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Examining the Engagement and Academic Success of Students in Blended Science Classrooms

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Abstract

Many educators believe traditional learning environments need to be enhanced to be more engaging to students. New educational methods need to be dynamic and responsive to connect with today's learners. One of the most popular new methods is blended learning, which combines dynamic online content with engaging face-to-face learning activities. This review of literature aims to explore the impacts this learning model has made in science classrooms. By changing the way that information is delivered to students, teachers are able to create more in-class learning opportunities for students. Students are able to practice more in the presence of their teacher, and classes can incorporate more hands-on learning. Although the initial set up of a blended classroom may take more time, there are positive outcomes for students.

Introduction

Many educators believe traditional learning environments need to be enhanced to be more engaging to students (Chitiyo, Stratton, Mathende, & Davis, 2019). New educational methods need to be dynamic and responsive to connect with today's learners (Vavasseur, et al., 2020). As technology has progressed rapidly in the 21st-Century, a significant opportunity for change is possible in the field of education (Akgündüz, & Akınoğlu, 2017). Over-reliance on traditional lecture-based instruction is dissonant with the needs and expectations of 21st-Century learners (Akgündüz, & Akınoğlu, 2017).

One of the most popular options is found in blended learning (Sunardi, Joyoatmojo, Sajidan, & Soeharto, 2016). The term blended learning was coined and popularized in the last decade (Hui, 2016). Blended learning is defined as a blend of formal in-person instruction and online learning with some student control over time, place, path, and/or pace (Angelone, 2019; Jones, 2017; Kassner, 2013; Patrick & Sturgis, 2015). It is an approach that can take many forms; however, there is always an element of online combined with offline activities (Alijani, Kwun, & Yu, 2014; Bazelais & Doleck, 2018; Donovan & Lee, 2015; Kassner, 2013; Rozeboom, 2017).

Since the early 2000s, educators have begun to increasingly explore digital media and technology in teaching (Shu-Chen, Lo, Lee, & Enriquez, 2018). In 2015, 87% of teens reported having computer access at home and 73% had access to a smartphone (Chitiyo, et al., 2019). Students are engaging in completely online classrooms or blended learning classrooms more each year (Kassner, 2013; Shu-Chen, et al., 2018). This increased prevalence of technology use in the classroom is allowing teachers and students to do things they never dreamt of (Chitiyo, et al., 2019).

Science education is seeing some of the largest benefits of this change (Donovan & Lee, 2015). Even a decade ago it was believed that science curriculum worked best in the traditional setting, compared to math and language arts where students were able to work at an individual pace (Watson, 2008). The traditional lecture approach continues to be the most prevalent means of instruction and is often criticized as an ineffective way of science instruction (Bazelais & Doleck, 2018). Blended learning is a shift to more student-centered learning (Watson, 2008). Student-centered learning provides opportunities to improve skills through interpersonal interactions in the science classroom (Burchett, 2016). The use of blended learning in science, technology, engineering, and mathematics (STEM) classrooms allows students to gain a deeper understanding through active learning and hands-on activities (Donovan & Lee, 2015).

Research on blended learning reveals positive student outcomes (Hui, 2016; Lack, 2013). This literature review aims to explore the research on blended learning and secondary students. It will examine the relationship between blended learning and student engagement and will review the qualitative and quantitative data about blended learning effects on student academic success and student motivation in STEM classrooms.

Common Applications of Blended Learning

The traditional lecture approach continues to be prevalent in both K-12 (Jones, 2017) and higher education (Bazelais & Doleck, 2018) but it may be an ineffective way for students to explore science. In the most passive version of these classrooms, students do not interact with the instructor or with each other (Perry, Danhausen, & Johnson, 2017; Velegol, Zappe, & Mahoney, 2015). The blended learning environment can increase student motivation through critical thinking and collaborative problem-solving (Alijani, et al., 2014; Ferri, Ferri, Majerich, & Madden, 2015).

The flipped classroom alters the sequence of in-class and out-of-class activities in a typical classroom (Hodgson, et al. 2017). Flipped classroom and blended learning have many characteristics in common; most of the literature overlaps (Bergmann & Sams, 2012; Ferri, et al., 2015; Limniou, et al., 2018; Miles & Foggett, 2016). The model originated with two chemistry teachers from Colorado: Bergmann and Sams (Chitiyo, et al., 2019). They began by recording their lessons for students who had missed class (Bergmann & Sams, 2014). In a flipped classroom students gain technical knowledge through online videos and complete online assessments, which prepare them to participate in in-class activities (Velegol, et al. 2015). Some of the most prevalent practices being used in STEM classrooms are blended learning strategies including the use of instructional video, hands-on learning, and the use of class time for homework problems.

Instructional Video

Instructional videos replace live lectures in a course that utilizes a flipped or blended model. Students can watch the videos as many times as necessary to understand the content, which allows students with prior knowledge to move quickly forward to new material and students who struggle sufficient opportunity to learn at their own pace without the pressure of holding other students back (Bergmann and Sams, 2012; Chitiyo, et al., 2019; Jones, 2019; Murphy & Stewart, 2015; Rozeboom, 2017). To be most effective, videos should be short and specific to one topic (Hui, 2016; Vavaseur, 2020; Velegol, et al., 2015).

Velegol, Zappe, and Mahoney (2015) published a case study of the change for an Environmental Engineering course with 145 students across two versions of the course. In version one, the professor recorded full-length lectures and posted them for students to watch before coming to class. In version two, short video segments were made and titled appropriately, allowing students to rewatch content of interest. Evaluations were made using both qualitative and quantitative measurements: qualitative measurements were taken from an end of course survey that included closed and open-ended questions. Through analysis of the student survey data, researchers discovered students in version two found the short videos more helpful than the long ones in version one. The one-way ANOVA showed no significant difference on the final exam grades between sections (Velegol, et al., 2015).

A three-year study followed medical students as they started their abdominal rotation, which included learning from 61 video lectures (Vavaseur, 2020). Students were given access to all 61 videos for the length of the three-month self-paced course while completing their rotation. A total of 353 students completed pre and posttest evaluations. The low pretest achievers demonstrated the highest improvements (M=11.3) while the highest achievers decreased their posttest scores slightly (M=3.6). Ninety-five percent of students reported they improved their knowledge using this method, and 99% of them would recommend the format to other students (Vavaseur, 2020).

In a 2019 study, Chitiyo, Stratton, Mathende, and Davis, examined the achievement and student perceptions of 6 seventh-grade science classrooms. Eighty-one students received traditional face-to-face instruction while 73 students received flipped instruction. Those flipped students were expected to watch videos the teacher had recorded, take notes, and submit questions. Multiple days were given to complete tasks to accommodate those students without internet access at home. The study compared pre to posttest data as well as student satisfaction surveys. There was no significant difference between posttest scores. While both genders scored the same on the pretest data, there was a slight increase in the scores of the female students in the flipped classroom on the posttest. Low ability students tended to fare slightly better with flipped instruction. In the Likert response survey data, 76% of students agreed with the statement “The flipped classroom gave me more time to practice what we learned”.

While instructional videos can improve student learning, students must exhibit self-motivation to learn from video content -- particularly if the teacher’s expectation is that videos should be watched prior to attending class. Hodgson, Cunningham, Mcgee, Kinne, & Murphy (2017) conducted a study on engagement in flipped secondary mathematics classrooms. After completing summer training on a flipped classroom, three teachers were observed delivering flipped and traditional lessons in two separate session. Flipped classrooms were to incorporate: a content-rich video, guided notes, or some other prompt to be completed by the student after watching the video, and classroom activities that built on the video content. Each teacher had multiple years of classroom experience and was teaching different levels. Teacher 1 (16 years) was teaching Algebra. Teacher 2 (28 years) was teaching apprentice-level Algebra. Apprentice was the designation this school gave to students who had not had success previously in school or mathematics. Teacher 3 (6 years) was teaching seventh-grade general math. The observations were taken by two different facilitators who selected six students each to watch for on and off-task behavior. Only students receiving instruction from Teacher 3 showed improved engagement in the flipped over the non-flipped lesson. Students receiving instruction from Teacher 2 had the same low level of engagement in both lessons and students receiving instruction from Teacher 1 showed high engagement in both lessons, but the engagement in the traditional lesson was marginally higher. This study suggests that engagement is a complex combination of instructional strategy, teacher abilities and actions, and student characteristics.

A flipped classroom is not one that has simply made video content available. In Murphy and Stewart’s 2015 study, a college physics professor began offering lecture videos halfway through the year. There was a minimal impact on only the low achieving students for this course. There was no impact on the majority of students. Murphy and Stewart (2015) tracked attendance and engagement in homework and they actually saw a 3% decrease in engagement after videos of the lectures were made available. Video alone doesn’t seem to have a positive impact on student achievement or engagement, instead the literature supports using video as part of an overall blended learning strategy.

Hands-On Learning

The Next Generation Science Standards (NGSS) put an emphasis on students creating understanding through experimentation (Angelone, 2019). Blended learning has the ability to minimize teacher-centered lectures through the use of instructional video, which opens up more time for hands-on learning (Bergmann & Sams, 2014). Experiential learning, such as hands-on experiments, can influence memory and recall (Ferri, et al., 2015; Velegol, et al., 2015). Blended learning may facilitate more hands-on learning through increased laboratory time, the creation of learning objects, and more time for practice during class.

Increased laboratory time. When instruction moves from lecture to digital resources in STEM courses, class time may be repurposed to increase comprehension of the content through laboratory experiences. Donovan and Lee (2015) conducted a study in a Food Science class at the University of Illinois at Urbana-Champaign. The course was redesigned as a blended course to increase the alignment between the laboratory material and the lecture content. The course had 54 undergraduates who participated in online lecture videos, in-class discussions, and laboratory activities each week. Students were given dynamic scenarios related to the food industry in lab each week. Data collected in a multiple-choice response survey showed the majority of students (n=45) strongly agreed that the course material covered in the lab directly reflected the materials covered in the lecture. In the open-ended section of the survey students commented on how they applied their knowledge from the classroom and videos during hands-on activities. The researchers were unable to examine if student reported perceptions of increased understanding translated to better examination scores. The use of blended learning facilitated the alignment between classroom and lab curriculum.

Ferri, Ferri, Majerich, and Madden (2016) examined the redesign of Circuit Engineering, a junior-based non-electrical engineering course. The course was designated as a two-hour lecture without a laboratory component. The course was redesigned with instructional videos to remove the need for lectures, which allowed the instructors to bring hands-on laboratory into the lecture room. After eight semesters over 2600 students participated in the blended learning format. The first few offerings had a mixed student reaction, but steps were taken to fix glitches and balance the workload. In the final exams, students performed statistically ($p < 0.05$) better on concepts related to labs than other basic concepts on the exam. A survey following the conclusion of the class had one free-response question that asked students to identify one way the labs helped them. Over 100 students responded that it gave them practical or real-life experience. Another 100 students stated that it helped them understand the theory. The students were able to have these hands-on experiences because instructors created space in class time by moving the traditional lecture out of the classroom.

Creation of learning objects. Blended learning tools offer students many alternatives to demonstrate their learning aside from traditional worksheets and tests. Madden and Dell'Angelo (2016) conducted a study on the use of photojournalism and environmental science. For each of six self-paced units, all of the 30 students were required to create a photojournal entry. Each entry needed one or more photographs representing the science content in the module and a description of the science content. Each entry was analyzed for evidence of developing eco-literacy. Madden and Dell'Angelo found that students in this class were able to connect scientific content to their personal lives and had a global reflection based on their photo journal entries. This different version of a lab helped students to redefine their science schema. By using digital photography and having to make presentations to submit to their class, students applied the science content differently.

Angelone (2019) allowed middle school students to explore atomic modeling in a self-paced unit. Students completed each task, which were located in their learning management system (LMS). The unit began with modeling compounds using marshmallows and toothpicks. They practiced naming and shapes of atoms. Ultimately, students built a digital model of an atomic compound which was then 3D printed. They then calculated the printed scale compared to the actual molecular size, coming up with approximately 58,800,00:1. Last, students evaluated each other's work. Angelone observed that students were able to ask questions among each other, showing a strong level of understanding.

Both undergraduate and secondary students seem to be able to make stronger connections with the use of laboratory or hands-on activities (Angelone, 2019; Burchett, 2016; Donovan and Lee, 2015; Ferri, et al., 2016; Madden, & Dell'Angelo, 2016). Hands-on activities help students create meaning of complex concepts, and can facilitate interpersonal communication between students (Angelone, 2019; Burchett, 2016; Ferri, et al., 2016). The use of digital tools and video instruction allows students to experience STEM instead of being told about it.

Homework Problems Done in Class

In a blended learning environment, teachers can spend more time helping students practice concepts and calculations to improve understanding (Bergmann & Sams, 2012). Issues arise when students attempt to master concepts through homework completed at home, but when the homework is actually done in class the teacher is there to help (Bergmann & Sams, 2014). By minimizing lectures and allowing for more student assessment and feedback, teachers are able to help smaller groups of students (Bergmann & Sams, 2012; Rozeboom, 2017).

In a case study by Velegol, Zappe, and Mahoney (2015), a professor in an Environmental Engineering course tested two versions of the flipped class. In both classes, the in-class time was modified to work on problem sets. Both versions had instructional videos that were to be watched before class. The first version of the class had class problems that were similar to the homework sets, in addition to out-of-class homework assignments. Students receiving the second version worked directly on the homework problems in class. In the first version, the addition of practice problems didn't help students to understand the content more; it left them feeling overwhelmed with the workload of the class. The second version took this into account and minimized outside work. In the final survey, those in version two found the work time significantly more useful to their understanding. Although it didn't affect the overall academic performance, the flipped format and problem solving also did not cause "harm" to student understanding. Even though students in the second version had less practice than the first, they scored just as well on the final. It isn't always about the amount of work a student does but the quality of understanding.

Rozeboom (2017) conducted field research on two sections of six-grade math. In one section, students received traditional instruction. In the second section, students learned through interactive problem sets and flipped videos. The problems were delivered using software that gave students immediate feedback on whether they had gotten each problem correct or not. Rozeboom observed that the flipped students were quick to help each other out in class time, a result that was not seen in the traditional group. Rozeboom noted that there was less time for students to practice the content in the traditional group. One student using the interactive problems stated that "Even though I hate when I get them wrong and have to do more problems, I feel like it helps me learn better." (Rozeboom, 2017). The blended group showed a higher improvement pre to posttest (m=6.92) than the traditional group (m=5.87).

In a university-level course on mechanics, Bazelais and Doleck (2018) assessed the intervention of blended learning with practice problems on students' understanding of basic mechanical concepts. The control group experienced a full ninety-minute lecture, which included conceptual questions and problem-solving examples. In contrast, the blended group watched a video lecture independently, followed by a 5-10 minutes discussion of concepts found in the video lecture, 10-15 minutes lecture with the aid of a smartboard, and 10-15 minutes to revisit concepts, and clarify misconceptions. The remaining class time was used to solve real problems in small groups. One-way ANOVA analysis showed average learning gains for the blended group at 40% compared to the 22% of the control group, which was statistically significant.

Both the use of experiential labs and class time for practice problems are predicated on minimizing lecture time. In face to face lectures, questions are asked to the whole and usually answered by a few. Blended learning can give more students practice and a voice (Larson & Sung, 2019).

Student perception of a flipped and blended classroom is fairly favorable (Chitiyo, et al., 2019; Vavaseur, 2020; Velegol, et al., 2015). However, studies to date have failed to establish a definitive answer as to the efficacy of the flipped approach with respect to engagement and achievement. There seems to be no significant impact for or against the use of flipped or blended learning (Chitiyo, et al., 2019; Vavaseur, 2020; Velegol, et al., 2015). More research would be beneficial to determine whether the flipped or blended classroom works better in some disciplines, or for specific types of students.

Challenges of Blended Learning

The transition to blended learning is not always a smooth one. Common challenges that arose from the literature in blended learning formats included an increase in teachers' workloads, re-training children to use technology for learning instead of entertainment, and pacing for optimal learning.

Increased Teacher Workload

Redesigning a class into a blended learning format can be challenging (Donovan & Lee, 2015; Ferri, et al., 2015). It is not a matter of just taking a traditional class and putting it online (Davies, 2011; Lack, 2013). There can be more initial work in finding or creating videos, determining activities, and identifying the needs of each student rather than preparing a single lesson for all students to hear one time (Angelone, 2019; Kassner, 2013; Rozeboom, 2017). With reformatting of classes, they may not always run smoothly the first year a blended learning environment is attempted. Science teachers may find some labs may take too much time while others do not have enough. This is an unfavorable, but almost inevitable, a consequence of a complete course overhaul (Donovan & Lee, 2015).

Academic Use of Technology

Teachers indicate students need to be re-educated in order to view their technology as a learning tool rather than as entertainment (Bergdahl, et al., 2018). In research from 2018, Bergdahl, Knutsson, and Fors interviewed two teachers through the process of technology integration in their classrooms. The teachers found that students were using the internet to solve their problems and it was reducing the critical thinking.

Perry, Danhausen, and Johnson (2017) interviewed multiple teachers at a high school that had implemented blended learning across all classes for the last four years. The teacher groups summarized student interaction with technology stating that students were very good with the technology they used socially. However, students were not good with the Office productivity side of technology. Many have trouble formatting a Word document.

Jones (2017) interviewed teachers from a rural Alabama high school who had experience teaching in a blended learning environment. The teachers reported that students needed to be monitored for off-task behavior, but they noted that the distraction was minor in nature and didn't take away from the good of blended learning

Student's lives are busy and this affects their engagement. Hui (2016) studied adult learners in a blended environment and noted a need for some form of accountability that will help to prioritize the course above other competing demands. Hutton and Robson (2019) observed that lower complexity tasks saw the most traffic in their prep-course learning community study.

It is not that students are unfamiliar with technology as a whole, but rather the ways students use technology has not been academic (Bergdahl, Nouri, & Fors, 2019). There is a digital skill gap that needs to be addressed. Bergdahl, Nouri, and Fors (2019) surveyed 552 secondary students in Stockholm, Sweden. Students filled out a six-point Likert scale survey on engagement and digital skills. Their grades were cross-referenced with their questionnaires. Findings showed students who possessed low skills for switching between technology for entertainment and technology for education had some of the higher rates of disengagement (Bergdahl, et al., 2019). A lack of digital balance seemed to have a negative effect on students' grades.

Pacing

Part of the appeal of blended learning is that learning can be self-paced. This can bring its own issues. Hui (2016) conducted a study of 123 participants enrolled in six self-paced online sessions. Each session took about one hour to complete, with one final three-hour in-person session at the end of the learning. Based on log-in data, Hui found that participants fell into two categories in the self-paced session: those who took their time to engage deeply in the content and those who did a crash course (Hui, 2016).

A similar finding was observed in 353 medical students enrolled in a self-paced course (Vavasseur, et al, 2020). The students were to watch 61 total videos over three months. Completion of the videos revealed two major peaks in students' work time, one at the beginning of the unit and one before a final deadline (Vavasseur, et al, 2020).

Angelone (2019) conducted field research in a middle school science classroom for a self-paced unit on atoms. Angelone (2019) found that students were unfamiliar with setting their own pace and taking ownership of their learning. Students can be provided a schedule of work to be completed or set small deadlines to help with pacing issues (Angelone, 2019).

Teachers' New Role

The move to use technology to improve teaching and learning is not only the decision of teachers. Federal legislation in the United States, Title IV part A of ESSA, currently mandates that technology be integrated into schools' curricula because of the popular belief that learning is enhanced through the use of technology (Levin, 2016). The mandate emphasizes technology integration in all areas of K-12 education (Davies, 2011; Jones, 2019). The integration of technology ultimately falls on the shoulders of teachers, and blended learning is one way to accomplish the integration. However, blended learning does change a teacher's role in the classroom.

Technical skills. Transitioning to blended learning will require a new skill set for teachers. They will need to find and/or make content in a very different way than they did while preparing for a single lecture in the past (Miles & Foggett, 2016). There are many sources for a teacher to use, and multiple web-based services for teachers to create content (Murphy &

Stewart, 2015; Rozeboom, 2017). Instructors have access to programs like Screencastify, which enable them to capture their screen and record their voice (Chitiyo, et al., 2019). Others have chosen to recreate the lecture environment with a fixed tripod so they can still give notes on the board (Murphy & Stewart, 2015). In both cases, there are some production skills teachers need to learn in order to make a quality product, including adjusting for noise levels and editing (Muphy & Stewart, 2015).

Content curation and app selection. Instead of reliance on textbook publisher curriculum and workbooks, educators who adopt a blended learning approach curate lessons with premade content – often from software apps, dynamic websites, and video collections. Rozeboom (2017) used Khan Academy and a math program, IXL, for students to learn and practice in the flipped study. He is not alone, in a 2019 report, Khan Academy reported their products supported 8,000 teachers (Khan, 2019). Jones (2017) interviewed eight teachers and each teacher identified at least two web-based learning platforms they used to supplement regular classroom instruction-- programs such as Grammar bytes, Edmodo, Socrative, EVER-FI, and Quill. Most of the resources had similar features: interactivity, self-paced components, student-friendly navigation, and assessment components.

The initial set up and training can be the most critical in the implementation process for an app or premade digital content (Alijani, et al., 2014). Support from administration and those with experience can be vital as the first implementation tends to have low student satisfaction (Bergdahl, et al., 2018; Jones, 2017; Miles & Foggett, 2016; Shu-Chen, et al. 2018). With time and practice, blended learning can have positive impacts (Perry, et al., 2017).

Use of instructional time. A common colloquium to describe teachers changing role is the shift from being the ‘sage on the stage’ to ‘guide on the side’ (Jones, 2017; Rozeboom, 2017;

Smith, Menkel, & Ochs, 2014). In a flipped classroom where new instruction is presented digitally as homework, and class time shifts from lecture to practice, teachers spend most of their time answering questions that arise from the flipped homework (Chitiyo, et al., 2019). The use of blended learning can alter how educators use class time allowing more personal interaction with students (Watson, 2008).

Blended learning has the ability to allow teachers to respond more quickly to students' needs. Limniou, Schermbrucker, and Lyons (2018) compared how two different instructors taught half of their lessons in a traditional manner and half in a flipped classroom. In the flipped classroom, teachers collected formative assessments from students using a survey and polling software, which allowed them to collect student data and provide immediate support. Teachers who used traditional lectures did not gather the formative data to support students. Immediate feedback allows teachers to guide students through the material. Previously the feedback would come as notes on homework. In the Likert response survey data, students gave a similar average for the enjoyment of both the traditional model (M=1.76) and flipped learning (M=2.11). Students perceived to improve more on the development of analysis, synthesis, and evaluation of new ideas in the flipped lessons than they did in the lessons taught in the traditional manner.

Jones (2017) noted the teacher's role as facilitator was a predominant theme when interviewing eight teachers from a rural Alabama high school. One of the teachers commented "I allow students to pair up or work independently, and I can act as a facilitator or a kind of monitor" (2017, p.82). The blended tools allowed students to be independent and for the teacher to move between them. Teachers are now assisting student learning instead of being the transmitter of knowledge.

In the redesign of the Food Science course, Donovan and Lee (2015) reported that the teaching assistants (TAs) who had previously spent a large amount of their time preparing laboratories were able to interact with students more. The laboratories were altered so students were designing their own group's tests and analyzing their results. The TAs no longer had to prepare the lab for the whole class. Instead they needed to listen to what the lab groups wanted to do and assist them in making their own test. Students reported that the laboratory testing helped them to understand the content from class.

These changes do not remove the need for the teacher; rather, they allow the teacher to give individualized attention to the learners (Bergmann & Sams, 2014). Rozeboom (2017) noted a positive of blended learning is the ability to work with small groups of students. Historically, if a teacher taught a lesson and 30-40% of students did not understand it, the teacher would re-teach that lesson to the whole class. Now they can use software to individualize instruction (Smith, et al., 2014)

The literature on the use of blended learning in STEM is diverse and sparse. The field is wide open for further investigation. Future areas of study should include longer blended versus face-to-face studies in the 6-12 grade levels. Most of the studies being done at this level are only a unit at a time, so may have some novelty engagement factored in (Chitiyo, et al., 2019; Rozeboom, 2017).

When looking at engagement, most of the reported results are based upon student or teacher perception of engagement (Alijani, et al., 2014; Donovan, & Lee, 2015; Hui, 2016; Madden, & Dell'Angelo, 2016; Rozeboom, 2017). Studies with more quantitative methods may give a better picture of how blended learning affects student engagement in the classroom.

Conclusion

Blended learning is not simply giving every student a device; it requires new attitudes and skillsets (Kassner, 2013; Patrick & Sturgis, 2015). The reach of the classroom has been extended by allowing students to do online activities (Murphy & Stewart, 2015). As the use of technology in the classroom increases, it is important to look at the impacts of these changes on students (Miles & Foggett, 2016).

The move to blended learning involves distributing information in new ways from the traditional lecture and having students use class time for hands-on learning and guided practice (Bergmann and Sams, 2012). Students will need to be re-educated about how to use their technology for learning and not as entertainment (Bergdahl, et al., 2018; Bergdahl, et al., 2019; Jones 2017). The literature shows varied results for student engagement in blended and flipped classrooms and shows a positive or neutral impact on student achievement. If there is no significant difference, then blended learning classes are at least equivalent to the face-to-face mode (Larson & Sung, 2013).

In a STEM classroom, a deeper understanding can be achieved if students are active participants in their learning (Bazelais & Doleck, 2018; Donovan & Lee 2015). Having students engage in deeper thought is shown to have stronger impacts on memory and recall (Burchett, 2016; Ferri, et al., 2015; Larson & Sung, 2013). When students interact with information in multiple ways, such as video, practice, and hands-on learning, they are able to make stronger connections between concepts (Ferri, et al., 2015, Sunardi, et al., 2016).

References

Akgündüz, D., & Akınoğlu, O. (2017). The impact of blended learning and social media-supported learning on the academic success and motivation of the students in science education. *Ted Eğitim Ve Bilim*, 69–90.

Alijani, G. S., Kwun, O., & Yu, Y. (2014). Effectiveness of blended learning in KIPP New Orleans' schools. *Academy of Educational Leadership Journal*, 18(2), 125-141.

Angelone, L. (2019). Blended learning in the science classroom. *Science Scope*, *043*(04).

Bazelais, P., & Doleck, T. (2018). Blended learning and traditional learning: A comparative study of college mechanics courses. *Education and Information Technologies*, *23*(6), 2889–2900.

Bergdahl, N., Knutsson, O., & Fors, U. (2018). Designing for engagement in TEL -- A teacher-researcher collaboration. *Designs for Learning*, *10*(1), 100-111.

Bergdahl, N., Nouri, J., & Fors, U. (2019). Disengagement, engagement and digital skills in technology-enhanced learning. *Education and Information Technologies*, *25*(2), 957–983.

Bergmann, J., & Sams, A. (2014). Flipped learning: Maximizing face time. *T + D*, *68*(2), 28-31.

Bergmann, J., & Sams, A. (2012). Flipping the classroom. *Tech & Learning*, *32*(10), 42-43.

Burchett, S. B. (2016). *Blended learning in chemistry laboratory courses: Enhancing learning outcomes and aligning student needs with available resources* (dissertation). ProQuest, Ann Arbor, MI.

Chitiyo, G., Stratton, E., Mathende, A. M., & Davis, K. M. (2019). Evaluating flipped versus face-to-face classrooms in middle school on science achievement and student perceptions. *Contemporary Educational Technology*, *11*(1), 131–142.

Davies, R. S. (2011). Understanding technology literacy: A framework for evaluating educational technology integration. *TechTrends, 55*(5), 45-52.

Donovan, J.D., & Lee, S.Y.. (2015). "How we flipped: Student and instructor reflections of a flipped-class model in a sensory evaluation laboratory course." *NACTA Journal*, vol. 59, no. 4, 2015, p. 335+. *Gale OneFile: Educator's Reference Complete*.

Ferri, B., Ferri, A., Majerich, D., & Madden, A. (2015). Effects of in-class hands-on laboratories in a large enrollment, multiple section blended linear circuits course. *Advances in Engineering Education*.

Hui, Y. T. (2016). Investigating engagement in a blended learning course. *Cogent Education, 3*(1).

Hodgson, T. R., Cunningham, A., Mcgee, D., Kinne, L., & Murphy, T. J. (2017). Assessing behavioral engagement in flipped and non-flipped mathematics classrooms: Teacher abilities and other potential factors. *International Journal of Education in Mathematics, Science and Technology*, *5*(4), 248–248.

Hutton, C., & Robson, J. (2019). Breaking barriers, building community: Improving student engagement with preparation for studying online multidisciplinary science by distance learning - a case study. *New Directions in the Teaching of Physical Sciences*, (14).

Jones, A. M. (2017). Exploring teachers’ blended learning experiences in a rural Alabama high school. (Order No. 10639618). Available from Social Science Premium Collection.

Jones, S. (2019). *The implications of blended learning in today’s classroom: A look into the history, views, impacts, and research* (thesis). *NWCommons*.

Kassner, L. (2013). A review of literature: Mix it up with blended learning in K-12 schools. *Online Submission*,. 1-16.

Lack, K. A. (2013). Current status of research on online learning in postsecondary education.

Larson, D. K., & Sung, C.-H. (2019). Comparing student performance: Online versus blended versus face-to-face. *Online Learning*, *13*(1), 31–42.

Khan, S. (2019). You + Us = Together We Change Lives. Khan Academy Annual Report 2019. https://khanacademyannualreport.org/.

Limniou, M., Schermbrucker, I., & Lyons, M. (2018). Traditional and flipped classroom approaches delivered by two different teachers: The student perspective. *Education and Information Technologies*, *23*(2), 797-817.

Madden, L., & Dell'Angelo, T. (2016). Using photojournals to develop ecoliteracy in a blended environmental science course. *Journal of College Science Teaching*, *46*(1), 26+.

Murphy, C. A., & Stewart, J. C. (2015). The impact of online or F2F lecture choice on student achievement and engagement in a large lecture-based science course: closing the gap. *Online Learning*, *19*(3), 91–110.

Patrick, S., & Sturgis, C. (2015). Maximizing competency education and blended learning: Insights from experts. *CopetencyWorks*.

Perry, W., Danhausen, T., & Johnson, C. (2017). Blended learning and student engagement in an urban high school. (Order No. 10683620). Available from Social Science Premium Collection. (1978046763).

Rozeboom, A. (2017). *Blended learning versus the traditional classroom model* (thesis). *NWCommons*.

Smith, S., Menkel, S., & Ochs, L., (2014). Reaching every child every day in 1:1 blended learning environments. *District Administration*, *50*(3), 38+.

Shu-Chen, Y., Lo, Y., Lee, A., & Enriquez, J. (2018). Learning online, offline, and in-between: Comparing student academic outcomes and course satisfaction in face-to-face, online, and blended teaching modalities. *Education and Information Technologies*, *23*(5), 2141-2153.

Sunardi, G. S., Joyoatmojo, S., Sajidan, S., & Soeharto, S. (2016). Blended learning-based self-directed learning on classroom action research training to improve teacher competency research. *Journal of Education and Learning (EduLearn)*, *10*(4), 327.

Vavasseur, A., Muscari, F., Meyrignac, O., Nodot, M., Dedouit, F., Revel-Mouroz, P., Dercle, L., Rozenblum, L., Wang, L., Maulat, C., Rousseau, H., Otal, P., Dercle, L., & Mokrane, F. Z. (2020). Blended learning of radiology improves medical students' performance, satisfaction, and engagement. *Insights into imaging*, *11*(1), 61.

Velegol, S. B., Zappe, S. E., & Mahoney, E., (2015).The evolution of a flipped classroom: Evidence-based recommendations. *Advances in Engineering Education*. Vol. 4, No. 3, pp. 1–37

Watson, J. (2008). Promising practices in online learning: Blended learning – the convergence of online and face-to-face education. Retrieved May 15, 2020, from https://aurora-institute.org/resource/promising-practices-in-online-learning-blended-learning-the-convergence-of-online-and-face-to-face-education/