

THE ANALYSIS OF TEACHING AN ONLINE STUDENT-CENTERED CLASSROOM
WITH MASTERY LEARNING TO HIGH SCHOOL BIOLOGY STUDENTS

by

Rodney Albert Knowlton II

A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2021

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ACKNOWLEDGMENTS

Thank you to my family. You have always been there to rejoice in the brightest of times, and to comfort in the darkest of times. I am so grateful that you are in my life.

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ABSTRACT

Education is developing a continually evolving practice with the implementation of new styles of teaching and uses of technology becoming more and more prevalent. Mastery learning allows for the ability of students to work at their own pace with more frequent feedback compared to a traditional learning environment. The classroom under study will be implementing a mastery learning technique while also having students be completely online. This study investigated the perceptions of students within an online mastery learning classroom. The study also investigated the effect on students' performance through a standardized assessment and observation of grades. Students and parent perception data were collected through survey and interviews. The results indicated that students disliked online learning and wished to return to in-person environments. Mastery learning methods seem to impact perceptions and engagement of students in a positive way. Student performance appeared similar throughout this method of teaching, but more research would be beneficial to implement into the future.

INTRODUCTION AND BACKGROUND

Context of the Study

As education continues to develop and change over the years one of the newest innovations that students are becoming accustomed to in the classroom is the usage of technology. In many districts, such as my own, students are given Chromebook computers to help promote learning. With the inclusion of this new technology, it makes room for a new way of thinking when it comes to how modern classwork can function.

One idea that my district has been pushing is student-centered learning. Student-centered classrooms have also been linked to the idea of a flipped classroom. Flipped classrooms have a focus on student's learning at their own pace with much more of their intrinsic motivations. To facilitate a more student-centered learning environment, I shifted my classroom using mastery learning and an emphasis on the student to understand how this improves the efficacy and perception of students. This contrasts with a more traditional style of teaching in a science classroom.

The class that I investigated in this research is a freshman honors biology course at Metea Valley High School located in Aurora, Illinois. According to Illinoisreportcard.com, there are 2,925 students enrolled with 20% being low income. The graduation rate is 97% and the site defines us as an exemplary school. It is a diverse school with 42% white, 13.2% black, 13.6% Hispanic, 26.3 % Asian, and the remaining 4% defined as other. With this diversity, students have a strong respect for their fellow peers and inclusivity is a key component to our message (Illinois Interactive School

Report Card, 2020). My class is on the higher end of performers from this overall demographic, as they have been recommended by their middle school teachers to be placed in the honors science curriculum. These students are motivated to succeed and generally have strong family systems to provide support to them.

The research idea started when my district started to implement only a select number of courses deemed blended. A blended course at Metea Valley High School means that students take the course but are only required to be in class a few days of the week. The rest of the week students can go anywhere to work in the school. This prompted to me think about my classroom, and how students would learn if they did not have direct connection from me as a teacher each day. As events unfolded in 2020, my research took an approach that no one would have ever expected. With the lockdowns of the COVID-19 pandemic, schools were closed for in-person learning, and all classes were provided electronically via a software called Zoom. I will not be creating a blended course in my study, but it is the inspiration for starting to flip my classroom to where the students are more responsible for their learning.

As the new plans were discussed my colleagues there were a few changes that we thought necessary to implement a classroom that had students taking ownership of their learning, we deemed mastery learning to be the best route. Mastery learning to an organic way to learn and I feel that it is something that we utilize frequently throughout our lives as human being even though the word mastery may not be attached to it. As an educator that is also an athlete, I use my experience in wrestling to describe mastery learning anecdotally. When a new athlete signs up for wrestling there are a multitude of

techniques that they can learn from the coach as they become more knowledgeable around the sport. However, before a coach should place them into a competition, there should be a set of skills that a mastered a proficient level before they are ready. With this example, we see mastery learning outside the contemporary classroom, but this can be utilized within the classroom for any type of subject matter, although this study will focus on the impact on the science classroom.

The first hurdle is how to organize the material to be done sequentially so that every student could work at their own pace. To implement this, we used a Grid model (Appendix A) in which all assignments are given to students at the beginning of the unit, and they can work through them at their discretion. In addition to just having all the material, we wished to also change how the learning was done. Research has shown that mastery learning is an effective way for students to understand the material, and much of this mastery means repeated efforts to have full comprehension. So, in addition to giving students everything for a Grid, we will also allow students to repeat assessments and activities until they had reached a threshold where it is considered that they had mastered the material. If the score was lower than the desired threshold, they were able to redo these assignments and still receive full credit.

Focus Question

With these implementations, it was an expectation that students would try to focus on the process of learning, rather than being stuck in the minutia of point collection. Also, there is an intention that students take more ownership of the material when they are not bound by the arbitrary pace of the teacher. However, there is an added variable of only

being able to implement instruction online due to the circumstances in the world at the time of research.

In overview, my research attempted to answer the following sub-questions:

1. What are student's perceptions of an online and student-centered classroom?
2. How does mastery learning impact the performance, grades and learning of students?
3. Does online learning allow for a classroom where each student can be successful, engaged, and able maintain a high level of learning?

CONCEPTUAL FRAMEWORK

Mastery Learning

In the classroom, it is the hope that not just some students are learning but all students. The effective teacher should strive to help students see that learning in the classroom needs to be through their effort (Morgan, 2011). Another way to think of this more modern classroom is that it inverts the normal expectations of students, having them focus on problem-solving and the application of materials (Altemueller, 2017) therefore mastery learning is an excellent way to shift the thinking of students.

The key to mastery learning is that students are required to show mastery of a concept before they are allowed to move on to the next concept....if students do not show mastery, then given additional instruction or resources and allowed to take the quiz again (Morgan, 2011, p. 7).

Many skeptics of mastery learning might argue that it is self-taught and that the teacher is not involved with students. “It is not that they do not need a teacher and can learn on their own—it is that they each need a teacher in a different way and at different points in time” (Morgan, 2011, p. 7). The recognition of mastery learning and the ability to truly differentiate an entire class starts to become a topic of interest due to proper implementation allowing the instructor to spend time with struggling students in a more one to one environment (Altemueller, 2017).

To deliver on a mastery level classroom, students benefit from the process of working at their own pace. This is where the student-centered classroom assisted with technology comes into play, also known as the flipped, hybrid or blended classroom (Caufield, 2011). The flipped classroom format comprises self-directed learner

preparation, followed later by an interactive didactic session. Thus, by its nature, it includes highly effective learning techniques such as spacing (spreading out study activities over time), retrieval practice (active recall of previously studied material), and – depending on the nature of the interactive session – elaborative interrogation (explaining why something might be true) and self-explanation (relating learning to other knowledge) (Vanneman, 2017).

Online Learning

The idea of online learning often comes with various names, whether it be distance learning, E-learning, or remote learning, significant changes need to be accounted for to student success. It is thought that the first instances of this style of learning were started in the 1980s (Moore, 2010). The consensus of what exactly makes these terms different is still up for debate, what connects these various terms is that we have students who are not directly interacting with the teacher in-person to progress their learning (Moore, 2010). In modern times, this idea is also associated with students working through a virtual setting with the integration of computers and technology in schools.

An instructor's role in the classroom can be varied in a traditional learning environment. When the discussion of online learning comes into question, there are even more variables with which educators have to contend with. From the research of how educators perceive online learning, one of the most important factors seems to be a lack of social interaction through virtual settings. Overwhelmingly remote educators have advocated for a strong presence of a teacher in what can best promote student growth.

The reasoning and actual implementation of this presence are still varied amongst practitioners. It is also important to recognize that deliberate expectations and communication must be maintained to establish an effective classroom environment (Richardson, 2016). In research conducted by Davies, it was thought that online learning would lead to greater performance. However, with infrequent interaction, it was found that students generally failed the courses. The goal is to continue research to investigate what other factors might be salient for online learning and manipulate the variables that would lead to the union of online and student progress (Davies, 2005).

The Student-Centered Classroom

The goals for a student-centered classroom are described by Rayens (2018),

our goal for a student-centered classroom is to change the mindset of the student from a 'renter' to an 'owner'. In a classroom of renters, fees are paid, and the management is expected to deliver. In a classroom of owners, students are forced to realize that it is their responsibility to engage, absorb, and retain. (p. 94)

To begin implementing this role reversal of the flipped classroom, teachers can implement multiple strategies for student success and shift in thinking about a classroom. The teacher will gain time by only requiring brief yet interactive lessons to get students started but then acts as a coach or facilitator as progression occurs. This means that the focus is on building rapport with students, being an expert with technology integration, and provided insightful feedback on all the activities. With this type of environment, the traditional style of classroom management does not need to be focused on, rather providing feedback and building relationships are key (Barnes, 2013).

Origins of Ideologies

Mastery learning is not a new concept. Benjamin Bloom wrote extensively on the topic. Bloom thought that most teachers only believe that a fraction of their students will effectively learn the material in their classes. However, with the proper instruction, a more holistic approach, and focus on individualized learning through mastery, he advocated that all students should be able to learn (Bloom, 1968). The underpinnings of this educational style can be further traced back to the psychological findings of B.F. Skinner, which focus on operant learning, and how this impacts the behavior of humans. The basic principles of this movement from Skinner are summarized in the review of a study by Hartley (1974). He summarizes the five steps as adopted from the psychological research

1. The learner should be given some clear idea of where he is going, i.e., the terminal behavior.
2. The instruction leading to this behavior must be sequenced into small steps.
3. The learner should work on each step alone and at his own pace.
4. At each step, the learner should be encouraged to actively respond.
5. The learner should receive immediate knowledge of results concerning the correctness or appropriateness of these responses.

The idea of mastery learning has since then been continually put under scrutiny and objectively observed. Block and Burns (1976) summarize in their intense review of the literature associated with this changing mentality of education,

This perspective points to the alterability of most student learning under appropriate instructional conditions and suggests that many students' capacities to learn and learn well have yet to be realized. This ideological implication is by far the most important implication of the mastery learning literature. We are convinced that such beliefs about the inalterability of some students' learning need reassessment, and we see the emerging view of the alterability of virtually all students' learning as

providing a basis for this reassessment. This view provides a counterpoint to the older view, thereby creating the conditions for a dialectic between those who cleave to the older view and those who hold the newer. Surely, some fresh perspectives on the real limits of students' capacities to learn and learn well should emerge out of this dialectic (1976).

The adoption of mastery learning is a representation of a new frontier of educational practices that can be utilized worldwide. It is a powerful learning stratagem but must be carefully considered to implement properly. When adopted, the benefits can be far-reaching into any type of education for the betterment of student learning. (McGaghie, 2017).

METHODOLOGY

Treatment

The purpose of this study was to determine the effect of student success using student-centered learning online approach as it compares to a more traditional style of learning. This student-centered approach was carried out with the concepts of mastery learning and the availability of technology. Students were instructed via a student-centered method where students can engage and learn the material at their own pace. Eighty-eight high school freshman, who made up three honors biology courses, participated in this study. They also completed online learning throughout this semester, due to the restrictions in 2020 with lockdowns taking place at the time. In the second semester, the goal is to transition to a course that models a traditional classroom environment including lectures, discussion, group labs, etc. This could change due to possible restrictions again in the school year under study, so comparisons were made from performance in previous school years instead. Both quantitative and qualitative data were collected from multiple sources.

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix F).

Data Collection Strategies

Classroom Likert Surveys

Two similar Knowlton classroom surveys were given at the start and end of each semester (Appendix A). Students were given a value to represent a chosen response for each of the eighteen questions. To strongly agree students were given five points, to strongly disagree only given one point. These surveys inquired about student performance and perception throughout the time in the honors biology class. Some questions were similar in posing the question to compare the validity of student response and to view consistency. The students responded with Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), or Strongly Agree (5). Post treatment responses quantified on this scale from one to five and distributed into normalized box plot to display summarized class responses.

In Class Interviews

A random sampling of students who were willing to be interviewed were taken at the end of each semester. These open-ended questions were posed to exhibit the attitude and understanding of the students throughout the class (Appendix B). Students were asked questions individually and given time to answer questions as they saw fit. This could range from a full story to merely one-word answers. Students were informed multiple times for openness that grades would not be affected by the content of their input. The data were analyzed for themes and used to support other findings.

Honors Biology Student Learning Objective Pre/Post Test

A standard exam using the over-arching ideas of energy learned throughout the course was given to students at the start and the end of the first semester (Appendix C). This was adapted from the biology concept inventory test and the collaboration of student learning objectives adopted by science staff at Metea Valley High School. The pre-test was collected without students experience any treatment of teaching, and purely using the knowledge gained from past experiences prior to the course. The post-test would be given at the end of the semester to compare growth over the semester with the mastery learning methodology of mastery teaching method enacted. The mean percent growth for each student will be analyzed as a comparison to average growth from previous courses using a traditional in-person learning style. This was displayed on a bar graph with standard deviation being considered.

Student Grade Point Average Comparisons

Student grade point averages were collected at the end of the first and second semesters and compared to performance in their eighth-grade year of science. These data will give an understanding of the baseline performance of each student regarding science content. A set of values will be given to each starting grade in the previous year. This will be compared to the current performance through mastery learning. As an example, a student will receive five points for having earned an A in the past year and will only receive a score of four for a B the following year. This will show a drop of one point for this student in their grade point averages. This data was compiled into two unique pie

charts to show the total percentages of scores within the class using mastery learning and traditional learning method.

District 204 Parent Perception Survey

The superintendent of schools in Indian Prairie School District 204 released data about surveys taken by parents and the learning of their students during the time of lockdowns (Appendix D). The data collected displayed parent perceptions of their student's understanding while working through the material. The survey also received input if parents wished to bring students back to in-person learning and if they thought there was currently too much work. These data were analyzed as a whole, to get sweeping perceptions of all parents in the district during this online learning time. For efficacy of student learning parents answered could answer from Unsatisfactory to Outstanding. The ability for student to manage workload were given the option to respond on a continuum of gets nothing done to completes all work. This data was compiled into a bar graph to show the percentage of parents that had feelings within the respective categories, showing the sentiment for the community overall. The data collection instruments are summarized in the triangulation matrix below (Table 1).

Table 1. Data Triangulation Matrix from Knowlton action research.

Focus Questions	Data Source 1	Data Source 2	Data Source 3
<i>Primary Question:</i> What are student perceptions of an online, student-centered classroom?	Post Treatment Student Likert Survey	Student Post-Treatment Interview Questionnaire	Parent Perception Likert Survey
<i>Secondary Question:</i> How does mastery learning impact the performance, grades and learning of students?	Honors Biology Student Learning Objective Assessment	Grade Comparison of Mastery vs Traditional Learning	Student Post-Treatment Interview Questionnaire
<i>Secondary Question:</i> Does online learning allow for a classroom where each student can be successful, engaged, and able maintain a high level of learning?	Student Post-Treatment Interview Questionnaire	Parent Perception Likert Survey	Post Treatment Student Likert Survey

DATA AND ANALYSIS

The multiple-choice Honors Biology Student Learning Objective Pre- and Post-Tests assessed proficiency in the scientific method, cellular biology and ecosystem ecology. Within these areas of study, the ideas of energy and its transfer were focused. This allowed for a marker if students performance and knowledge increased from their baseline understandings via mastery learning. The results indicated that the average percent increase from before treatment to after treatment for mastery learning was 34%, respectively ($n=88$). This is compared to the same test given to a traditional style course where the average percent increase from before treatment to after treatment was 39% ($n=91$). To better understand variation in the data, the standard deviation was calculated for growth scores and found to be 13.7% and 14.5% respectively (Figure 1). The data suggests that even with error, there was significant growth for both learning styles, upwards of 20%, from pre to post test. Although the traditional styles showed growth at slightly larger levels, based on the variability both groups performance increased to a significant level (Figure 1). This improvement in understanding over first semester materials was reflected in the student interviews. When students were asked “did you learn using the mastery method?” they overwhelmingly expressed high levels of learning and engagement and were satisfied with their depth of understanding of the content. One student said, “I don’t think any other style of learning could help me to understand better!”

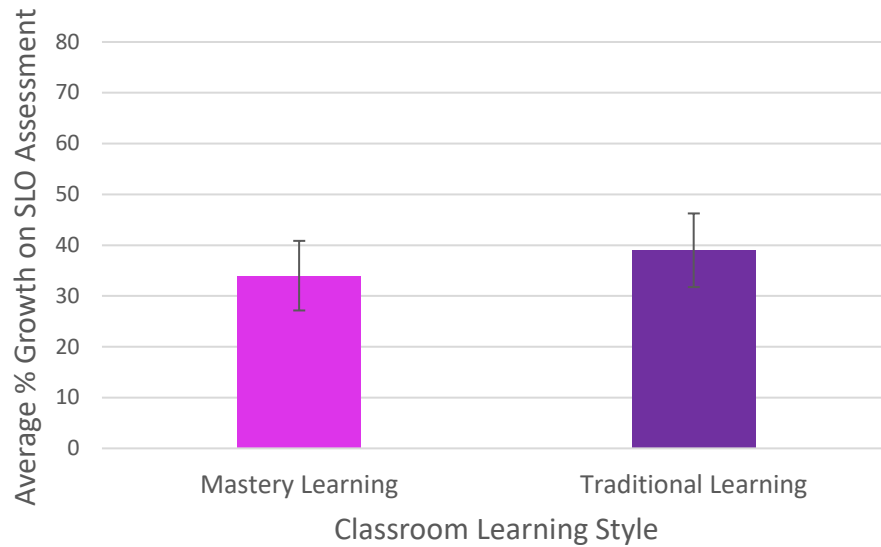


Figure 1. Average percent growth of student achievement on student learning objective assessment comparing mastery learning and a traditional classroom environment, ($N=178$).

Comparisons of grade point averages from 2020 using mastery learning in freshman year of high school were compared to similar student grades received during their 2019 middle school grades using a traditional learning style. Again, analyzing grade point averages gave an idea of overall learning efficacy in the mastery learning style. Grades were defined through the contemporary system of grading with an A, B, C and D corresponding to 100-90%, 89-80%, 79-70% and 69-60% respectively. No students received a grade of lesser than 60% falling into the failing, F, range of achievement. In the more traditional year of learning in middle school, student grades seemed to be clustered in a higher than expected range with 22.70% of student receiving a B and 77.30% earning an A. Whereas with mastery learning, in their freshman year of high school, class data displayed a more striated and typical grade distribution of 2% receiving

a D and 22% earning a C in the lower levels. In the higher achieving category, 39% of students received a B and 37% earning an A (Figure 2). Although all students receiving high marks might appear as an overall net positive, this might point to a lack of rigor with this traditional learning style. Whereas we see the differentiation of student success being dispersed throughout the achievement categories as they enter high school. This suggests that mastery learning not only keeps a strong rigor within the classroom, but it requires students to learn skills of time management and personal responsibility. In one student interview, they said “I like working at my own pace, it puts responsibility on me for completing assignments and getting things done on time”. Another student mentioned “Although it’s tough to plan my time, I definitely prefer this method overall. I feel like I have a deeper understanding when I plan out my schedule and have time to learn from my mistakes”. It is evident that students were pushed to areas beyond their understanding in mastery and required engagement to succeed. These could be correctly identified as markers to a rigorous and compelling classroom environment.

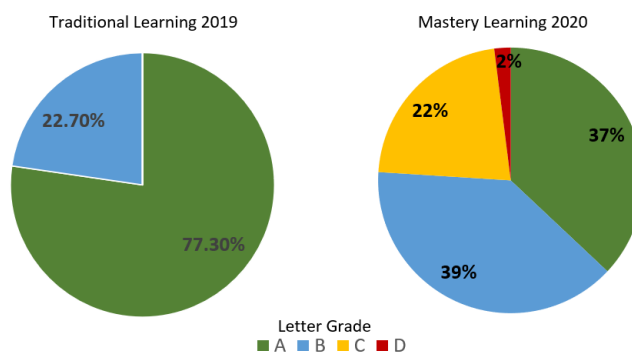


Figure 2. Class percentage grade comparison from mastery to traditional learning environments, ($N=88$).

Results from the student Likert survey post treatment illuminated insight into perceptions on the mastery learning method. Student responses were tabulated and then calculated into a percentage score out of all participant answers (Figure 3). Students were asked if mastery learning is helping to be more engaged in biology. Students responses by percentage were Strongly Disagree 2%, Disagree 5%, Neutral 17%, Agree 48% and Strongly Agree 28%. This denotes that 76% of the class had positive responses that mastery learning is helping them to stay engaged, whereas only 7% answered in a negative way. This suggested that students feel, as a group, a sense of strong engagement from the mastery learning style. Students were also asked if mastery learning allows for learning science material more effectively. Students responses by percentage were Strongly Disagree 3%, Disagree 5%, Neutral 28%, Agree 52% and Strongly Agree 13%. This denotes that 65% of the class had positive responses that mastery learning is a more effective way to learn, whereas only 8% held it in a negative regard. Overall, these data point to a classroom perception of either neutrality or positivity to the engagement and benefits of implementing a mastery learning method. In a student interview the student explained “Mastery learning allows more freedom, more independence....and it is really easily accessible.” Another student decided to use singular words to describe their experience, using words such as “Flexibility, engaging, organized and fun!”

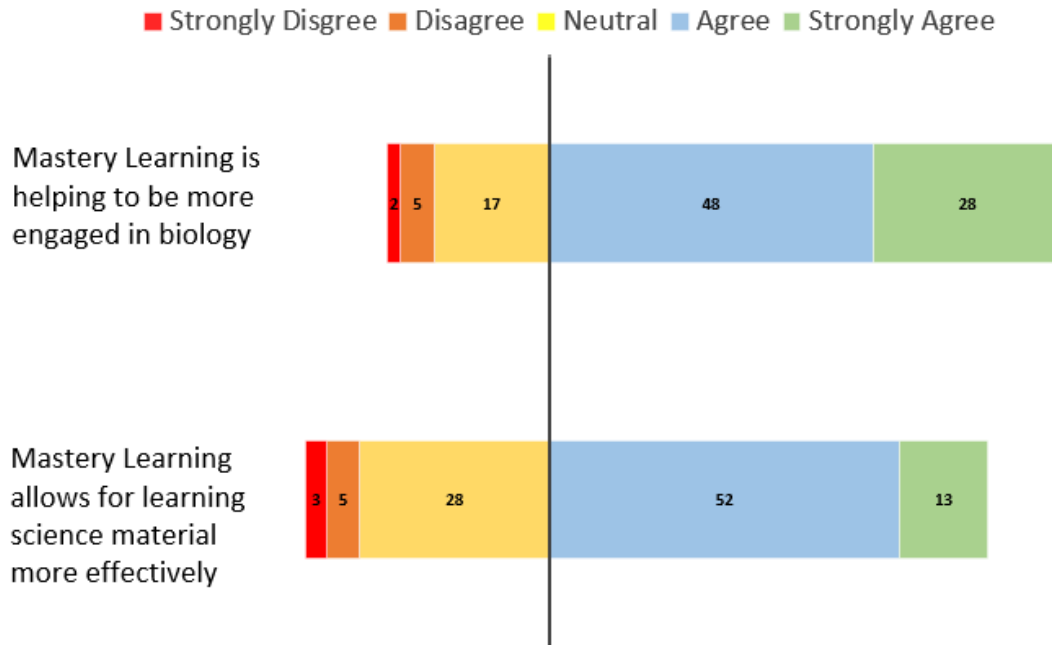


Figure 3. Likert survey results for student perceptions of mastery learning, percentage of students they say they ___ with each of the following statements, ($N=88$).

Data from the same student Likert survey post treatment also provided insight into perceptions and effectiveness of online learning. Student responses were tabulated and then calculated into a percentage score out of all participant answers (Figure 4). Students were asked about their enjoyment of the online format in the current year. Student responses by percentage were Strongly Disagree 13%, Disagree 13%, Neutral 40%, Agree 17% and Strongly Agree 17%. This constituted an ambiguous response representation of 40% had neutral impressions whereas the 26% negative responses were similar to the 34% positive responses. However this trend started to shift as students were asked if they would be excited to return to online learning next year. Student responses by percentage were Strongly Disagree 27%, Disagree 27%, Neutral 30%, Agree 8% and Strongly Agree 8%. This meant that nearly 84% of students had no excitement or were

opposed to the idea of online learning into the following year. To compound this negative trend, they were also asked if they enjoyed this online year of school more than their experience in person last year. Student responses by percentage were Strongly Disagree 22%, Disagree 35%, Neutral 33%, Agree 8% and Strongly Agree 2%. With nearly 57% of the students giving a negative response versus only 10% positive, we observe that sentiment to the online learning environment is overall low. This was reiterated in every student interview in some way. One student said, “I feel isolated in online learning and it makes it hard to socialize” another student mentioned, “I have heard about increased mental issues from kids being home alone. And honestly, I feel like we are all lazier when we stay at home.” Even another student explained, “I absolutely prefer in-person learning compared to online, I stay more connected and I miss the social interactions”. This points to perceptions from students that are outside of the realm of academics but rather the social emotional effects of online learning and being isolated from peer groups at their high school. This seemed to be a major contributing factor in the lower overall perceptions of online learning.

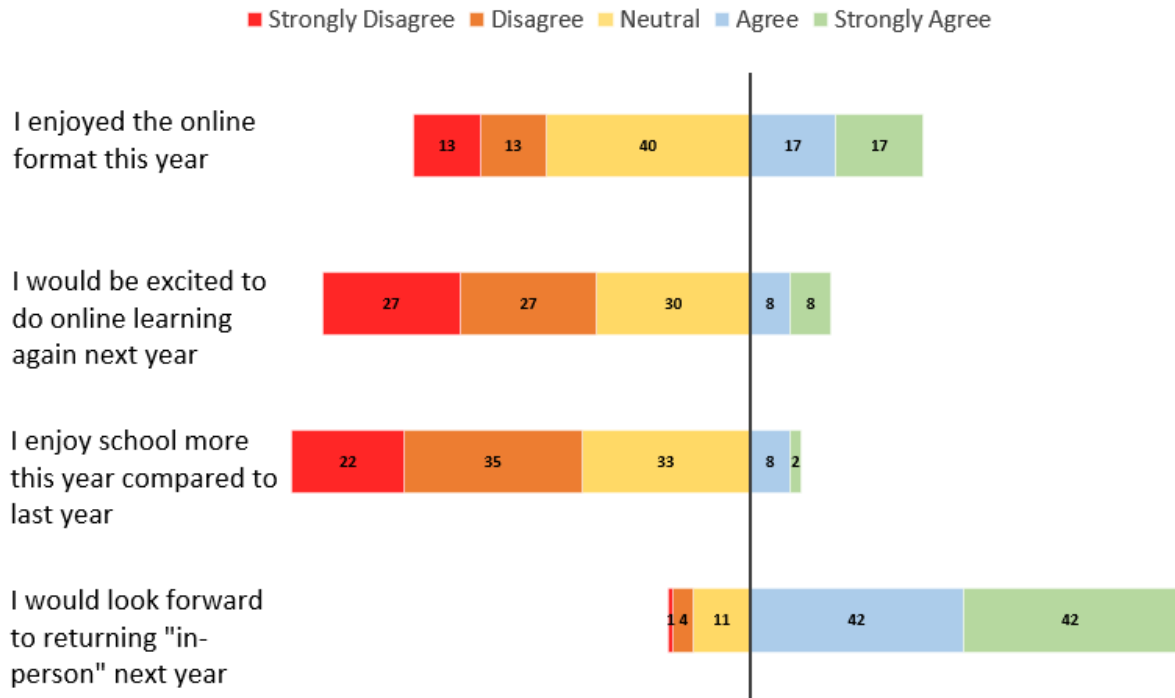


Figure 4. Likert survey results for student perceptions of online learning, percentage of students saying they ___ with the following statements, ($N=88$).

Even though teachers spend a large amount of time with students throughout the year, it cannot compare to the time and input that parents and guardians learn about their child. For this reason, parent perceptions of the efficacy of online learning were taken in district 204 (Figure 5).

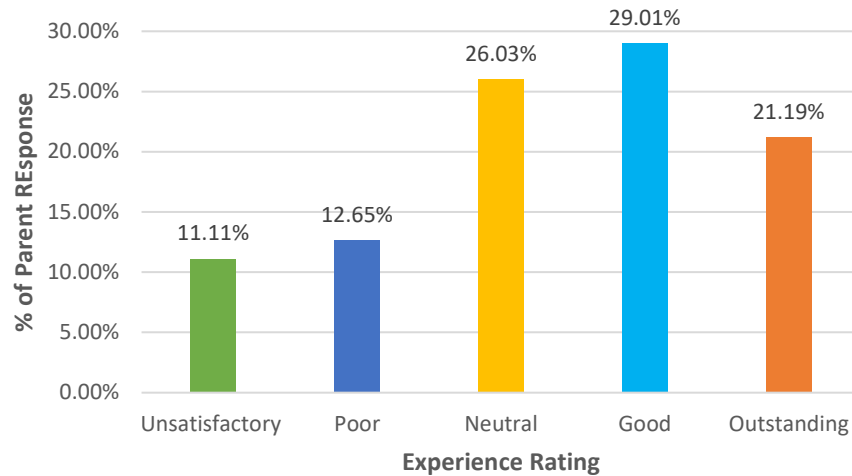


Figure 5. Indian Prairie School District 204 parent survey results on efficacy of student online learning experience, (N=11,881).

Data was also collected to assess the work effort of students by the amount of time and effort they observed their student completing classwork (Figure 6). Parent responses were tabulated and then calculated into a percentage score out of all participant answers. Parent responses of online efficacy by percentage were as follows: Outstanding 21.19%, Good 29.01%, Neutral 26.03%, Poor 12.65% and Unsatisfactory 11.11%. Ignoring the middle of the road responses, we find that approximately 50% of parents had a positive perception of online learning whereas about 24% had negative feelings. This seems to point at a more inclination for parents to experience online learning in a favorable way, although the negative sentiment is not at levels to be ignored. Parent responses of ability for student to manage workload by percentage were as follows: completes all work 49.29%, completes most work 20.11%, completes some work 16.05%, completes little work 8.64% and gets nothing done 5.91%. The overall

perception of student's being able to handle with workload is positive with nearly 70% saying that it can be managed effectively. This contrasts with only about 15% that seem to communicate that students were having a hard time completing work. This provides evidence that students are not struggling to stay on pace during this online learning time, but there might be other barriers that play a factor in the overall perceptions.

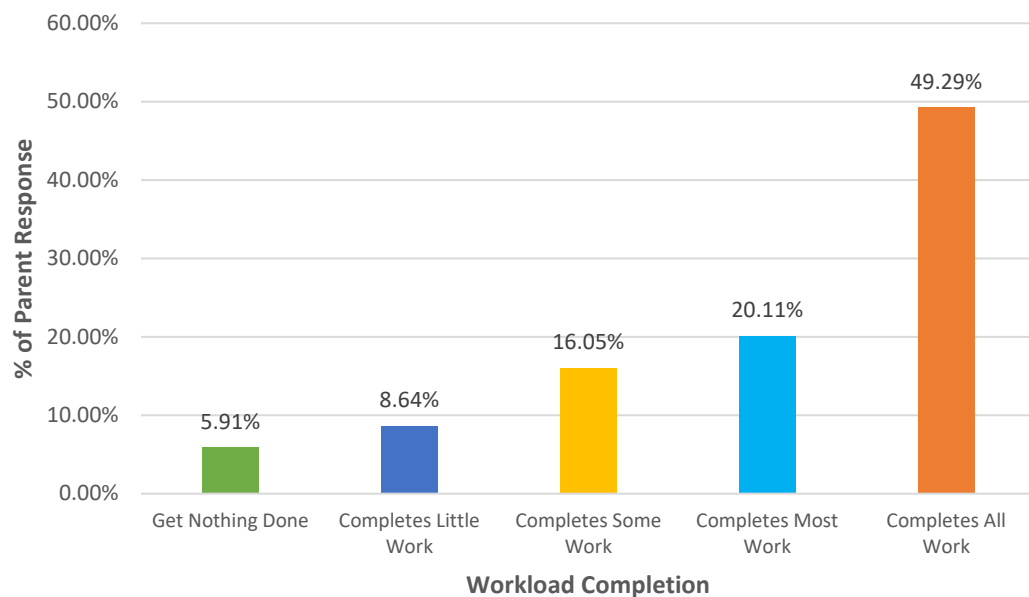


Figure 6. Indian Prairie School District 204 parent survey results on ability of student to manage workload during online learning, ($N=11,881$).

CLAIM, EVIDENCE & REASONING

Major Findings

When it comes to perceptions of students in the specific type of classroom environment that was able to be provided, it is essential to have it broken down into two areas: mastery and online learning. With mastery learning there is an observed positive perception from students in terms of being able to work at their own pace, understand the importance of their work, and being able to receive quick feedback as they work on assignments. This is opposed to the feelings on the online learning format. Even though parents did not seem to have a negative perception of the effectiveness or ability to manage workloads, it seems that students still were not excited about this type of learning. Based on interviews and anecdotal evidence, it seems that student success and engagement is linked to the ability for the social environment. Only being able to see and interact with peers via an online format cannot compare to the importance of face to face interpersonal interactions. With this missing, the content of the classes does not warrant the negative connotation, but the need to be back with peers is obvious from the student body.

When observing student achievement, it is an ambiguous set of data regarding if mastery and online learning together result in a more effective experience. Student learning objective data had slightly lower average growth but there was also more striation in grade point averages from years prior. With this data compiled, there is confidence to say that the performance level is not lesser than a traditional classroom, but data does not suggest that it is significantly better either. This performance of student

achievement would be better suited for additional research to analyze the effect of mastery learning within an in-person environment as a comparison to achievement in years prior. This is also a year with much chaos and unpredictability that would also negatively impact the confidence and connection of students having lived through a pandemic as the world has never witnessed before. All these things considered the performance level would be more effectively understood with additional research.

Value

As education continues to evolve and strive for new practices of allowing students to learn and grow, there are risks that need to be taken. Mastery learning is a system which takes large amount of pre-planning and reorganization of the classroom to be effectively implemented. However, it seems that once initiated within the classroom, mastery learning provides an alternative way to think of educating our youth. It draws from experiential learning and remediation of understanding as students progress. Added on top of all these things, educators understand how differentiation is extremely important in a classroom, and mastery learning allows for each student to have that experience in their own unique way. With all of these good implementations, we observe students that are not as focused in getting “points” but more connected to the overall understanding of the content as every step of the way requires this mastery to be shown. It can be argued that this process also allows for students to develop better habits as they enter into college and the work world, as understanding time management and priority of tasks is essential for every human being, even after their educational careers.

Online learning is another area of evolution that can be looked at to better understand the value within a contemporary environment. It is clear, that completely going online strips the students of these opportunities that they are not able to have replicated through the internet. More so, there are social variables and experiences that students seem to look forward to that looking into a video screen cannot replicate. It is important to tread lightly when it comes to educators fully implementing online learning in the future. It seems to be a good tool to help students stay connected during illness or other issues that would not allow for students to be safely in person. However, as a full-scale transition into online learning indefinitely, it appears that with the demographic and perceptions of students in the Chicagoland area, that would not be an appropriate or effective learning style.

Impact on Teaching

As I summarize the action research that was conducted two main things come into mind when thinking about the impact on teaching. It is recommended that all educators try mastery learning, as it seems to be a positive impact on the perceptions of students. Moreover, educators might suggest that these experiences are not as in depth or rigorous, but this research suggests that the mastery learning if not more rigorous is comparable to a traditional environment. The second main idea comes with the idea of online learning. It is recommended that educators and districts use caution in the future when implementing full scale online learning. The evidence from honors level students is that they are missing out on an important aspect of their educational experience. It would be interesting to see the effect of these online learning scenarios with a different

demographic of student. As it might stand to reason that these negative perceptions could be exacerbated with students that already struggle with engagement and motivation. Overall, I feel that this research has given me confidence in the ability to implement a mastery learning technique in my high school honors biology courses. This will be a style that I advocate into the future for colleagues, as I see firsthand the positive impact that it has on students. I will continue to analyze data in future years to come on performance as compared to more traditional years of school, as the online format is something uncontrollable in this year, and one would assume that it is an event to be remembered in history, but that we will not have to again experience in the near future.

Online Educational Resources

The resources a teacher utilizes in the class are influential to carry out both effective and engaging lessons. Resources that were essential are mentioned here to aid in future educators starting on the path to online mastery learning. Edulastic.com is a helpful formative and summative assessment tool. It allows for usage of test banks, sharing amongst educators as well as being able to be programmed to truly support mastery. Edpuzzle.com is a popular video distribution software to students, allowing for both teacher created and online videos to be shared with students while also asking for understanding. When not able to see students in person, Explorelearning.com is a phenomenal resource that can replicate numerous biology labs and allows for a grading system that supports mastery learning. The textbook Biology for a Changing World 2nd edition, by Shuster et al, that has an integrated suite of resources in addition to the online e-book, that was also a truly influential tool throughout mastery learning.

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APPENDICES

APPENDIX A

GRID METHOD ORGANIZATIONAL CLASSROOM TOOL

LEVEL 4: Construct & Design TARGET: Apply the eight science and engineering practices to evaluate a scientific argument. All assignments must be completed with at least 85% mastery for each box to earn full points	4A: Osmosis Stem Case Complete the Stem Case assigned. NEED: Stem Case Link ASSESSMENT: Activity SCORE: RECORD HERE			
LEVEL 3: Explain and Justify TARGET: Analyze evidence to justify a model or explanation that answers a question or solves a problem. All assignments must be completed with at least 85% mastery for each box to earn full points	3A: Grid 3 One Pager Activity Directions posted on Google Classroom. NEED: Paper and Coloring Pencils ASSESSMENT: One Pager SCORE: RECORD HERE	3B: Cell Structure and Function Summative - Ch. 3 This quiz will be taken individually and will cover all of the content on this grid. NEED: Edulastic Link ASSESSMENT: Need at least 85% to achieve mastery SCORE: RECORD HERE		
LEVEL 2: Apply & Demonstrate TARGET: Apply knowledge of cell structure to demonstrate how molecules could be transported across membranes. All assignments must be completed with at least 85% mastery for each box to earn full points	2A: Transport in Cells Activity Complete the Activity and show mastery on edulastic NEED: POGIL worksheet, Edulastic link ASSESSMENT: Activity & Edulastic Check SCORE: RECORD HERE	2B: Edpuzzle-Osmosis Complete the Edpuzzle assigned NEED: EdPuzzle Link ASSESSMENT: Edpuzzle Score SCORE: RECORD HERE	2C: Gizmo-Osmosis Complete the Osmosis Gizmo worksheet and submit to google classroom NEED: Gizmo WS, Gizmo link ASSESSMENT: WS submitted SCORE: RECORD HERE	
LEVEL 1: Define & Recall TARGET: Define and recall the key structural features of cells and the concepts of membrane transport. All assignments must be completed with at least 85% mastery for each box to earn full points	1A: Edpuzzle- Cell Tour Complete the Edpuzzle assigned NEED: EdPuzzle Link ASSESSMENT: Edpuzzle Score SCORE: RECORD	1B: Gizmo-Cell Structure Complete the Gizmo assigned then show mastery on the edulastic check NEED: Gizmo Worksheet, Gizmo link ASSESSMENT: Activity and Edulastic Check SCORE: RECORD	1C: Membrane Structure and Function Activity Complete the Activity and show mastery on edulastic NEED: POGIL worksheet, Edulastic link ASSESSMENT: Activity & Edulastic Check SCORE: RECORD	1D: Ch. 3 Reading Read all of the assigned sections of Ch. 3 on Launchpad. Complete the Learning Curve. NEED: Launchpad Link ASSESSMENT: Ch. 3 Learning Curve SCORE: RECORD

APPENDIX B
STUDENT SURVEY

Questions in Survey

Each of these prompts can be answered with Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree. Participation in this research is voluntary and participation or non-participation will not affect your grade or standing in the class in any way.

- 1) I am interested in learning biology
- 2) Doing well in school is important to me
- 3) I look forward to coming to class with Mr. Knowlton
- 4) My Teacher does a good job of answering student questions
- 5) I always complete my homework
- 6) I have felt extra stress due to the lockdowns
- 7) I am interested in pursuing a career in science or science related field
- 8) I really enjoy the online format of school this year
- 9) I am looking forward to returning to school "in person"
- 10) I would be excited if we did online learning in school in future years
- 11) I prefer learning within class lectures compared to videos that we watch on our own
- 12) I am more engaged in class when I interact with my peers
- 13) I feel that the GRID method (mastery learning) is helping me be more engaged in biology
- 14) I find the GRID method (mastery learning) confusing
- 15) I enjoy school more this year compared to last year
- 16) I feel that my grade is better with the GRID method (mastery learning)
- 17) I wish that we could return to a more regular type of class instead of the GRID (mastery learning)
- 18) The GRID method (mastery learning) allows me to learn material in science more effectively

- 19) I would be willing to be interviewed about my progress and feelings about mastery learning in science later in the year
- 20) Is there any other things you would like to mention about the course?

APPENDIX C

STUDENT POST-TREATMENT INTERVIEW QUESTIONNAIRE

Student Interview on Remote Mastery Learning in Honors Biology

“Verbally stated: participation in this research is voluntary and participation or non-participation will not affect your grade or standing in the class in any way.”

1) How do you feel about remote learning? Do you prefer it to traditional in school class? It would be helpful to explain your reasoning.

2) How do you feel about mastery learning aka The Grid? Would you prefer to have a more traditional style of learning? It would be helpful to explain your reasoning.

3) What are the pros and cons of mastery learning aka The Grid? It would be helpful to explain your reasoning.

4) Do you feel you learned more during remote mastery learning? It would be helpful to explain your reasoning.

5) What are specific things we did in Mastery Learning that made it difficult or easy?

6) Do you have any suggestions on how this class could be improved for future students taking it?

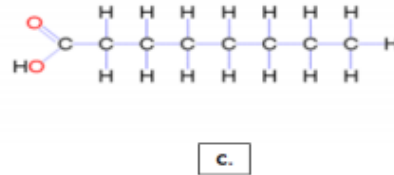
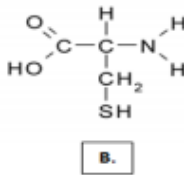
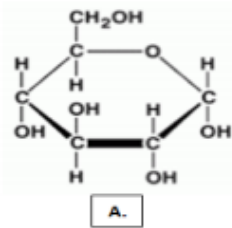
APPENDIX D

HONORS BIOLOGY STUDENT LEARNING OBJECTIVE ASSESSMENT

Honors Biology Pre-Test

- Which of the following could occur as the result of a hydrolysis reaction?
 - Transform amino acids into polypeptides
 - Transform polysaccharides into monosaccharides
 - Transform fatty acids into amino acids
 - Transform a glycerol into glucose
- Which category of macromolecule is **most diverse** in terms of the variety of functions it can serve in the human body?
 - protein
 - carbohydrate
 - fat
 - polysaccharide
- Which of the following is a typical usage of a monosaccharide?
 - degradation of DNA
 - expeditious energy
 - component of phospholipids
 - All of the above

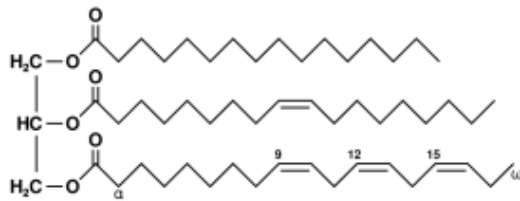
Use the molecular structure diagrams to answer the next question.



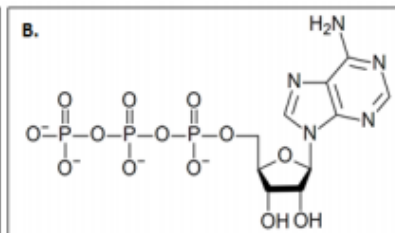
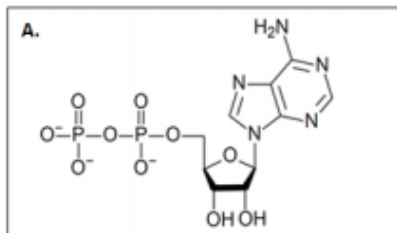
- Which of the three molecules pictured above would be used to produce a protein?
 - Figure A
 - Figure B
 - Figure C
 - None of the above

Use the molecular structure diagram below to answer the next question.

- Which of the following describes the molecular structure
 - polypeptide
 - polysaccharide
 - triglyceride
 - monosaccharide

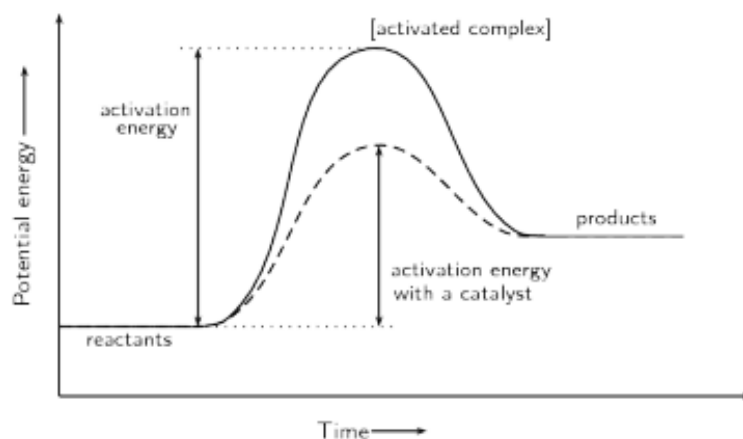


Use the following diagrams in order to answer the next two questions.



6. What is the function of molecule **B** in all living organisms?
- used as a major structural molecule in the plasma membrane
 - used as a source of energy for cellular metabolism
 - used as a building block to construct proteins
 - used as a hormone to transmit cellular messages
7. Which of the following is the best description of the relationship that exists between molecules A & B?
- molecule A is broken down through a chemical reaction to build molecule B
 - molecule A has more potential energy than molecule B
 - molecule A is a product of the reaction that releases energy from molecule B
 - molecule A does not share any relationship with molecule B
8. In human muscle cells, glucose is made available for immediate energy use by breaking down the glycogen stored in cells. During exercise when enough oxygen is available to process the glucose entirely, what is the total gain of ATP from the complete breakdown 1 molecule of glucose?
- 2 ATP
 - 4 ATP
 - 32 ATP
 - 84 ATP

The diagram below shows a chemical reaction that take place in plants.



9. Based on the graph above, which statement is true?
- The energy within the catalyst allows for the reaction to go slower.
 - The products have less potential energy than the reactants.
 - It requires more activation energy to continue this reaction without the presence of a catalyst.
 - An activated complex produces overall more products than it does reactants.
10. Which of the following processes ATP in plants in the absence of Oxygen?
- Alcoholic Fermentation
 - Lactic Acid Fermentation
 - The Krebs Cycle
 - The Electron Transport Chain

11. Which molecule is considered a by-product of photosynthesis?

- A. CO_2
- B. H_2O
- C. NADH
- D. Oxygen

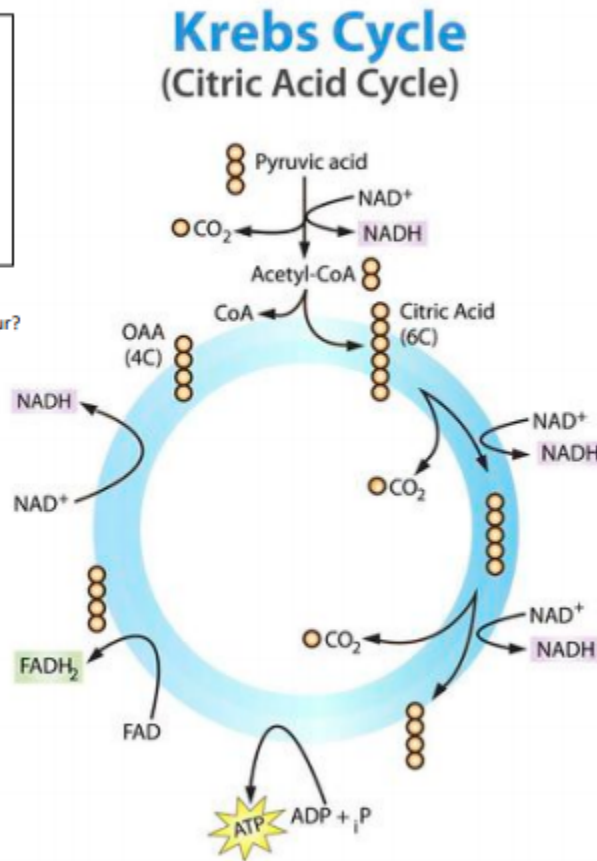
Refer to the Diagram of the Krebs cycle to answer the next two questions.

Answer Choices

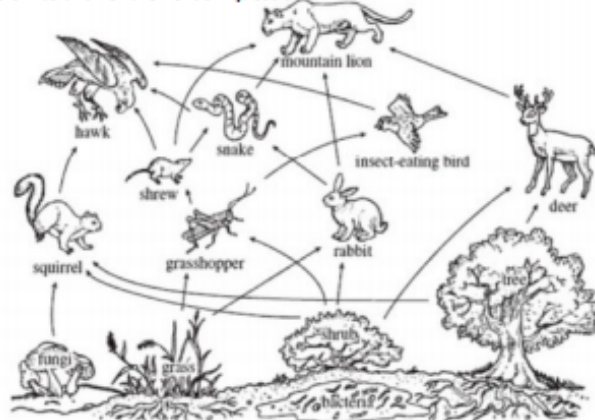
- A. $\text{C}_6\text{H}_{12}\text{O}_6$
- B. NADH
- C. CO_2
- D. ATP
- E. NAD^+
- F. ADP
- G. FADH_2

12. Which substances from the list above are reactants needed for the Krebs Cycle to occur?
MARK ALL THAT APPLY!

13. Which substances from the list above are produced by the Krebs Cycle?
MARK ALL THAT APPLY!



Refer to the diagram below to answer the next six questions.



14. According to the food web pictured, which of the following would qualify as an herbivore?
 - A. fungi
 - B. grasshopper
 - C. shrew
 - D. snake
 - E. none of these
15. Which of the following is not clearly represented in the food web above?
 - A. producer
 - B. secondary consumer
 - C. omnivore
 - D. heterotroph
 - E. quinary consumer (5th level)
16. According to the food web pictured, which trophic levels does the mountain lion belong to?
 - A. trophic level 1
 - B. trophic level 2
 - C. trophic level 3
 - D. trophic level 4
 - E. trophic level 5

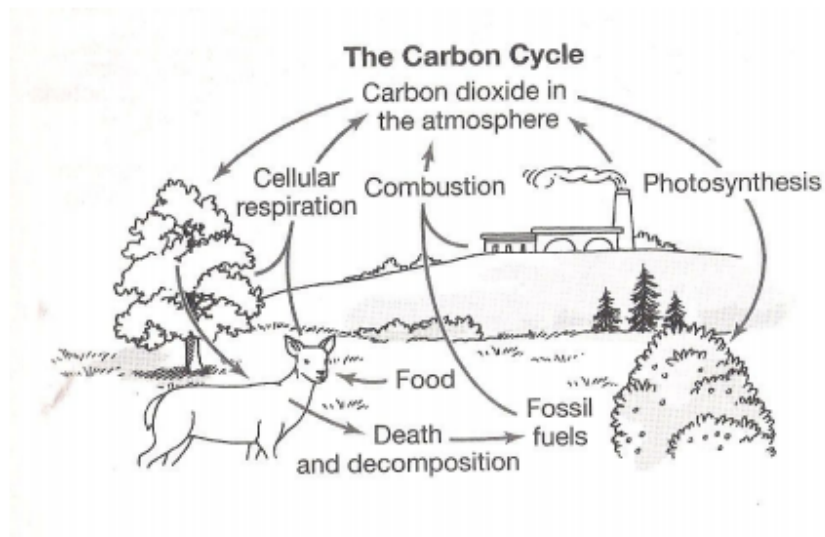
(MARK ALL THAT APPLY)
17. Consider a scenario in which hunting has greatly reduced the rabbit population in this ecosystem. Which of the following would be the most likely to occur as an immediate result of this change?
 - A. the snake population would drop
 - B. the grass population would rise
 - C. the squirrel population would drop
 - D. this would not have any effect on the other members of this food web
18. The arrows in the food web above represent:
 - A. who is eating who
 - B. the direction of energy flow
 - C. the cycling of nutrients
 - D. the shift between biotic and abiotic material
19. Why do ecosystems rarely contain more than a few trophic levels?
 - A. energy transfer efficiency is high
 - B. energy cannot flow through levels
 - C. energy amounts remain constant
 - D. energy transfer efficiency is low

Refer to the food chain to the right to answer the next two questions.

20. If we assume that the bird possesses 2,000 calories of energy, about how many calories would you expect to be transferred to the owl?
- A. ~ 20,000 calories
 - B. ~ 200 calories
 - C. ~ 20 calories
 - D. ~ 2 calories

21. Which of the following organisms would you expect to make up the greatest total mass within this ecosystem?
- A. plant
 - B. snake
 - C. grasshopper
 - D. owl

Use the Diagram below to answer the next two questions:



22. In the carbon cycle, atmospheric CO_2 is converted into organic (living) material by which process?
- A. cellular respiration
 - B. photosynthesis
 - C. decomposition
 - D. combustion
23. Which of the following statements is supported by the diagram?
- A. photosynthesis is a plant process while respiration is an animal process
 - B. plants perform both photosynthesis and respiration
 - C. animals perform both photosynthesis and respiration
 - D. oxygen is returned to the atmosphere via respiration

Read the passage below and answer the next 2 questions.

A student performed 2 studies to investigate the factors that affect the germination of peony seeds.

Study 1

Peony seeds were placed in dry containers. Some of the containers were stored at 5°C for either 4, 6, 8, or 10 weeks. The temperature and time periods were defined as the storage temperature and the storage period, respectively.

The peony seeds were divided evenly so that there were 20 sets of 25 seeds. Twenty petri dishes were then prepared. Each contained damp paper. Each set of seeds was placed in a separate petri dish. Each petri dish was maintained at 1 of 4 temperatures for 30 days. The temperature and time periods were defined as the germination temperature and the germination period, respectively. Table 1 shows the number of seeds that germinated in each dish.

Study 2

Peony seeds were placed in dry containers. The containers were stored at various temperatures for 10 weeks.

The peony seeds were divided evenly so that there were 20 sets of 25 seeds. Twenty petri dishes were then prepared. Each contained damp paper. Each set of seeds was placed in a petri dish. The petri dishes were maintained at 1 of 4 temperatures for 30 days. Table 2 shows the number of seeds that germinated in each dish.

Storage period (weeks)	Number of peony seeds that germinated when maintained at a germination temperature of:			
	13°C	18°C	23°C	28°C
0	0	0	0	0
4	0	2	0	0
6	3	8	6	0
8	7	22	18	0
10	15	24	21	1

Storage temperature (°C)	Number of peony seeds that germinated when maintained at a germination temperature of:			
	13°C	18°C	23°C	28°C
0	15	24	21	1
5	16	23	21	1
10	0	6	4	0
15	0	0	0	0
20	0	0	0	0

24. Suppose another set of 25 peony seeds had been included in Study 2 and these seeds had a storage temperature of 25°C and a germination temperature of 18°C. Based on the information provided, the number of seeds that would have germinated after being maintained for 30 days would most likely have been closest to?

- A. 0
- B. 8
- C. 16
- D. 24

25. The experimental designs of Study 2 and Study 1 differed in that in Study 2:

- A. storage temperature was held constant
- B. storage time was held constant
- C. germination temperature was varied
- D. germination time was varied

APPENDIX E

DISTRICT 204 PARENT PERCEPTION LIKERT SURVEY

Questions in Survey

- 1) Which school does your student attend?
- 2) Does your student have an IEP plan?
- 3) What is your child's grade level?
- 4) Rate your child's Remote Learning experience so far. (1-5)

1 -My Child is Not benefiting From Remote Learning (Unsatisfactory) 2 3 4 5 -My Child is Learning A Lot in Remote Learning (Outstanding)

- 5) Rate your how well your child can manage their school workload each day during Remote Learning. (1-5)

1 -My Child Barely Gets Anything Done 2 3 4 5 -My Child Gets All Their Work Done

- 6) What do you think about the amount of screen time in remote learning?

a. It is the correct amount of screen time to maintain their academic goals.

b. The amount of time should be slightly adjusted to reduce the time online even if that mean more time "out of class" completing schoolwork.

- 7) We would like to know, with appropriate safety measures, if you comfortable sending your child to school for in-person instruction during the second quarter.

a. Yes, I am comfortable sending my child to school for in-person instruction second quarter.

b. No, I would prefer my child continue remote learning at home second quarter.

APPENDIX F

IRB EXEMPTION APPROVAL LETTER

The research described in this submission is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

(b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.