An early exploration of undergraduate student definitions of learning, memorizing, studying, and understanding

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Abstract

Biology education research often utilizes the terms learning, memorizing, studying, and understanding without providing their specific definition. When definitions have been provided, they are often inconsistent across publications. As part of a larger research study, we interviewed 11 participants on 2 occasions while they were enrolled in a sequence of anatomy and physiology courses. Part of the interview protocol asked participants for their definitions of learning, memorizing, studying, and understanding. Definitions were isolated from the transcript, deidentified, and sorted by qualitative similarities. The research team developed code categories and assigned definitions to these groups after discussing coding differences. Multiple definition groups emerged for each term. Learning, memorizing, and studying definition groups highlighted processes, outcomes, or a combination of both a process and outcome. Understanding definition groups focused solely on an outcome. These findings highlight the need for communication between students and instructors with regard to term usage. In addition, future research in biology and physiology education should be careful to provide working definitions of these terms to ensure communicative and interpretive validity and to promote transferability and repeatability of findings.

student definitions; student learning; student perspective; undergraduate education; validity

INTRODUCTION

The terms learning, understanding, memorizing, and studying are commonly discussed and used by instructors and education researchers within the life sciences (1–5). Education researchers use these terms within interview protocols and surveys and may or may not define them in publications. In data collection, definitions for these terms are often assumed rather than being specifically defined, introducing a significant threat to interpretive validity, or the extent to which researcher interpretation of data reflects the actual meaning intended by the participants (6). Much literature about student learning utilizes survey data from large populations of students, with items incorporating the terms in question to quantify student behavior. (See the following examples in Refs. 7–9.) Given the broad use of these terms in instructional and research settings, ensuring congruent definitions by researchers and their participants is important for effective application of research to practice.

Within instructional practice, instructors use these terms within syllabi and course objectives and during discussions with their students. Instructor definitions of the terms learning, understanding, memorizing, and studying may be evident in their syllabi or derived from how they are used, but the specific interpretations of these terms on the part of students has not been reported.

In this qualitative research project, we asked students to provide their definitions of these terms in response to an open-ended interview prompt at the beginning and end of a two-semester anatomy & physiology (A&P) course sequence. The use of qualitative data can provide richer, context-dependent examples from the environment in question (10) but is not intended to provide generalizable information about the full population of undergraduate science students. As stated by Kelleher and colleagues (11): “Findings of educational research using phenomenological methodology can be transferable to other settings if they illuminate essential aspects of the meaning of the phenomenon that will resonate with other teachers and learners.” (p. 142) The purpose of this project was to identify the variations of ways students in undergraduate A&P courses define and interpret commonly used terms in educational research (learning, memorizing, studying, and understanding).

Background of Terms in Literature

A clear and succinct definition of “learning” is essential in biology education and associated research. However, coming to a definition is a difficult task, since many studies provide no specific definition of the term learning despite using the term frequently. Among publications where definitions are provided, the definitions vary considerably.
In the final chapter of the book *Improving Learning: New Perspectives*, Marton and Ramsden (12) state:

“Learning should be seen as a qualitative change in a person’s way of seeing, experiencing, understanding, conceptualizing something in the real world—rather than as a quantitative change in the amount of knowledge someone possesses. It is logically impossible for learning defined in this way to be content- and context-free. Learning techniques and instructional strategies are inextricably linked to subject matter and the students’ perceptions.” (p. 271)

Roth and Anderson (13) use a similar definition, saying that learning is a “difficult and complex process of conceptual change, not a process of acquiring and memorizing facts” (p. 139). These definitions are in agreement with each other that learning is a process that changes the learner and focuses on higher order cognitive skills, rather than solely on acquiring facts or information.

These definitions also appear to be in agreement with the intent of the widely cited Bloom’s Revised Taxonomy (BRT) (14). Although the editors do not provide a specific definition of “learning,” they state:

“Two of the most important educational goals are to promote retention and to promote transfer (which, when it occurs, indicates meaningful learning) … In short, retention requires that students remember what they have learned, whereas transfer requires students not only to remember but also to make sense of and able to use what they have learned.” (p. 63)

BRT provides one link between research on learning and instructional practice with many instructors using action verbs based on BRT to articulate course learning objectives. Previous research has developed tools to facilitate this process in biology education (5, 15, 16).

More recent work in biology education research has adopted a definition of learning to include both acquisition of facts and conceptual change. Southard and colleagues (17) have defined learning as “a dynamic process involving the acquisition of new ideas, the development of connections between ideas, and the reorganization of prior knowledge” (p. 3). Within the A&P literature, Wilhelmsson and colleagues (18) define learning as “the ability to identify structures with their internal relationship and the talent to compile details into a three-dimensional whole.” (p. 154). All of these studies and others (19) are in agreement that learning is context dependent and may take many forms, but they disagree about the inclusion of quantitative changes or knowledge acquisition.

Given the wide variety in how educational professionals define learning, it is reasonable to assume that students would also hold a variety of interpretations of the term.

“Understanding” has been defined in multiple ways within the literature as well, and most of these definitions differ from that provided by BRT (14): “constructing meaning from instructional messages, including oral, written, and graphic communications” (p. 67). Kember (20) provided the definition most closely aligned, defining understanding as “the intention of seeking inherent meaning” (p. 343). Within the A&P literature, Pyrenius and colleagues (21) defined the term to mean “capability in action” (p. 151). Wilhelmsson and colleagues (22) provide a more detailed definition, stating that understanding is “the mental act of connecting parts into a coherent system, as well as decomposing larger objects into sub-parts” (p.154).

In addition to a lack of agreement on the definition of understanding, there is also a lack of consensus on the appropriate method to measure this state. Nonetheless, previous studies consistently indicate that instructors believe that understanding is the desired end point or “destination” of student learning, while also noting that memorization is frequently employed by students as a course strategy (18, 20, 23–25). In addition, the term “understand” appears in multiple descriptions of the Core Competencies described in *Vision and Change* (1) but is not clearly defined within the document.

“Memorizing” is rarely defined in the literature despite its frequent use. It is usually described as an inferior or undesirable outcome in college courses. Both Michael (24) and Slominski and colleagues (26) report instructor belief that physiology is hard for students because of confusion between memorization and learning. These instructor beliefs are based on anecdotal experience with students. No prior research has specifically examined this potential confusion from the student perspective.

“Studying” is also rarely defined in the literature. In some instances, the definition may be inferred from context to mean the processes utilized by students in their quest for learning, memorizing, or understanding (cf. Refs. 2, 27). There are few direct reports in the literature about how students define this term, despite the fact that student practices are frequently examined. Hora and Oleson (28) investigated study habits of undergraduate Science, Technology, Engineering, and Mathematics (STEM) students but also report three different definition groups for this term, which range from simple exposure to course material to conceptions of learning with a task orientation. For the purposes of their additional analysis, the authors provided this definition: “any interaction with course material outside of the classroom” (p. 7) but also indicate the need for additional research to investigate student conceptions of this term. Overall, this gap in the literature yields a threat to the application of research to practice, as recommendations for study practice by well-informed practitioners may be interpreted in an entirely unintended manner by the student audience.

**Implications for Student/Instructor Interactions**

Within the undergraduate classroom, the terms learning, understanding, memorizing, and studying are used by both students and instructors. Instructors may use the terms “learning” and “understanding” within their course objectives. They may encourage students to “study” course material and discourage them from “memorizing.” Prior publications have highlighted the beliefs of undergraduate instructors about how students view and employ memorization (24, 26). In both cases, instructors expressed agreement with the statement: “Students believe that ‘learning’ is the same thing as ‘memorizing.’”
While the above provides evidence about how instructors define or use these terms, they provide no direct evidence about how students view these terms. If students do confuse learning and memorizing, as claimed above, interventions would be important to clarify this confusion and encourage learning. Additionally, an intervention would require a description of how students use and apply these terms. However, if instructors have made incorrect assumptions about their students’ definitions of these terms, course objectives, class discussions, and possible interventions could lead to confusion and frustration on the part of students as they unsuccessfully attempt to follow the directions of course instructors.

Implications for Participant/Researcher Interactions

Lo and colleagues (29) noted the prevalence of quantitative surveys in biology education research. The terms learning, understanding, studying, and memorizing are commonly used in surveys about student approach and perceptions (9, 30). In the Revised Study Process Questionnaire (R-SPQ-2F), eight of the 20 items include one of these four terms and all four of the terms appear at least once (30). In the Colorado Learning Attitudes about Science Survey (CLASS), 16 of the 32 items contain one or more of these terms (9). Neither of these surveys define the terms in the survey instructions. If student participants in research using these instruments interpret these terms differently than survey developers or researchers, the reliability and validity of data interpretation are called into question. This may be true in spite of employing the best practices for survey development [see Johnson et al. (31) as an example].

Questions of quality are important in all areas of discipline-based education research. As stated by Walther et al. (6):

“Quality, rather is based on an overall judgment of knowledge claims that considers the trustworthiness of their production as well as the value of their application in generating understanding or effecting positive change in other social contexts.” (p. 629)

Walther and colleagues developed the Q3 Quality Framework, a process-oriented model, which is concerned with validity/accuracy and reliability/precision throughout the research process. They describe multiple typologies of quality strategies. Communicative validity is concerned with ensuring that knowledge is socially constructed within the relevant community (6). Practically, this means that “data gathering needs to capture the respondents’ intersubjective reality” and that “the researcher’s abstract interpretations need to be grounded in the accounts of the participants” (pg. 640). Additionally, interpretive validity is concerned with ensuring that participant words, behavior, and perspective are interpreted in a way to capture the participant’s perspective (10). If there is incongruence between participant and researcher definitions of terms within a survey or interview protocol, this would present a threat to both interpretive and communicative validity of research findings and interpretations. Therefore, a clear understanding of student definitions is imperative to ensure quality in biology education research and in subsequent application of that research to practice.

Research Question

This qualitative study attempts to answer the following question: what are the variations of ways that undergraduate A&P students define the terms learning, memorizing, studying, and understanding?

Regardless of definition, there is an interest in the processes and improvements of learning, studying, and understanding in our undergraduate biology curriculum. To strengthen communicative and interpretive validity and avoid misapplication of research results, it is important to know how students conceive and use these important terms. To this end, we conducted 19 interviews over 2 semesters with 11 students enrolled in an A&P course. While small-sample qualitative findings are not intended to be generalizable, they can be transferable to other settings and can shed light on essential aspects of a particular phenomenon (11). The variations that emerged within our results are contextualized by discussing alignment with definitions provided in the literature.

METHODS

Methodology and Methods

This study was conducted as a small part of a larger comparative case study investigating the cognitive processes and pathways of A&P students during a two-semester sequence of anatomy and/or physiology courses at an R1 (32) institution in the southeastern United States. The full study was grounded in the theoretical framework of the 3P Model, which combined the 3P Model of Biggs (30) with findings from Pandey and Zimitat (25) and Fyrenius and colleagues (21). The 3P Model consists of four interconnected areas that impact context-dependent student learning: student characteristics, teaching context, processes, and outcomes (30). The additional frameworks provided more information and structure to the process component of the 3P Model (21, 25).

In this paper, we report the findings from interview questions that were included to ensure accurate reporting of student activities.

The research was reviewed and approved as exempt by the Institutional Review Board at Clemson University (2018-310) before the beginning of the project. All names within this manuscript are the participant’s self-selected pseudonyms.

Sample Selection

The larger study investigated the processes undergraduate students employed to learn within the context of their A&P courses (33). Based on noted shortcomings of previous literature (22, 23), we sought to recruit participants from two curricular structures and those who showed a strong preference for either a surface or deep approach to learning. In Fall 2018, students enrolled in three sections of anatomy and physiology were contacted to complete a short survey. Of these sections, two were a sophomore level anatomy & physiology course (Anatomy & Physiology I), which led to a second semester in the sequence (Anatomy & Physiology II).
The remaining section was a junior level course of functional human anatomy followed by a human physiology course. These courses were taught by instructors not affiliated with the research team. A total of 824 students were enrolled in these sections, and 231 students completed the full survey (27.9% response rate).

From this survey, we separated responses based on the course students were enrolled in and also ranked ordered the deep and surface approach to learning differential score calculated from the data. Complete details about this process are available (31, 33). The intention of the research team was to recruit eight participants from each course, with four of those manifesting a high deep approach to learning score and four manifesting a high surface approach to learning score. Although we believed this represented oversampling for the year-long project, we also recognized that some participants might choose to leave the study before the conclusion of data collection. After 5 weeks of e-mail invitations to survey completers, we were able to recruit 11 participants for a 2-semester project. Since this represented sufficient participants for the larger study that required data across the academic year, we closed recruitment and proceeded with data collection. Data collection began with seven students from the Functional Human Anatomy course (A–P) and four students from Anatomy & Physiology I (A&P). Of these students, five displayed a strong deep approach to learning and six displayed a strong surface approach to learning score. Participants provided their current academic major but no other demographic data about race/ethnicity, gender/gender identity, or socioeconomic status. Overall, six majors were represented: Biological Sciences (6 participants) and Biochemistry, Nutrition, Microbiology, Nursing, and Health Science (1 participant each). Three participants left the study before the second interview. One participant (Sally) cited an emerging health issue. The other participants (London and Tigers123) chose not to take the second course in sequence, which was a requirement to continue in the full two-semester study.

**Interviews**

The 11 participants were interviewed in September/October 2018, and 8 of those participants (5 from A–P, 3 from A&P) were interviewed again in April 2019. This provided a total of 19 interviews. Participants received incentives in the form of coupons to local businesses and a small package of snacks at each interview, as well as earning entries to a drawing for a $25 gift card.

The semistructured interview protocol contained multiple questions related to the larger research study and allowed participants the freedom to expand or elaborate on their responses. During both interviews, participants were asked the following questions related to the current research questions:

- How do you define learning?
- How do you define memorizing?
- How do you define studying?
- How do you define understanding?

These questions were included to ensure that the researchers captured and interpreted participant words and reported actions as the participants intended in the analysis of the full study (6). The questions were asked at different points of interviews 1 and 2, with the questions following student description of their A&P course in interview 1 and being the last questions unrelated to course content in interview 2. However, in both interviews, the questions were preceded by a statement directing the participants to think about their overall or general definition of the words. We were not attempting to frame the questions to restrict their definitions to a specific disciplinary context. Rather, we were seeking a definition that captured how each participant operationalized each term in the context of their full educational experience. The full interview protocols are included as Supplemental material (at http://dx.doi.org/10.13140/RG.2.2.15753.36961).

Interviews were digitally recorded and transcribed using Descript software (34) to capture participant words. Transcripts were developed using the automated system and were then checked and corrected by a member of the research team. Before analysis, the definition excerpts from each interview were unitized (35) and all identifying information (participant identification and interview number) was removed from the excerpt. These tasks were completed by the first author.

**Analysis**

Qualitative analysis of participant definitions used conventional methods for holistic coding, as described by Hsieh and Shannon (36) and Saldaña (37). Participant definitions for each term were grouped by one research team member according to qualitative similarities within the definitions provided by the participants. This researcher developed a code with a complete description of the boundaries/definition of that code for each term group. A second research team member then sorted the data according to the code descriptions. Code descriptions and boundaries were discussed and revised until consensus was reached in the assignment of data to the final code groups.

At the conclusion of code group assignment, the research team noted how the word choices within the student definitions of terms showed alignment with BRT. Because the taxonomy is widely recognized and used by both researchers and instructors, we chose to use BRT as an analytical lens and report the code groups based on this overlap. In BRT (14), six cognitive process categories are outlined: Remember, Understand, Apply, Analyze, Evaluate, and Create. These categories associated cognitive processes may be visualized as shown in Fig. 1.

**Validity and Reliability in Qualitative Research**

Care was taken to ensure validity and reliability of the data, giving attention to the collection and analysis steps of this project. In this case, we are concerned with the ways students define terms that are relevant to their learning (learning, understanding, memorizing, and studying). The use of open-ended interview prompts supported both theoretical and communicative validity. All interviews were captured by digital recording and transcribed to ensure accurate capture of participant definitions, supporting process reliability, which is defined as making the research process as independent as possible from random influences (6). Before coding, identifiers were removed from the definitions to reduce researcher bias and further support communicative and interpretive validity. Open coding was utilized during the
initial coding pass (37), which provided an opportunity for communicative validity. In addition, two coders grouped and discussed all definitions and coded to agreement. These steps in analysis also provided an opportunity for procedural validity, which concerns itself with ensuring that the research design improves the fit between theory and reality (6).

RESULTS

The full code book with descriptions and boundaries for each code is presented in Tables 1-4.

Learning

Three main definition groups emerged during analysis, with one group divided into additional subcategories. Definitions focused on the process for learning, a specific outcome, or a combination of process and outcome. The process for learning identified within definition groups was “acquisition of information,” but the outcomes used by students varied. Group L1 represents an action or process by an individual and falls outside of the outcomes of BRT. However, each of the group 2 definitions include the process or action or acquisition as part of their definition. In contrast, group 3 defines learning solely as an outcome, but this could include any or all of the first three BRT levels.

Definition group L1 focused on a process only with no specific outcome mentioned. We categorized this as falling outside the bounds of BRT. One quote was grouped here with conditions, as the participant stated that she was providing a definition from her Psychology course. Because of this comment, we were concerned that this definition was not based on her practical engagement with course material. For the

Table 1. Code groups, boundaries, and example quotes for “learning”

| Code Name                        | Code Description                                                                 | Excerpt                                                                                                                                                                                                                                                                 |
|----------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L1: Acquisition of information   | Excerpts reference a process of acquiring information but provide no information about an intended outcome. | “Acquiring new information on a topic or attempting to acquire information on a topic that you were not previously familiar with.” (Walt Owens, Interview 1)                                                                                                    |
| L2a: Acquisition of information leading to recall | Excerpts reference a process of acquiring information and define the outcome of that process to be the ability to recall the information at a later time. | “Typically learning would then mean knowing it and you point it out after that. Or at least knowing about it after that. . . . a big part of learning is actually understanding, remembering, and being able to recall the information.” (Sally, Interview 1) |
| L2b: Acquisition of information leading to understanding | Excerpts reference a process of acquiring information and define the outcome of that process to be the ability to understand the information. | “I think to hear something and internalize it, and kind of like understanding how it works. Be able to describe it to somebody else.” (Kate, Interview 2)                                                                                                      |
| L2c: Acquisition of information leading to application | Excerpts reference a process of acquiring information and define the outcome of that process to be the ability to apply the information to another situation or context. | “Taking in information and applying it. . . . to everyday life things. . . . consistently.” (Angie, Interview 1)                                                                                                                                                     |
| L3: Recall or Application        | Excerpts reference the intended outcomes of recall or application of information. No process or action is provided in relation to how this outcome would be achieved. | “Being able to explain the material without notes. And in like a thorough manner. You’re not just like spitting out like, something.” (Shay, Interview 1)                                                                                                           |

Names are participant-selected pseudonyms.
other definitions that were grouped to this category, the definition focused solely on the process of learning, which was defined as acquisition of information. Definition group L2a focused on both a process, specifically acquisition, leading to the specific outcome of information recall. These definitions may mention additional outcomes for learning but specifically include recall of the information within their definition. Definition group L2b focused on both acquisition leading specifically to the outcome of understanding alone. Several of these definitions also expanded the outcome of understanding to describe this state as being able to explain the information to someone else. Definition group L2c focused on acquisition of information leading specifically to the outcome of applying the information. Definition group L3 omitted any reference to a process or procedure for learning but focused solely on the outcome or results of learning.

**Understanding**

Three definition groups emerged during analysis that focused solely on an outcome. These definitions ranged from knowing or retelling details to having an ability to teach or explain the information to others.

Definition group U1 was centered on the ability to teach or explain the information in question. However, definition group U2 is more centered on the learner but defines understanding as a higher order cognitive process. The definitions provided in group U3 focused on the knowledge itself rather than an outcome that could be easily observed. Only group U1 defined this term consistent with BRT, while group U2 actually defined this term as a higher order cognitive level.

**Memorizing**

Five definition groups emerged during analysis. These definitions centered on outcomes achieved through memorization or a combination of a process and the outcome. While the processes related to memorization centered on repetition, outcomes varied from simple temporary memory to a lack of understanding.

Groups M1b and M2b included the specific action or task of using repetition to achieve an outcome of either short-term or

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**Table 2. Code groups, boundaries, and example quotes for “understanding”**

| Code Name                                      | Definition                                                                                      | Excerpt                                                                                                                                                                                                 |
|------------------------------------------------|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| U1: Ability to teach or explain information to others | Excerpts describe an outcome of being able to teach or explain information to others. No process or action is provided. | “If someone is able to ask you a question about it, and you’re able to give them like an example or an answer that they understand. Or if you’re telling them something and they ask a question to like, build off of it, you know the answer to that.” (Shay, Interview 1) |
| U2: Ability to apply or connect knowledge       | Excerpts describe an outcome of being able to apply or connect knowledge to other tasks or situations. No process or action is provided.     | “Studying for like long-term... Knowledge of the topic or skill. So rather than just memorizing it but knowing how it fits in with like everything else.” (Walt Owens, Interview 2) |
| U3: Knowing details or being able to retell in depth | Excerpts describe an outcome of having retained detailed information or having the ability to share details with another. No process or action is provided. | “Understanding would be taking a concept and being able to... reword it in your own language or your own... Yeah, in your own way.” (K Diddy, Interview 2) |

Names are participant-selected pseudonyms.

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**Table 3. Code groups, boundaries, and example quotes for “memorizing”**

| Code Name                                      | Definition                                                                                      | Excerpt                                                                                                                                                                                                 |
|------------------------------------------------|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| M1a: Provides recall                          | Excerpts describe an outcome of allowing for recall of information. No process or action is provided.     | “be able to recognize what you learned... you would be able to draw it back up. You wouldn’t have to just look at something and you wouldn’t be reading it. It would be coming out of your head.” (Tigers123, Interview 1) |
| M1b: Temporary memory                         | Excerpts describe an outcome of retaining information for a short amount of time. No process or action is provided. | “This word to me is short-term... And it’s often something that I don’t care about or if it is, I’m just trying to get a good grade and I don’t have a lot of time.” (Kate, Interview 2) |
| M2a: Repetition resulting in recall           | Excerpts describe the process of utilizing repetition of information to attain the outcome of recall of information. | “Continually going over information, until you know it like front and back... But just like through repetition.” (Shay, Interview 1) |
| M2b: Repetition resulting in temporary memory | Excerpts describe the process of utilizing repetition of information to attain the outcome of retention of information for a short amount of time. | “It’s just showing as many things into my brain with, like repetition. And then I usually forget it pretty soon after.” (Kate, Interview 1) |
| M3. Not understanding                         | Excerpts describe the outcome of memorizing as a lack of understanding. No process or action is provided. | “Being able to... look at information and then repeat it back... without necessarily understanding of that information.” (Wait Owens, Interview 2) |

Names are participant-selected pseudonyms.
Table 4. Code groups, boundaries, and example quotes for “studying”

| Code Name | Code Description | Excerpt |
|-----------|------------------|---------|
| S1: A “process” | Excerpts explicitly describe an action as a “process”. | “Studying is… basically the process of learning the material that was discussed in class on your own time outside of class… in your own way… through just whatever mechanisms you find most helpful.” (K Diddy, Interview 2) |
| S2: Use of time | Excerpts describe tasks or actions generally, but explicitly describe the need for “time.” | “I guess [studying is] dedicated learning time.” (Michelle, Interview 2) |
| S3: Action leading to an extrinsic act (e.g., test) | Excerpts describe actions or tasks specifically linked to an extrinsic event or act, like a test. | “Taking what you learned in class… so that you master the topic… for an exam or whatever.” (K Diddy, Interview 1) |
| S4a: Action leading to memorization | Excerpts describe actions or tasks specifically linked to the specific outcome of memorization. | “Knowing the material enough to be able to like, answer questions without notes. But its being able to like go in depth and provide examples. So yeah, it’s like reviewing the material enough times to be able to do that… in order to study, I have to be learning material, understanding it, and memorizing it at the same time.” (Shay, Interview 1) |
| S4b: Action leading to understanding | Excerpts describe actions or tasks specifically linked to the specific outcome of understanding. | “Knowing the material enough to be able to like, answer questions without notes. But its being able to like go in depth and provide examples. So yeah, it’s like reviewing the material enough times to be able to do that… in order to study, I have to be learning material, understanding it, and memorizing it at the same time.” (Shay, Interview 1) |
| S4c: Action leading to memorization and understanding | Excerpts describe actions or tasks specifically linked to the specific outcomes of both memorizing and understanding. | “Knowing the material enough to be able to like, answer questions without notes. But its being able to like go in depth and provide examples. So yeah, it’s like reviewing the material enough times to be able to do that… in order to study, I have to be learning material, understanding it, and memorizing it at the same time.” (Shay, Interview 1) |

Names are participant-selected pseudonyms.

temporary memory or remembering. This is in contrast to group M3, which simply defined memorizing as a lack of understanding. Definition group M1b focused on the outcome of retention of information for a short amount of time but gave no information about how this is attained. However, definition group M2b highlighted the process of repetition but explicitly mentioned the outcome of retention for a “short-term.” In contrast, definition group M2a focused on possible outcome of information recall alone. Definition group M2b focused on both the process of memorizing, referencing the use of repetition, as well as the outcome of being able to recall or reproduce the information. Definition group 3 focused on a lack of understanding when information is memorized. Some of these quotes provided a process or outcome related to information, but clearly associated memorizing with a lack of understanding. Participants did not describe a specific amount of time that qualified as short-term or temporary memory. Some used the specific term “short-term” (i.e., example quote for definition M1b on Table 3) or indicated the information as something they would not permanently retain (i.e., examples quote for definition M2b on Table 3).

Studying

Four definition groups emerged during analysis with one group subdivided into an additional three subcategories. Like the definitions of learning and memorizing, these definitions centered on either a process or action or were a combination of process and outcome. The outcomes mentioned ranged from extrinsic to intrinsic factors. One participant’s definition (London, interview 1) was excluded since the recording was not audible for key portions and the interviewer notes did not include specific detail to provide confidence in categorization.

Definition group S1 all defined studying as a process. While the outcome of this process varied, these definitions explicitly defined the term as a “process.” Definition group S2 focused on the requirement or need for time to study. No information was provided about how the time was used. Definition group S3 specifically tied the action of studying to a specific extrinsic outcomes or event, like a test. Definition group S4a indicate specific actions, but tie those to the outcome of simple information recall or memorization. However, definition group S4b provides evidence of the requirement for both an action and an outcome, and specifically mention understanding as an intended outcome of the process. Definition group S4c specifically mentions a process but includes multiple specific outcomes of memorizing and understanding. Again, participants frequently describe tasks or actions they take to achieve different outcomes as part of their term definition.

Discussion

Our results describe how undergraduate students employ a range of definitions terms commonly used in biology education research. Code groups for learning, memorizing, and studying highlighted processes, outcomes, or a combination of both a process and outcome. However, understanding code groups focused solely on an outcome. These findings
provide additional evidence of the variety of student conceptions of these terms and support the recommendations of Hora and Oleson (28) for the need of additional study to better understand the ways students employ these terms. However, these data also support the need for clear communication between students and instructors with regard to term usage. Future research in biology and physiology education should be careful to provide working definitions of these terms or to undertake additional testing of existing survey instruments to ensure communicative and interpretive validity and to promote transferability and repeatability of findings.

The definitions provided by participants have broad implications for instructor/student interactions and for researchers working to ensure reliability and validity for their findings. The data provide some evidence of cognitive skill levels that students expect to employ during their undergraduate education. In addition, these data highlight similarities and differences between student definitions of these terms and those employed in practice by instructors and researchers.

While most publications describe learning to include qualitative changes of seeing and conceptualizing, there is disagreement on whether fact or knowledge acquisition should be included. However, examples within biology education research do include acquisition in their definitions (17, 18). All code groups associated with learning in this study included an acquisition component and are consistent with definitions used by biology education researchers. That strengthens the applicability of research specifically using the term "learning" within biology education. However, while participant-provided definitions encompass a broad range from BRT, not all categories are present. Notably, neither synthesis nor creation are included in student definitions of learning. This has significant implications for instruction, particularly in cases where instructors have higher order thinking as key desired learning outcomes for a course.

Definitions of understanding drawn from the literature vary in their description of intended outcomes, including construction of meaning (14), capability in action (21), and connecting related information or decomposing to subparts (22). The participants in this study focused solely on outcomes, but these varied greatly from recall of information to application and analysis. Each of the definitions used by researchers fails to capture the variation in outcomes for understanding as expressed by students in this study. This is a significant threat in particular to interpretive validity of research using instruments that rely on the word "understanding" in data collection. For example, one item on the widely used R-SPQ-2F prompts students for their level of agreement with the statement: "I test myself on important topics until I understand them completely." A researcher who implicitly defines understanding as "construction of meaning" is likely to misinterpret a response of "strongly agree" from a participant who interprets understanding as recall of information. Furthermore, although understanding is a specific level of BRT, participant definitions provide connections to multiple BRT categories. Group U1’s definition (Understanding is the ability to teach or explain information to others) is consistent with BRT, referring to the cognitive process of explaining. However, the remaining groups are not fully consistent with BRT’s understanding and related subcategories. Group U2 (Understanding is the ability to apply or connect knowledge) shows a partial match as the intention to connect could be viewed as similar to the cognitive process of comparing. However, this group extends to include the BRT level of Apply, which indicates that these participants view understanding as encompassing a broader range than do researchers or educators. In contrast, group U3 (Understanding is knowing details or being able to retell in depth) provides a definition which is consistent with BRT’s Remember. If course learning outcomes or study guides rely on the verb “understand” without clear definition, students may prepare themselves for different types of tasks than those intended by the instructor.

As mentioned previously, the term memorizing is rarely defined in the literature. Michael (24) and Slominski and colleagues (26) found that instructors of A&P believed that students found the subject to be difficult because students believe that memorizing is the same as learning. However, our data indicate that this is not the case. In fact, students utilize very different definitions for these terms. While memorizing is an action that is not explicitly part of BRT, three of the code groups make a connection to category 1: Remember. Some participants equate memorizing with recall of information, while other participants equate memorizing with short-term memory. However, these definition groups would fall outside BRT (14) and its description of learning since Remember is defined as “retrieving relevant knowledge from long term memory” [emphasis added (p. 30)].

When comparing the definitions of studying to previous work, there is little overlap in the definitions. Hora and Oleson (28) report three main definition groups:

1. Studying is “any exposure to course material, such as attending a class” or “completing assigned tasks.”
2. Studying is completing “activities that were not assigned and took place outside of class.”
3. Studying is not task-oriented and may involve “folk” theories of learning or ideas about phenomena that are not necessarily grounded in evidence.

The majority of definitions described by the participants of our study do have a “task” component, but they added specific outcomes to their definition that are not reported previously.

When comparing the definition groups to each other, there is a similar structure in the definitions of learning, memorizing, and studying. Each of these groups include processes or actions, outcomes, and a combination of processes and outcomes within the definition groups. However, understanding was defined solely as different outcomes with the new knowledge or information.

When comparing the definitions provided by the participants for these terms, there is no overlap in the processes or actions described by students. However, there are overlaps in the outcomes for the terms and these are presented visually in Fig. 2. For instance, memorizing is an outcome for groups S4a and S4c and understanding is an outcome for groups L2b, S4b, and S4c. Interestingly, groups L2c and L3, as well as group U2, identify Application as an outcome. Application is a BRT’s category 3 task and is considered a higher cognitive skill than understanding.
Implications for Student/Instructor Interactions

Our data note the variations of student definitions and how they vary from those provided in the research literature, which is frequently authored by instructors. Undergraduate instructors are encouraged to apply tools such as BRT in their instructional choices (15, 16), which could align with adoption of definitions, as well. In these cases, our findings indicate a lack of agreement between instructors and students in their definitions of these commonly used terms. In fact, the findings of Michael (24) and Slominski and colleagues (26) highlight assumptions made by instructors in terms of student definitions rather than providing information about how students are actually defining the terms “understanding” and “memorizing.” These types of incongruity may lead to misunderstandings, frustration, or other unintended negative outcomes on the part of the student. For example, instructors may define studying to be certain processes used by the student to remember and understand course material. If a student holds to definition group S4a (studying is an action that leads to recall), choices of how to approach the material and the depth and cognitive level of knowledge required could fall short of the needs to be successful on course assessments. Therefore, it might be more beneficial to students for instructors to avoid the use of terms and replace them with clear expectations for content knowledge and cognitive levels.

Implications for Participant/Researcher Interactions

Incongruent definitions between researchers and participants are threats to the reliability and validity of educational research. Different working definitions of these terms in a research setting is a threat to communicative and interpretive validity and may lead to lack of transferability of findings (6, 10). Our results indicate threats to the communicative and interpretive validity of prior work in biology education research and perhaps to discipline based education research, more broadly (38). Previous work from our laboratory supports this claim. As part of the recruitment process to the larger study from which these data were collected, participants completed the R-SPQ-2F (30). A complete description of this mixed methods analysis is available in Johnson and colleagues (31). We found impacts on how students responded to survey items based on their term definitions provided at the first interview. As an example, item 4 on the R-SPQ-2F asks for level of agreement with this statement: “I only study seriously what’s given out in class or in the course outlines.” A pattern emerged in the alignment or misalignment of participant responses on the R-SPQ-2F and information provided in the first interview. Participants who defined studying as solely an action (definition groups S1 and S2) always aligned their survey response with their qualitative response. In contrast, participants that defined studying as a combination of an action and an outcome (definition groups S3 and S4a, b, and c) almost always displayed a misalignment with their survey response.

The lack of consistent definitions for these commonly used terms from student participants should cause us to reconsider our use of these terms in research without providing additional information or context. This might involve additional work in the form of qualitative data collection from our target population prior and adjustment of survey language to ensure congruence of definitions. Another strategy could include providing the researcher’s definition of these terms within the instructions or the specific item, as demonstrated by Chasmar (39). Since biology education research is concerned with questions related to student learning and often uses survey instruments (29), these results should cause us to review our survey development and use practices and how we ensure reliability and validity in their responses and interpretation.

Conclusions

Overall, the goal of this work was to provide an early exploration of the ways that students in undergraduate A&P courses define the commonly used terms of learning, memorizing, studying, and understanding. We make no claims that these findings provide a representative or exhaustive list of definitions. However, since this fairly homogeneous sample from a single institution has yielded such a large number of definitions for each term, additional study on this topic seems warranted.

Limitations

This work is limited by the fact that these data were collected as a portion of an interview to learn more about the cognitive processes used by students in A&P courses, and opportunities to probe for additional depth on the topic of student definitions could have been missed. These interviews were conducted with a specific audience and similar work with a different population may identify different definitions.

Future Work

While some of the reported code groups employ vague language, it was important to not make assumptions about the meanings of participant words. However, as previously mentioned, student and instructor definitions should be studied further, asking additional open-ended questions and utilizing
similar coding methods to determine if these definitions are broadly held by both life science undergraduate students and across STEM disciplines. These participants should be recruited from a range of institution types and sizes. Extension of this work could also include a comparison of student and instructor definitions for congruence and how that impacts course performance or emotional outcomes. In addition, additional validity and reliability studies should be conducted for key instruments utilized in discipline-based education research that rely on the four terms discussed here.

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DISCLOSURES

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AUTHOR CONTRIBUTIONS

S.N.J. and E.D.G. conceived and designed research; S.N.J. performed experiments; S.N.J. analyzed data; S.N.J. and E.D.G. interpreted results of experiments; S.N.J. prepared figures; S.N.J. drafted manuscript; S.N.J. and E.D.G. edited and revised manuscript; S.N.J. and E.D.G. approved final version of manuscript.

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