European Journal of Alternative Education Studies
ISSN: 2501-5915
ISSN-L: 2501-5915
Available on-line at: www.oapub.org/edu

DOI: 10.46827/ejae.v7i2.4563 Volume 7 | Issue 2 | 2022

LITERATURE REVIEW OF THE INNOVATIVE LEARNING GLASS™ / LIGHTBOARD™ IN HYBRID EDUCATION

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Abstract:
This article provides a review of recent literature regarding the use of the innovative Learning Glass™-type technologies in different educational settings. Learning Glass™ "LG" / Lightboard™ in Hybrid education, a modern educational tool produced in the United States (Western Michigan University, Southeastern University, San Diego State University & Cornell University) which works a two-sided flip board proven to promote learning growth and keeps students of typical and non-typical development engaged. Our purpose is to investigate the potential of this technology to serve as a supplement tool in a range of specifically targeted education settings, including culturally diverse learners, hybrid education and social media involvement. Preliminary evidence indicates the capabilities of LG to help instructors retain their students' attention in the meta COVID-19 era.

Keywords: Learning Glass™, Lightboard™ in education, looking glass, IT in education, hybrid education, education technology, supplement digital tool in education, alternative education, media in education

Περίληψη:
Αυτό το άρθρο παρέχει μια ανασκόπηση της πρόσφατης βιβλιογραφίας σχετικά με τη χρήση των καινοτόμων τεχνολογιών τύπου Learning Glass™ σε διαφορετικά εκπαιδευτικά περιβάλλοντα. Το Γυαλί Μάθησης™ "LG" / Lightboard™ στην υβριδική εκπαίδευση, είναι ένα σύγχρονο εκπαιδευτικό εργαλείο που παράγεται και χρησιμοποιείται στις Ηνωμένες Πολιτείες (Πανεπιστήμιο Δυτικού Μίτσιγκαν, Πανεπιστήμιο Southeastern, Πολιτειακό Πανεπιστήμιο του Σαν Ντιέγκο & Πανεπιστήμιο Κορνέλ), λειτουργεί με μια πλακέτα διπλής όψης που αποδεδειγμένα προωθεί τη γνωστική ανάπτυξη και κρατά αφοσιωμένους μαθητές τυπικής και μη

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τυπικής ανάπτυξης. Σκοπός μας είναι να διερευνήσουμε τις δυνατότητες αυτής της τεχνολογίας και το πώς χρησιμεύει ως συμπληρωματικό εργαλείο σε μια σειρά ειδικών στοχευμένων εκπαιδευτικών πλαισίων, συμπεριλαμβανομένων πολιτιστικά διαφορετικών μαθητών, μέσω της υβριδικής και δια ζώσης εκπαίδευσης και της συμμετοχής στα μέσα κοινωνικής δικτύωσης. Τα πρώτα στοιχεία υποδεικνύουν τις ποικίλες δυνατότητες του LG, το οποίο βοηθά τους εκπαιδευτές να διατηρήσουν την προσοχή των μαθητών τους στην εποχή της μετα COVID-19.

Λέξεις-Κλειδιά:
Νέες Τεχνολογίες στην Εκπαίδευση, Νέα Μέσα στην Εκπαίδευση, Γυαλί Μάθησης, Εκπαιδευτική Τεχνολογία, Καινοτομία στην Εκπαίδευση

1. Introduction

1.1 Theoretical Background

A. IT in Education

Computers were firstly installed in schools in the early 1980s, and some researchers had already reported that ICT (Information Computer Technology) will be an important part of education for the next generation (Bransford et al., 2000). Dawes (2001) emphasized that new technologies have the potential to support education and its curriculum. They can provide opportunities for effective communication between teachers and students. The instructors are driven to include cutting-edge teaching approaches, resources and material in classroom instruction, such as new technologies (Konstantakis et al., 2022). Today, the ability to use educational programs with multimedia technology, creates new, attractive learning environments of an interactive nature, providing students with the opportunity to approach and process knowledge holistically and with a variety of combinations. At the same time, it pushes them to experiential-communicative practices, supporting collaborative learning models, enhancing interpersonal communication and highlighting common learning interests. With the special ability of interaction that the computer has, it can be adapted to the particular learning rhythms of the student, providing environments in which all the senses are involved (Karasavvidis, 2001). In this way, the student can achieve cognitive, social and emotional goals.

Bassetas (2009) states that learning is the change in a person's behavior that is the result of the influence of the environment or their experience. This means that people focus on a spiritual level and cultural improvement. For this reason, the environment of each child is very important for the socialization that each child will receive (Gregoriadis et al., 2020; Aslanidou, 2019; Aslanidou, 2021). Beka–Bajrami (2022) states that the development of picture books based on information technology has a broad development prospect. Universities and colleges mandate to upload projects in their Moodle™ and interact with the professors through Skype™ or Zoom™. Image has become a major tool for teaching.

Nowadays in post-COVID19 era, life has completely changed and students must stay focus and study in front of a computer / tablet / mobile screen. Education Technology uses all information and communication technology tools for the benefit of learning. It provides platforms with many tools which include products and services such as E-learning systems, digital libraries, learning management systems, mobile learning systems and social media (Rostislav, 2014). To ensure quality in an educational system, teachers should integrate information technology into teaching (Negi et al., 2011). It is crucial that they find new ways to enhance their lessons, because education is currently changing and new technologies are going to change education as we know it.

Many researchers point out that there is a positive change in student attitudes when technology is used in the classroom (Todman & Duck, 1993; Salomon & Gardner, 1986). Most likely, the initial enthusiasm that most students show when using educational technology is due to the impact of innovation (Elliott, 2000). Hybrid Education might be the key to academic success and to the new alternative educational system.

B. Hybrid Education

Hybrid Education (or Blended Learning) combines online and face-to-face learning environments. Instructors should understand the use of multiple online learning tools and face-to-face classroom activities to organize and teach hybrid courses accordingly (Hall & Villareal, 2015). Blended learning is a rapidly evolving form of education, as American universities are already striving for fair and alternative ways of enrolling students of all social classes in their courses, while emphasizing that it is not degraded the quality of education (Gleason & Greenhow, 2017). New digital tools are the key to blended learning.

Koppe, Norgard, & Pedersen (2017) indicated that hybrid education invites uncertainty, open-endedness, critical creativity, dialogue and democracy into the heart of education. There is an alternative way of designing for future higher education. These researchers also added that Hybrid Education can serve both as a guideline for the utilization of digital technologies in Education and as a methodology for fostering new forms of participation, inclusion and engagement in society (Pedersen et al., 2018). New supplement digital tools are the key to attracting students' attention span.

In such manner, Schweiker & Levonis (2020) created a quick guide on how to produce a virtual chemistry course for online education. They state that the new generation of students use the internet, tablets, smartphones and computers and they have embraced technology in their daily life and in their education. For this reason, these two Australian professors have created software platforms which are available for blending students' experience by using the augmented laboratory, voice-over presentation, lightboard with augmented reality and virtual classrooms. The conclusion is that there is a need for more digital tools, in order to achieve students' academic engagement.

C. What a Learning Glass™ / Lightboard™ Is

As mentioned above, modern educators' aim is therefore to create educational tools that help school facilities, universities and colleges. One basic and traditional tool for every teacher is the blackboard in which they write and they explain basic concepts to the students. However, a blackboard is limited by human anatomy, making its use poorly suited to large auditoriums even when oversized chalk is used (Skibinski et al., 2015).

On the other side, the Learning Glass™ / Lightboard™ is an innovative new educational tool that promises student participation and effective learning improvement. Another name of a Lightboard™ is Learning Glass™. This type of board has been created by different people and different universities, but their use is the same. The instructors use them to write on them and they create educational videos, so they can help their students. The students have the opportunity to rewatch the videos asynchronously, whenever they would like to.

The Lightboard™ technology has only been around since 2013 and further research is needed because the relevant literature review does not provide clear insight into the benefits that a Lightboard™ and its videos would provide (Lubrick et al., 2019). It was conceptualized and created by Northwestern University engineering professor Michael Peshkin. The results of its use are promising, with equivalent learning benefits for all students, including minority and financially disadvantaged students. On the other hand, there is a lack of research related to Lightboard™ videos, so there is a need to systematically explore its potential and best practices.

The Learning Glass™ is also new, because it was created at 2016, by Matt Anderson, professor in physics, in San Diego State University, USA. In short, the Learning Glass™ screen acts as a transparent board. The instructor writes on a glass screen with illuminated LED edges. A camera on the opposite side of the glass records the video and inverts the image horizontally (and therefore the instructor does not have to write backwards as shown in Figure 1). The Learning Glass™ is viewed in reflection and the students can see the instructor writing in reverse. The glass might be fragile, expensive and heavy, but its biggest advantage is that the lecturer doesn't face away from the class.

Figure 1: Teaching while using the LG-Firouzian, Rasmussen, & Anderson (2016)

According to Skibinski et al. (2015), when the lecturers use a Lightboard™ during their teaching, they face the class, writing with commercial markers on a glass supported at a comfortable angle. Their image is captured from the backside of the glass using a tablet computer. The image (see Figure 2) on the tablet shows the lecturer writing normally, because front-facing cameras on tablets are intended for videoconferencing and most of them transpose the captured image in the horizontal plane. This image can be streamed in real-time to a receiver and then displayed using a television. The instructor can create tutorial videos or live-stream a lesson. The students can attend the live-stream and they can rewatch the tutorial videos as many times as they need to.

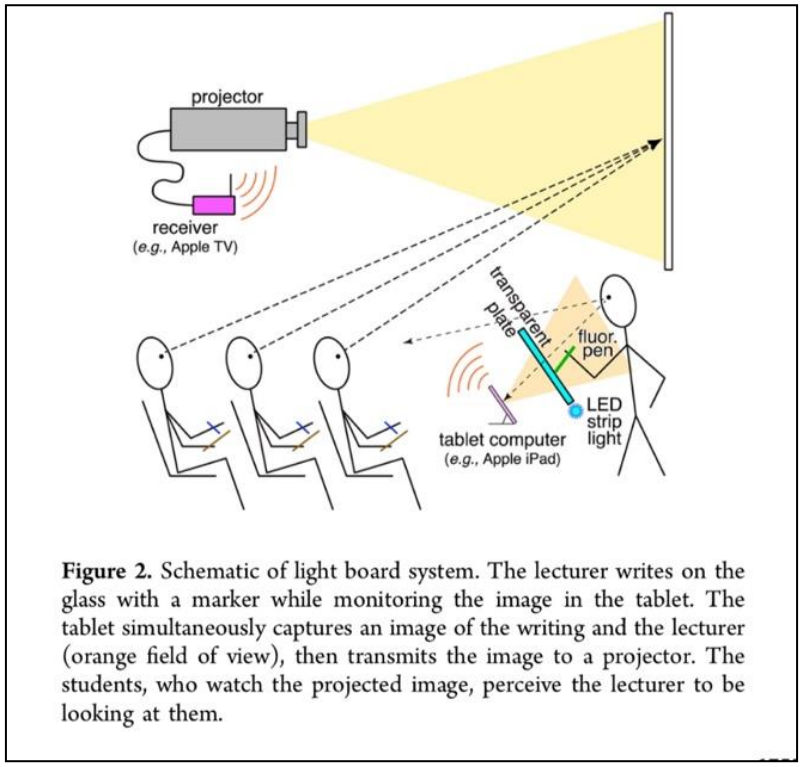

Figure 2. Schematic of light board system. The lecturer writes on the glass with a marker while monitoring the image in the tablet. The tablet simultaneously captures an image of the writing and the lecturer (orange field of view), then transmits the image to a projector. The students, who watch the projected image, perceive the lecturer to be looking at them.

Figure 2: How a Lightboard™ works-Skibinski et al., (2015)

The Learning Glass™, therefore, allows the educator to use a full range of communication methods and visual cues to clarify ambiguous or subtle concepts and promotes student involvement in the learning process (Firouzian et al., 2016). Michael Peshkin and Matt Anderson use a set of lecture recording tools that allow the production of high-quality videos where the instructor faces the audience and writes on a glass board as they would in a regular class (Firouzian et al., 2016; Fung, 2017). Fung (2017) supports that the Lightboard™ technology could potentially serve as a replacement for current whiteboard-based and PowerPoint-based lecture videos, whose lengths often exceed the average attention span and lack the level of human engagement.

In addition, research at San Diego College has shown that the use of the Learning Glass™ has significant potential to increase the degree to which learners feel connected and form relationships with their instructor, even in large lectures and online/hybrid classrooms. Instructor's immediacy and sense of presence when using Learning Glass™

has proven to be a key indicator of persistence, especially for women and underrepresented students (Good et al., 2012).

Specifically, educational technologies were the means for lecturers that ensured the continuity of education during the COVID-19 lockdowns through teaching and learning in an online environment (Kaqinari et al., 2022). These technologies are the application of modern technology in the area of educational development (Tosheva, & Abdullaeva, 2022). The last trend in technology is the upcoming Metaverse™ which represents virtual and augmented technology. Misirlis & Munawar (2022) added that the use of a new hybrid environment is more than a necessity for schools. There are also many digital platforms that are used for distance learning, such as Moodle™, Sakai™ and Elgg™.

Due to the covid-19 pandemic, millions of children are experiencing lockdowns and they are forced to remain at their houses (Hatzigianni et al., 2018). Educators should find new methods and new educational digital tools to use, so they can make their teaching more interesting. According to Sofos (2021), students should be able to know, to choose and to use different media even those who do not have access the New Media. For all these reasons, a literature review regarding the importance of the new education technology, the use of the Learning Glass™ / Lightboard™ technology in education can contribute to a more holistic understanding of the findings of recent studies.

D. Methodological Issues Regarding Learning Glass™ / Lightboard™ in Education

It is important to know the benefits of the Learning Glass™ in Education, because Firouzian et al. (2016) supported that it might help transform the traditional passive courses into more engaged courses by increasing instructor immediacy and facilitating communication. Educational scientists' goal is to find different and new ways to attract students' attention in the meta-COVID 19 Era. The Learning Glass™ is a media which provides all of the affordances associated with rich media when used in a synchronous manner. Rich media with advanced features like video, audio and other elements enable opportunities for learning in both real and virtual higher education contexts, especially in developing countries (Naismith et al., 2004).

According to Bober-Michel (as stated in Firouzian et al., 2016), participants were exposed to higher-immediacy instructor behaviors using rich media and they performed better at the post-test immediately following the teaching session. Foss, Oftedal & Lokken (2013) showed through their study that a clear majority of students scored the Rich Media "e-compendium" as a better learning tool than lectures and textbooks. This means that rich media and Learning Glass™ can work together and be perceived as better learning tools than traditional learning tools.

Birdwell & Peshkin (2015) supported that the Lightboard™ can be used for recording lectures for flipped or hybrid classes, creating lectures for distance learning courses and MOOCs, holding live on-line review sessions, creating engineering graphics tutorials, and recording solutions for homework and example problems. When an

instructor uses the Lightboard™ to create compelling videotaped lectures, then the result is vivid and helpful for their students.

2. Main Goals

The purpose of this article is to understand how a Learning Glass™ works and to review all the research that has been done until today. Laurillard, Oliver, Wasson & Hoppe (2009) argue that interactive and cooperative digital media has an inherent educational value as a new means of intellectual expression. According to these researchers, the use of digital technologies is to enhance intellectual expressiveness and creativity: helps the students in their appropriation of the world with a special emphasis on their intellectual development. It is essential for the education system to incorporate new digital media tools for intellectual expression and production. Professors like Schweiker, Griggs & Levonis (2020) created a series of Lightboard™ videos demonstrating key organic mechanisms to enhance the active learning environment and they avoided their students' passively listening to an academic instructor.

In addition, Mayes & De Freitas (2007) stated that the challenge is to describe how the technology allows underlying processes common to all learning to function effectively. Ivanovic, Xinogalos, Pitner & Savic (2017), also, pointed out that technology-enhanced learning is influencing university education, mainly in overcoming the disadvantages of direct instruction teaching approaches, and encouraging creativity, problem-solving and critical thinking in student-centered, interactive learning environments. Sofos (2021) pointed out that education in general and media education, in particular, can contribute focused to the reduction of inequalities produced through the education system.

The Learning Glass™ and the Hybrid education have a perspective on education and our aim is to explore their potential in the educational process. The specific main questions of the current literature review are as follows:

1) What research has been done about the Learning Glass™ / Lightboard™ to date in the academic community?
2) How can the Learning Glass™ / Lightboard™ be used in hybrid education?
3) How can the Learning Glass™ / Lightboard™ bridge the distance with lifelong learning?

Many researchers like Rogers & Botnaru (2019) examined the effect of Lightboard™ videos on student learning and perceptions in a Flipped Classroom Model and they proved that there is a strong endorsement of Lightboard™ videos for students' understanding, engagement and satisfaction. In this way, the focus of this review is to collect all the articles from 2010 and examine how important and useful a Learning Glass™ / Lightboard™ is. The focus was from 2010 until today, because Learning Glass™ and Lightboard™ are new educational technology tools and before 2010 they did not exist.

3. Method

3.1 Search Procedure

The current paper is a social study, a systematic literature review. For this reason, its' method is based on Petticrew & Roberts's (2006) method for executing systematic reviews "*of mapping out areas of uncertainty, and identifying where little or no relevant research has been done, but where new studies are needed. Systematic reviews also flag up areas where spurious certainty abounds. These are areas where we think we know more than we do, but where in reality there is little convincing evidence to support our beliefs*" (p. 2). The steps which were followed for the review are:

a) Main questions were formulated.
b) The search terms were defined and relevant databases were selected.
c) Inclusion and exclusion criteria were identified and used for the literature research.
d) Only studies that met the quality criteria were included in this review, which makes it legitimate.
e) Data answering the research criteria and questions were extracted.

In order to explain this phenomenon, a qualitative approach was chosen and the process had to have a more interpretive character. (Cohen, Manion & Morrison, 2000, p. 456).

3.2. Search Criteria

A systematic review was conducted using the Hellenic Academic Libraries Link (HEAL LINK), which includes the scientific database "Scopus". Other databases which were used are "Google Scholar", "ResearchGate" and "Academia". These databases were chosen, because they have a variety of high-index scientific journals involving educational research. According to Petticrew & Roberts's (2006), "*the type of information being sought will depend on both the review question and the inclusion criteria*" (p. 80). In this way, many search terms were combined.

At the beginning, several combinations were used of search terms, like "The Learning Glass in education", "The Learning Glass", "Enhanced Technology and the Learning Glass", "Hybrid Education and the Learning Glass". The search was limited to Greek, English and French, because these are the three languages the researchers can speak fluently. Journals and ebooks were searched and the focus was on research into all taxonomic numbers. The research was also focused from 2010 to 2022 and whether the research was illustrated or not was irrelevant. Then, the same procedure was repeated from the beginning but this time it was not limited to Greek, English and French. The finding was that there are only four published papers about the Learning Glass. This strategy revealed thousands of articles and only the relevant ones were selected from them. Then, the search term "Lightboard in education" was used and the findings shows that there are only five relevant articles about it. The conclusion is that the Learning Glass™ / Lightboard™ technology is a new educational technology that can utterly

replace the blackboards in schools and more research is needed to prove the advantages of its use in education. In total, only of nine papers, were completely relevant and were selected for the final checklist and discussed in the present literature.

3.3. Literature's Review Process-Inclusion & Exclusion Criteria

According to Cohen et al. (2000), in the protocol of a systematic review, the criteria for inclusion and exclusion of the various studies are clearly defined and then precisely applied, so that, finally, the most appropriate studies emerge, the results of which will be used in the meta-analysis. It is also crucial that the criteria applied must be objective and scientific and not intended to facilitate any researchers.

In this way, only the articles which were published in scientific peer-reviewed journals were taken under consideration. Also, publications from 2010 to present (as of 1st of October 2022) were only included, because the current and the newest studies in this field were in the main research of this review. All the abstracts of the publications were studied. Even though the empirical studies and the researcher's interests concerned bilingual kids, the literature review revealed that there are not many papers focused on learning glass in education, even in the mainstream education. Lubrick, et al. (2019) argued that the lightboard technology may improve student achievement and learning engagement and they tried to provide a literature review about it. Their review did not, however, provide clear insight about the benefits of a lightboard and they suggested empirical research directly studying Lightboard™ videos.

After applying all these inclusion and exclusion criteria to all the publications, the search strategy resulted in thousands of articles, most of them being irrelevant. The criteria were again applied to the full-text versions of these articles, which resulted in a total of nine articles that were selected for the final quality check. The data of these studies were drawn from studies of American, Australian and Asian Universities.

3.4. Initial Data Extraction and Quality Check

A study quality for a systematic review means "internal validity", the extent to which a study is free from the main methodological biases, such as observer bias (Petticrew & Roberts's, 2006, p. 127). To evaluate the scientific quality of the studies, the data extraction that was used included the following sections:

1) General information: Study title, author, year of publication (2000 and after), country, research context, and journal.
2) Topic: Qualitative research showing the Lightboard / Learning Glass's positive effects in higher education.
3) Research design: Research question, description of the study, research design, research method, length of the research in Lightboard technology, and data analysis method.
4) Research population: Number of students, gender, and age of the students.
5) Results: Findings that are related to the research question.

All the articles were checked using 10 quality criteria drawn from Petticrew & Roberts (2006) (p.142-143) (see Table 1).

Table 1: Quality criteria

Category	Quality criteria
General orientation questions	1. What question is the study aiming to answer? 2. Is the research done using the chosen method capable of finding a clear answer to the research question?
Selection of the sample	3. Are the study participants adequately described (age, sex, country etc.)? 4. Is the sample surveyed representative?
Method	5. Do the researchers state the research methods used? 6. Are the measures used in the study the most relevant ones for answering the research question? 7. Are they objective and reliable?
Data analysis	8. Are the results clear presented? 9. Did formal test for change in trend (such as ANOVA) use an appropriate method?
Conclusion	10. Is the research question answered using empirical evidence from the research that was done?

3.5. The Learning Glass™ / Lightboard™ in Education: A Young Field of Study

The Learning Glass™ / Lightboard™ in Education is a young field of study which is mainly used in two American Universities; San Diego State University (SDSU) and Western Michigan University. Dorantes (2016) is an economics instructor and she uses "The Learning Glass™ Technology" at SDSU. She stated that it allows the instructor to diagram and draw complicated problems for the undergraduate students in real-time. The point of this literature review is to present how much the Learning Glass™ can affect student engagement and how much it can increase the effectiveness of the instructors' lectures. Studying the available literature, it is crucial to point out that Lightboard™ / Learning glass™ technology is mainly implemented in STEM Instructional Programs for Undergraduate students.

Likewise, the creator of the Learning Glass™, SDSU Physics professor Matt Anderson (2016) working with his colleagues Firouzian and Hattay demonstrated the Learning Glass™ using LED side lighting on Sapphire shower glass with neon-erase markers to create a see-through whiteboard. More precisely, there is a small mirror mounted in front of the camera which flips the image right-side-out for viewers. He has created sample lessons on his YouTube channel in order to demonstrate this enhanced tool technology. These videos can be watched at: http://youtu.be/hHsPmtEqX5c and the language that is used is English.

Furthermore, the studies that were examined used qualitative methods to measure the learning glass' effectiveness in education, such as worksheets, surveys, Elearning through D2L, posters, Quasi-Experimental design and identical pre- and post-course assessments for evaluation. These articles are not many and this field of study is young in the scientific society. Looking at Figure 3, the only thing that is noticed is that in 2020

there was an interest in this growing field, because of COVID-19, but there is no newer research. According to the publication dates of the nine articles reviewed in this study, it becomes apparent that all the articles were published in 2018 and after. Also, it is obvious that studies on Learning Glass have mostly been conducted in the United States of America.

Lubrick et al. faced the same issues when they conducted their literature review about the lightboard videos for students' achievement and engagement in learning, back in 2019. They searched three databases (ERIC, PsycINFO, and the Leddy Library, but due to a lack of published research, their review relied on related studies. Their conclusions were general in nature and they suggested quantitative research on the Lightboard™ technology. They suggested that the experimental studies should involve one group watching a lightboard video and another group watching an equivalent one. These studies should be in an original class and they should measure a variety of conditions, such as the use of gestures etc. Last but not least, it should be intriguing to study the social aspect of the instructor on screen.

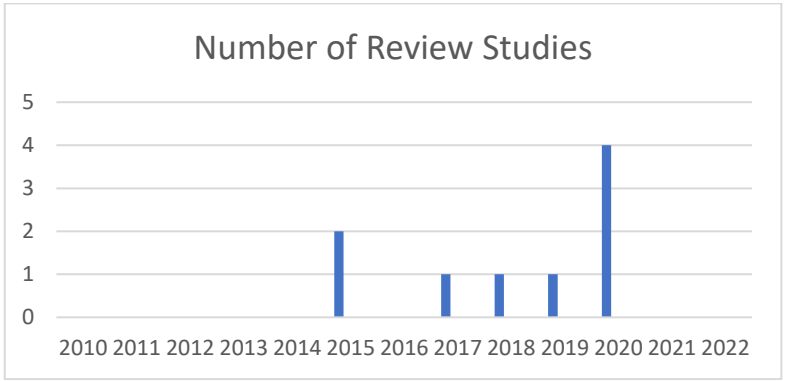

Figure 3: Frequency distribution for year of publication for reviewed articles

4. Results

4.1 Students' Academic Engagement through Learning Glass™ / Lightboard™ Videos

Western Michigan University has created Learning Glass™ Videos to supplement the material in Algebra II and Precalculus sections, for their STEM Instructional Program. Out of 171 students, 121 (70.76%) of them preferred videos made by WMU and out of 185 students, 124 (67.03%) of them were interested in having more Learning Glass™ videos available to them. Only 7 (3.78%) students were not interested in having more Learning Glass™ videos available to them. Most of them agreed that the videos clarified or strengthened their understanding of the material (Talanda-Fisher, 2020). This showed that the majority of the students tend to like the Learning Glass™ videos and they would love to have more videos available to them.

Students who participated in these programs, using Learning Glass™ videos as an educational supplement, enjoyed physically seeing their instructors explain and solve problems behind the glass. They also loved the quick, direct and simple delivery of the material and the ability to watch the videos any number of times they wanted to. The

videos resolved any confusion that students had after the material was first presented in class and deepened students' understanding of it (Talanda-Fisher, 2020).

Firouzian et al. (2016) created two classes of Introductory Calculus-Based Physics, at San Diego University (USA). The 542 students were divided into two groups; the first one had 215 students who used the Learning Glass™ while they were taught and the second group had 327 students who used a projector during the course. The researchers conducted a study between an online calculus-based physics course using Learning Glass™ technology and a big auditorium-style lecture hall taught via a document projector. They concluded by suggesting integrating the Learning Glass™ technology into the online classroom. This technology can provide an effective opportunity where students can reach the same level of learning outcomes as the students in a standard face-to-face classroom. Using the Learning Glass™, while the presenters were teaching, had significant potential for increasing the extent to which learners feel connected and form relationships with their instructor, in large-lecture and hybrid classes. The comparison did not show statistically significant differences between average learning gains of the traditional classroom where the lecture was delivered on learning glass synchronously. The most interesting finding is that the mean immediacy in a Learning Glass™ class was significantly higher than in the traditional classroom. They pointed out that Learning Glass™ has the capability also, to provide equal learning opportunities for students from all walks of life, which means that if somebody is a student, it does not matter their age they are in. In general, the results were promising, with equivalent learning gains for students, including minority and economically disadvantaged students.

In addition, Georgia Southern University (USA) used Lightboard™ Videos in a Flipped Classroom Model. Their study targeted 68 civil engineering undergraduate students at a 4-year program. There was a control group and their classes did not use Lightboard™ videos. In the meantime, there was a study group which used Lightboard™ videos within the same section of the course. The overall means on the Likert scale survey showed a strong endorsement of Lightboard™ videos for understanding, engagement and satisfaction. The students' academic performance increased in the overall score on in-class assignments. There was an improvement in average student scores and a strong endorsement of Lightboard™ videos for understanding, engagement and satisfaction (Rogers & Botnaru, 2019).

Fung conducted a study (2017) while teaching organic chemistry to first-year college students, at the National University of Singapore (Asia) and the research showed that Lightboard™ videos are useful for lecturers of STEM subjects, who need to complement verbal explanations with equations and diagrams. According to the researcher, Lightboard™ format can allow a dynamic and engaging way to convey concise information. Its use can keep the attention span high. Students' response to Lightboard™ videos has been positive, and they have even been using the Lightboard™ for their own creative endeavors as well.

Specifically, students of the department of mechanical engineering at Northwestern University recorded final presentations for their class, and designed

competition entries, and promotional videos for philanthropic and extra-curricular organizations, using the Lightboard™. Undergraduate students have also used the Lightboard™ to record final project presentations for classes, which were uploaded for instructor and peer grading They also enjoyed the Lightboard™ videos (technical buckling problems with equations and diagrams) that their instructors made because they were able to watch the problems repeatedly online with the ability to pause and rewind. Even the freshman advisers used the lightboard to create videos to cover commonly asked questions that freshmen had (Birdwell & Peshkin, 2015).

Another research at Bond University (Australia) showed that when some Lightboard™ videos became available to undergraduate health science students through an online learning platform, their learning engagement got stronger and their active learning environment was enhanced (Schweiker et al., 2020). The sixty students who took part in the program were divided into groups of approximately six students at collaborative tables. Two academics were helping the students who were struggling to understand the concepts. A peer-led learning environment was created, which helped the students consolidate their understanding and made their experience collaborative and enjoyable. Their feedback was positive and they were enthusiastic about the subject. They appreciated the extra mechanisms and resources their professors provided them with. The students overall showed an increase (17.87%) in their academic performance in organic chemistry mechanisms and a bigger engagement over time.

4.2 Value of Learning Glass™ / Lightboard™ Videos in Distance Learning

According to Chan & Cushman (2020), Learning Glass™ can be invaluable in addressing the challenges of distance learning. The researchers conducted research with 201 undergraduate students and managed to create supplement material (Learning Glass™ videos) in Algebra II and Precalculus sections in Western Michigan University. Their STEM Instructional program had the opportunity to use the new technology on their campus and create a Learning Glass™ studio. They were able to create high-quality class material when they were not able to meet with their students. A great example was that they created a Learning Glass™ video for Calculus I which became a crucial instructional component for the course in distance learning. The instructors were writing on the board and they were making eye contact with the camera, creating a more dynamic experience than a video of someone at a blackboard would.

It is worth to mention that Learning Glass™, according to Hallas (2020) boosted the collaboration between some team members of the staff of Western Michigan University, because while they were creating the educational videos, they were able to make revisions to the scripts to reflect what they were experiencing. The researcher used the Learning Glass™ in a class of algebra II & precalculus and the undergraduate students that took part were 201. Hallas also stated that it is beneficial for the instructor to create videos, because they can improve their public speaking, while increasing their video quality.

Rogers & Botnaru (2019) taught students who were enrolled in a Fluid Mechanics course and they proved through their research that students commented positively on the collaborative aspect of in-class problem-solving in Flipped Classroom Model. This Model shifted the first exposure to outside of class through a pre-class element (online courses), so that class time could be allocated software applications, and class discussions.

Firouzian et al. (2016) included two classes of Introductory Calculus-Based Physics (San Diego State University). In the first class, they used the Learning Glass™ in front of a live studio audience of rotating sets of 20 students that were enrolled in the course. The lecture streamed to the remote students via MediaSite™. In the second class, they did not use the Learning Glass™. During the first week of the semester, there was very little movement of students to different sections, about 10% attrition from Learning Glass™ to face to face section. The independent-samples-t-test confirmed that there was no significant difference in comprehensive attitude score between the face-to-face class and the Learning Glass™. They claimed that integrating Learning Glass™ technology into the online classroom can provide an effective learning opportunity where students reach the same level of learning outcomes as the students in a standard face-to-face classroom.

Additionally, faculty of the department of mechanical engineering at Northwestern University have used the Lightboard™ for recording lectures for flipped and hybrid classes, created lectures for distance learning courses and MOOCs and answered student questions with video responses. They also, held live on-line review sessions, created engineering graphics tutorials and recorded solutions for homework and example problems. YouTube-live provided better results than transcoding which is handled by Google™ (Birdwell & Peshkin, 2015).

4.3 Learning Glass™ / Lightboard™ vs Traditional Tools (Black Board and Textbook)

The Lightboard™ technology helped instructors to create videos at a glass board. Chan & Cushman (2020) showed through their research that when an instructor creates a video using a Lightboard™, a more dynamic experience is created than a video of an instructor at a blackboard would (Chan & Cushman, 2020). Hallas (2020), also, added that the staff of Western Michigan University created videos by explaining algebra and precalculus topics. One main advantage was that the instructors could write on the Learning Glass™, while they were facing the camera. This is something that a black board does not provide to their users. The students were able to see the instructor as if they were addressing in the class directly.

According to Birdwell & Peshkin (2015), in a traditional class, the presenter must turn away from the audience to write on the board and their bodies often obscures the material. This is the reason why they developed the Lightboard™ at the Department of Mechanical Engineering, Northwestern University, so they avoid the liabilities of chalkboards and to produce upload-ready video segments without any post-production. When they did teleconferences, they also removed the video switcher and they used a

Blackmagic Design Ultrastudio Mini-Recorder, so they can avoid the echo cancellation software of teleconferencing services.

Other researchers at Bond University in Australia (Schweiker et al., 2020) created a series of Lightboard™ videos demonstrating key organic mechanisms and their undergraduate students showed an increase in performance in the subject. Also, they showed a deeper engagement over the time. On the other hand, Skibinski et al. (2015) conducted a study in a 500-person auditorium (Department of Chemistry and Chemical Biology, Cornell University, Ithaca, New York, USA) and they mentioned that a lightboard had many advantages; the lecturer's writing, face and gestures were never blocked and the system was inexpensive. On the other hand, the traditional lecture disengaged the students from learning. supported that the blackboard form factor is limited by human anatomy and their technology for recording blackboard lectures is unsatisfactory.

Furthermore, the researchers Schweiker, Griggs, & Levonis (2020) pointed out that the Lightboard™ videos allow the presenter to discuss and draw on the lightboard without turning their back to the camera. The students who were given to study from the textbook only got an average score (3.00/5.00), whereas the students who were given the Lightboard™ stimulus as an educational supplement (3.50/5.00). Over the four-year period, they saw a clear improvement in their students' exam scores, while they were using the Lightboard™ videos as a supplement (17.87% increase in the assessment item).

According to Fung (2017), white boards and PowerPoint™ presentations lack of human interaction between the viewers and presenter and require lengthy editing. On the other side, in a Flipped Classroom, students learn at their own pace through prerecorded video lectures (Lightboard™ videos) outside the class. Birdwell & Peshkin (2015) added that PowerPoint™ slides can be merged in real-time with the Lightboard™ camera stream, which can be useful for the presenter who can interact with the material and can annotate it with markers on the glass board.

Furthermore, in Georgia Southern University, the overall means for all students were above a 4.0 on a 5.0-point scale, which showed a strong endorsement of Lightboard™ videos for understanding, engagement and students' satisfaction (Rogers & Botnaru, 2019). The academic data might not seem to unequivocally support this, but their perception about Lightboard™ videos was positive.

Fung (2017) at National University of Singapore, as mentioned before, created a series of Lightboard™ videos for the course "Chemistry for Life Sciences". The researcher noted another advantage of Lightboards. Lightboard™ videos were less logistically demanding than expected. In reality, this means that the videos are recorded and disseminated immediately and the presenter does not need to write backward. The instructors use a simple setup comprising a glass board, lighting equipment, a video-recording device, and a mirror that inverts the image.

4.4 Suggestions / Limitations of Creating Learning Glass™ / Lightboard™ Videos

Students enjoyed the Lightboard™ / Learning Glass™ videos and they would like to see more of them (Rogers & Botnaru, 2019). Hallas (2020) mentioned some key takeaways for the instructors who would like to create educational videos using the Learning Glass™. She suggested that the instructor should practice the script in advance and the background should be dark, but not too dark or bright, because it might make the writing on the board overlapping with the clothes and it would be difficult for the viewer of the video to see, as the markers are bright colors.

Moreover, Schweiker, Griggs, & Levonis (2020) added that the presenter should use a black background to improve the focus of the video onto the instructor and their message. They also, suggested that black attire might be the best to use as the instructor would blend into the background and their face and hands would be clear. They should remove any jewelry or shiny objects before filming (Fung, 2017).

It is also important to remind students to pause the videos often to check their understanding, because instructors tend to explain the material quickly. The videos should be short and if the instructors make some mistakes, it could be beneficial to show that even the instructor can make a mistake. Also, the presenter should write up prompts in advance, so they can make sure any problem or scenario in consideration is precise (Hallas, 2020; Schweiker et al., 2020). Birdwell & Peshkin (2015) suggested that the individual video segments should be short, typically five minutes or less.

Other suggestion by Hallas (2020) is that instructors should detail their thoughts thoroughly, since the students cannot ask questions during the video. In this way any confusion is avoided. The researcher suggested that additional demonstrations can be edited into a video to expound on points lacking clarity. Fung (2017) along with Hallas added that the instructor should be mindful of the bounded area of the glass board, as the camera captures a certain part of the board. Students of Western Michigan University suggested that Learning Glass™ videos should provide more examples, demonstrate multiple ways to approach examples, improve the audio and light qualities of the video, and give to them access to the videos outside of the eLearning to increase playing speed (Talanda-Fisher, 2020).

In addition, Rogers & Botnaru (2019) mentioned that they used small size of students' sample in their study and the focus was on engineering students only, which prevented them from generalizing the results. Future studies should investigate Lightboard™ video use in large classes or over the course of multiple semesters. They also added that the ideal suggestion is to have one class as a control group and another one as a study group and collect additional measures of academic performance, such as test grades in addition to in-class assignments, to better evaluate the Lightboard™ video effect on learning.

Also, Firouzian et al. (2016) noticed that the students in the Learning Glass™ class and the standard face-to-face class had similar learning gains. Ad interim, students in the Learning Glass™ section expressed their positive experience and they found the instructor more immediate that the face-to-face section. In conjunction with this, Birdwell

& Peshkin (2015) pointed out that when the instructor writes on a lightboard, they are able to interact with the material facing the camera and writing on the board.

Fung's students (2017) found Lightboard™ videos to be useful for learning, because they could rewatch them at any time, as opposed to live lectures, where there were common classroom distractions and in-class questions. General criticism of these videos centered on their length and content. The students even suggested shorter videos and more "Khan Academy"-style videos. The main two difficulties that the instructors faced were: 1) Chirality could not be explained with the use of physical model kits, because of lateral inversion, and 2) The contents of the lecture had to be planned meticulously, if the instructor does not want to record many times the same model.

Additionally, Birdwell & Peshkin (2015) mentioned that they use video recording designed for live television production, which is the Blackmagic Design ATEM Television Studio™ hardware device and they can record compressed video efficiently. In the meantime, they can even mix in other cameras or sources such as PowerPoint™ slides. When a recording is made, it can be uploaded to cloud services, such as YouTube™ and everybody can watch this video. This is a quick method and can be useful to every instructor that does not want to have any assistance on creating their own educational material.

Last but not least, using the Lightboard™ technology with PowerPoint™ slides can be frustrating, if instructor does not take under consideration the following issue; the handwriting views through the glass is backward. To correct this, the lecturer should use a mirror or flip the image digitally. The videos can be stunning, but the glass should be protected, because it is fragile, expensive and very heavy, if it is a blackboard-size piece of glass (Skibinski et al., 2015). This is the reason why Skibinski et al. (2015) at Cornell University (NY) suggested an inexpensive way to create a Lightboard studio™. The instructor can use an iPad which sits on the same surface as the lightboard frame and is supported at the appropriate angle by an aluminum plate that is connected to the frame and to the glass. This equipment is inexpensive and instructors are encouraged to create their own Lightboard™ studio following their manual. The equipment is also easy to use.

5. Discussion

The purpose of this article was to review the recent literature regarding the use of the Lightboard™ / Learning Glass™ videos technology for student learning. Although there is a need for more research on this field, students' evaluations showed that most of them had a high preference for these videos and they were asking from their instructors to create additional ones (Rogers & Botnaru, 2019). In general, the Lightboard™ videos are very user friendly, easy to learn and provide presenters as an additional resource for their teaching. It is crucial to have the support of a teaching center in creating and editing videos, which makes the process more efficient and less consuming.

Similarly, Firouzian et al. (2016) pointed out that although there was no significant difference in learning gains for students in the face-to-face class and students in the

learning Class, the students in the Learning Glass™ section though, felt connected with the instructor. This feeling is a key predictor of persistence in STEM fields, so one can claim that Learning Glass™ technology has the potential to enhance retention rates in undergraduate STEM majors. This could mean that if instructors use the Learning Glass™ during a hybrid class, they could have similar results with a traditional class, which is promising for meta COVID-19 era. Further research should be conducted.

For a flipped classroom, it could serve as a replacement of a whiteboard or PowerPoint™ based lecture videos. The Lightboard™ format could allow teachers of organic chemistry or educators to prepare engaging with little effort to no postproduction (Fung, 2017). One advantage of a Lightboard™ studio is that faculty can address a topic by creating and uploading a video in a matter of minutes. Videos of this nature can be created in response to student email requests, or to expand on a lecture topic for which there is not sufficient time in class (Birdwell & Peshkin, 2015).

In addition, the Lightboard™ technology can be used not only for teaching, but also to create a series of videos to cover commonly asked questions, such us how to choose first classes when somebody is a freshman in a university. A great example it that the team of freshman advisers at Northwestern University created videos to cover the freshmen questions on how to choose their first classes and what each major entailed. These were then posted on the school's website and social media pages. Last but not least, Rogers & Botnaru (2019) suggested future research projects which should target larger samples and use multiple sources of performance indicators to examine whether Lightboard™ videos increase student learning. In the near future, according to Skibinski et al. (2015), a Lightboard™ should be superseded by a big-screen tablet equipped with a stylus and a front-facing camera. Although the Lightboard™ could benefit both academics and students in many aspects, there are no many universities or school facilities that know about this new technology.

There is also a YouTube™ channel, created by The Hellenic American Academy NPO, a learning center in Zakynthos Island, Greece, EU, and the researcher Eftychia Aslanidou, PhD Cand. of the Ionian University (Department of Digital Media & Communication). They have created various Greek educational sample lessons (math, reading, and writing) utilizing The Learning Glass™ Technology with Elementary School Students. Their channel http://www.youtube.com/c/thehellenicamericanacademy even features videos created by elementary students themselves (6-10 years old) giving new hope to the future of the Greek technological educational progress! (Figures 4 & 5)

Figure 4: Aslanidou teaching

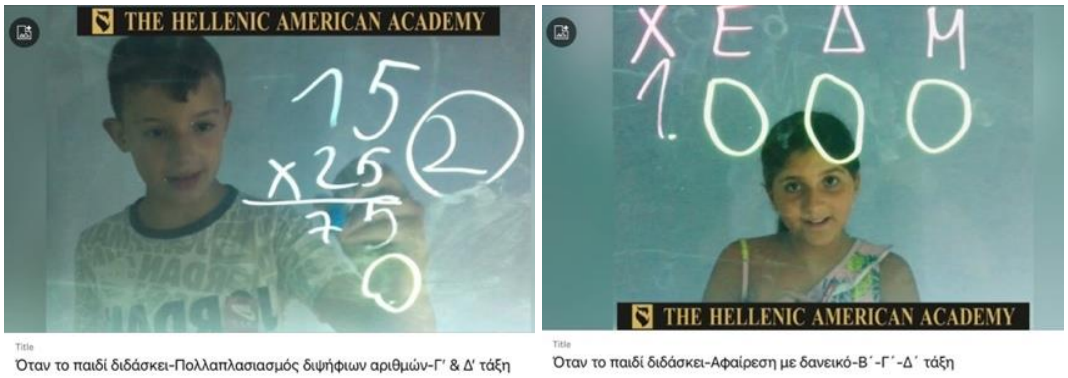

Figure 5: Children from Zakynthos teaching math

Our aim is to proceed to further research about this emerging education technology. The focus is going to be on the use of the Learning Glass™ in education. The questions that need to be answered are if it is a tool that can improve primary and tertiary education in Greece and if it can bridge the gap between lifelong, synchronous and asynchronous education. Something that no other research studies is the use of the Learning Glass™ technology in the Metaverse™ platforms. Students and academics could share the videos they create using the Learning Glass™, so they are connected with their peers. It would be intriguing to see how Greek academics and students use this new technology in their education, while they create new educational videos, using the social media platforms, such as META™ or Alphabet™. The social platforms are used for entertainment, but what if we could also use them for the humans cognitive and social development?

Conflict of Interest Statement

The author declares no conflicts of interest.

About the Author

Eftychia Aslanidou, is a PhD Cand. at the Ionian University, in the Department of Digital Media & Communication. She completed her first studies at the School of Primary Education at the University of Crete. She was distinguished by the State Scholarship Foundation for her ethos and her academic performance for each and every year of study

2008-2012 as the "top of the graduate student in Greece". She was also awarded the "Triantafyllia Kriezi" scholarship as the top Macedonian student. Eftychia left her homeland to see what more she could learn and consequently bring back to offer to the children of Greece. She continued her studies of bilingualism abroad, in New York. There she attended the prominent universities City University of New York, Long Island University, and Westchester College while also teaching at the Greek-American school Plato. When she returned to Greece, she continued her studies at both the European University for Special Inclusive Education and at the Aristotle University for Preschool Education. She has presented her findings on inclusive education to several national conferences and journals and taught in public schools in Zakynthos until cofounding "The Hellenic American Academy" with Steve Krause. She designed the model learning center as a means to offer the most effective excellent education, tailored to the individual needs of children in Zakynthos. Eftychia, PhD Cand. of the Ionian University, along with The Hellenic American Academy, and its partners envision a bright future for the next generation. In the demanding environment of modern education, she promises to support children and their parents' educational needs with cutting-edge methods, child-centered teaching practices and the development of parental relationships.

References

Anderson, M. (2016). *The Learning Glass with Matt Anderson*. SDSU: CSU Institutional Repository.

Aslanidou, E. (2021). The importance of social situations, relational phenomena in young children: A review of recent evidence. *European Journal of Open Education and E-Learning Studies*, 6 (1), 35-39.

Aslanidou, E. (2019). Home Learning Activities and Children's Learning Outcomes: A Review of Recent Evidence. *European Journal of Education Studies, 6 (1),* 100-159. doi: https://dx.doi.org/10.46827/ejes.v0i0.2375.

Beka-Bajrami, F. (2022). The use of Information Technology in education on the time of COVID-19-case study. *11th International Conference of Technium Science*, 15-01.

Birdwell, J. A., & Peshkin, M. (2015). *Capturing Technical Lectures on Lightboard*. In 2015 ASEE Annual Conference & Exposition, 26-325.

Bransford, J., Brown, A., & Cocking, R. (2000). *How people learn: Brain, mind, experience and school* (2nd ed). Washington, D.C.: National Academy Press.

Chan, M. W., & Cushman, R. (2020). Beyond the Learning Glass. *STEM Instructional Graduate Teaching Assistant Posters*, 19. https://scholarworks.wmich.edu/stem-gta-posters/19

Cohen, L., Manion, L. & Morrison, K. (2000). *Research methods in education (5th edition).* New York: Taylor & Francis.

Dawes, I. (2001). *What stops teachers using new technology?* In M. Leask (Ed.), Issues in Teaching using ICT. London: Routledge, 61- 79.

Dorantes, A. (2016). *Economics and 'The Learning Glass' Technology*. SDSU: CSU Institutional Repository. https://hdl.handle.net/10211.3/165572

Elliott, S. N., Kratochwill, T. R., Cook, J. L., & Travers, J. F. (2000). *Educational psychology: effective teaching, effective learning*. NY: McGraw-Hill.

Firouzian, S., Rasmussen, C., & Anderson, M. (2016). Adaptations of learning glass solutions in undergraduate STEM education. *The XIX Annual Conference on Research on Undergraduate Mathematics Education*, 25-27, Pittsburgh, PA.

Foss, B., Oftedal, B. F., & Lokken, A. (2013). Rich Media e-Compendiums: A New Tool for Enhanced Learning in Higher Education, *European Journal of Open, Distance and Learning, 16 (1)*, 102-114.

Fung, F. M. (2017). Adopting Lightboard for a Chemistry Flipped Classroom to Improve Technology-Enhanced Videos for Better Learner Engagement, *Journal of Chemical Education, 94 (7)*, 956-959.

Gleason, B. & Greenhow, C. (2017). Hybrid Education: The Potential of Teaching and Learning with Robot-Mediated Communication. *Online Learning Journal, 21 (4)*, 159-176.

Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of personality and social psychology, 102(4)*, 700-717.

Gregoriadis, A., Grammatikopoulos, V., Tsigilis, N., & Zachopoulou, E. (2020). Assessing Teacher-Child Relationships: A cultural context perspective. In O. Saracho (Ed.). *Handbook of Research on the Education of Young Children*. 4th edition, pp. 322-332. New York, NY: Routledge. Doi: 10.4324/9780429442827

Hall, S., & Villareal, D. (2015). The Hybrid Advantage: Graduate Student Perspectives of Hybrid Education Courses. *International Journal of Teaching and Learning in Higher Education, 27 (1)*, 69-80.

Hallas, J. (2020). Behind the Learning Glass. *STEM Instructional Graduate Teaching Assistant Posters, 13*. https://scholarworks.wmich.edu/stem-gta-posters/13

Ivanović, M., Xinogalos, S., Pitner, T, & Savic, M. (2017). Technology enhanced learning in programming courses – international perspective. *Educ Inf Technol* 22**,** 2981–3003. https://doi.org/10.1007/s10639-016-9565-y

Kaqinari, T., Makarova, E., Audran, J., Döring, A. K., Göbel, K., & Kern, D. (2022). A Latent Class Analysis of University Lecturers' Switch to Online Teaching during the First COVID-19 Lockdown: The Role of Educational Technology, Self-Efficacy, and Institutional Support. *Education Sciences*, *12*(9), 607.

Karassavidis, I. (2001). *Constructivist learning online. Possibilities and perspectives.* In V. Makrakis (ed.), Proceedings of the Panhellenic Conference, 8-10 June 2001, Rethymnon.

Konstantakis, M., Lykiardopoulou, A., Lykiardopoulou, E., Tasiouli, G., & Heliades, G. (2022). An Exploratory Study of Mobile-Based Scenarios for Foreign Language Teaching in Early Childhood. *Education Sciences, 12 (5),* 306.

Koppe, C., Norgard, R. T., & Pedersen, A. Y. (2017). *Towards a pattern language for hybrid education.* VikingPLOP '17: Proceedings of the VikingPLOP 2017 Conference on Pttern Languages of Program.

Laurillard, D., Oliver, M., Wasson, B., Hoppe, U. (2009). *Implementing Technology-Enhanced Learning*. In: Balacheff, N., Ludvigsen, S., de Jong, T., Lazonder, A., Barnes, S. (eds) Technology-Enhanced Learning. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-9827-7_17

Liu, G. & Zhu, L. (2022). *Information Technology-Based Picture Book Design of Children's Intellectual and Educational Anecdotes. International Conference on Cognitive based Information Processing and Applications (CIPA 2021).* Springer: Singapore. 982-985.

Lubrick, M., Zhou, G., & Zhang, J. (2019). Is the future bright? The potential of lightboard videos for student achievement and engagement in learning. *EURASIA Journal of Mathematics, Science and Technology Education, 15*(8), em1735.

Mayes, T., & De Freitas, S. (2007). *Technology-Enhanced Learning, The Role of Theory*. In: H. Beetham, R. Sharpe. (eds) Rethinking of Pedagogy for a Digital Age, Routledge, New York.

Misirlis, N., & Munawar, H. B. (2022). An analysis of the technology acceptance model in understanding university students' behavioral intention to use metaverse technologies. In *12th International Conference: The Future of Education* (pp. 159-163).

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). Literature Review in Mobile Technologies and Learning. *Future Lab Report, 11*.

Negi, P. S., Negi, V. & Pandey, A. C. (2011). Impact of information technology on learning, teaching and human resource management in educational sector. *International Journal of Computer Science and Telecommunications, 2 (4)*, 66-72.

Pedersen, A. Y., Norgaard, R. T., & Koppe, C. (2018). Patterns of inclusion: Fostering Digital Citizenship through Hybrid Education. *Educational Technology & Society, 21 (1),* 225-236.

Petticrew, M., & Roberts, H. (2006). *Systematic reviews in the social sciences: A practical guide*. Oxford, England: Blackwell.

Rogers, P. D., & Botnaru, D. T. (2019). Shedding Light on Student Learning through the Use of Lightboard Videos. *International Journal for the Scholarship of Teaching and Learning, 13 (3),* 6.

Rostislav, F. (2014). Mobile Technologies Education. *Procedia-Social and Behavioral Sciences, 143*, 342-346.

Salomon, G., & Gardner, H. (1986). The computer as educator: Lessons from television research. *Educational Researcher, 15 (1),* 13-19.

Schweiker, S. S., Griggs, B. K., & Levonis, S. M. (2020). Engaging Health Student in Learning Organic Chemistry Reaction Mechanisms Using Short and Snappy Lightboard Videos. Journal of Chemical Education, 97 (10), 3867-3871.

Schweiker, S. S., & Levonis, S. M. (2020). A quick guide to producing a virtual chemistry course for online education. *Future Medicinal Chemistry, 12 (14),* 1289-1291.

Skibinski, E. S., DeBenedetti, J. I., Ortoll-Bloch, A. G., & Hines, M. A. (2015). A Blackboard for the 21st Century: An Inexpensive LightBoard Projection System for Classroom Use, *Journal of Chemical Education, 92 (10),* 1754-1756.

Sofos, A. (2021). *Teaching practices for intercultural education using New Media*. Athens: ION. [In Greek]

Talanda-Fisher, M. (2020). Through the Learning Glass. *STEM Instructional Graduate Teaching Assistant Posters*, 18. https://scholarworks.wmich.edu/stem-gta-posters/18

Todman, J., & Duck, G. (1993). Primary children and teachers' attitudes to computers. *Computers in Education, 20 (2),* 199-203.

Tosheva, N., & Abdullaeva, G. (2022). The Concept of Innovation and Types of Innovative Technologies. *Scientific progress*, *3*(3), 586-589.