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Integration of ICT in Flipped Classroom Physics Learning: Systematic Review

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Abstract. The integration of technology in classroom learning has become a common trend among educators. The use of technology in LMS, video conferencing, and others that are integrated with the learning process is very important. This review aims to analyze the integration of models and learning media in a flipped classroom for learning physics. The method used is a systematic review. The data was collected on an academic database, namely Scopus with the help of the Harzing's Publish or Perish application using the keyword "Flipped". The analysis sample used is articles about learning Flipped Classroom as many as 1614 articles published in 2011-2021. Based on the six inclusion criteria, the articles analyzed were 20 articles. The instrument used is a coding sheet that summarizes the data and information of the article.
The results show that the flipped classroom can use various media, in the form of videos, quizzes, LMS, online textbooks, blogs, discussion groups, Facebook groups, quizzes, LMS, PDF materials, PPT materials, Phet simulation, or in web form. The most commonly used media are videos, quizzes and LMS. In general, the use of media in flipped classrooms has been effective, but there are things that need to be considered in making media, including: 1) Making videos with shorter durations, 2) showing more video examples, 3) videos linked to the YouTube platform are good in LMS or independently, 4) Requires class guidance and agreement so that the use of media is effective.

Keywords: Systematic Review; Flipped Classroom; Physics Learning; media integration

INTRODUCTION

Understanding reverse classes is very easy. Flipped classroom learning is doing things that are usually done in class and can be done at home (Arnold-Garza, 2014; Bergmann & Sams A, 2011; Li & Yuan, 2018). Students are given the task of understanding learning materials using various media before the class is held, then during class learning, students are involved in higher-order thinking and measurement as well as in applying concepts in group settings with teacher guidance to achieve them. Competence (Saichaie, 2020). Technological developments strongly support the implementation of flipped classroom learning. Submission of material can be through digital media, such as videos, tutorials, and free assignment completion times to allow students to apply the basics of the material in class meetings with their teachers.(Arnold-Garza, 2014; Bergmann & Sams A, 2011)

In learning, there is a lot of diversity in students, both in students' initial abilities, readiness to learn and students' interest in learning (Bergmann & Sams A, 2011). This is certainly an obstacle for a teacher. This problem is solved by using reverse classroom learning. Reverse classes establish a framework that ensures students receive an education tailored to their individual needs (Bergmann & Sams A, 2011). Flipped classroom provides an opportunity for teachers to integrate it with other models or media.

Another thing that is very important in flipped classroom learning is focusing on student center learning and training students to be responsible. Students are responsible for viewing videos/tools provided by the teacher within the agreed time. Students are asked to ask questions and can also take notes on important things (Bergmann & Sams A, 2011). Another important thing is that students feel class time is more effective because FL creates a more inclusive classroom environment by providing more opportunities for students to interact with friends and receive reinforcement from the teacher (Lage et al., 2000).

In physics learning, teachers are required to carry out practical or project-based learning. One of the disadvantages of project-based learning and practical work methods is that they take more time to implement (Holubova, 2008). The reverse classroom model provides an environment that includes Project-based or real-world practice for students to better learn the subject in class time. Understanding student concepts and implementing practical activities are carried out in class so it takes longer. This is a distinct advantage for the implementation of flipped classroom learning.

A systematic review of the analysis of the integration of models and instructional media in the reverse class for physics learning has not been carried out. Therefore, researchers are very interested in conducting this review. The purpose of this review is to analyze the analysis of models and media in reverse classroom physics learning. In order for this systematic review to be more focused, the research objectives are described in the form of research questions, including 1) how is the use of the media used in the flipped classroom for learning physics? 2) how is the integration of models or media in the flipped classroom for learning physics?

METHODS

Methods Include: Explanation of how / step of research in a systematic way and detailed step by step written in the section. The method does not contain any theory, but rather emphasize what has been done in research to obtain results in line with the objectives.

This review uses a systematic review method. A systematic review is a review that uses explicit and systematic methods to compile and synthesize findings that answer clearly formulated questions (Page et al., 2021). Systematic review using The Preferred Reporting Items for Systematic review and Meta Analyzes (PRISMA) 2020 guidelines using flowcharts for the most recent systematic review

Data collection was carried out through an academic database using the Harzing's Publish or Perish application by searching Scopus indexed journals with the keyword “Flipped” in the range of January 2013 to 2021. The article search results obtained 1614 articles which were then brought to the inclusion process with the help of the Mendeley application. according to the inclusion criteria into 55 articles. Identification is carried out based on the following inclusion criteria:

Table 1. inclusion criteria

Inclusion Criteria	Information
Scope of Study	Flipped classroom on Physics Learning
Publication Year	2013-2021
Sample	At all levels (elementary, junior high, high school, college)
design review	Qualitative, Quantitative and Mixed Research
Language	English
Type	Articles and proceedings

RESULTS AND DISCUSSION

Based on the inclusion process, 55 articles and proceedings were obtained as shown in table 2.

Table 2. List of analyzed research studies

No	Writer	Title
1	(Capone, 2017)	A Flipped Experience In Physics Education Using CLIL Methodology
2	(Chaipidech, 2017)	A Flipped Inquiry-based Learning with Mobility to Improving Students' Learning Performance in Science: A Comparative Study
3	(Bauer-Reich, 2020)	A preliminary study to define limits of active learning strategy effectiveness in physics courses
4	(Cukierman, 2019)	A Student-Centered Approach to Learning Mathematics and Physics in Engineering Freshmen Courses
5	(Wang, 2018)	An investigation on teaching performances of model-based flipping classroom for physics supported by modern teaching technologies
6	(JCY Sun, 2016)	Analysis of Learning Achievement and Teacher–Student Interactions in Flipped and Conventional Classrooms
7	(Miller, 2016)	Analysis of student engagement in an online annotation system in the context of a flipped introductory physics class
8	(Sánchez-Azqueta, 2019a)	Application of a Flipped Classroom for Model-Based Learning in Electronics
9	(Jao, 2017)	Application of a MOOC in a general physics flipped classroom
10	(Govindaraj, 2017)	Blending Flipped Classroom and Station Rotation Models in Enhancing Students' Learning of Physics
11	(Wood, 2016)	Characterizing interactive engagement activities in a flipped introductory physics class
12	(Kannan, 2019)	Contextualising the Learner-Centric MOOCs Model for Effective Blending of Flipped-Classroom Method in Engineering Physics Course
13	(Magalong, 2019)	Effects of Flipped Classroom Approach Using Gooru Learning Management System on Students' Physics Achievement

No	Writer	Title
14	(Basriyah, 2020)	Effects of the Flipped Classroom on Understanding the Thermodynamic Concept at High School Students
15	(Moore, 2018)	Efficacy of Multimedia Learning Modules as Preparation for Lecture-Based Tutorials in Electromagnetism
16	(Lin, 2017)	Exploring physics students' engagement with online instructional videos in an introductory mechanics course
17	(Parappilly, 2021)	Feasibility and Effectiveness of Different Models of Team-Based Learning Approaches in STEMM-Based Disciplines
18	(Kannan, 2020)	Flip & Pair – a strategy to augment a blended course with active-learning components: effects on engagement and learning
19	(Matthews, 2020)	Flipped Classes: An Opportunity for LowStakes Group Problem Solving
20	(Asiksoy, 2016)	Flipped Classroom adapted to the ARCS Model of Motivation and applied to a Physics Course
21	(Finkenberg, 2019)	Flipped classroom in secondary school physics education
22	(Kettle, 2013)	Flipped physics
23	(Chong, 2019)	Flipped-Classroom with Interactive Videos in First Year Undergraduate Physics Course in Hong Kong
24	(Bawaneh, 2020)	Flipping the Classroom for Optimizing Undergraduate Students' Motivation and Understanding of Medical Physics Concepts
25	(Evangelista, 2019)	Flipping the High-School Classroom: Contributions for Learning in a Case Study
26	(Aki, 2017)	Freshman year computer engineering students' experiences for flipped physics lab class: An action research
27	(Forndran, 2019)	Gamified experimental physics classes: a promising active learning methodology for higher education
28	(Sánchez-Azqueta, 2019b)	ICT-based didactic strategies to build knowledge models in Electronics in Higher Education
29	(Elmehdi, 2019)	Impact of Flipped Physics Classes on the Performance of Engineering Students: University of Sharjah Case Study
30	(Hey, 2018)	Innovation Method of Architectural Physics Teaching Based on Flipped Classroom Idea
31	(Rafon, 2020)	Interactive Engagement in Rotational Motion via Flipped Classroom and 5E Instructional Model
32	(Anindhyta, 2020)	Is the Android Digital Web Module based on Flipped Classroom Needed by Teachers and High School Students in Pati District during the Covid-19 Pandemic?
33	(Perez, 2019)	Learningoriented assessment in action: impact on students of physics for engineering
34	(Wood, 2021)	Lecture capture as an element of the digital resource landscape - a qualitative study of flipped and non–flipped classrooms
35	(Buskulic, 2014)	No magic wand for teaching physics
36	(Square, 2020)	Poster presentations as an approach to implementing a 'flipped learning' pedagogy in introductory physics
37	(Princess, 2021)	Students' view of flipped classroom in physics' class
38	(Wood, 2018)	Teacher-student discourse in active learning lectures: case studies from undergraduate physics
39	(Torio, 2019)	Teaching As Coaching: Experiences With A Video-Based Flipped Classroom Combined With Project-Based Approach In Technology And Physics Higher Education
40	(Pankova, 2019)	Teaching Feynman's quantum physics at secondary schools using current digital technologies
41	(Oleksii, 2020)	The Adaptive Course of Physics at a Technical University
42	(Astra, 2019)	The effect of flipped classroom model on student's physics learning outcome in work and energy concept
43	(Santyasa et al., 2021)	The Effect of Problem-Based Flipped Learning and Academic Procrastination on Students' Critical Thinking in Learning Physics in High School
44	(J. Sun, 2017)	The effect of the flipped classroom approach to OpenCourseWare instruction on students' self-regulation
45	(Prasetyo et al., 2018)	The effectiveness of flipped classroom learning model in secondary physics classroom setting
46	(Ahmed, 2021)	The Effects of Gamified Flipped Learning Method on Student's Innovation Skills, Self-Efficacy towards Virtual Physics Lab Course and Perceptions
47	(Aşıksoy, 2018)	The effects of the gamified flipped classroom environment (GFCE) on students' motivation, learning achievements and perception in a physics course
48	(Cagande, 2018)	The flipped classroom and college physics students' motivation and understanding of kinematics graphs
49	(Astuti, 2019)	The Implementation Of Flipped Classroom Models To Increase Self-Reliance And Motivation Of Student Learning

No	Writer	Title
50	(Olaniyi, 2020)	Threshold concepts: designing a format for the flipped classroom as an active learning technique for crossing the threshold
51	(Şengel, 2016)	To FLIP or not to FLIP: Comparative case study in higher education in Turkey
52	(Hung & Young, 2021)	Unbundling teaching and learning in a flipped thermal physics classroom in higher education powered by emerging innovative technology
53	(Miller, 2018)	Use of a Social Annotation Platform for Pre-Class Reading Assignments in a Flipped Introductory Physics Class
54	(Sengel, 2014)	Using The 'Flipped Classroom' To Enhance Physics Achievement Of The Prospective Teacher Impact Of Flipped Classroom Model On Physics Course
55	(Senthilkumar, 2018)	Work in Progress: An Investigation on the Use of SCORM Based Pre-class Activities in the Flipped Classrooms

The use of tools/media in Flipped Classroom learning is very helpful in achieving the objectives. As many as 76% of researchers use video in flipped classroom learning, followed by quizzes by 15 studies and 14 studies using the Learning Management System (LMS). The use of tools/media in flipped classroom learning is shown in table 3.

Table 3. Tools/media used

Tools/media	frequency
Videos	42
Quiz	15
LMS	14
Online textbook	8
Discussion forum	6
Simulation	4
Blogs/websites	3
PPT	3
Textbook	2
Virtual Lab	1

Flipped Classroom is a learning method that conveys material content to students at home through electronic means and uses class time for practical application activities, hopefully it will be useful for learning information literacy (Arnold-Garza, 2014). In the research studies analyzed, many videos were commonly used. The use of flipped classroom using a facebook group is an alternative choice (Capone, 2017), use of websites and blogs (He, 2018; Kettle, 2013; Lin, 2017; Torío, 2019), use of textbooks in home preparation (Bauer-Reich, 2020; Moore, 2018; engel, 2016; JCY Sun, 2016; Wood, 2016, 2018), Another part of the research study analyzed using the Learning Management System (LMS) in the Flipped Classroom (Forndran, 2019; Magalong, 2019; Oleksii, 2020).

Video is not only often used in flipped classroom learning, but is also widely used in other learning. Video media has been widely used in the learning process because of the ease of making and accessing it (Ou et al., 2019). Videos for reverse classroom learning should involve more than presenting content through short video demos, but videos should be designed to achieve learning objectives through sequential instruction of content and learning activities. In this case, it needs to be developed for the development of making learning videos for online learning (Ou et al., 2019).

The use of video in the flipped classroom gives rise to various impressions, including students feeling that they can understand the material at their own pace, not depending on other students (Asiksoy, 2016; Govindaraj, 2017). Students feel better prepared to learn in class (Govindaraj, 2017). This flexibility allows students to study and take notes at their own pace at a time and location that they can best focus on (Chong, 2019).

Students enjoy access to videos anytime and from anywhere, making it more convenient for them overall. Students have the opportunity to watch videos as often as they want and can learn things they don't understand by watching more and more. Students stated that watching videos making preparations ahead of time allowed them to participate in the lesson actively rather than listening passively (Asiksoy, 2016). Students feel that learning through the use of videos gives students flexibility because when students don't understand a material, students just play it back (Govindaraj, 2017). Students can master certain materials because the video examples are quite clear and can be played back as needed (Cagande, 2018).

Flipped classroom is more effective than online learning to improve students' critical thinking skills. In the study, it was stated that the influencing factor was the level of interaction and student satisfaction in learning. One of the things that are considered interesting for students is video media. The provision of learning videos before learning is the main attraction for students to learn to increase learning satisfaction (Sulisworo et al., 2019).

The results of this study may not be far from the fact that students who use flipped classrooms understand more the practical aspects of concepts by viewing video clips than their peers who only share knowledge based on abstract understanding (Sunday et al., 2020) Researcher stated that 95% of students agreed to embed videos in the LMS so that students would be helped in learning. Adding a video site or simulator increases student engagement as well as perception of learning.

There are several things that need to be considered in the use of flipped classrooms using videos, including students who want to make learning videos shorter and less detailed, hoping for more examples of questions in the video recording (Mzoughi, 2014). This is in accordance with research conducted by (Chong, 2019) which states that some students feel bored if the videos they watch are long. Many lessons use the duration of time for videos ranging from 10-15 minutes, this allows students not to get bored while studying the material in the video(Princess, 2021).Another thing that can be done is to add interactive video features so that students can interact with what they are learning.

Students hope that videos can be accessed on more public platforms such as YouTube for easy access (Govindaraj, 2017). Limited application access, limited memory on the device, and limited video settings in the application may be obstacles in accessing videos, the YouTube platform is an option, besides being free, there are features that can be downloaded and can be opened offline, and image quality can be adjusted as needed.

In Mzoughi's research (2014), it was stated that only 34% of respondents had seen video recordings before class. In another lesson, some students take notes, and some students don't. Students who did not take notes or summarize lessons stated that watching videos made them skip breaks, and generally the videos were boring. Students are responsible for viewing videos/tools provided by the teacher within the agreed time. This will make it difficult for students who do not have self-regulation and responsibility in doing assignments(Bergmann & Sams A, 2011). Therefore, there is a need for guidance and direction from the teacher so that students can complete flipped classroom learning well.

Various studies on flipped classrooms integrate various media for learning. Learning Management System(LMS) is an application for learning activitiesin the network. Another part of the research study was analyzed using the Learning Management System (LMS) in the Flipped Classroom. An LMS is a software application for the administration, documentation, tracking, reporting, and delivery of educational courses, training programs, or learning and development programs. In the learning process, the LMS concept is used in online learning (Rahman, 2019). LMS is an application tool that is easy to use, has many features, and can be embedded with other media that support it. LMS is highly recommended for flipped classroom learning (Rahman, 2019). There are various kinds of LMS in learning including MOOC, Moodle, Google Classroom, and others.

LMS is an application that may contain the most complete learning resources, and can be filled with various media, whether in the form of videos, PPT, PDF, quizzes, discussion forums, online books, learning resource links, and others. The LMS can also contain online textbooks that allow annotation learning to occur. The teacher provides external sources in the form of hyperlinked journals so as to provide opportunities for students to find their own references in order to gain an understanding of the material being studied.

At LMS, videos and assessments are uploaded to the networking platform, regardless of gender, age, location and time of day, as long as there is a network, people with a passion for learning can engage in self-study at their own pace. MOOCs can enable people in rural locations or with poor economic status to have opportunities. MOOC can not only be used as a self-study course on the Internet but can also be applied in reverse classrooms on campus (Jao, 2017).The use of LMS can increase enthusiasm for learning and progress in learning outcomes, (Jao, 2017).The flipped classroom learning model carried out with the help of Google Classroom can be done well if the teacher can improve reciprocal relationships and active communication in forums (Princess, 2021).

One of the disadvantages of LMS is that teachers need to spend more time preparing reverse classes as preview material than traditional teaching methods (Jao, 2017). Teachers must prepare content in the form of videos, pdfs, online books, or others so that students have a meaningful experience. In addition, if there is a discussion forum, the teacher must accompany and strengthen the discussions carried out by students.

LMS is a software application for

administrative activities, documentation, tracking, reporting, and delivery of educational courses, training programs, or learning and development programs. In learning the LMS concept is used in online learning (Rahman et al., 2019). LMS is an application tool that is easy to use, has many features, can be inserted with other media that supports it. LMS is highly recommended for flipped classroom learning (Rahman et al., 2019). Another research confirms that multimedia tools in the reverse classroom have a positive impact on learning. Students enrolled in an LMS with multimedia content develop a degree of self-direction. This fact is also stated by Lam (2014) which states that multimedia devices and digital technology are very important to help students have a higher awareness and understanding of their goals and strategies in learning.

The use of quizzes in this flipped classroom is interesting. Quiz tool is a distinct advantage when used. Quiz filling which is done at the end after analyzing the material in the form of reading or watching videos must be completed before offline learning so that the quiz can turn off the task of understanding the material through videos or readings that have been done (Arnold-Garza, 2014). Of course this will help the teacher in checking students' understanding and help students realize their level of understanding of the material.

CONCLUSION

The purpose of this systematic review is to find out the application of the model and the integration of media in the reverse classroom in learning physics. Learning in the classroom can be done on the material and physics lessons. In practice, flipped classrooms can use various media, in the form of videos, quizzes, LMS, online textbooks, blogs, discussion groups, Facebook groups, quizzes, LMS, PDF materials, PPT materials, phet simulation, or in web form. The most commonly used media are videos, quizzes and LMS. In general, the use of media in flipped classrooms has been effective, but there are things that need to be considered in making media, including: 1) Making videos with shorter durations, 2) showing more video examples, 3) videos linked to the YouTube platform are good in LMS or independently, 4) Requires class guidance and agreement so that the use of media is effective.

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