

EFFECTIVENESS OF KLEWS ON HIGH SCHOOL FRESHMAN ENGAGEMENT AND
PERFORMANCE DURING BIOLOGY DISCUSSIONS

by

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TABLE OF CONTENTS

1. INTRODUCTION AND BACKGROUND	1
The Context of the Study	1
Background	2
Focus Questions	3
2. CONCEPTUAL FRAMEWORK	4
Effectiveness of CATs Among In-Person Students	4
Effectiveness of CATs Among Online Students	5
Newest CATs in Science Education	7
3. METHODOLOGY	9
Data Collection and Analysis Strategies	10
Use of Discussion Engagement Charts	12
Use of Pre-Likert Surveys	13
Use of Post-Likert Surveys	14
Unit Exam to Assess Academic Achievement	15
Student Interviews to Analyze the Effectiveness of KLEWS	15
4. DATA ANALYSIS	17
Results of Discussion Engagement Chart	17
Results of Pre-Likert Survey	18
Post-Likert Survey of Experimental Class After Unit Exam	19
Results of Unit Exam	20
Results of Student Interviews	21
5. CLAIM EVIDENCE AND REASONING	23
Does the Use of KLEWS Increase Student Engagement	23
Does the Use of KLEWS Improve Student's Attitudes Toward Biology	24
Does the Use of KLEWS Improve Academic Performance	24
Future Implications of Study	25
Professional Reflection and Growth	26
6. REFERENCES CITED	27
7. APPENDICES	30

TABLE OF CONTENTS CONTINUED

APPENDIX A: Data Triangulation Matrix.....	31
APPENDIX B: Discussion Engagement Chart	33
APPENDIX C: Pre-Treatment Likert Survey	35
APPENDIX D: Post-Treatment Likert Survey	37
APPENDIX E: Unit Exam	39

LIST OF TABLES

Table	Page
1. Data Triangulation Matrix	12
2. Discussion Engagement Chart	13
3. Pre-Treatment Likert Survey	14
4. Post-Treatment Likert Survey	16
5. Results of Biochemistry Unit Exams Among Experimental and Control Classes	23

LIST OF FIGURES

1. Discussion Participation Scores Between Class A and Class B	20
2. Results of the Pre-Likert Survey From Experimental Class	21
3. Results of the Pre-Likert Survey From Control Class	22
4. Results of Post-Likert Survey Among the Experimental Class	23

ABSTRACT

The implementation of this action research was at Bradford Area School District (BASD) in Bradford, Pennsylvania. KLEWS were used at Bradford Area High School (BAHS) with freshman Biology students. KLEWS is an acronym that stands for “Know,” “Learning,” “Evidence,” “Wonderings,” and “Scientific Principles.”. This is an example of a CER “Claims, Evidence, Reasoning” framework of teaching that has been shown to aid in learning progression by utilizing a scaffolding approach to teaching (Yao & Guo, 2016). CER was a framework developed to model scientific explanation and justify claims by using appropriate evidence and scientific research (Yao & Guo, 2016). There were five data collection methods used for this action research: discussion engagement charts, pre-treatment Likert surveys, post-treatment Likert surveys, unit exam, and student interviews. The duration of this action research was eight weeks and involved 57 freshman biology students. At the end of the eight weeks, two sections of biology students took a unit exam, and the results were analyzed using a standardized t-test.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

The Context of the Study

Bradford Area School District (BASD) is located in Northern Pennsylvania, a small rural community. According, to the United States Census Bureau, Bradford has a population of 8,770 and a poverty rate of 30.7%. This rate is nearly three times higher than the national average poverty rate of 11.7% (United States Census Bureau, 2021). This means that a high percentage of students that attend BASD come from low-income households. This is significant because poverty has been proven to have detrimental effects on academic achievement (Lacour & Tissington, 2011). In a study conducted by Sum and Fogg (2011), students that came from a low-income household only scored in the 19th percentile on standardized assessments, while students from middle-income households scored in the 66th percentile (Lacour & Tissington, 2011.) That same study also showed that 43.5% of students from low-income households did not meet any required subject area assessments, while less than 15% met all required subject area assessments (Lacour & Tissington, 2011).

With such a high percentage of BASD's students coming from poverty, there was a need to determine if interventions such as KLEWS could increase student engagement and performance during discussions. This need is what drove the process of this action research design. The purpose of this study was to determine if the implementation of KLEWS could increase academic engagement during discussions and performance among high school freshman at BASD. I utilized a traditional experiment design with an experimental class that received weekly implementation of KLEWS, and one class that did not receive the weekly

implementation of KLEWS. At the end of the biochemistry unit, student engagement and academic performance during discussions and on a common unit exam were assessed

Background

BASD is broken into four different schools: two elementary schools (Pre-K – 5), one middle school (6-8), and one high school (9-12). Classroom Assessment Techniques (CATs) were used at Bradford Area High School (BAHS) with freshman Biology students. BAHS has a total of 770 students, with a 16:1 student to teacher ratio. With only a 5% minority enrollment, it is 29% less than the state average (Public School Review, 2015). In total, there were two sections of Biology where CATs were implemented. One section had 25 students (11 male and 14 female) and the other section had 22 students (12 male and 10 female). Of these 47 students, seven had IEPs for various reasons such as Dyslexia, ADHD, Autism, and other health impairments. The class was all in-person, except for students who were quarantined due to Covid-19 exposure. These students joined class through a Microsoft Teams live stream.

Historically, freshman have performed worse than upperclassmen at BAHS and the staff seems to think it is because of the change in rigor between middle school and high school. Also, students have a hard time communicating frustrations and concerns. Some students do not know how to ask questions or are simply too shy to ask. This lack of communication leads to confusion about assignments and concepts, which ultimately results in incomplete or unsatisfactory work. To address these concerns, we decided to flip our teaching model. Prior to Covid-19, BAHS was a very traditional school. Most teachers utilized a teacher-centered classroom and used paper/pencil assignments. With so many students that having communication barriers, this model became ineffective. As a district, we decided to switch to an online platform called, Canvas. This

is an online platform that allows teachers to post assignments, discussions, and other materials online. Students have 24/7 access to this, and it allows for a smooth transition between students quarantining from Covid-19 exposure and coming back in-person are what lead to the focus questions driving this study.

Focus Question

My focus question for this action research design was, How does instruction with the implementation of KLEWS prior to classroom discussions impact student performance, attitudes, and engagement?

My sub-questions include the following:

1. Does the use of KLEWS increase student engagement during discussions among freshman biology students?
2. Does the use of KLEWS improve students' attitudes towards biology?
3. Does the use of KLEWS improve academic performance among freshman biology students?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Effectiveness of CATs Among In-Person Students

According to Hanson and Florestano (2020), Classroom Assessment Techniques (CATs) improve the learning process by increasing student engagement, student learning, student performance, and course design. CATs are a quick and efficient way to evaluate several important factors of a classroom such as student comprehension and teaching efficacy (Babinčáková et al., 2020). According to the Center of Teaching at Vanderbilt University (2020), CATs are generally simple, non-graded, anonymous, in-class activities designed to give the teacher and you students useful feedback on the teaching-learning process as it is happening. One of the key components of CATs is that they are formative and not summative. Summative assessments summarize and clarify student comprehension at the end of a unit and are usually graded while formative assessments are not graded and are used to provide teachers with instant feedback to enhance their teaching (Babinčáková et al., 2020). Instant feedback through formative assessment is crucial to create an atmosphere for learning and gives students the opportunity to discretely express an area of concern about a given topic being discussed in class (Babinčáková et al., 2020).

One of the main benefits of using CATs in science education is the data that they provide instructors with. Instant feedback is used to make quick and necessary changes to a lesson. This data can be used to transition a traditional teacher-centered classroom into a student-centered classroom (Hanson & Florestano, 2020). In science, the need for lab-based assignments cannot be overstated. Using CATs to create a student-centered classroom gives students the confidence

to complete lab-based assignments with their peers and enhance their understanding of the content (Hanson & Florestano, 2020)

Effectiveness of CATs Among Online Students

The evidence for the effectiveness of CATs in a traditional in-person classroom environment is abundant. However, within recent years, more schools have elected to offer online remote options for students. This is becoming even more popular since the Covid-19 pandemic of 2020. With this recent transition to online learning, the information regarding the effectiveness of CATs in online education is somewhat limited, but the limited number of studies that have been conducted show that CATs are just as effective online as they are in-person. CATs can increase student participation online, but also positively impact assessment scores as well. In a 2014 study, Steele and Dyer (2014) found that online undergraduate courses that implemented the use of KWL (know, want to learn, learned) charts showed higher student participation compared to classes that did not utilize KWL charts (Cross & Palese, 2020). These charts allow instructors to look at three essential components to a lesson. First, they can see what students already knew coming into a lesson. Second, they can see what students still want to learn, or need to have retaught. Finally, they can see what students learned from a lesson. All these factors give instructors the ability to make immediate changes to lesson set-up and delivery.

Another researched CAT that has shown to be beneficial to students is a form of ungraded direct questioning. This alleviates stress and allows students to focus on the question without the anxiety of answering incorrectly. This is often when students perform their best and it gives instructors the best representation of what students know. With this feedback, corrections

and feedback were given to students and it was used to scaffold between topics (Cross & Palese, 2020). Feedback from direct questioning has been shown to have a positive impact on student learning and comprehension. In a study conducted by Babinčáková et al. (2020), formative assessment classroom techniques (FACTS) such as KWL charts, concepts maps, vocabulary cards, exit tickets, and true and false statements were analyzed. These researchers gave a pre-test and post-test to 202 students that asked the same questions. Between the two tests, one group received the FACTs daily, and the other group did not receive any FACTs. After the study was completed, the data showed students who received the FACTs scored higher on the lower-cognitive and higher-cognitive questions of the post-test and saw a larger margin of improvement between their pre-test and post-test. (Babinčáková et al., 2020).

KWL charts have also been found to be effective at creating an enhanced online learning environment by increasing student participation. Two researchers, Steele and Dyer (2014) measured the effect that KWL charts had on student engagement by analyzing the number of times students posted discussions for an online class. After analyzing two classes, one that received daily KWL chart prompts and one that didn't, they found that the students receiving the KWL prompts posted an average of 75 discussions throughout the course, while students in the class that did not receive the KWL charts only posted an average of 66 times (Steele & Dyer, 2014).

Newest CATs in Science Education

Recently, pioneers in the field of education, Hershberger and Zembal-Saul (2020) have developed new CATs. Among the most popular is KLEWS, which is a chart that stands for:

K: What do we think we know?

L: What are we learning (claims)?

E: What is our evidence?

W: What do we still wonder about?

S: What scientific principles/vocabulary explain the phenomena? (Hershberger & Zembal-Saul 2020):

In science education, the need to understand vocabulary and apply it phenomena is crucial for comprehension. KLEWs are a CAT that were designed around this idea. They act as an anchor to a lesson and allow students to organize ideas, concepts, and evidence that support scientific phenomena. It also allows them to apply the vocabulary associated with the lesson in an organized manner (Hershberger & Zembal-Saul 2020). This method of organization is an example of scaffolding. According to Van de Pol et al. (2018), scaffolding considers a student's prior knowledge, and a teacher connects closely to this prior knowledge to promote students' learning as new information is integrated into the students existing knowledge schemes. Both, the Claim-Evidence-Reasoning (CER) framework and scaffolding were influenced by Vygotsky's zone of proximal development (ZPD). Vygotsky defined the ZPD as "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peer" (Shabani, 2016). Scaffolding and CER allows teachers to stay within a students' ZPD, which increases student performance (Van de Pol et al., 2018). In one pretest and posttest experiment, researchers concluded that student performance on multiple-choice assessments increased 50% to 80% when scaffolding was implemented, while non-scaffolding conditions only showed a 30-40% increase on the pretest and posttest (Van de Pol et al., 2018).

CHAPTER THREE

METHODOLOGY

The purpose of this mixed methods action research design was to determine if KLEWS increased engagement during discussions, student attitudes toward biology, and academic performance among freshman enrolled in biology at Bradford Area School District. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix F).

In total, there were two sections of Biology where CATs were implemented. One section had 25 students (11 male and 14 female) and the other section had 22 students (12 male and 10 female). Between the two classes, there was a total of 47 students. Of these 47 students, seven had IEPs for various reasons ranging from Dyslexia, ADHD, Autism, and other health impairments. The class was all in-person, except for students who were quarantined due to Covid-19 exposure. These students joined the class through a Microsoft Teams live stream

Data Collection and Analysis Strategies

Qualitative and quantitative data collection methods were used to answer the research questions in this study. Of these data collection methods, the Student Interviews are qualitative and the Discussion engagement Charts, Pre-Treatment Likert Survey, the Post-Treatment Likert Survey, and the Unit Exam are quantitative. The focus question "Does the use of KLEWS increase student engagement among freshman Biology students?" was answered with the discussion engagement chart, pre-treatment Likert surveys, post-treatment Likert surveys, and student interviews. The focus question "Does the use of KLEWS improve students' attitudes towards biology?" was answered with pre-treatment Likert surveys, post-treatment Likert

surveys, and student interviews. The focus question “Does the use of KLEWS improve academic performance among freshman Biology students?” was answered with post-treatment Likert surveys, the unit exam, and student interviews. The “Data Triangulation Matrix” shown below outlines the data collection methods in this action research design (Table 1).

Table 1. Data Triangulation Matrix, ($N=47$).

Data Collection Instruments	Focus Questions		
	Does the use of KLEWS increase student engagement during discussions among freshman Biology students?	Does the use of KLEWS improve students’ attitudes towards biology?	Does the use of KLEWS improve academic performance among freshman Biology students?
Discussion Engagement Chart	X		
Pre-treatment Likert Survey	X	X	
Post-treatment Likert Survey	X	X	X
Unit Exam			X
Student Interviews	X	X	X

This study was conducted over an eight-week period and covered eight different biochemistry topics that are listed in the Keystone Biology Standards. These biology standards are what students see when they take the Keystone Biology Exam, which is the state test issued in Pennsylvania. A traditional experimental design was used to conduct this action research with one class (class A), receiving weekly implementation of KLEWS, and the other class (class B), receiving regular instruction with no implementation of KLEWS. Class A served as the experimental group in this study and class B served as a control group.

Use of Discussion Engagement Charts

Throughout the study, each class received two discussion prompts per week and this is where engagement was measured by using a Discussion Engagement Chart (Appendix B). Discussion engagement charts are a simple and targeted way to provide quick feedback (Mertler, 2020). This chart had four criteria that included responding to the prompt, responding to at least two peers, asking at least one question to another peer, and responding to a question asked by a peer. One example of a discussion prompt used during the study was “Why do you think studying biochemistry is an essential part of medicine and human health?” This prompt was asked on a Monday, and students had two days to address all components of the Discussion Engagement Chart rubric. I would then analyze all of the responses and complete a rubric for each student. The second prompt would be posted on a Wednesday or Thursday, and they would have until Sunday night to complete that one. After that, I would complete another rubric for each student and compare the results between class A and class B. It is worth noting that only relevant responses were included when analyzing data. If a student responded to the prompt or to peers with a statement or questions completely unrelated to science it was excluded.

Table 2. Discussion Engagement chart, (N=47).

Criteria	Observed	Not Observed
Student responded to all parts of discussion prompts		
Students responded to at least two peers		
Students asked at least one question to another peer		
Students responded to question asked by peer		

Use of Pre-Likert Surveys

The second data collection instrument was the Pre-treatment Likert Survey (Appendix C). The use of a Pre-Treatment Likert Survey was used to gather baseline data regarding two of my research questions. The first, “Does the use of KLEWS increase student engagement during discussions among Biology students?” and the second, “Does the use of KLEWS improve students’ attitudes towards biology” This pre-treatment survey provided information about students’ attitudes toward KLEWS. Conducting a pre and post-test allows a researcher to perform an independent t-test to measure the statistical significance of the treatment (Gautreau & Bins, 2012). Another benefit of conducting a pre and post-test is that it gave me the ability to run a split-plot factorial ANOVA test to measure statistical differences between student responses (Gautreau & Bins, 2012). The pre-treatment Likert survey (Appendix C) was given to both of my classes before the biochemistry unit began. This survey allowed me to conclude how each section of my Biology classes felt about the course before I implemented the use of KLEWS in my experimental class.

Table 3. Pre-Treatment Likert Survey, (N=47).

Question	1: Strongly Disagree	2. Disagree	3. Neither Agree or Disagree	4. Agree	5. Strongly Agree
I enjoy biology class					
I find class discussions engaging and meaningful in biology					
I am motivated to complete class discussion in biology					
I am active in class discussion during biology					

Use of Post-Likert Survey

After the unit test (Appendix E) concluded, the fourth data collection method, the Post-Treatment Likert Survey was conducted (Table 4). The biology class that was the experiment group that used the KLEWS received as their Posttest Likert Survey, while the biology class that did not receive the implementation of KLEWS (control group) received the Pretest Likert Survey as their Posttest Likert Survey as well. Calculating the mean, median, and mode of the student responses between the Pre and Posttest Likert Surveys will show if there are any significant differences in the data. If the student responses in the experimental group did not change between the Pre and Posttest Likert Surveys, it can be concluded that the KLEWS did not have a significant impact on the attitudes of biology students. If there was a significant change in student responses among the experimental group, it is likely that KLEWS did have an impact on

the students' attitudes toward biology class. Among the control class, the student responses were not expected to change significantly, because they did not receive the implementation of KLEWS. If there is a drastic change, it can be contributed to different factors.

Table 4. Post-Treatment Likert Survey, (N=47).

Question	1: Strongly Disagree	2. Disagree	3. Neither Agree or Disagree	4. Agree	5. Strongly Agree
I enjoy biology class					
I find class discussions engaging and meaningful in biology					
I am motivated to complete class discussion in biology					
I am active in class discussion during biology					
The use of KLEWS in biology has helped my engagement in class discussion					
I feel like the use of KLEWS has improved my academic performance in biology					

Unit Exam to Assess Academic Achievement

The third data collection method was the the Unit Exam (Appendix E). This exam was evaluated quantitatively, and a paired t-test was used to compare the scores between the experimental and control classes. A paired t-test is used when there is an independent and dependent variable (Salkind, 2010). In this case, the independent variable was KLEWS and the dependent variables were scores of the experimental and control classes. These scores were used to conduct a t-test, which provided a t-value that was measured against a p-value to show statistical significance (Salkind, 2010). If there was a significant difference ($p \leq .05$), the

conclusion that KLEWS did have a positive impact on student academic performance could be made. If there was no significant difference ($p \geq .05$), I could not conclude that KLEWS had a significant impact on the academic performance of biology students.

Student Interviews to Analyze the Effectiveness of KLEWS

After the unit exam was completed, I interviewed five students from class A. These students were asked three questions that addressed the focus questions guiding this study.

The three questions asked were:

1. Do you think the use of KLEWS improved your comprehension of the material covered during our biochemistry unit?
2. Did using KLEWS help with your engagement with discussion posts?
3. Did KLEWS help improve your attitudes biology in any way? Please explain why or why not.

I used a transcript to make notes of the conversations between the students and myself. After the transcripts were completed, I used a method called “coding scheme” to organize the responses (Mertler, 2020). Coding scheming involves looking for specific responses or events that begin to repeat themselves (Mertler, 2020). Observing these trends and patterns allowed me to see where students shared similar beliefs and opinions, which helped me draw conclusions from the interviews

CHAPTER FOUR

DATA ANALYSIS

After analyzing the data, there was evidence to support my first research question, *Does the use of KLEWS increase student engagement during discussions among freshman Biology students?* There was also evidence to support my second research question, *Does the use of KLEWS improve students' attitudes towards biology?* However, there was no significant statistical data that supported my third research question, *Does the use of KLEWS improve academic performance among freshman Biology students?*

Results of the Discussion Engagement Chart

After eliminating the irrelevant responses from the data, there were two parts of the Discussion Engagement Chart that showed a distinct difference between the experimental class and control class. For the second criteria "Students asked at least one question to a peer," the experimental class had 14% more students ($n=7$) complete this requirement than the control class. This indicated that the experimental class had a higher rate of engagement and participation than the control class throughout the experiment. The third criteria "Students responded to at least two peers" was met by 56% of students ($n=27$) in the experimental group and 41% of students ($n=20$) in the control group. This also indicates more engagement and participation among the experimental class.

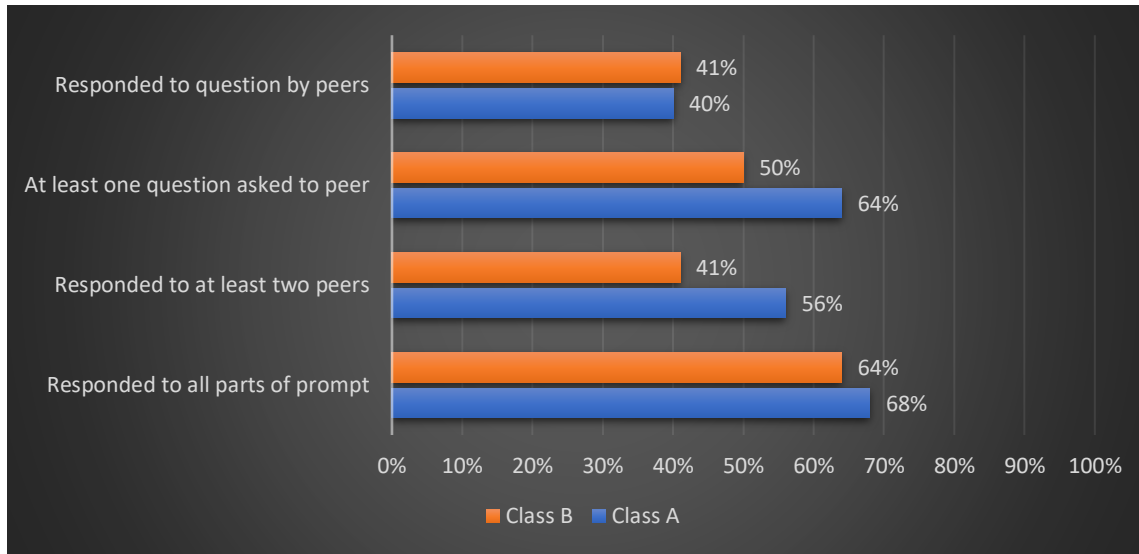


Figure 1. Discussion participation scores between Class A and Class B, ($N=49$).

Results of Pre-Likert Survey

The second tool used to analyze engagement and participation was the Pre-Likert Surveys from the experimental and control classes (Figures 2 & 3). For all four Likert statements, the experimental class had more students choose “Strongly agree,” with an average of 17% ($n=8$), while the control group only had an average of 9% of students ($n=4$) choose “Strongly agree.” One key finding from the Likert survey was that 27% of students ($n=13$) from the control class chose “Strongly disagree” for the statement “I enjoy Biology class,” while only 12% of students ($n=6$) from the experimental class chose the same response. However, 24% of students ($n=12$) from the experimental class said that they strongly disagreed with the statement “Discussions are engaging and meaningful in Biology,” while only 14% of students ($n=7$) in the control class felt the same way. This indicated that although students generally enjoyed Biology more in the experimental class, it was not because of the discussions.

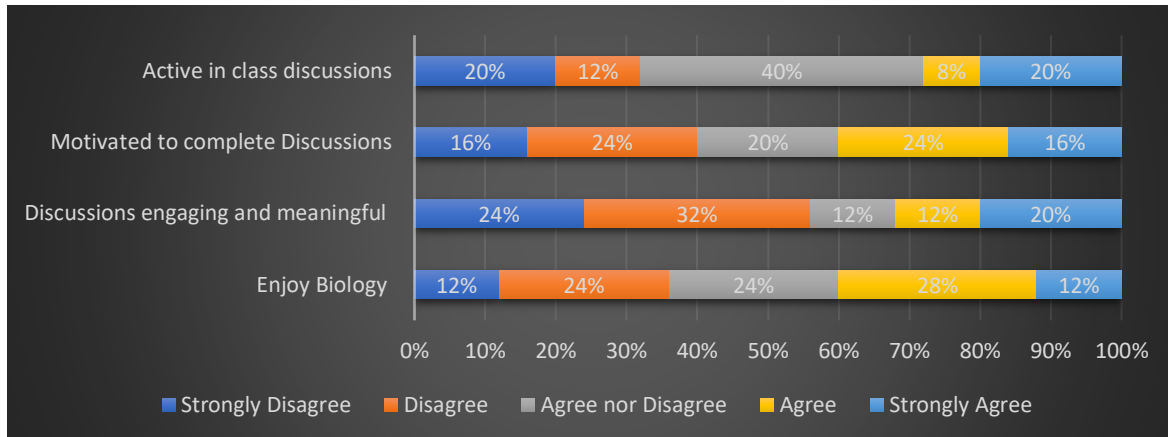


Figure 2. Results of the pre-Likert survey from experimental class, ($N=25$).

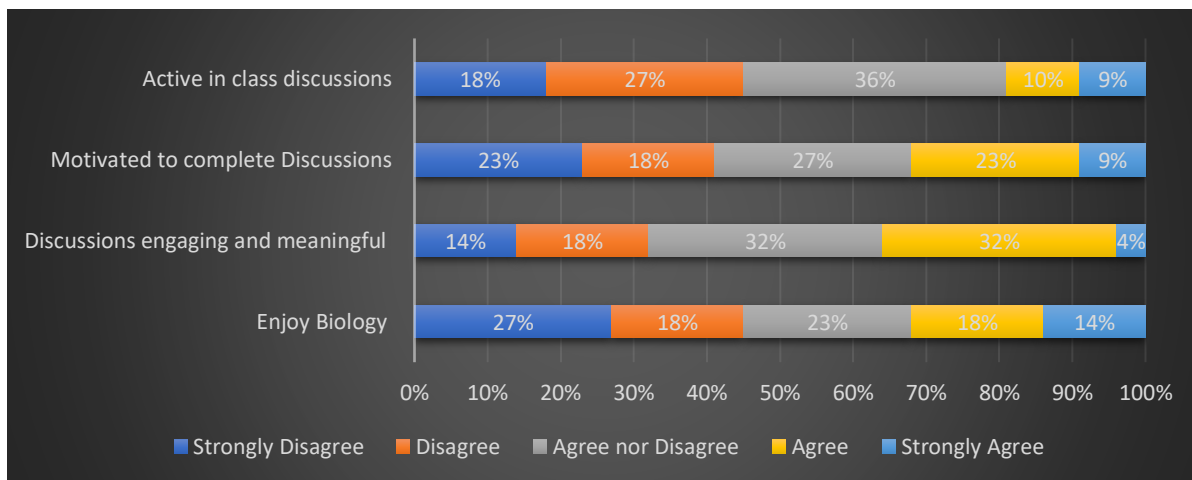


Figure 3. Results of the pre-Likert survey from the control class, ($N=22$).

Post-Likert Survey of Experimental Class After Unit Exam

After the eight-week module on Biochemistry, the experimental class was given an identical Likert survey with two additional statements: “KLEWS improved my biology performance” and “KLEWS helped my engagement in Biology.” The post-Likert survey showed that 4% of students ($n=2$) strongly agreed with the statements “I enjoy Biology class,” 4% strongly agreed ($n=4$) with “I am active in classroom discussions.” To the statement “I am motivated to complete classroom discussions,” there was an 8% increase in students that chose “Strongly agree” compared to the pre-Likert Survey.

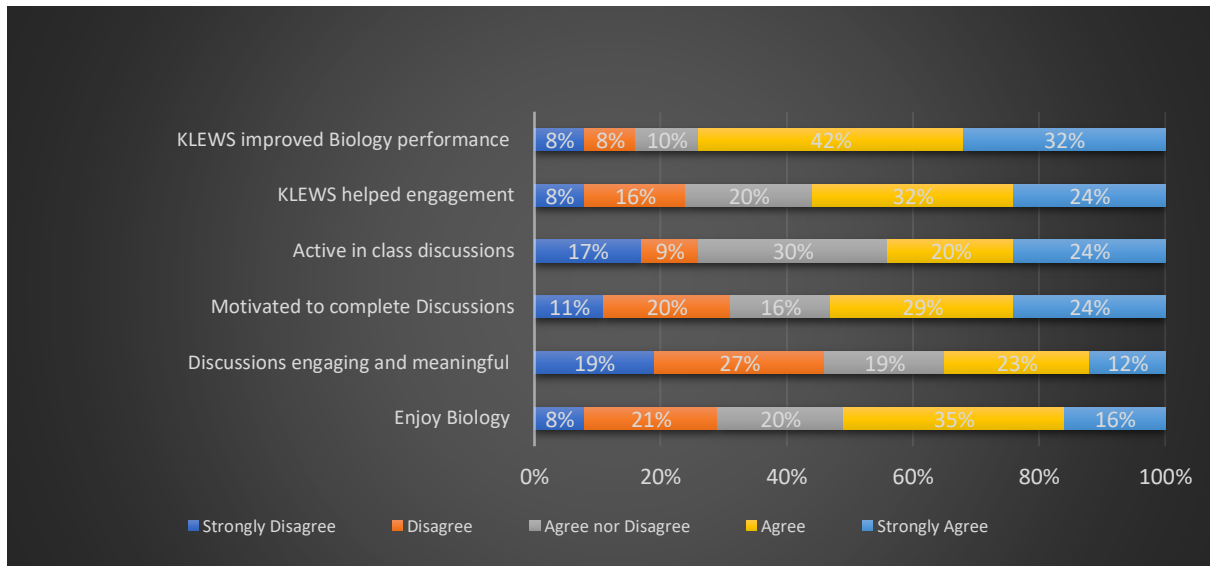


Figure 4. Results of post-Likert survey among the experimental class, (N=25).

Results of the Unit Exam

At the end of the eight-week module, the experimental and control classes took identical exams (Appendix E) and the results showed an average score of 67% in the experimental class that received the implementation of KLEWS, and 63% in the control class that did not receive the implementation of KLEWS. A two-sample t-test, assuming unequal variances was conducted to determine statistical significance with a p-value of <0.05 . With a p-value of 0.59, there was no statistical significance between the two classes (Table 5).

Table 5. Results of Biochemistry unit exams among experimental and control classes, (N=47).

<i>t-Test: Two-Sample Assuming Unequal Variances</i>	<i>Class A</i>	<i>Class B</i>
Mean	0.6668	0.631818
Variance	0.044589	0.054263
Observations	25	22
Hypothesized Mean Difference	0	
df	43	
t Stat	0.536591	
P(T<=t) one-tail	0.297158	
t Critical one-tail	1.681071	
P(T<=t) two-tail	0.594315	
t Critical two-tail	2.016692	

Results of Student Interviews

At the end of the treatment, five students from the experimental class were interviewed to assess their feelings about KLEWS. Each student was asked the following questions:

1. Do you think the use of KLEWS improved your comprehension of the material covered during our biochemistry unit?
2. Did using KLEWS help with your engagement with discussion posts?
3. Did KLEWS help improve your attitudes biology in any way? Please explain why or why not.

Among the five students interviewed, three of them passed the exam with an 80% or higher and two of them scored less than 70%. Student A scored a 94%, Student B scored an 82%, Student C scored an 88%, Student D scored a 64% and Student E scored a 51%. To the first question, Students A, B, C, and D all said that KLEWS did help with the comprehension of material covered during the Biochemistry unit. Students B and C both said that KLEWS in conjunction with the demonstration of a dehydration reaction of sugar helped them understand

how chemical bonding worked, and why carbon is the “backbone” of life. Student B shared the following statement:

Seeing carbon being extracted from sugar was really cool. I could not believe that much black carbon was contained within that little amount of white sugar. When completing my KLEWS, I used this demonstration from my “Evidence” for carbon being the backbone of life.

To the second question, all five students said KLEWS helped with their engagement on discussion posts. Three of the five students explained how the hardest part of discussions was knowing what to write and KLEWS helped them organize information and gave them material to talk about within the discussion posts. Rather than opening multiple page documents of notes, they were able to just open their KLEWS and pull out the main details, like a graphic organizer.

The third question had the most diversity among the responses. Only two students said KLEWS helped improve their attitudes in Biology, and the other three students were neutral on the question. The two students that did say KLEWS helped improved their attitudes about Biology both said it was because of organization. The KLEWS helped them make sense of a topic before moving onto a new topic and this helped them transition to new subject matter, while applying previous concepts. The three students who said KLEWS didn’t improve their attitudes toward Biology all had different reasons why. One student said, “It was just more work, and I have a hard time doing the regular assignments.” The other two both expressed frustration about the part of the KLEWS where they needed to provide evidence for the concept being taught. Upon reflection, I realized to incorporate KLEWS as a weekly classroom assessment technique, they needed to be modeled by a teacher so students know what is expected of them.

CHAPTER FIVE

CLAIMS EVIDENCE AND REASONING

Does the use of KLEWS Increase Student Engagement During Discussions Among Freshman Biology Students?

Throughout the interviews with students, I concluded that KLEWS do help with engagement during discussion posts for several reasons. First, all students interviewed said that KLEWS helped them stay organized when responding to discussions. It was brought up that many times when students were not completing all requirements it was not due to a lack of motivation, it was due to a lack of organization and readily available resources. Discussing macromolecules is not something that high school freshmen are accustomed to discussing. Asking them to carry on a conversation about something brand new to them is unreasonable. Having KLEWS readily available was a tool that students used to gather talking points from. I believe this is why there was a significant discrepancy between class A and class B when addressing the second and third criteria of the Discussion Engagement Chart. Class A had those KLEWS available to reference, while class B did not.

Does the use of KLEWS Improve Students' Attitudes Towards Biology?

The data also suggests that students who received the implementation of KLEWS did have a more positive attitude about biology compared to the students who did not receive the implementation of KLEWS. Over 50% of students from class A agreed or strongly agreed with the statements "KLEWS improved their biology performance" and "KLEWS helped with their engagement on discussion posts." Many students expressed that KLEWS are a great way to take

new rigorous material and condense it. Rather than having pages of notes to sort through and try to make sense of, students are able to reference an organized table that highlights key points of each topic. This clarity eliminates some of the anxiety associated with learning a new science for the first time. Consequently, attitudes about biology improve when anxiety is alleviated, which is evident by 11% more students from class A agreeing or strongly agreeing to the statement “I enjoy Biology” on the post-Likert survey.

Does the use of KLEWS Improve Academic Performance Among Freshman Biology Students?

The only research question that my data did not suggest KLEWS were helpful was the third one regarding academic performance. However, there are several reasons why this could be. First, I did not properly model how to use KLEWS. We did one practice KLEWS as a class at the beginning of the biochemistry unit and never revisited it. That was a huge mistake on my part. Not only were the students asked to learn scientific content brand new to them, they were also expected to complete a new form of assessment they had never seen before. In addition to only modeling KLEWS once, I never went over them throughout the unit. I was more concerned with collecting data that the efficacy of KLEWS was compromised.

Another mistake I made was the way in which I analyzed test scores. I took one class average and neglected multiple sub-strata cohorts that could have been included. For example, I did not look at how the test scores differed between my lowest and highest performing students. If I would have done so, I believe I might have seen a difference between my lowest performing students from each class. While the class averages with similar there was a smaller range of test scores in class A than there was in class B. This shows that the lowest grades in class A were higher than the lowest grades in class B.

Future Implications of Study

This study provided me with multiple insights moving forward. Throughout this study, I realized how important organization is for student engagement and perceptions of biology. Moving forward, I will continue to implement KLEWS in my biology class. However, in the upcoming years I will be sure to efficiently model how to effectively use KLEWS and go over them in class. As the research concludes, formative assessment classroom techniques (FACTS), such as KLEWS provide multiple benefits. First, it allows teachers to provide instant feedback to students, which alleviates stress. Second, it provides the teacher with feedback, so they are able to adjust their lesson to address the specific needs of students. Lastly, it ensures that teachers are staying within the zone of proximal development, which allows for smooth scaffolding between topics (Van de Pol et al., 2018).

Professional Reflection and Growth

Upon reflection, I have identified several areas of growth that will have a significant role on me, both professionally and personally. First, it allowed me to take a step back and remember what it is like being a freshman in high school. As I was conducting my research, I realized I was so focused on covering the content, I neglected other skills that are absolutely essential to young high school students. Two of these skills are note-taking and organization. KLEWS serve as a graphic organizer for students to help them stay organized and provides them with detailed notes that does not require shuffling through pages of random notes. Perhaps, one of the biggest realizations from this action research was accidental. After looking back, I realized how much KLEWS helped my students that struggle with reading and writing. These skills have become a significant area of concern in the school district, especially in the science department when

assigning lab reports. It has been mentioned by several teachers at department meetings that trying to assess the comprehension of lab-based assignments is becoming increasingly difficult because of the poor writing skills. KLEWS can be used as an alternate form of lab report because they are less focused on writing and more focused on identifying the scientific phenomena seen in the lab, and the evidence for it. This does not mean science teachers should forget trying to enhance writing skills and address cross-curriculum principles, but I believe ensuring student comprehension of scientific principles should come first.

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APPENDICES

APPENDIX A

DATA TRIANGULATION MATRIX

Data Collection Instruments	Focus Questions		
	Does the use of KLEWS increase student engagement among freshman Biology students?	Does the use of KLEWS improve students' attitudes towards biology	Does the use of KLEWS improve academic performance among freshman Biology students
Discussion Engagement Chart	X		
Pre-treatment Likert Survey	X	X	
Post-treatment Likert Survey	X	X	X
Unit Exam			X
Student Interviews	X	X	X

APPENDIX B

DISCUSSION ENGAGEMENT CHART

Criteria	Observed	Not Observed
Student responded to all parts of discussion prompts		
Students responded to at least two peers		
Students asked at least one question to another peer		
Students responded to question asked by peer		

APPENDIX C

PRE-TREATMENT LIKERT SURVEY

Question	1: Strongly Disagree	2. Disagree	3. Neither Agree or Disagree	4. Agree	5. Strongly Agree
I enjoy biology class .					
I find class discussion engaging and meaningful in biology					
I am motivated to complete class discussion in Biology					
I am active in class discussion during biology					

APPENDIX D

POST-TREATMENT LIKERT SURVEY

Question	1: Strongly Disagree	2. Disagree	3. Neither Agree or Disagree	4. Agree	5. Strongly Agree
I enjoy biology class .					
I find class discussion engaging and meaningful in biology					
I am motivated to complete class discussion in Biology					
I am active in class discussion during biology					
The use of KLEWS in biology has helped my engagement in class discussion.					
I feel like the use of KLEWS has improved my academic performance in Biology					

APPENDIX E

UNIT EXAM

Name: _____

Chemistry and Biochemistry Test

Matching: In the space provided, write the letter of the description that best matches the term or phrase. Each letter will only be used **ONE TIME**.

- ____ 1. The smallest piece of matter.
 - ____ 2. The backbone to all organic compounds
 - ____ 3. The process of breaking about polymer by adding a water molecule
 - ____ 4. Building blocks of the cell membrane
 - ____ 5. Bond that is formed when one or more electrons are taken from one atom by another
 - ____ 6. Spot on the enzyme where the substrate connects
 - ____ 7. Make chemical reactions happen faster
 - ____ 8. Process that changes or transforms, one set of chemicals into another
 - ____ 9. Provide long term storage of energy
 - ____ 10. Substance that consists of only one type of atom
 - ____ 11. Provide short term storage of energy
 - ____ 12. The process of combining monomers by removing a water molecule
 - ____ 13. Bond that is formed when electrons are shared by two atoms
 - ____ 14. Molecules that are used to turn on and off enzymes within the body
-

- a- Covalent bond
- b- Atom
- c- Element
- d- Chemical reaction
- e- Enzyme
- f- Dehydration
- g- Active site
- h- Ionic bond
- i- Regulatory Molecules
- j- Phospholipids
- k- Carbon
- l- Starches
- m- Fats
- n- Hydrolysis

Multiple Choice: In the space provided, write the letter of the term or phrase that best completes each statement or best answers each questions.

- ____ 15. Monosaccharides are an example of what?
- Starch
 - Sugar
 - Protein
 - Amino Acid
- ____ 16. A chain of many monomer pieces is called...
- Substrate
 - Polymer
 - Monomer Chain
 - Peptide
- ____ 17. _____ are the chemicals at the beginning of chemical reactions
- Enzymes
 - Products
 - Reactants
 - Polymers
- ____ 18. _____ attaches to the enzyme at the active site and are the reactants that are catalyzed
- Chemicals
 - Substrate
 - Proteins
 - Active enzyme
- ____ 19. An ionic bond is formed as a result of
- Transfer of electrons
 - Sharing of electrons
 - Electrical shock
 - Hydrogen bonding
- ____ 20 . Amino acids are the monomer form of which major organic compound?
- Nucleic Acids
 - Carbohydrates
 - Proteins
 - Lipids
- ____ 21. Starches and sugars are examples of what group of organic compounds?
- Nucleic acids
 - Lipids
 - Carbohydrates
 - Proteins

____22. Nucleic acids are one of four major macromolecules. The main functions of nucleic acids are to

- a. Aid in development, the immune system, and blood clotting
- b. Carry genetic material and create structures inside the cell
- c. Act as enzymes, cell signals and structural support for the cell
- d. Store the transport energy and structural components in the cell

____23. Fats, steroids and cholesterol are examples of what organic compound

- a. Lipids
- b. Carbohydrates
- c. Proteins

____24. A polymer is a large molecule that forms when smaller molecules known as monomers bond covalently in a repeating pattern. There are many biological polymers such as nucleic acids, proteins and starches.

What are the monomer units that make up proteins?

- e. Glucose
- f. Fatty acids
- g. Amino acids
- h. Nucleotides

____25. Nucleic acids, proteins, and other large biological molecules are known as polymers because

- i. They contain many small, repeating subunits bonded together
- j. They all contain only ionic bonds
- k. They are the base units used in the formation of plastics
- l. They all have the capability of functioning as enzymes

____26. Enzymes are considered to be a part of which major group of organic compounds

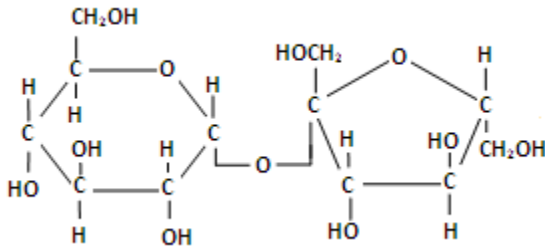
- a. Proteins
- b. Lipid
- c. Carbohydrates
- d. Nucleic Acids

____27. Nucleotides are the monomer form of which of the following organic compound?

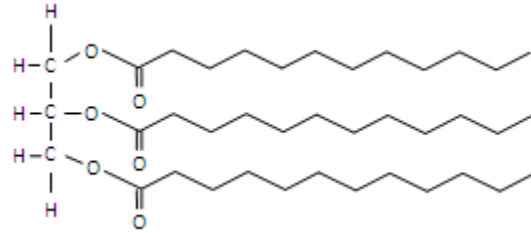
- a. Proteins
- b. Carbohydrates
- c. Lipids
- d. Nucleic Acids

Keystone Questions

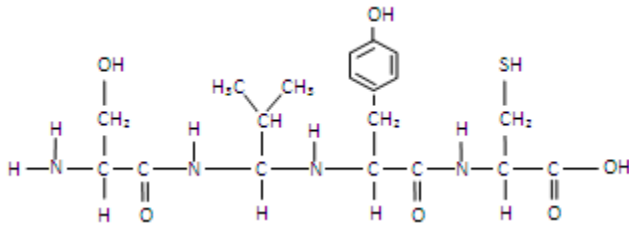
___28. Lipids, also called fats or oils, can be found in cell membranes. Which of the molecules shown below is a lipid?



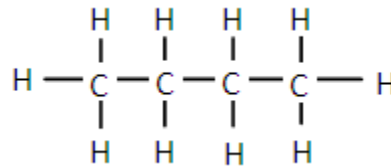
W.



X.



Y.



Z.

___29. A scientist removed the cell membranes from bacteria cells in a culture. She analyzed the cell membranes for specific molecules. Which of these was probably the most common type of molecule present in the bacteria cell membranes?

- Lipid
- Amino acid
- Nucleic acid
- Carbohydrate

___30. Wolves are high level predators that have a variety of prey. A wolf gets many nutrients from its food including amino acids, sugars, fats, and vitamins. Which of these can be built directly using the amino acids?

- Carbohydrates
- Lipids
- Minerals
- Proteins

___31. The table below provides information about the composition and function of four important molecules in living organisms.

Which of the molecules in the table is a carbohydrate?

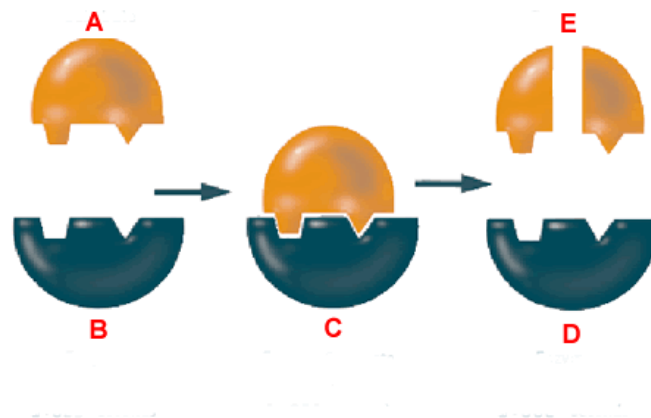
- i. 1
- j. 2
- k. 3
- l. 4

Molecule	Composition	Function
1	amino acids	reaction catalyst
2	fatty acids	membrane component
3	monosaccharides	energy source
4	nucleotides	genetic information

Short Answer: Answer the question to the best of your ability.

32. What are the 4 main reasons carbon is the building block of all living things?

33. Label the following parts of a reaction that involves an agent that speeds up the reaction. (active site, substrate, enzyme and products)



APPENDIX F

IRB APPROVAL

MONTANA STATE UNIVERSITY
Request for Designation of Research as Exempt
MSSE Research Projects Only

THIS AREA IS FOR INSTITUTIONAL REVIEW BOARD USE ONLY. DO NOT
 WRITE IN THIS AREA. Confirmation Date: 11/30/21
 Number:

Application *Mark J. Quinn*

Address each section - do not leave any section blank.

I. INVESTIGATOR: Mitchell McEwen

- Okay as exempt
- MSSE classroom assessment
- Little/no risk
- Principal approved
- No concerns

DATE OF SUBMISSION: 11/30/21

MQ 11/30/21

Name: **Mitchell McEwen**

Home or School Mailing Address: **304 Seaward Ave,
 Bradford, PA 16701** Telephone Number: **(814) 598-0513**

E-Mail Address:

DATE TRAINING COMPLETED: **2/25/21**

Investigator Signature: *Mitchell McEwen*

Name of Project Advisor: Jessica Anderson

E-Mail Address of Project Advisor: Jessica.Solberg@ecat1.montana.edu

II. TITLE OF RESEARCH PROJECT: **Effectiveness of KLEWS on high school freshman engagement and performance in Biology**

- III. BRIEF DESCRIPTION OF RESEARCH METHODS (If using a survey/questionnaire, provide a copy).
- IV. RISKS AND INCONVENIENCES TO SUBJECTS (do not answer 'None'): **No foreseeable risks are involved with the action research**
- V. SUBJECTS:
- A. Expected numbers of subjects: **57**
- B. Will research involve minors (age <18 years)? **Yes** No
(If 'Yes', please specify and justify.) **All students are high school freshman**
- C. Will research involve prisoners? **Yes** No
- D. Will research involve any specific ethnic, racial, religious, etc. groups of people?
(If 'Yes', please specify and justify.) **Yes** No
- VI. FOR RESEARCH INVOLVING SURVEYS OR QUESTIONNAIRES:
(Be sure to indicate on each instrument, survey or questionnaire that participation is voluntary.)
- A. Is information being collected about:
- | | | |
|---------------------------------------|-----|-----------|
| Sexual behavior? | Yes | No |
| Criminal behavior? | Yes | No |
| Alcohol or substance abuse? | Yes | No |
| Matters affecting employment? | Yes | No |
| Matters relating to civil litigation? | Yes | No |
- B. Will the information obtained be completely anonymous, with no identifying information linked to the responding subjects? **Yes** No
- C. If identifying information will be linked to the responding subjects, how will the subjects be identified? (Please circle or bold your answers)
- | | | |
|----------------------------------|-----|----|
| By name | Yes | No |
| By code | Yes | No |
| By other identifying information | Yes | No |
- D. Does this survey utilize a standardized and/or validated survey tool/questionnaire? **(If yes, see IRB website for required wording on surveys and questionnaires.)** **Yes** No
- VII. FOR RESEARCH BEING CONDUCTED IN A CLASSROOM SETTING INVOLVING NORMAL EDUCATIONAL PRACTICES:

A. This research project must be approved by your Principal or School Administrator, unless there are circumstances or policies that do not make this possible. **Provide a copy of the principal's signed approval.** If such approval is not possible, please explain.

B. Participation of your students in research must be voluntary and can never affect their rights. Please make this issue clear on all of your research surveys (use introductory text, see below) and/or interviews (use introductory verbal statement, see below). The following wording or something similar can be used for the introductory text or statement: **Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

C. Extra credit should not be used to encourage participation. If you absolutely need to use extra credit, then an alternative activity involving the same amount of time and effort must be provided for those who choose not to participate. This must be clearly described in your IRB application.

E. Depending on your school policies, **consent forms may or may not be required for your research.** Please indicate whether you will be using consent forms or not. If you are not using consent forms, please justify (e.g., school policy, etc.). **If you do use consent forms, you must include signature lines for parental consent AND student assent.** (Please use accepted format from our website and provide a stand-alone copy. Do not include form here.)

Exemption Regarding Informed Consent and Administrator Approval

I, Dave Ray, Principal of Bradford Area High School, verify that the classroom research conducted by Mitchell McEwen is in accordance with established or commonly accepted educational settings involving normal educational practices. To maintain the established culture of our school and not cause disruption to our school climate, I have granted an exemption to Mitchell McEwen regarding informed consent and I approve this project.

_____ *David Ray* _____ (Signed
Name)

_____ David Ray _____ (Printed Name)

November 16, 2021 _____ (Date)