Research Question:

How does technology impact middle school science?

Sub Questions:

1. How do LEGO robotics programs help engage middle school science classes?

2. How do technology programs and resources impact science classes?

1. Barak, M., & Zadok, Y. (2009). Robotics projects and learning concepts in science, technology and problem solving. *International Journal of Technology and Design, 19*(3), 289-307.

This article looked at how students solve problems from robotics activities, the knowledge addressed while working on robotics projects, and how students use science and technology concepts with project-based programs. Data was collected through class observations, student interviews, and analysis of student artifacts and reflections. The study was part of a junior high robotics course that was offered at an engineering-oriented college. The instructors had a minimum of five years of experience with robotics. Students attended class two hours a week for 15 weeks. The first year of the study included 80 students (38 girls). In the second year, 76 students (29 girls) participated in a revised course. The third year included all second year students in an advanced course and 116 new students (67 girls) in a basic course. The first year resulted in problems due to lack of motivation, so alterations were made the second year resulting on less emphasis on teaching subject matter to the entire class. With more time spent on doing activities, student involvement increased and more creativity was used in solutions. The third year focused more on students explaining their solutions using various digital methods, and encouraged students to use science and technology related terminology. This article

demonstrated how students can still learn science material in project-based environments. When instructors switched to shorter lectures and used posters to showcase important terms, students were more motivated to work on the project, and still demonstrated knowledge of science and technology related topics.

2. Blasco-Arcas, L., Buil, I., Hernadandez-Ortega, B., & Sese, F. (2013). Using clickers in class. The role of interactivity, active collaborative learning and engagement in learning performance. *Computers & Education, 62*, 102-110.

The primary objective of this study was to investigate the effectiveness of clickers on student learning performance. Participants included 198 undergraduate business students at a university in Spain. Students attended class two days a week for four hours during the semester. Three teachers taught the four classes involved in the study. Students were given individual and group clicker tests throughout the course. Students also completed a survey as part of the study. The results showed that students felt clickers facilitated more interactions with peers and the instructor. Students also felt able to actively collaborate on their learning experience. The results also showed that students were more engaged and comprehension improved. Although this study focused on older students and non-science classes, these same concepts could apply to middle school science classes and help students become more engaged in their learning process.

3. Cain, J., Black, E. P., & Rohr, J. (2009). An audience response system strategy to improve student motivation, attention, and feedback. *American Journal of Pharmaceutical Education, 73*(2), 1-7.

This article investigated how an audience response system (ARS) could improve student motivation and attention during lectures, and provides immediate feedback to both the instructor and students. Data was collected from 111 first-year pharmacy students who used ARS devices

to answer questions throughout several 50-minute science lectures. Data was also assembled from focus group reports, course and instructor evaluations, grade comparisons, and instructor self-reflections. All students preferred lectures that integrated an ARS than those that did not use an ARS. Almost all students felt using an ARS maintained their attention throughout class and was beneficial for summarizing and reviewing. Students gave more positive feedback about the course in general when using an ARS, and courses that used an ARS showed the highest final average percent grade. Student feedback showed positive results for improving student motivation and attention along with improved grades. These same standards could be applied to a middle school science classes to help improve enthusiasm and engagement.

4. Caldwell, J. E. (2007). Clickers in the large classroom: Current research and best-practice tips. *CBE - Life Sciences Education, 6*(1), 9-20. doi:10.1187/cbe.06-12-0205

This article focused on the use of response clickers in classroom settings and how their potential for increasing student learning was emphasized by several researchers and educators. The author examined 55 articles in her study, and learned that when response clickers were part of grades and used daily, attendance increased. The author noted that clicker activities needed to account for at least 10% of the grade to see improvements in attendance. With consistence use of clickers, students prepared more for quizzes and were more alert during classes. The author created a list of best practice tips based on her research. She discussed tips for planning and communicating expectations with students. She also made suggestion on ways to write effective questions. All of these tips could easily be applied to middle school science classes to help engage students.

5. Castledine, A.-R., & Chalmers, C. (2011). LEGO Robotics: An authentic problem solving tool? *Design and Technology Education, 16*(3), 19-27.

This article examined problem solving strategies used with LEGO robotics, and looked at how students related their strategies to real-world situations. The study was conducted in a Grade 6 classroom in an outer Brisbane primary school. The class consisted of 23 students, 12 of which were female. Students participated in daily, hour long lesson for two weeks. The researchers observed the students, focusing on the type of problem solving strategies used, and how the students connected the strategies to real-world situations. Students answered a short questionnaire at the conclusion of the study. The data showed two common themes for problem solving strategies: estimating and trial and error. Initially the students struggled to make connections from their strategies to real-world situation, but with further prompts students found relationships between their approaches and life examples. Problem solving is an essential tool in science classes, and is especially beneficial with middle school students. Using a program like LEGO robotics would impact science classes by improving problem solving skills and increasing student engagement.

6. Chambers, J. M., & Carbonaro, M. (2003). Designing, developing, and implementing a course on LEGO robotics for technology teacher education. *Journal of Technology and Teacher Education, 11*(2), 209-241.

A course was developed for undergraduate and graduate education technology students as part of this study. The goals of the course were to support technology curriculum using LEGO robots, and to immerse students in a constructionist environment leading them to teach by example in their future classrooms. The pilot class included 12 undergraduate and graduate students, all familiar with computers and programming. The students digitally recorded their progress throughout their five days of sessions. Data was also collected through observations and feedback from the participants. Technical glitches and points of frustration occurred, but every

student experienced success in programming and building their robot. The level of success depended on the technological skills and prior experience each student possessed. The students gave positive feedback about the program, and felt capable of using examples to teacher their own students. This is a great of example of what all teachers should do before trying new projects and activities. A teacher needs to work through an activity or project ahead of time to see where students might struggle. Middle school students get frustrated easily when projects and ideas do not work. By knowing the roadblocks ahead of time, a teacher can help eliminate those challenges and keep students engaged and working on a solution.

7. Chambers, J. M., Carbonaro, M., & Murray, H. (2008). Developing conceptual understanding of mechanical advantage through the use of LEGO robotic technology. *Australasian Journal of Educational Technology, 24*(4), 387-401.

This study explored the effectiveness of robotic technology with elementary children. It specifically focused on teaching science concepts of gear function and mechanical advantage. Data was collected through verbal interviews, as well as pretest and posttest questions. The study involved 22 students ages nine to ten who participated in six afternoon sessions using LEGO robotic materials. The sessions took place over a six-week time period and each session ranged from 90 to 150 minutes. The posttest results showed that students were better able to describe how to make a robot faster and more powerful. Students used scientific terms and specific examples in their posttest descriptions. Some students still struggled with the concepts of mechanical advantage and gear function, but overall the session improved students' scores from pretest to posttest. Despite the fact that not all students mastered the intended science concepts, the article demonstrated the usefulness of hand-on activities and how engineering concepts can be integrated into science classrooms.

8. Chen, T. L., & Lan, Y. L. (2013). Using a personal response system as an in-class assessment tool in the teaching of basic college chemistry. *Australasian Journal of Educational Technology, 29*(1), 32-40.

Student perceptions of using a personal response system (PRS) were examined in this study. Two science courses were used for this study over an 18-week time period. Ten quizzes using a PRS were given through the semester. Surveys were collected from students, examining student perceptions of a PRS used in place of paper-based tests. Interviews were also conducted and student performance data was analyzed, including weekly online homework grades, midterm and final exam scores, in-class PRS scores, and semester grades. Students had an overall positive view on using a PRS as an in-class assessment tool. Many students felt using a PRS enhanced their learning. Despite positive feedback, nearly half the students believed that using a PRS interfered with their ability to think clearly while taking a test. When adopting a similar program with middle school science students, it would be beneficial to expose children to the technology tool several times before using it for a graded assignment. This would reduce some of the anxiety of using an unfamiliar testing tool.

9. Flick, L., & Bell, R. (2000). Preparing tomorrow's science teachers to use technology: Guidelines for science educators. *Contemporary Issues in Technology and Teacher Education, 1*(1), 39-60.

This article explained how science teachers should use technology in the classroom, and offered a technology use guideline for science educators. Both authors were university professors in science and math departments. The authors researched the importance and impact of technology in science classes. Information for the guidelines also came from K-12 science teachers. The authors stressed how the impact of digital technology was more extensive than any other

previous curriculum or instructional innovation. Technology has changed hands-on science and instructional strategies in science. Proposed guidelines included using technology to introduce content, addressing appropriate understanding, extending instruction beyond what can be done without technology, making scientific more accessible, and developing an understanding of the relationship between technology and science. Technology should not be implemented for the sake of using it. Technology needs to be applied and utilized appropriately to enhance science classes and engage students at all levels.

10. Gauci, S. A., Dantas, A. M., Williams, D. A., & Kemm, R. E. (2009). Promoting student-centered active learning in lectures with a personal response system. *Advances in Physiology Education, 33*(1), 60-71. doi:10.1152/advan.00109.2007

This article investigated active learning approaches using personal response systems (PRS), and the impact PRS had on student engagement and learning outcomes. The study included 175 undergraduate science students. The second-year, 12 week physiology course met three times a week for 50 minutes, and included 10 two-hour computer assisted sessions. Students were assigned a PRS unit for the entire semester. Instructors used the PRS units to track attendance and give a questionnaire at the end of the semester. All instructors had experience teaching physiology and were instructed on the use of the PRS prior to the start of the semester. Questionnaire responses showed that students felt more engaged and motivated to think using the PRS during lectures. Significant improvement was also evident with increased scores on mid-semester and end-semester exams over a three year period. The study demonstrated that minor changes in lecture techniques can keep students more engaged and therefore improve learning. Adopting a personal response system at a middle school level could be quite beneficial in a science classroom.

11. Gebru, M. T., Phelps, A. J., & Wulfsberg, G. (2012). Effect of clickers versus online homework on students' long-term retention of general chemistry course material. *Chemistry Education Research and Practice, 13*(3), 325-329. doi:10.1039/C2RP20033C

The effectiveness of clickers on students' long term retention compared to online homework and traditional lectures was the emphasis of this study. The participants included 160 undergraduate students at a university who took Chemistry I and II during spring and fall semesters. Three separate teaching styles were examined when collecting data. The first class used clickers to obtain data from four to six multiple choice questions per class. The students in this class were given optional practice questions ahead of time, although many students chose not to complete the optional questions. The second class used an online program for homework. Finally, the third class used more traditional methods of lecture and non-online homework to present material to students. The results showed that the clicker students and the online homework students scored higher on the final exam than the lecture-only group. A higher retention rate in future chemistry classes was also noted from students in the clicker and online homework classes. This article demonstrated that traditional lecture-only styles of teaching may not be what is best for current students. Middle school children are accustomed to constant feedback from technology through gaming and social media, so it would be beneficial to replicate the same instant feedback in schools to improve learning.

12. Guzey, S. S., & Roehrig, G. H. (2012). Integrating educational technology into the secondary science teaching. *Contemporary Issues in Technology and Teacher Education*, *12*(2), 162-183.

This study examined how teacher motivation, beliefs, and content knowledge contributed to their use of technology in the classroom. Teacher participants included a middle school Earth science

teacher, a middle school life science teacher, and a high school physics teacher. The teachers participated in the study during their first three years of teaching, and all three teachers frequently used technology tools in their classroom. Classroom observations, interviews and classroom artifacts established the data for this study. All three teachers used technology because they found it rewarding and enjoyed using it. The teachers all believed in student-centered learning approaches and used technology to promote inquiry. The teachers also felt technology tools were invaluable for engaging students and presenting science concepts. For technology to be beneficial with any grade level, it needs to be implemented wisely and be supported by the instructor. If teachers want students to use technology, then teachers need to show their support, beliefs, and enthusiasm with the tools in order for the tools to be seen as valuable by the students.

13. Hakverdi-Can, M., & Dana, T. M. (2012). Exemplary science teachers' use of technology. *Turkish Online Journal of Educational Technology - TOJET*, *11*(1), 94-112.

This study examined how an exemplary science teacher used technology in their instruction and how often the teacher required their students to use technology as part of class. The authors examined 67 articles during their research process. The participants included 92 middle and high school science teachers who received the Presidential Award for Excellence in Science Teaching (PAEST). Data was mainly collected through a web-based questionnaire. Email and letter surveys were also conducted. The author used the data to determine common practices among exemplary teachers. The findings revealed that not all exemplary science teachers frequently use technology in their teaching. Many tools were utilized, including the Internet, digital cameras, online communications, presentation tools, and data collection probes, but the frequency of use averaged around a few times a month to less than six times per year. The frequency students were required to use technology as part of class also had similar results, which were limited to a

few computer tools in lessons. While most exemplary science teachers had high comprehension levels with technology, the frequency of technology used in the classroom was not as high. This articled demonstrated that it is not always the tool that makes a great classroom, but rather the instructor. Technology can be important for middle school science students, but students also need a skillful instructor to help guide them on their journey.

14. Hakverdi-Can, M., & Sonmez, D. (2012). Learning how to design a technology supported inquiry-based learning environment. *Science Education International, 23*(4), 338-352.

The article looked at the opinions of science teachers on development and application of a WebQuest inquiry-based learning environment. It also focused on how science teachers viewed WebQuests as a teaching tool, and their intent to use WebQuests. The semester long study involved 22 education majors at a university in Turkey. Participants had previous courses in basic computer skills, webpage design, and creating inquiry-based learning environments in science. Data was collected through open-ended questions. The participants found the WebQuest experience to be valuable, despite some limitations, and had high opinions of the resource. In general, the participants stated that they would use the resource in their classrooms. This data was supported by other studies. Technology supported, inquiry-based learning environments can help motivate students in their learning process. Middle school students can be tough to motivate, so resources that improve participation are invaluable.

15. Karp, T., Gale, R., Lowe, L., Medina, V., & Beutlich, E. (2010). Generation NXT: Building young engineers with LEGOs. *IEEE Transactions on Education, 53*(1), 80-87.

This article described the key success factors for implementing a LEGO robotics engineering program for elementary students. The author noted the decrease in electrical and computer engineering majors, as well as the increase in students who were not prepared for engineering

courses over the last decade. These problems have resulted in many engineering colleges creating outreach programs. LEGO Robotics has always been a significant part of outreach programs and was the primary emphasis for this article. Flexibility was a key fact for success of the outreach program. Every school and teacher had different needs and being able to cater to those needs made the program more successful. Supplying the necessary tools and software was another key success factor. Creating a mentorship between the teacher and electrical and computer engineering students helped success rates of the program. Finally, holding events at electrical and computer engineering campuses helped students make connections to future careers and opportunities. Outreach programs are beneficial at any grade level. Middle school students are beginning to thinking about possible career options. The more students are exposed to engineering and science related options and see future possibilities, the more likely they will be to engage in current science lessons.

16. Martyn, M. (2007). Clickers in the classroom: An active learning approach. *Educause Quarterly, 30*(2), 71-74.

The author compared the learning benefits from using clickers to another active learning method: class discussion. The study compared two classes that used clickers with two classes that used class discussion, with a total of 92 participants. All four introductory computer information systems classes were taught in the same semester at a small liberal arts college in the Midwest. Classes met twice a week for 75 minutes. Data was collected from pretest and final exam scores. The study also compared student perceptions about their learning. Results showed very little if any differences in scores from the group that used clickers and the group that used class discussions. The data showed that students felt using either clickers or class discussions improved their grade and understanding of the subject. Despite not proving one method being

better than the other, this article demonstrated the need for more interactive lessons and the benefit technology can have to enhance lessons for all students of all ages.

17. Milner-Bolotin, M., Antimirova, T., & Petrov, A. (2010). Clickers beyond the first-year science classroom. *Journal of College Science Teaching, 40*(2), 14-18.

Studies on clickers in science classes have been widespread over the past decade. Most research is centered on first-year science courses. This article examined the use of clickers in a small, second-year physics course. The article also assessed effectiveness of clickers in upper-level courses to collect data, along with instructor and student feedback. The 25 second-year physics students all previously used clickers in their introductory physics course, and therefore all students were familiar with using the technology. Researchers used anonymous surveys to obtain data, along with interviews conducted by research assistants. The majority of students found clickers to be useful in upper-level courses. Participants felt more opportunities were available to participate and obtain immediate feedback. Instructors found clickers to be beneficial in attaining information about misconceptions and student progress. Because students were familiar with clicker technology, results were not affected by technical issues and helped illustrate the benefits of clicks in classroom settings. With proper instruction, middle school students could benefit from the same technology in science classes.

18. Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*(5), 509-523. doi:10.1016/j.tate.2005.03.006

Preparing science and mathematics teachers to integrate technology into their classrooms was the main concentration of this article. The author was part of the science and mathematics education department at a university. The author examined first-year graduate level students focused on

integrating technology in their classrooms. The author noted that the method teachers learned material from may not necessarily be the way current students need to be taught in the 21st century. The author also pointed out that few teachers are taught how to teach their subject matter using technology. The participants included 22 students, along with faculty and supervisors whom all previously taught science or mathematics in middle or high schools. The students were exposed to various technologies throughout the course. The students also had lessons on technology strategies and how to teach and learn with different technologies. While all teachers were recommended for their licenses, they had varying degrees of progress in abilities to implement technology into the classroom. If teachers are not aware of how to appropriately integrate technology into science classes, students will not be able to benefit from the engagement and interactions the technology can offer.

19. Norton, S. J., McRobbie, C. J., & Ginns, I. S. (2007). Problem solving in a middle school robotics design classroom. *Research in Science Education, 37*(3), 261-277. doi:10.1007/s11165-006-9025-6

The relationship between teacher beliefs and activities involving design approaches, problem-solving, and constructing in a LEGO robotics environment was the focus of this study. The study followed two middle school robotics classes for one semester. Both classes had a combination of eighth, ninth, and tenth grade boys and girls. Neither of the two teachers taught robotics prior to this study, but each had a science background. Data was collected through observations and videotapes of classroom interactions. The results supported previous findings that LEGO robotics can be a valuable, problem-solving educational tool. Teacher beliefs did lead to different learning environments. Scaffolding by one teacher encouraged students to replicate the teacher solutions and not create their own solutions. The second teacher required students to create a

flow chart before programming. This forced the students to think about possible solutions, but did not offer the basic program necessary to complete the task. Problem-solving skills play an important role in middle school education. The more those skills are nurtured, the better the students will be prepared for future careers.

20. Oppliger, D. (2002). Using FIRST LEGO League to enhance engineering education and to increase the pool of future engineering students (work in progress). *In Frontiers in Education, 3*, 11-15. Retrieved from http://fie2012.org/sites/fie2012.org/history/fie2002/papers/1342.pdf

This article focused on the importance of increasing the pool of future engineer students, particularly through the FIRST LEGO League (FLL) program. The author noted how heavily the U.S. relies on foreign countries for its technical work force and how the U.S. needs to rely more on American technology students. The FLL program involves students aged 9-14 working in teams to create and program a robot to complete various tasks. Each year a new challenge is presented and students are encouraged to learn the science behind the challenge. Students are judged on creativity of their presentation and accuracy of their research. The author is still trying to determine if FLL increases the number of students who choose to study engineering related fields. The FLL program has only existed for four years, so measurable data was not available at this point. The author included survey results from 61 Minnesota FLL coaches. The coaches had positive views of the program and student involvement. The one drawback noted was the expensive costs necessary to participate in the program. The author suggested that universities should mentor FLL teams to help encourage more engineering related careers. Science and technology careers are a large part of our future. The more students enjoy these topics in middle school, the more apt they will be to choose a science or technology related career.

21. Roschelle, J. M., Pea, R. D., Hoadley, C. M., Gordin, D. N., & Means, B. M. (2000). Changing how and what children learn in school with computer-based technologies. *Future of Children, 10*(2), 76-101.

Roschelle is a senior cognitive scientist, Pea is the director of the Center for Technology, Hoadley is a research and computer scientist, and Means is the coordinator of the Center for Technology all at an independents research organization in California. Gordin is a research staff member at IBM in New York. This article explored ways computer technology could be used to improve how and what students learn in the classroom. Specifically, the article examined how technology supports active engagement, participation in groups, frequent interaction and feedback, and connections to real-world contexts. The authors found that technology enhanced engagement in laboratories by eliminating some of the tedious tasks and instantly graphing data. This allowed more time for students to be active in the project. The authors also discovered that technology can be used to perform tasks with others, giving students the opportunity to accomplish complex tasks that would otherwise be difficult to execute alone. Using computer technology offered immediate feedback for students, and helped children analyze their performance. Finally, computer technology provided students with tools to apply concepts to real-world situations. These techniques for improving how and what students learn by using computer technology can be applied to middle school science students and positively impact their learning process.

22. Sevian, H., & Robinson, W. (2011). Clickers promote learning in all kinds of classes-small and large, graduate and undergraduate, lecture and lab. *Journal of College Science Teaching, 40*(3), 14-18.

Numerous studies have focused on using clickers in large classroom settings. This article examined the use of clickers in small and large classrooms to see if benefits were present in both situations. The study included two mid-sized undergraduate chemistry classes with 60 and 120 students, three small undergraduate laboratory sections with 18 to 21 students per section, and one small graduate-level lecture course with five students. Data was collected over two semesters pertaining to issues with clickers, questions used, and student reflections. Most issues were apparent in all types of classes and were easily solved with slight modifications. The authors found that effective use of clickers varied among class type. Laboratory classes had more difficulties integrating clickers into sessions. Students worked at their own pace making it difficult to have the whole class answer a question at the same time. It was discovered that clicker questions were most effective at the beginning and end or laboratory sessions to determine if students were prepared for the lab, and to share lab results. In both small and large lecture sessions at undergraduate and graduate levels, students felt clickers were most useful for stimulating discussions. Students also appreciated receiving immediate feedback. Middle school students would benefit from integrating clickers into regular science lessons, and would help eliminate many misconceptions quite quickly with the immediate feedback received.

23. Spitzer, B. A., & Stansberry, S. (2004). Public school teacher use of instructional technology from an organizational culture perspective: An explanatory case study of two middle schools. *Association for Educational Communications and Technology*, 769-781. Retrieved from http://www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED485068

This study focused on how instructional technology was used in two middle schools with different technology resources and guidelines. Particularly, the study looked into preferences for

instructional technology and teacher attitudes about instructional technology. The participants included select teachers and administrators from two different K-12 school districts in Oklahoma. Participants gave feedback through online surveys and face-to-face interviews. Data was also collected through observations and document analysis during the six month study. Teachers at Maple Grove who had more access to technology resources used instructional technology more frequently in their classrooms than teachers at Hillwood Junior High. Teachers at Hillwood lacked access to hardware and therefore did not use instructional technology regularly. Hillwood teachers also had set guideline on programs and resources that could be used, so the teachers did not generally have a positive attitude towards adding technology to instruction. Maple Grove teachers on the other hand, were able to make their own choices about appropriate technology resources and programs. This led to more positive opinions about using technology and a better understanding for the importance of instructional technology. Because teachers at Maple Grove did not have set guidelines on technology used in the classroom, there was no consistency or collaboration among the staff. While the results showed a more positive outcome with allowing teachers to have authority in choosing technology for their classroom, a few guidelines and standard procedures would benefit the staff and students in general. Middle school students do need structure and guidelines, and would benefit across the curriculum from teachers that collaborated.

24. Stowell, J. R., & Nelson, J. M. (2007). Benefits of electronic audience response systems on student participation, learning, and emotion. *Teaching of Psychology, 34*(4), 253-258.

The authors of this study compared student feedback from clickers to more traditional teaching methods of lecture, hand-raising, and response cards. The study included 140 undergraduate psychology students who were split into four groups, each representing one of the feedback

techniques. The lecture group posed open-ended questions throughout the course and randomly called on students. The hand-raising group answered several multiple-choice format questions with a show of hands. Response cards with printed choices were uses in the third group for students to give responses to multiple choice questions. Students in the fourth group utilized clickers to give answer to class questions. Student surveys, percent participation and quiz scores were used to collect data. Surveys indicated that student enjoyed using clickers, and all students in the clicker group participated in class questions. Nearly the entire response card group participated in class questions while only three-quarters of the hand-raising group participated in answering questions in class. Although results showed that the hand-raising group performed the best on the formal questions, the difference could be due to lack of honesty and students not participating when they did not know the answer. The results demonstrate that clickers help encourage participation from all students because anonymity is maintained from other classmates while still receiving feedback about learning progress. Clickers would be a beneficial tool for middle school students because it encourages participation without penalties or embarrassment of answering questions incorrectly.

25. Vital, F. (2011). Creating a positive learning environment with the use of clickers in a high school chemistry classroom. *Journal of Chemical Education*, *89*(4), 470-473.

This article looked at the effectiveness of clickers in a high school science class. Data was collected over several years, comparing scores of students who had access to clickers and those who did not use clickers in the classroom. The students participating were all first-year chemistry students with class sizes ranging from 22-24 students. Data was collected through daily use of clickers, along with comparing final exam scores. Daily use of clickers allowed the teacher to focus on problem areas quickly and help students understand difficult concepts. Clickers had

minimal to no effect on improving scores on mathematics concepts. Calculation questions were difficult to administer with the clickers and took more time than traditional methods. Using clickers gave students the opportunity to be assessed without penalizing their grade. It was noted that creating high level clicker questions required creativity and time. The study showed that clickers can be just as effective at a high school levels as in university setting. Using clickers in high school science classes helped keep students engaged in lessons and showed improvements in units that focused on content knowledge. These same principals could be applied to a middle school science classroom to improve engagement and content knowledge.

26. Wang, C., Ke, Y., Wu, J., & Hsu, W. (2012). Collaborative action research on technology integration for science learning. *Journal of Science Education and Technology, 21*(1), 125-132. doi:10.1007/s10956-011-9289-0

Enhancing students' understanding of science concepts is main goal of science educators. These authors chose project-based learning (PBL) as the heart of their research. The article focused on how PBL affected student learning, and the learning needs that were ignored when using technology tools. Research was conducted at an elementary school district in Taiwan with very limited technology resources. Participants included 32 sixth grade science students during a semester course. The researchers included the classroom teacher and two other doctoral classmates, all of whom previously obtained their elementary teacher's license. Along with the classroom teacher, one of the researchers was an administrator with 25 years teaching experience, while the other researcher was a full-time counselor and part-time instructor at a college. Data was collected through observations, student questionnaires, interviews, informal parent feedback, student blog postings, and student assignments. The researchers discovered that incorporating technology into project-based learning increased their enthusiasm for learning.

Having several options for feedback allowed students who were shy to ask questions on blogs instead of verbally. Students also used feedback to make revisions and improvements on their project, showing their pride and ownership in their creation. Problems arose with students' lack of knowledge in using the internet and understanding plagiarism. Studies like this show how beneficial technology can be when integrated into middle school classes. If teachers explain internet usage and plagiarism ahead of time, problems can be eliminated and students can use the technology to engage in the content.

27. Whittier, L. E., & Robinson, M. (2007). Teaching evolution to non-English proficient students by using LEGO robotics. *American Secondary Education, 35*(3), 19-28.

The article looked at how LEGO robotics could be used to address the basic science principles of evolution to two middle school non-English proficient classes. All 29 students in the study were from at-risk, low socioeconomic groups having been in the United States for two years of less. The classes met every other day and the robotics unit consisted of ten 60 minute sessions. The students were challenged to build a robot that either was the best at one thing or second best at everything. Students were given a pretest at the beginning of the unit. The unit was concluded with a posttest and written summary of the project. Data was also collected through discussions and observations from each class period. Although mastery was not obtained, all students showed significant growth in understanding evolution based on the pretest and posttest scores. Students were also better able to both discuss and write about fundamental science topics. Hands-on activities keep middle school students active, and if students are involved in their learning, they are more likely to retain information.

28. Wolter, B. H., Lundeberg, M. A., & Herreid, C. F. (2011). Students' perceptions of using personal response systems ("clickers") with cases in science. *Journal of College Science*

Teaching, *40*(4), 14-19. Retrieved from http://www.oneonta.edu/faculty/horvattg/Download/Pubs/NSTA_2011.pdf

Students' perceptions of using clickers in an undergraduate biology class were the focus of this study. Researchers also looked at possible influences on students' perception of using clickers. Twelve faculty members from nine universities and 1,457 students participated in the study. Faculty members alternated instruction between lecture and clickers through the semester. At the end of the semester, students completed a survey about their perception of using clickers. Results indicated neutral attitudes towards using clickers. When results were broken down by variables it was noted that women and non-science majors had more positive views towards clickers. The type of system also changed students' views on using clickers. This study showed that there can be multiple factors that affect whether students view technology usage as positive. These are important factors to consider when implementing new technology programs and tools with middle school science students.