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Perceptions of Undergraduate Agricultural Education Students on the Effects of Question Difficulty and Post-question Wait-time on Cognitive and Emotional Processes

Kyle C. Gilliam[1], John Rayfield[2], Matt Baker[3], Rudy Ritz[4], and R. Glenn Cummings[5]

Abstract

The purpose of this study was to explore the perceptions of undergraduate agricultural students on the cognitive and emotional processes produced after exposure to low- and high-level questions, as well as the effects of post-question wait-time to determine the benefits of differing lengths of post-question wait-time based on the level of question. Forty students were shown four different treatment videos in this with-in subjects design, with each video being followed by either a low- or high-level question. Following each question, a wait-time period of either five seconds or ten seconds was employed before the subjects were instructed to answer the question. The student perceptions resulted in a difference between low- and high-level questions on question difficulty, variability in cognitive engagement, and positive and negative emotions, as well as a difference on their perceptions of what constituted an adequate amount of post- question wait-time for low- and high-level questions.

Keywords: question difficulty; post-question wait-time; cognitive engagement; cognitive processes; emotion; emotional processes

Introduction

Educational research continues to focus on understanding the learning process and improving techniques and methods used by teachers. Many researchers have focused on the development of higher-level thinking skills. McCormick and Whittington (2000) examined the different academic challenges provided to undergraduate agriculture students and how they were being assessed during higher cognitive challenges. Ewing and Whittington (2009) described the cognitive level of professor discourse and student engagement and determined much of the professor discourse and student engagement from their subjects was in the lower levels of cognition. Ball and Garton (2005) determined that while the majority of preservice teachers' educational objectives were developed at higher levels of cognitive engagement, their classroom discourse primarily modeled lower levels of cognition.

In addition to cognitive processing at higher levels, emotional processing may have an effect on how individuals retain and use information (Dolan, 2002; Leutner, 2014; Linnenbrink, 2006; Vince,

[1] Kyle C. Gilliam is the Manager of Global Strategies and Trade at the U.S. Grains Council, 20 F Street NW, Suite 900, Washington, DC, 20001, kylecgilliam@gmail.com.
[2] John Rayfield is an Associate Professor of Agricultural Education in the Department of Agricultural Education and Communications at Texas Tech University, Box 42131, Lubbock, TX 79409-2131, john.rayfield@ttu.edu.
[3] Matt Baker is a Professor and Department Head of Agricultural Leadership, Education, and Communications at Texas A&M University, 2116 TAMU, College Station, TX 77843-2116, mabaker@tamu.edu.
[4] Rudy Ritz is an Associate Professor of Agricultural Education in the Department of Agricultural Education and Communications at Texas Tech University, Box 42131, Lubbock, TX 79409-2131, rudy.ritz@ttu.edu.
[5] R. Glenn Cummings is an Associate Professor of Journalism and Creative Media Industries in the Department of Journalism and Electronic Media at Texas Tech University, Box 43082, Lubbock, TX 79409, glenn.cummings@ttu.edu.

2016; Zull, 2002). Zull (2002) suggested emotional processing may have an influence within all components of the learning cycle. Cognition and emotion have been tied together with the discovery by neuroscientists that emotional processing and cognitive processing occur in the same parts of the brain (Vince, 2016).

In order for students to develop their ability to process information critically at higher levels of cognition, they must be challenged at higher levels of cognition during classroom instructional techniques (McCormick & Whittington, 2000). An instructional technique suggested by many teaching methods experts is the use of post-question wait-time (Borich, 2014; Burden & Byrd, 1999; Gage & Berliner, 1998). Rowe (1974) offered a definition for post- question wait-time as the amount of time after asking a question that a teacher waits for a student response. Early research on the use of post-question wait-time revealed that the average time a teacher waits for a student response after posing a question is one second (Rowe, 1969). Other research has concluded that an appropriate amount of wait-time to be utilized by a teacher should be between three and five seconds (Burden & Byrd, 1999; Gage & Berliner, 1998; Rowe, 1974). In addition, Gage and Berliner (1998) suggested that for higher level questions, teachers should utilize up to 15 seconds of post-question wait-time.

Theoretical Framework

Bloom et al. (1956) developed a framework for classifying educational goals. This original framework consisted of six levels that ranged from lower order thinking skills to higher order thinking skills. The original six levels from lowest to highest were knowledge, comprehension, application, analysis, synthesis, and evaluation. This taxonomy for classifying education goals have been widely adopted and applied by educators at all levels in the development of their own educational objectives and questions. In 2001, Anderson and Krathwohl revised Bloom's taxonomy. The revised Bloom's taxonomy utilized verbs instead of nouns for the title of each level to indicate the action that takes place at that level. The revision also included switching the two highest levels, making the category of creating the highest order of thinking. The current six levels of the revised Bloom's taxonomy are (Anderson & Krathwohl, 2001):

1. Remembering – the recall of knowledge from memory or the retrieval of facts and basic concepts previously stored within the memory of an individual.
2. Understanding – the explaining of ideas or concepts by constructing meaning from knowledge through interpretation, summarization, or comparing of information.
3. Applying – the using of information under new conditions or circumstances.
4. Analyzing – the ability to draw connections between ideas and concepts by breaking them down and determining how each component is related to each other or related to a larger overarching concept.
5. Evaluating – Justifying a decision by making judgements based on set criteria.
6. Creating – Production of original work developed by combining elements through the synthesizing of prior knowledge.

Purpose and Research Questions

The purpose of this study was to explore the perceptions of undergraduate agricultural students on the cognitive and emotional processes produced after exposure to low- and high- level questions, as well as the effects of post-question wait-time in order to determine the benefits of differing lengths of post-question wait-time based on level of question. This study supports Research Priority 4 – meaningful, engaged learning in all environments, of the American Association for Agricultural Education Research Agenda (Roberts et al., 2016). To address this purpose, the following research questions were utilized:

RQ1: Is there a significant effect of question difficulty on the perceptions of agricultural education teacher certification students on difficulty of question?
RQ2: Is there a significant effect of question difficulty on the perceptions of agricultural education teacher certification students on cognitive engagement?
RQ3: Is there a significant effect of question difficulty on the perceptions of agricultural education teacher certification students on positive emotional response?
RQ4: Is there a significant effect of question difficulty on the perceptions of agricultural education teacher certification students on negative emotional response?
RQ5: Is there a significant effect of question difficulty and time on the perceptions of agricultural education teacher certification students on post-question wait-time?
RQ6: What effects do question difficulty and amount of post-question wait have on the quality of answers produced by agricultural education teacher certification students?

Methods

The population for this study was undergraduate students seeking teacher certification in the field of agricultural education at Texas Tech University. A convenience sample consisted of 40 students who volunteered from the Department of Agricultural Education and Communications at Texas Tech University, who were currently enrolled as agricultural education teacher certification students. Subjects were paid $20 for their participation in the study as an incentive. Fraenkel et al. (2015) recommend a minimum of 30 subjects when conducting experimental and quasi-experimental research. Of the 40 subjects, 27 were female and 13 were male. The sample consisted primarily of upperclassmen (n = 36) with a mean age of 21.21 years old (SD = 1.96). The mean GPA for the sample was 3.30 (SD = 0.43). These attributes are similar to student attributes in studies conducted on similar populations (Carraway, 2015; Morales Vanegas, 2015).

This study utilized a quasi-experimental counterbalanced design, where subjects were randomly assigned a treatment condition (Ary et al., 2019). The research design for this study was a 2 (question difficulty) X 2 (question repetition/amount of wait-time) within-subject design. Each participant received all combinations of each treatment condition (Ary et al., 2019; Keppel & Wickens, 2004).

The treatment stimulus consisted of five video lessons over characteristics of effective teachers. An introduction to Rosenshine and Furst (1971) was used for the first video in all treatment conditions. The remaining videos addressed the specific characteristics of clarity, variability, enthusiasm, and task oriented and business-like behavior. Each video was paired with a specific question about the video. The questions were presented on the screen after the conclusion of each video.

Following each question, the subjects were given either five or ten seconds (post question wait time) to process and formulate a response. At the end of the post question wait time, the subjects were instructed to deliver their response to the posed question, as well as respond to a self-report questionnaire. To control for extraneous variables, Keppel and Wickens (2004), as well as Fraenkel et al. (2015) suggest using a counterbalanced design. To do this, two different orders of the stimulus videos were created with the independent variables being counterbalanced.

Independent variables included question difficulty and post-question wait-time. Question difficulty was developed using Bloom's Taxonomy. Bloom's Taxonomy consists of six hierarchical levels of questioning and thinking. The six levels from lowest order to highest order are: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating. Bloom's Taxonomy provides a

framework for developing questions that provide an increasing level of difficulty. Question difficulty was operationalized as low- and high-levels of difficulty. Four questions were generated from the remember and understand (low difficulty) levels of Bloom's taxonomy (Anderson & Krathwohl, 2001). There were two low level questions written for the video on clarity and two low-level questions written for the video on enthusiasm. Four more questions were generated from the evaluate and create (high difficulty) levels of Bloom's taxonomy (Anderson & Krathwohl, 2001). Two questions were written for the variability video and two questions were written for the task-oriented and business-like behavior video. All eight questions were submitted to a panel of experts on Bloom's taxonomy from various universities across the U.S. Individuals selected for the panel were considered experts if they had previously published studies on or utilizing Bloom's Taxonomy. The panel rated each question as a high- or low-level question. Questions that did not receive a unanimous rating from the panel were removed from the question pool. The following questions were chosen for the low difficulty portion of the study: 1. Give an example of how a classroom teacher could exhibit clarity while teaching. 2. List three ways discussed in this lesson that can be used to exhibit enthusiasm. The high difficulty questions chosen for the study were: 1. Critique this lesson on variability. How might you improve the variability in this lesson? 2. Explain why or why not task-oriented and business-like behavior is important for a teacher.

Post-question wait-time is defined as "the pause following any teacher utterance and preceding any student utterance" (Tobin, 1987, p. 90). Wait time for this study consisted of two levels (five seconds and ten seconds). At the completion of posing each question, a black screen was produced that lasted the duration of the wait time, five seconds for the first level and ten seconds for the second level of wait-time. This study was a part of a larger psychophysiology study, which measured heart rate and skin conductance to determine the extent of cognitive and emotional processing. The black screen was utilized to ensure that the physiological measures accurately measuring the cognitive and emotional processes used to answer the question, instead of measuring physiological responses to re-reading the questions.

Dependent variables for the study included post-question response and subject perceptions. The post-question response is the individual responses to each question posed within the study. This was operationalized as the percentage of subjects who correctly answered each question. Each question was scored on a 100-point scale. For lower difficulty questions of remembering or understanding, answers were scored for accuracy by noting if they were correct or incorrect based on the content provided. Higher difficulty questions were evaluated using a rubric that considers referencing correct content presented in the lesson and responses that connect content from the lesson to other knowledge or experiences.

Subject perceptions were measured using a self-report questionnaire that consisted of five Likert-type items utilizing a five-point scale. The scale ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). Subjects were prompted and responded to these items following each stimulus video question. The first Likert-type item was: This question was difficult. This item measured the perception of the subject on how difficult they perceived each question from the treatment stimulus. The second Likert-type item was: This question elicited a strong cognitive response. This item measured the subject's perception on the amount of cognitive engagement produced by each question from the treatment stimulus. The third Likert-type item was: I had a strong positive emotional response to this question. This item measured the subject's perception of any positive emotional response produced by each question within the stimulus. The fourth Likert-type item was: I had a strong negative response to this question. This item measured the subject's perception of any negative emotional response produced by the questions within the stimulus and was included to counterbalance the Likert-type item on positive emotional response. The fifth Likert-type item was: I had enough time to process this question before being prompted to answer. This item measured the perception of the subjects on whether they

had enough post-question wait-time after each question to process and formulate an answer for both five second and 10 second wait-times.

Subjects selected for the study were required to come to the on-campus research laboratory located in the Center for Communication Research at Texas Tech University. Upon arrival of the subjects, they were asked to complete a demographics questionnaire to collect data on gender, age, and classification. Once the questionnaire was completed, the subjects were seated in a reclining chair situated approximately four feet away from a flat panel television. They were asked to turn off their cell phone to eliminate the risk of outside interference. The lights were lowered, and the door was shut prior to the beginning of the experiment. Subjects then saw instructions on the screen before them that indicated the procedures to be used for the display of the treatment videos and the data collection process.

Each participant was exposed to one of the two orders of the treatment videos. After exposure to each stimulus video, the subjects were given the prescribed amount of wait-time (five seconds or 10 seconds) and then prompted to answer a question related to the stimulus video. After responding to each stimulus video question, the subjects were directed to complete the self-report questionnaire associated with each stimulus video question.

A 2X2 factorial repeated measures ANOVA was utilized to test the research questions to determine the differences between low and high-level difficulty of questions, the differences between five and ten second post question wait times, and the interaction effect of both factors for cognitive engagement. This design allowed the researchers to test for a main effect for level of question difficulty, a main effect for time (five seconds or 10 seconds), and an interaction effect between level of question difficulty and time for cognitive resource allocation.

The research questions were tested with significance set *a priori* at $p = .05$. Mauchly's test was used to test the assumption of sphericity (Field, 2014). When the assumption of sphericity is violated, Field (2014) suggests using the Greenhouse-Geisser estimate to correct the *F*-ratio. According to Stevens (2002), multivariate procedures are more powerful than univariate procedures when there is a large violation of sphericity and a sample size larger than ten subjects. P-values provide limited information and cannot determine the size of an effect (Wasserstein & Lazar, 2016) and appropriate effect sizes should be calculated for each analysis (Keppel & Wickens, 2004). Effect sizes are used to determine the size of the effect. Keppel and Wickens (2004) suggested using partial omega squared to calculate effect size. Effect sizes for this study were interpreted based on the recommendations of Keppel and Wickens (2004).

Results

Table 1 shows the means and standard deviations for the self-report items at each level. Mean scores for difficulty and cognitive engagement were greater for the high cognitive level questions. Mean scores for positive emotions were higher across all levels than the mean scores for negative emotions. Mean scores for satisfaction of enough post-question wait-time were similar between both low-level questions, as well as similar between both high-level questions. The mean scores were higher for satisfaction of enough wait-time for low-level questions than for the high-level questions

Table 1

Means and Standard Deviations for Self-Report Items

Testing Time	LL 1	LL 2	LL Mean	HL 1	HL 2	HL Mean
Difficulty						
M	1.55	1.30	1.43	2.68	2.38	2.53
SD	0.90	0.61	0.76	1.21	1.31	1.26
Cognition						
M	3.18	3.20	3.19	4.05	4.18	4.12
SD	0.93	1.22	1.08	0.90	0.84	0.87
Positive Emotion						
M	4.10	4.25	4.18	3.58	4.13	3.86
SD	0.84	0.74	0.79	1.01	0.79	0.90
Negative Emotion						
M	1.53	1.43	1.48	2.28	1.65	1.97
SD	0.78	0.71	0.75	1.18	0.86	1.02
Wait-Time (n = 20) *						
M	4.15	4.20	4.18	3.35	3.50	3.43
SD	1.27	1.01	1.14	1.46	1.28	1.37

Note. 5-point Likert scale with 1 = Strongly Disagree and 5 = Strongly Agree. LL = Low-level question, HL = High-level question

*Data collection error resulted in usable data from only 20 subjects

Table 2 shows the repeated measures ANOVA for question difficulty and question repetition for perceived difficulty of question. Sphericity was not violated for the main effects of question difficulty, question repetition, or the interaction effect as there were only two levels for each variable.

Table 2

Repeated Measures ANOVA for Question Difficulty and Question Repetition on Perceived Difficulty of Question

	SS	*df*	*MS*	*F*	*p*	ω_p^2
Question Difficulty						
Within groups	48.40	1.00	48.40	70.96	< .01	.63
Error	26.60	39.00	0.68			
Question Repetition						
Within groups	3.03	1.00	3.03	2.46	.13	.03
Error	47.98	39.00	1.23			
Question Difficulty X Question Repetition						
Within groups	0.03	1.00	0.03	0.04	.84	<.01
Error	23.98	39.00	0.62			

There was a significant main effect of question difficulty on perceived question difficulty, $F(1, 39) = 70.96$, $p < .01$, $\omega_p^2 = .63$. There was not a significant main effect of question repetition on perceived question difficulty, $F(1, 39) = 2.46$, $p = .13$, $\omega_p^2 = .03$. There was not a significant interaction effect between question difficulty and question repetition on perceived question difficulty, $F(1, 39) = 0.04$, $p = .84$, $\omega_p^2 < .01$.

Table 3 shows the repeated measures ANOVA for question difficulty and question repetition for perceived level of cognition. Sphericity was not violated for the main effects of question difficulty, question repetition, or the interaction effect as there were only two levels for each variable.

There was a significant main effect of question difficulty on perceived level of cognition, $F(1, 39) = 41.36$, $p < .01$, $\omega_p^2 = .50$. There was not a significant main effect of question repetition on perceived level of cognition, $F(1, 39) = 0.39$, $p = .53$, $\omega_p^2 < .01$. There was not a significant interaction effect between question difficulty and question repetition on perceived level of cognition, $F(1, 39) = 0.25$, $p = .62$, $\omega_p^2 < .01$.

Table 3

Repeated Measures ANOVA for Question Difficulty and Question Repetition on Perceived Level of Cognition

	SS	*df*	*MS*	*F*	*p*	ω_p^2
Question Difficulty						
Within groups	34.23	1.00	34.23	41.36	< .01	.50
Error	32.28	39.00	0.83			
Question Repetition						
Within groups	0.23	1.00	0.23	0.39	.53	<.01
Error	22.28	39.00	0.57			
Question Difficulty X Question Repetition						
Within groups	0.10	1.00	0.10	0.25	.62	<.01
Error	15.40	39.00	0.40			

Table 4 shows the repeated measures ANOVA for question difficulty and question repetition for perceived positive emotional response. Sphericity was not violated for the main effects of question difficulty, question repetition, or the interaction effect as there were only two levels for each variable.

Table 4

Repeated Measures ANOVA for Question Difficulty and Question Repetition on Perceived Positive Emotional Response

	SS	*df*	*MS*	*F*	*p*	ω_p^2
Question Difficulty						
Within groups	4.23	1.00	4.23	11.96	< .01	.21
Error	13.78	39.00	0.35			
Question Repetition						
Within groups	4.90	1.00	4.90	10.56	< .01	.19
Error	18.10	39.00	0.46			
Question Difficulty X Question Repetition						
Within groups	1.60	1.00	1.60	3.39	.07	.06
Error	18.40	39.00	0.47			

There was a significant main effect of question difficulty on perceived positive emotional response, $F(1, 39) = 11.96$, $p < .01$, $\omega_p^2 = .21$. There was a significant main effect of question repetition on perceived positive emotional response, $F(1, 39) = 10.56$, $p < .01$, $\omega_p^2 = .19$. There was not a significant interaction effect between question difficulty and question repetition on perceived positive emotional response, $F(1, 39) = 3.39$, $p = .07$, $\omega_p^2 = .06$.

Table 5 shows the repeated measures ANOVA for question difficulty and question repetition for perceived negative emotional response. Sphericity was not violated for the main effects of question difficulty, question repetition, or the interaction effect as there were only two levels for each variable.

There was a significant main effect of question difficulty on perceived negative emotional response, $F(1, 39) = 17.87$, $p < .01$, $\omega_p^2 = .29$. There was a significant main effect of question repetition on perceived negative emotional response, $F(1, 39) = 9.77$, $p < .01$, $\omega_p^2 = .18$. There was a significant interaction effect between question difficulty and question repetition on perceived negative emotional response, $F(1, 39) = 7.97$, $p = .01$, $\omega_p^2 = 15$.

Table 5

Repeated Measures ANOVA for Question Difficulty and Question Repetition on Perceived Negative Emotional Response

	SS	*df*	*MS*	*F*	*p*	ω_p^2
Question Difficulty						
Within groups	9.51	1.00	9.51	17.87	< .01	.29
Error	20.74	39.00	0.53			
Question Repetition						
Within groups	5.26	1.00	5.26	9.77	< .01	.18
Error	20.99	39.00	0.54			
Question Difficulty X Question Repetition						
Within groups	2.76	1.00	2.76	7.97	.01	.15
Error	13.49	39.00	0.35			

Table 6 shows the repeated measures ANOVA for question difficulty and time for the perception of enough wait time. Sphericity was not violated for the main effects of question difficulty, question repetition, or the interaction effect as there were only two levels for each variable.

Table 6

Repeated Measures ANOVA for Question Difficulty and Time on Perception of Enough Wait-Time

	SS	*df*	*MS*	*F*	*p*	ω_p^2
Question Difficulty						
Within groups	11.25	1.00	11.25	20.85	< .01	.49
Error	10.25	19.00	0.54			
Time						
Within groups	0.20	1.00	0.20	0.21	.65	<.01
Error	18.30	19.00	0.96			
Question Difficulty X Time						
Within groups	0.05	1.00	0.05	0.05	.83	<.01
Error	20.45	19.00	1.08			

There was a significant main effect of question difficulty on perception of enough wait-time, $F(1, 39) = 20.85$, $p < .01$, $\omega_p^2 = .49$. There was not a significant main effect of question repetition on perception of enough wait-time, $F(1, 39) = 0.21$, $p = .65$, $\omega_p^2 < .01$. There was not a significant interaction effect between question difficulty and question repetition on perception of enough wait-time, $F(1, 39) = 0.05$, $p = .83$, $\omega_p^2 < .01$.

Table 7 shows the effects of question difficulty and post-question wait-time on the percentage of correct answers provided by the subjects. Ninety-five percent ($n = 38$) of subjects provided correct

answers to low-level questions when given five seconds of post-question wait- time. One hundred percent (n = 20) of subjects provided correct answers to low-level questions when given 10 seconds of post-question wait-time. Sixty-five percent (n = 13) of subjects provided correct answers to high-level questions when given five seconds of post-question wait- time. Sixty-five percent (n = 26) of subjects provided correct answers to high-level questions when given 10 seconds of post-question wait-time.

Table 7
Effects of Question Difficulty and Post-question Wait-time on Percentage of Sufficient Answers

	Sufficient Answers	Insufficient Answers	Total	% of Sufficient Answers
Low-Level X Five Seconds	38	2	40	95.0%
Low-Level X Ten Seconds	20	0	20	100.0%
High-level X Five Seconds	13	7	20	65.0%
High-level X Ten Seconds	26	14	40	65.0%

Conclusions

The purpose of this study was to explore the perceptions of undergraduate agricultural students on the cognitive and emotional processes produced after exposure to low and high-level questions, as well as the effects of post-question wait-time to determine the benefits of differing lengths of post-question wait-time based on level of question. When examining the results for question difficulty, there was a significant difference in the perception of question difficulty reported by the subjects. The subjects reported the low-level questions as being not very difficult and reported that the high-level questions were only moderately difficult. Similarly, the subjects reported a significant difference between low and high-level questions on the amount of cognitive processing that took place. The subjects reported a moderate level of cognitive processing for low-level questions and a high level of cognitive processing for the high-level questions.

The significant difference between level of difficulty for each type of question, as well as the significant difference for cognitive processing for each type of question, is representative of the hierarchy presented in the revised Bloom's taxonomy (Anderson & Krathwohl, 2001). This is further solidified by the large effect sizes reported for question difficulty (ω_p^2 = .63) and cognition (ω_p^2 = .50). It can also be concluded that while the subjects found low-level questions to be not very difficult, there was still a fair amount of perceived cognitive processing that took place as the subjects processed the question and recalled the answer they wish to provide. This cognitive processing indicates that at least some post-question wait-time is needed for students to formulate an answer for low-level questions. When comparing the sufficient answers provided for low-level and high-level questions, it can be concluded that the low-level questions were easier for the subjects to provide a sufficient or correct answer. This indicates that low-level questions can be utilized to engage students cognitively and possibly even build confidence in answering questions before moving on to higher-level questions. Ewing and Whittington (2009) reported that the majority of professor discourse and student engagement fell into lower levels of cognition and called for the utilization of higher levels of cognition when teaching. While higher levels of cognitive discourse can elicit deeper cognitive processing, an over-utilization of a discourse at this level may negatively impact student engagement.

Both positive and negative emotional responses were perceived as being significantly different based on question difficulty. This was indicated by the large effect size for self-reported positive (ω_p^2 = .21) and negative (ω_p^2 = .29) emotions. In addition, there was a significant difference between question repetition for both positive and negative emotional responses. When examining the mean

scores for both emotional response items, it can be concluded that the subjects had a more positive reaction to all questions, rather than a negative reaction. The subjects were more likely to find a positive reaction to low-level questions than to high level questions. In comparing the low-level questions, the subjects had a stronger positive reaction to the question on enthusiasm than to the question on clarity. The comparison of high-level questions revealed a stronger positive reaction to the question on task-oriented and business-like behaviors than the question on variability. This indicates that the way a low-level or high-level question is asked may impact the emotional response of a student.

The subjects reported having a greater negative reaction to high-level questions than to low-level questions. When comparing low-level questions, the subjects had a greater negative response to the question on clarity than the question on enthusiasm. The comparison of high-level questions revealed that subjects had a greater negative response to the question on variability than to the question on task-oriented and businesslike behavior. When comparing the reported perceptions of the subjects on emotional response to the percentage of sufficient answers, emotional response may have played some role in whether a participant provided a sufficient answer. In the case of low-level questions, the second question that pertained to enthusiasm received a higher positive rating and a greater percentage of sufficient answers. In contrast, low-level questions were reported as less likely to elicit a negative response than high-level questions. This higher reported rating for negative response of high-level questions might explain why high-level questions only received sufficient answers at a rate of 65%. This could be further justified by Plass et al. (2014), who reported that positive emotions produced better comprehension among students.

The reported perception of enough allotted wait-time revealed that there was a difference in the satisfaction of wait-time allocated by question difficulty, with a large effect size ($\omega_p^2 = .49$). Low-level questions were perceived to have enough wait-time at both five and 10 seconds of wait-time. High-level questions were perceived as having a moderate amount of satisfaction for enough allotted wait-time at both five and 10 seconds. This indicates that these undergraduate students felt that five seconds of wait-time was sufficient for low-level questions. It also indicates that they may have preferred a longer wait-time for higher-level questions. When comparing these perceptions to previous literature, Gage and Berliner's (1998) recommendations of three to five seconds of wait-time for low-level questions and up to 15 seconds of wait-time for high-level questions, would be the most appropriate way for teachers to utilize post-question wait-time. This would allow enough time for students to process both low- and high-level questions and formulate a sufficient answer.

Zull (2002) suggested that emotions can have an impact on all parts of the learning cycle. Therefore, it is further recommended that future research be conducted to explore the effects of positive and negative emotional responses on the learning process.

This study had strictly controlled internal validity, which in turn limits the external validity of the study (Campbell & Stanley, 1963). Ary, et al. (2019) states that researchers should not be concerned with external validity until internal validity has been established. For this reason, these findings from the design of this study may currently better inform the practice of instructor-led questioning in a distance education setting. It is suggested that the study be replicated in college and university classrooms to more accurately inform teacher-led questioning in face-to-face instruction.

It is important to note that this study was part of a larger psychophysiology study that examined the emotional and cognitive engagement of students using physiological measures. The researchers are reserving judgement on the examination of the consistencies and inconsistencies of the larger study, until the psychophysiology data has been subjected to and undergone the scrutiny of independent reviewers.

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