering (mechanical engineering)	Surveys

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	McGivney-Burelle and Xue (2013)	Learning gains	NA	University Physics (calculus)	Exam scores (self-developed)
	Davis et al. (2013)	Learning gains, Student's perception of the course	NA	college-level information systems spreadsheet course	Pre-Post Tests Surveys (self-developed)
	Baepler, Walker & Driessen (2014)	Learning gains	NA	University Chemistry	MC examination (GC08C by ASC) and exam (self-developed)
	Velegol et al. (2015)	Learning gains Student's metacognition	NA	University Engineering (environmental Engineering)	Pre-Post Tests MSLQ Survey
	Yong et al. (2015)	Learning gains	NA	University Math	EMCS (Singh & Rosengrant 2003) Exam scores
	Limueco & Prudente (2019)	Learning gains	NA	High School Teaching (9th grade)	(self-developed)
FC less effective	Gundlach et al. (2015)	Learning gains	NA	University Statistical Literacy Class	Exam scores (self-developed)

Note. FC = Flipped Classroom, ES = effect size, IC = investigated construct

Even if the overview classifies a large number of studies as more effective, the significance of the individual studies remains limited. The design of the FC varies greatly between individual studies. Furthermore, the definition of the previous conventional teaching remains fairly unclear. As the discussion of the various attempts at defining the FC has already shown, the concept can be used in a wide variety of ways. Therefore, a comparison of the effectiveness only seems to make sense if the framework conditions are transparent and easily comprehensible. In their review, Bishop and Verleger (2013) criticized the unclear framework conditions, especially with regard to the didactic design of the attendance phases. 24 published articles met the requirements of the restrictive definitions of Bishop and Verleger (2018), while eleven studies did not meet these requirements. They state that perception of the concept tends to be positive in the reviews studied, but one group of students described the FC approach very negatively: "Despite differences among studies, general reports of student perceptions were relatively consistent. Opinions tended to be positive, but there were invariably a few students who strongly disliked the change" (Bishop & Verleger, 2018).

The "Monitor Digitale Bildung. Die Hochschulen im digitalen Zeitalter" (2017) showed that 64% of students in Germany already used videos for private learning. "Beyond Millennials: The Next Generation of Learners" (2018) showed that 59% of students aged 14-23 voted YouTube as their preferred medium of learning, ranked it more highly than in-person group work. At this point, it has to be again made clear that videos can differ greatly. The quality and nature of videos varies as much as the implementation and design of the attendance phases. Two of the studies evaluated the performance of the students and found significantly higher scores in exam questions related to the material conveyed in the videos (Moravec et al. 2010). Day and Foley found that students scored significantly better on homework, tests and projects. However, neither conventional teaching nor the implementation of the FC are discussed in detail. The assumption that the provision of video recordings would mean students would no longer participate in classroom events and that direct exchange with the teacher would become superfluous, often expressed in the context of the FC, cannot be confirmed (Stone 2012). More

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precise results are not given. However, it is also stated that students prefer "live in-person lectures" to video lectures. This is a result which is not discussed further in the Bishop and Verleger review (2013), but at first is very surprising.

The very limited number of studies conducted in a school setting is also striking. Only five of the 26 studies listed examined the FC in a school setting, though most of them were able to demonstrate significant improvements in learning groups. Even after the publication of Bishop and Verleger (2013), the focus of FC research was centered on university environments rather than schools (see Table 2).

Even if the comparability between the studies is only guaranteed to a limited extent, some advantages and disadvantages of the FC can be determined from the practical examples. Karabulut-Ilgu et al. (2017) mentioned flexibility as the most frequent advantage in a large number of studies (e.g. Buechler et al., 2014; Kiat & Kwot, 2014; Mok, 2014; Simpson et al., 2003; Velegol et al., 2015). Particularly from the perspective of the learners, the permanent access to instructional materials enables flexible design in the self-learning phase. This allows for an individual phase of knowledge acquisition adapted to the learner's own learning type. This also includes the possibility of varying the playback speed of videos or repeating individual passages. Videos often act as substitutes for reading. The flexible outsourcing of knowledge transfer can generate scope for working on more complex tasks during the attendance phases (O'Flaherty & Phillips, 2015), allowing for more peer interaction time. Learners particularly appreciated working with their peers and the role of the teacher as coach or learning guide. Karabulut-Ilgu et al. (2017) also point out that some studies argue in favor of the FC, as this approach promotes learners in skills such as life-long-learning (Luster-Teasley et al., 2014), learner autonomy (Kim et al., 2014; Mok, 2014), critical thinking (Chetcuti et al., 2014) and interpersonal skills (Yelamarthi et al., 2015). Another advantage of the FC approach is the commitment of the learners. In a number of studies (see e.g. Karabulut-Ilgu et al., 2017), it has been observed that learners are better prepared for classroom instruction (Chetcuti et al., 2014; Jungic et al., 2015; Mok, 2014; Popadopoulos & Roman, 2010) than they are with conventional teaching approaches. Werner et al. (2018) found that the FC offers more opportunities for differentiation, and that students allocate their time much more effectively. "The former was implemented, among other things, through tasks with different levels of requirements, competence checks, interview results and additional tasks for faster or more capable children and adolescents with different roles (e.g. listener and assistant) in group work" (Werner et al., 2018, p. 58-59).

Despite the many potential advantages that are strongly dependent on the individual implementation of the FC concept, it should not be overlooked that a significantly higher workload for teachers, especially before and during the lessons, is sometimes seen as the greatest challenge (Clark et al., 2014; Ghadiri et al., 2014; Kalavally et al., 2014). This is due to the increased time required for the preparation and selection of materials for the self-study phase, and also for the individual support of each learner during the presence phase and the methodological and didactic design of the latter. While there is already an abundance of learning videos from third party providers at school level, videos for special topics at a university level often have to be produced by the lecturer. However, if videos that were produced for the self-study phase can be used again in subsequent years, the time required for preparation on the part of the teachers and lecturers is considerably reduced. Learners often complain about technical problems, such as internet connection speeds (Everett et al., 2014). Observations have shown that technical problems often occur due to a lack of equipment or non-functioning school servers (Werner et al., 2018). Furthermore, it becomes clear that learners are often overwhelmed by the higher responsibility associated with self-organized learning (Margoniner, 2014; Werner et al., 2018). Therefore, a comprehensive introduction to the method is particularly important. An introduction to the teaching methods should make the requirements and the process transparent

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to learners. Learning with videos, if they are to be used, should also be something for which training is done in advance. This problem can be applied to universities and schools alike. For example, self-regulated learning is less of a problem in universities than in schools, but the break with conventional teaching - especially in advanced semesters - often brings about new problems. As explained in the role shift, lecturers at universities also need to be trained to use the FC in an active way during the presence phases. The most significant advantages and disadvantages from the research are shown in Table 4.

Table 4

Most Prominent Advantages and Disadvantages in the Flipped Classroom Literature

Advantages	Disadvantages
Learners can perform better (see Table 3)	Success of the method depends heavily on learner's preparation during the self-study phase (Karanicolas et al., 2016)
Learners can learn at their own pace (e.g. watch videos several times) (Nouri, 2016)	Mandatory internet connection and playback media (Clemens et al 2013; Everett et al., 2014)
Learners work on cognitively more demanding tasks while being supervised (Lee & Lai, 2017)	Learners are often overwhelmed with new approaches (Amresh et al. 2013; Bland, 2016)
Teachers are more flexible in class (Bergmann & Sams, 2014)	Learners have problems organizing themselves within the FC (Margoniner, 2014)
Mostly positive perception of the FC by learners (Bishop & Verleger, 2013)	Increased workload, especially on forehand (Ghadiri et al., 2014; Kalavally et al., 2014)
Video material can be used several times	

Insights gained from research into the FC approach make it clear that a theoretical framework for a uniform design and implementation is still lacking. The basic form of the Flipped Classroom, based on Finkenberg (2018), offers one possibility for unifying the design. Subject didactics are only involved in the planning, implementation and evaluation of the FC, both at the university level and in a school context, in exceptional cases. This is particularly evident in the didactic design of the self-learning and presence phases. Learning objectives, methods chosen and material used remain unmentioned in most studies.

However, transparency regarding the design of the attendance phases is a prerequisite for being able to make statements about the effectiveness of the FC, since the success of the concept, like the success of traditional teaching, depends largely on lesson planning (Lee & Lai, 2017). Freeman et al. (2014) have already shown that learners perform better in the natural sciences if they are involved in various active learning tasks, i.e. problem solving in groups, personal response systems and workshops.

The positive results for the effectiveness of the FC when compared to conventional teaching from the listed studies may be due to the "active learning" of the students. This hypothesis was tested by Jensen et al. (2015) in a study comparing the FC approach to traditional but active learning university teaching. "Results show that the benefits of the flipped model over a non flipped active-learning model are insignificant [...] when holding all other variables constant" (Jensen et al., 2015, p.10). In their conclusion, Jensen et al. (2015) stressed that the additional expenditure for the implementation of a FC would not provide significant added value if the students were to participate in lessons which were already designed through active learning. Nevertheless, apart from missing evidence to support this claim further, the FC concept is a possibility for putting the active learning of students into the focus of the learning activities. Young et al. (2015) came to a similar conclusion. They compared the performance of students after one semester using pre- and post-tests in a control group design for an introductory course to differential calculus, and found no significant differences between the groups. They also pointed out that the general conditions and the method of implementation are crucial for the

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success of the Flipped Classroom. "Therefore, it is possible that as we improve our instructional methods in the flipped classes, we may see statistically significant differences in student learning and attitudes." (Yong & Lape, 2015, p. 919) Furthermore, they point out that more research is needed to determine under which conditions and in which contexts the FC approach will yield the best results for as many learners as possible.

The different ways of implementing the FC approach, or rather the lack of a common framework for its use, quickly became the focus of AALAS— an association of 100 teachers and lecturers that developed a framework for the FC— which founded a "Global Standards Project" to counteract the problem (https://aalasinternational.org). "The Global Standards Project offers a framework and benchmarks to enable Flipped Learning practitioners to access and employ the most current international best practices" (AALAS, 2018). The result of the project is reflected in 187 "best practices", including "understand each student's cognitive needs", "promote collaborative and group work", "explain to students how they can become effective Flipped Leaners". According to this, the goal of the Global Standard Project is to create global standards for teaching according to the FC approach. To what extent 187 very general "best practices" offer a framework for implementing the FC or embody much more general recommendations for teaching remains questionable. Many of the best practices can be used for both flipped and traditional lessons. The important distinction between traditional teaching and FC remains blurred. Furthermore, the best practices do not standardize the implementation of the approach. 187 different recommendations do not allow a clear, guided and structured implementation, but rather apply to all possible forms of implementation, regardless of the chosen teaching methodology.

In summary, it can be said that there is some evidence to support the effectiveness of the FC (see Table 3). A significant amount of research has been carried out, especially in the university sector. Research in the school sector is still very limited. Nevertheless, there is also some positive evidence. While many studies examine the learning gains of students, empirical scientific research of affective characteristics of learners (beyond reporting impressions and experiences such as motivation and interest) is lacking.

Research in Schools and Universities

While research has progressed in recent years, it should be emphasized how FC approaches differ between universities and schools. Results from more advanced research in university teaching cannot be transferred to the school context. Compared to university teaching, its implementation in schools requires different framework conditions, starting with the timing of lessons and moving on to the ability to organize learning independently. The structural framework between universities and schools change, as well as the potential problem areas. There is a tendency for most learners to evaluate university teaching based on the FC concept more positively than conventional teaching. Nevertheless, there is often a group of students who reject the FC, or rate it very poorly. They prefer normal lectures with face-to-face contact to the lecturer (Bishop & Verleger, 2013; Yong, 2015). However, differences in the perception of different groups of students are also conceivable. For example, the question arises as to what extent pre-service teachers perceive the approach compared to students that do not want to become teachers, especially in the natural sciences, where the traditional approach of practice groups differs significantly from the idea of presence phases in the FC. Here, the methodical and didactic design of the presence phase may offer incentives for teaching that can later be designed by the students themselves, and could be of particular interest to pre-service teachers.

In the school context, there is a one problem group in particular: weaker learners seem to have problems with self-organizing their learning. Last but not least, it should be noted that the

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Flipped Classroom method places great demands on independent learning - which means that there is a risk that weaker students will be disadvantaged (see Werner et al., 2018).

Discussion

The number of teachers and lecturers implementing the FC is continuously growing. The FC is also gaining media attention, though solid empirical evidence remains a rarity. The Covid-19 pandemic in particular has further boosted the already high level of media attention (see Figure 1). The limitations of normal school and university operations during the pandemic make it necessary to implement digital alternatives, including the FC. “This crisis also represents an opportunity for the universities, because they are sounding out what can be done digitally and are already successfully implementing many things" (Alt, President of the German Rectors' Conference). However, schools are struggling with the fast implementation of digital teaching alternatives. The newspaper Der Spiegel reports that “Students consider a lack of digitization as a 'most urgent problem’”. At the same time, traditional lectures are the focus of media criticism. If one believes international journals, traditional lectures could be replaced by online alternatives, even after the pandemic. For example, the New York Times states: “Don’t Kid Yourself: Online Lectures Are Here to Stay”, while the Guardian speaks of “‘The Netflixisation of academia’” and asks “is this the end for university lectures?”

While some progress has been made in the field of university teaching, evidence supporting the effectiveness of the FC in school settings is still lacking, as shown in Table 3. However, it is these studies that allow teaching according to the idea of evidence-based teaching, an educational practice based on the results of well-designed scientific studies. The implementation and research of the FC approach is, however, often based on the initiative of individual teachers and lecturers, leading to a lack of distinction between traditional lectures, exercises and the innovations that come with the FC. Unclear structures, the hybridization of FC approaches and traditional teaching make it difficult to classify previous evaluation results and field reports. While the efforts of individual teachers are to be emphasized positively, the evaluation of these efforts usually falls short of scientific standards (see Schmid, 2017, p. 6).

A lack of evidence and vague definitions are not a shortcoming of the FC concept, but rather a characteristic of research in a new field. The development of a new field is mainly characterized by the gathering of different experiences and research. Further research is needed to further sharpen definitions and support initial results with additional evidence. Adding to this, studies are still difficult to interpret, as there is often no clear indication of methods, teaching content or timing. It is hardly possible to classify the extent to which different settings implement active learning in their respective FC. In future studies, it will be necessary to clarify what was treated and discussed in the FC, how it was done and what methods were used. In addition to the description of the content components, it is important that future studies are more transparent, so that measuring instruments and evaluation procedures become more comprehensible. “This will allow us to identify which aspects, technologies and concepts of the flipped classroom work better than others, and to form best practices, providing a springboard for other scholars” (Sampson et al., 2018, p. 41).

Overall, only a precise and didactic description of the design, implementation and evaluation of the FC allows statements about the effectiveness of the concept and its components to be contrasted with traditional teaching.

> “Commonly, the flipped classroom approach is taken for granted as effective in improving student learning, and the experimental setting or flipped classroom approach used is not fully described. To conclude, rigorous and empirically well-grounded studies currently seem to be rare in the research on flipped classrooms. Very few studies can make generalizable or transferrable knowledge claims

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> and thereby contribute to the development of the field of interest around flipped classrooms." (Lundin et al., 2018, p.14)

Studies that assess the affective characteristics of learners by using validated items and comparing them with traditional teaching continue to form a research gap. An investigation of learning gains by means of control group studies has become the focus of research in recent years, producing positive initial results. Here, too, replication and further research in various disciplines would be desirable (especially in school settings) to strengthen trust in the FC approach.

Conclusions and Implications

The present research has shown that the unclear structures and attempts at implementing the FC are reflected in vague definitions of it (see Table 2). It has been seen that, over the developmental course of the FC, these have changed considerably. While early definitions highlighted e-learning and video-based learning in the self-learning phase as being core elements, later definitions opened this up further. In order to create a comparable basis between the implementation approaches and results of studies, the question of a satisfactory definition must be fully clarified. An overly broad definition makes it difficult to compare studies and implementation attempts. On the other hand, a narrow definition excludes promising approaches that follow the core concepts of the FC. Therefore, it does not necessarily make sense to define the FC via e-learning. Even if video learning can be integrated into an FC approach well, it should not become its defining element. A move towards an open definition and a basic form (see Figure 2) seems justified. The proposed definition of the FC does not limit the transfer of knowledge to a specific medium. In a synchronous presence phase, content from the self-learning phase is developed and consolidated by collaborative and student-centered methods, under the supervision of the teacher or lecturer.

The study's findings suggest that the FC has not been sufficiently researched in schools to make clear conclusions about its mode of action and effectiveness. Reviews and meta-analyses have shown that only a few publications have met scientific standards, although the literature base has grown considerably in the last decade. While there is much debate around the self-learning phase, the research and discussion around face-to-face instruction in the FC falls short. Statements about materials used, lesson designs and subject areas would make it easier to compare studies and draw more concrete conclusions. It has been shown that the media attention surrounding the concept and its increasingly frequent implementation as a teaching method would imply a different, empirically validated state of research. A variety of studies provide contrasting results. Replication studies and strongly controlled studies are needed to assess the effectiveness of the concept in more detail.

Although methodologically varied teaching is highly desirable, lecturers and teachers should not fall back on the concept just because it is currently being hyped by the media. The FC can contribute to varied teaching and provide an excellent framework for the use of digital media and cooperative forms of learning. However, it should be noted that FC use alone does not easily solve student challenges and problems. They are instead presented with new challenges, such as self-organized learning. Social injustices that make learning at home more difficult and thus have a negative impact on students' performance should also be considered, especially in the FC. For example, care should be taken to ensure that students are given the opportunity to prepare for lessons in self-study phases at school. Overall, the analysis of previous research suggests that the FC should be seen as a supplement to traditional instruction. The potential of FC and the research gaps identified make the FC an attractive field of research which remains in need of further development.

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Lars-Frederik Weiß *(Corresponding author)*	MEd, Scientific Assistant & PhD Student, Leibniz University Hannover, Welfengarten 1A, 30167 Hannover, Germany. E-mail: weiss@idmp.uni-hannover.de ORCID: https://orcid.org/0000-0001-6686-8855
Gunnar Friege	Professor, Leibniz University Hannover, Welfengarten 1A, 30167 Hannover, Germany. E-mail: friege@idmp.uni-hannover.de ORCID: https://orcid.org/0000-0003-3878-9230