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A Survey of Exam Methods in College A&P Courses

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Abstract

Exams are a form of assessment that is ubiquitous in college STEM classrooms yet is infrequently studied from the experiential perspectives of instructors or students. To better understand the forms, methods, and experiences of college STEM exams, we conducted survey-based research with instructors in anatomy and physiology courses, a well-defined and popular subset of STEM courses. We used a combination of qualitative and quantitative questions to learn about exam methods in the classrooms of 63 instructors, through which many thousands of exam-student interactions happen each year. Our data suggest that exams are a significant, possibly onerous undertaking for instructors, including many forms of optional support for students, and that they have an outsized impact on students' grades (and thus their persistence towards STEM careers). Instructors' survey responses imply that sustainability of the methods they use for assessment is a key and pressing concern in their professional lives. This need for sustainability may lead to tradeoffs that impact students, such as decreasing the transparency of the exam experience, sometimes to an extent that exams may be perceived as highly secretive. The feasibility of instructors accommodating students' absences and of students challenging instructors' grading are discussed as exemplars of the complex communication that, for better or worse, is central to student-instructor relationships and the outcomes of STEM classrooms.
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Key words: equitable testing, instructor workload, summative assessment

Introduction

College STEM courses are a gateway to science careers and human progress, but also act in practice as strong barriers and filters that decide which students are allowed to continue forward. Certain introductory STEM courses such as A&P, calculus, and organic chemistry have reputations as "weed-out" courses, also known as gateway or barrier courses (Seymour et al., 2019). Courses develop these reputations in large part from their high rates of low or failing grades and withdrawals (DFW rates; Hatfield et al., 2022), which lead many students to abandon their plans to major in STEM subjects (Hunter, 2019) and/or start careers in STEM-related areas such as nursing (Tripp et al., 2024). While attitudes along the lines of "not everyone can be a scientist" remain prevalent among college faculty (Canning & Limeri, 2023), there also is increasing interest among science educators in ensuring broader, more equitable access to such academic and career options (Shukla et al., 2022).

Improving equity in STEM education is a complex challenge that must be tackled in part at broad levels (e.g., across departments and institutions) to address systemic structural biases (e.g., Denaro et al., 2022). However, within individual classes, the professors, faculty, teachers, and teaching assistants (TAs; hereafter, "instructors") have some agency and some responsibility to employ techniques to improve equity (Crowther & Wiggins, 2024; Tanner, 2013). Many of these classroom practices are elaborations of the general strategy of "active learning" (Freeman et al., 2014); to measure the extent of adoption of this strategy (Stains et al., 2018), there are validated research tools such as the Classroom Observation Protocol for Undergraduate STEM aka COPUS (Smith, 2013), Practical Observation Rubric To Assess Active Learning aka PORTAAL (Eddy et al., 2015), and Decibel Analysis for Research in Teaching aka DART (Asgari et al., 2021). This work is worthwhile and important, yet in and of itself does not directly address the low test scores that --

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since test scores dominate the determination of final grades (Momsen et al., 2010; Uminski et al., 2024) -- contribute to the high DFW rates and their often-devastating consequences for students (Holland et al., 2019). We discern a relative dearth of research on how undergraduate science students are tested, as opposed to how they are taught. For example, the closest analogue of COPUS, PORTAAL, and DART in the realm of assessment may be the 3-Dimensional Learning Assessment Protocol (3D-LAP) (Laverty et al., 2016), which, while regularly discussed and cited, has not been implemented nearly as widely as the observation tools for classroom practice. We focus on exams as an under-researched but crucial aspect of STEM education, and therefore one that is potentially ripe for improvement.

Our understanding of exams as an important, underexplored aspect of college education is focused on the student experience. Students' lived experiences within college STEM courses are crucial to the ways in which they can be included, or prevented from participating, in the practices and careers of science (Aguillon et al., 2020; Bonous-Hammarth, 2005; Meaders et al., 2019, 2020; Olson & Riordan, 2012). The degrees to which students identify as scientists in these spaces is one aspect of the experience, and these experiences largely determine whether or not students have and successfully use opportunities to persist within a large, complicated, and historically marginalized community (Cimpian et al., 2020; Dewsbury, 2020; Estrada et al., 2016). It is through student experiences that power relationships play out, especially for assessments like exams, and these relationships can be motivating or can be barriers to success (Crowther & Wiggins, 2024; Delpit, 2003). Why do some exams increase motivation while others discourage students? What emotional challenges are included with a particular method of exam grading? Do some types of exam support help students to be either resilient or pressure them into anxiety? Studying the social practices of writing, giving, and grading exams through a lens on student experiences means focusing on a broad range of student outcomes instead of solely highlighting issues of scientific content or instrument validity or demonstrated learning, all of which should also be the subject of research into college STEM exams (Branchaw et al., 2020; Mor & Erşen, 2023; Pellegrino et al., 2023; Sireci, 2015). We are interested in how college students' lives are likely to be impacted, well or poorly and under what conditions, by the exam practices created in their STEM courses.

In addition to focusing on student experiences, any analysis of current college teaching practice must foreground the constraints and affordances of the instructors. Within a postsecondary education system that follows many of the original designs of the 19th century, college science instructors are tasked with maintaining multiple cross-coordinated specialties in pedagogy and science while subject to mandates and incentives very different from those of their K-12 teaching counterparts (Beach & Grubb, 2011; Dudley-Marling & Burns, 2014). Any inspection or judgment of their teaching practice can only be meaningful or useful if it incorporates and understands the unique challenges in this teaching environment.

Large-scale study of exam practices in K-12 is primarily conducted on standardized assessments. While some college STEM exams (like those used as entrance exams for professional schools) are in widespread use, the vast majority of the exams in college STEM are within individual courses. This is a complicated ecology, and far too large in scope for any single investigation to characterize fully. To begin this research, we sought a scientific subfield that has relatively well-defined content, standardized learning goals, economic importance, and sufficient popularity to be found in a range of institution types and classroom sizes. Human Anatomy and Physiology (A&P) is an excellent fit; the science is within a single species, there is a national professional society (the Human Anatomy and Physiology Society) with a subscribed membership and published exemplar learning goals, A&P courses are widely required for advanced healthcare professional schools, and the importance for careers in medicine, nursing, therapy and research is clear. Even more usefully, the known membership of HAPS allows for some estimation of the extent to which our survey has reached instructors in the field. Survey-based research is an appropriate fit for this initial exploration of the state of exam practices in this scientific subfield.

Given this opportunity to better understand the diversity of exam methods used by college A&P instructors, we entered this work with the following research question (RQ):

RQ1: Which aspects of exam practices are most and least prevalent in college A&P courses?

For this general inquiry, we assumed that the survey responses would (at least indirectly) indicate these instructors' relative priorities, and the compromises they may make in defending those priorities. Therefore our second and final RQ was the following:

RQ2: Based on college A&P instructors' implementation of exams, what can we infer about their primary goals for and tradeoffs with these exams?

To begin to address these questions, we developed the Exam Methods Survey for data collection within the A&P teaching workforce.

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Methods

Survey Development

The goal of the Exam Methods Survey was to systematically collect data on methods, trends, and practices within the population of college science courses on Anatomy and Physiology in the United States. This population was chosen as a delineated subfield within postsecondary STEM education for the relatively standardized curriculum compared to other common courses, the large impact on industry (primarily in the health care sector) and the availability of a central teaching-focused organization (the Human Anatomy and Physiology Society, hereafter HAPS) from which we could estimate the size and scope of the overall population. Focusing on the themes that were most prevalent in our own experiences with professional development and writing of exams, we developed an initial set of 9 fixed-choice (7 choose-all-that-apply, 2 single-best-answer) and 9 corresponding open-ended survey items through a short series of research group writing tasks and editing sessions (Dillman, 2014). To create an instrument that was likely to capture as many trends as possible from a complex human practice (i.e., the giving of exams), survey items had as many multiple-select answers as the authors had encountered or heard of in their careers. Corresponding open-ended questions provided opportunities for participants to follow up on each item with optional, unlimited text. A set of 8 context items (e.g., institution type) were added to the survey. The overall survey draft was built into Google Forms for ease of use and edited to balance collection of contextual information with instrument brevity to prevent survey fatigue. This project was approved by the Shoreline Community College IRB apparatus under IRB#STUDY000324 and informed consent was obtained from all participants as described.

Cognitive Testing

Content validity of the initial questions was provided through individual think-alouds (Gubrium & Holstein, 2002) with five instructors who are actively involved in exam development for their own courses and/or as science education researchers. These participants read each survey item silently, then aloud, and then were asked to answer the survey items and to justify their answers. They were coaxed to explain or identify problematic items and to suggest alternative language if applicable. Items were then edited based on this instructor talk during the think-alouds, with the mutual goals of maintaining coherence of instructor language and fidelity to the original goals of the survey and research questions. Two contextual questions were removed during this testing process.

Recruiting and Sampling

Our goal was to broadly and deeply sample from the entire population of people teaching college A&P courses in the United States. Because this population is difficult to estimate across a wide range of academic institutions, this initial survey was targeted to a known subset of motivated instructors who are members of HAPS. With permission from HAPS leadership, recruitment emails were sent to the HAPS listserv with links to the survey and (to promote snowball sampling) explicit encouragement to forward the survey widely. From HAPS leadership, we know that there are roughly 1,740 members of HAPS at any given time, and our goal was to receive participation from at least 2% of membership and at least 50 total full participants. To incentivize participation, two prizes of $250 each were offered to participants who completed the survey and provided contact information expressly for this purpose. Over 8 weeks, further recruitment was attempted through posts on professional social media via LinkedIn, by personal emails to colleagues in A&P, by handing out fliers at the spring 2024 annual meetings of HAPS and the American Physiological Society (APS), and through an interview with the authors on a podcast series on A&P teaching. The resulting sample of 63 participants included 41 self-reported members of HAPS (~2.4% of membership). 47 of the 63 provided contact information to learn about the results of the survey and were subsequently sent an initial summary of findings as part of best practices in returning information to the community of participants.

Coding of Responses to Open-Ended Questions

For the 9 open-ended questions, a total of 323 free responses were collected (~5.1 per participant). 12 participants left all open-ended items blank and 22 participants answered all of the optional questions. Each response was read by an author and double-checked to ensure that it did not indicate a response opposite to what was given in the corresponding fixed-response question (this occurred in less than 0.1% of all responses). All responses were read by authors to give background to the experiences within the study population. For several questions, further qualitative analysis was conducted, as follows:

- *Q1: How do you help students to prepare for your exams?* Participants provided a wide range of methods for supporting students. Methods were tabulated as an aid to understanding the workload that A&P instructors voluntarily take on to help students and also as a resource for instructors looking for new methods of student support.

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- *Q2: How do you choose material for your exams?* To better understand the range of sources that instructors use to decide what material should be on an exam or not, authors mined these responses looking for sources that had not been previously selectable in the survey items. Seven new sources were noted that will be written into future versions of the survey instrument.
- *Q4: What feedback do students receive after your exams?* A discussion with reviewers had highlighted that the choices available might confound some responses in which instructors would return aspects of the exam to students but in a way that was temporary or otherwise unable to be used as a resource for study, challenge, or reflection. We mined the responses looking for examples of this complex combination of multiple-select and open-ended responses. The responses noted in this additional analysis, and their impact on the data, are discussed below.
- *Q5: Can (or, how do) students challenge the grading on your exams?* From prior discussions with students, the authors were aware that the ability to challenge an exam grade might be perceived differently between them and their instructors. Open-ended responses were iteratively coded into four final codes: "Instructors encourage challenges and/or review", "Instructors describe opportunities to review", "Instructors are open to review only with student completion of prior preparative work", and "Instructors discourage, or never receive requests to, review exam grades". The prevalence of responses in these four codes is discussed below.

Synthesis of Responses to Fixed-Choice and Free-Response Questions

Since each required fixed-choice question was paired with an optional free-response question, we sometimes considered each respondent's answers to both questions simultaneously in compiling data. For example, if a respondent did not check a fixed-choice response but provided equivalent information as a free-response comment, we credited the respondent with affirming that fixed-choice response.

Results

Demographics of Survey Respondents

Our survey was completed by a total of 63 A&P instructors, 41 of whom (65%) self-identified as current members of HAPS. All but two of these instructors indicated that undergraduate students in their first two years were a description of many of their students.

Fifty-one (81%) of the instructors self-identified as full-time instructors who were either tenured, on a tenure track, or on the functional equivalent with a title such as "Lecturer with Security of Employment". Seven (11%) instructors are Staff Instructors, and one each who identified as a Graduate Student and an Undergraduate Student. Only three instructors (4.7%) self-identified as part-time or adjunct faculty. HAPS membership overall is similar in the relative lack of temporary faculty, with only 4.6% specifically identifying as adjunct or part-time instructors (and another 2.6% identifying as graduate students, who are likely to have part-time teaching duties). While this indicates a relative match in titles and roles between our sample population and HAPS membership, it is notable that adjunct instructors are underrepresented compared to the likely overall distribution of all A&P instructors teaching in US higher education, assuming that general college-level trends (Culver & Kezar, 2020) apply to A&P.

Regarding surveyed instructors' institution types, 29 (46%) were at community or technical colleges, 13 (21%) were at R1 or research universities, 11 (17%) were at private liberal arts colleges, 4 (6%) were at regional or comprehensive universities, and several did not neatly fit within these classifications of postsecondary institutions. For HAPS membership as a whole, 22.1% of members are at community colleges, 39.7% are at universities, and 28.9% are at other colleges, with the remainder classified as High School or Other. Thus, our sample is enriched for instructors at community and technical colleges and under-samples those at universities compared to HAPS membership, and our sample is likely a reasonable match with the overall population of bachelor's-degree-obtaining students in the US, nearly half of whom have taken courses at community colleges (Fink et al., 2024).

Numerical Impact of Exams

The 63 survey respondents give an average of 4.8 exams per course, with the 54 instructors teaching on a semester schedule giving 4.98 exams per term and the 9 instructors teaching on a quarter schedule giving 4.00 exams per term. These instructors' courses varied from 5 to 1,400 students per class, with a median of 35 and an average of 93 students per term. If we assume that the data contributed to this survey is representative of a term by each professor, then by multiplying the exams per term by the number of exams given by the number of students per course, we can approximate that the students of these 63 instructors are collectively taking something on the order of 51,000 individual A&P exams in each academic year. Assuming that this study population is roughly representative of all of HAPS membership gives an estimate of more than 1.1 million individual exams taken by students given per academic year within this small society.

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In computing final course grades, surveyed instructors weigh their exams to be worth an average of 61% of the final grade, exam weights ranging from as low as 20% to as much as 90% (Figure 1). There was no significant relationship that we could detect between exam weighting and class size, instructor type, or institution type.

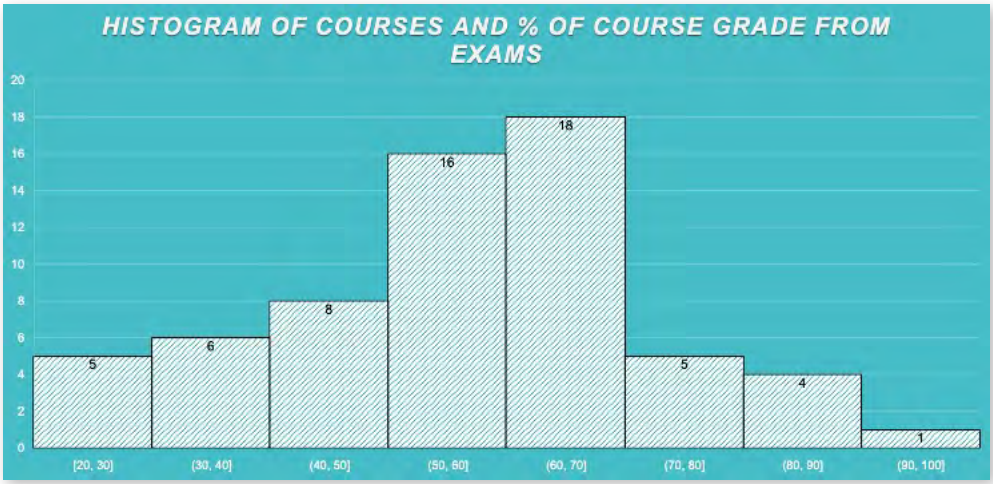

Figure 1. *The weighting of exams in the determination of A&P course grades given by surveyed instructors.*

Instructors' Training in Executing Exams

When instructors were asked to report the ways in which they developed the skills needed to build and implement exams, our mix of categorical responses and written comments indicated that 26 (41%) instructors used only knowledge ascertained from their own experiences as students themselves or in teaching their own courses. Nationally, there is no formal mandate that college instructors have training in exam-writing, so this was not surprising to us. An additional 9 instructors (14%) indicated that they drew upon informal experiences beyond their own courses. A further 13 (21%) indicated their training in exam methods came from professional development, and another 10 (16%) instructors indicated completion of specific coursework that guided their use of exams. Finally, 5 instructors (8% of the participants) hold a specific degree in teaching, education or a related field beyond their scientific credentials that they draw on when creating exams. Collectively, the non-overlapping count of the last three groups suggest that 42% of instructors have completed training in the writing of exams that extend beyond their own backgrounds as science students. However, our data did not demonstrate a significant relationship between depth of training and any other aspect of exam experiences for students.

Instructors' Effort in Executing Exams

Administering exams is an instructor responsibility that includes several subtasks addressed by our survey: selecting material for exams, writing/editing exams, helping students prepare for exams, and accommodating makeup exams and retakes. (Our survey did not specifically ask about grading exams.)

In selecting material for exams, most instructors said that they use learning goals that were specific to the course and/or specific to their view of the course (top two rows of Table 1). A sizable number (rows 3-5 of Table 1) relied on outside sources: the course textbook (generally written by someone other than the instructor), the department, and/or national/international societies, with 30-45% of instructors using each of those options. Relatively few instructors said that they selected exam topics/questions at random (25.4%) or specifically emphasized things that students have historically struggled with (19.0%). Aside from the options we provided for instructors, the most popular "write-in" sources of inspiration for exam questions included textbook publishers (3 respondents), relevance to professional or graduate programs in health sciences (3 respondents), and conversations with former students (2 respondents).

Source of exam material (fixed-choice options)	***Number of instructors:***
"learning goals that are specific to my course"	49
"what I see as important for students in possible careers"	41
"nationally- or internationally-standardized learning goals"	27
"college- or departmentally-standardized learning goals"	25
"provided by a textbook or learning management system"	20
"the ideas I get from people in relevant careers"	19
"what will make the most interesting exam questions"	18
"random selection from course material"	16
"areas that students traditionally struggle with"	12

Table 1. *Sources of material for exams. Percentages were compiled from each respondent's fixed-choice selections and free-response comments.*

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Instructors devote effort to having their exams reviewed for clarity, accuracy, and appropriateness. 45 (71%) of participants did this editing without enlisting anyone else in a review process. For those that used outside assistance to edit, that assistance came from colleagues for 13 instructors (21%), from Teaching Assistants or other staff for 3 instructors (5%), and from students for 6 instructors (9%), some of whom were given course credit for finding errors that would improve future exams or inform possible class-wide grading changes on the current exam.

Instructors spend significant effort to support and guide student studying by producing documents, resources, and practice opportunities. Based on fixed-choice and free-response answers, a sizable number of instructors (rows 3-6 of Table 2) generated documents or opportunities that could be optionally used by students to prepare for exams, with 50-80% of instructors providing each of these options. Relatively fewer instructors said that they provided old exams (32%), gave opportunities to work through practice questions in class (19%), provided a partial version of the upcoming exam (16%), or facilitated review sessions in class (11%). Aside from the options we provided for instructors, the most popular "write-in" types of pre-exam support were online practice quizzes (5 respondents indicated graded and 4 respondents indicated ungraded), in-class gamification of exam practice using Kahoot, Jeopardy, or other models (5 respondents), case studies (2), connections with outside tutoring (2), sample study calendars (2), and exam wrapper assignments (2) (Soicher & Gurung, 2017). In all, instructors reported an average of 4.8 extra tasks taken on (i.e., an average of 4.8 options checked for Q1, helping students prepare) to help students prepare for exams in their courses.

Every survey respondent reported using approaches that help students to overcome challenges with illness and absences. Of the instructors surveyed, 57 (90%) allow students to take rescheduled exams after the rest of the class; the other 6 instructors all gave relatively large numbers of exams and allowed students to drop individual exams. (Three instructors mentioned in comments that they allow ALL students to retake exams to improve scores.) Finally, a large number of instructors (34 of 63, or 54%) habitually spend time adjusting or rewriting exams as part of allowing late/makeup testing.

Return of Exam Information to Students

Table 3 summarizes the post-exam artifacts and information that instructors report giving to students. The most transparent and idealistic options were selected by relatively small numbers of instructors: less than 40% reported giving students answer keys or individualized written or oral feedback, and only 12.7% reported providing rubrics for exam answers (though this percentage may be low in part because some exams include only fixed-choice answers and thus do not require a rubric).

Methods for supporting student preparation for exams:	***Number of instructors:***
Provide information about the format of each exam	61
Provide practice questions	54
Provide summary study guides	45
Publish learning objectives for each exam	35
Publish learning objectives for each class session	33
Provide old exams for students to practice with	20
Provide and/or work through practice questions in class	12
Provide a partial or full copy of the actual exam	10
Facilitate an exam review session in class	7

Table 2. *What instructors provide for students to help them prepare for exams, from combined non-overlapping results of surveys and comments.*

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What students receive after an exam is graded:	Number of instructors:
Their own exam score	63
Class average and/or median	42
Scores on each individual exam problem	41
Their own exam (or a copy of their exam)	33
Key to the exam with correct answers	23
Individual written feedback	18
Rubric(s) for exam answers	8
Temporary access to their own exam	6
Individual verbal feedback	4
[No feedback of any kind is given]	1

Table 3. *What students receive after an exam, from combined non-overlapping results of surveys and comments.*

We were especially interested in the issue of whether students receive their own exam back. This facet of Table 3, which comes from combining instructor responses to the fixed-choice question and the open-ended question on this topic, is replotted as Figure 2. Overall, only 52% of students had what we would call "full access" to their graded exam (meaning that they could take it home and study it outside of class).

Students' relatively limited access to their own exams (Fig. 2) might be less of a concern for cases where exams constitute a relatively small percentage of the total course grade. However, when the Fig. 1 data and Fig. 2 data were considered together, we saw evidence of the opposite, i.e., students were *less* likely to get their exams back in courses where exams constituted the bulk of the course grade (Table 4).

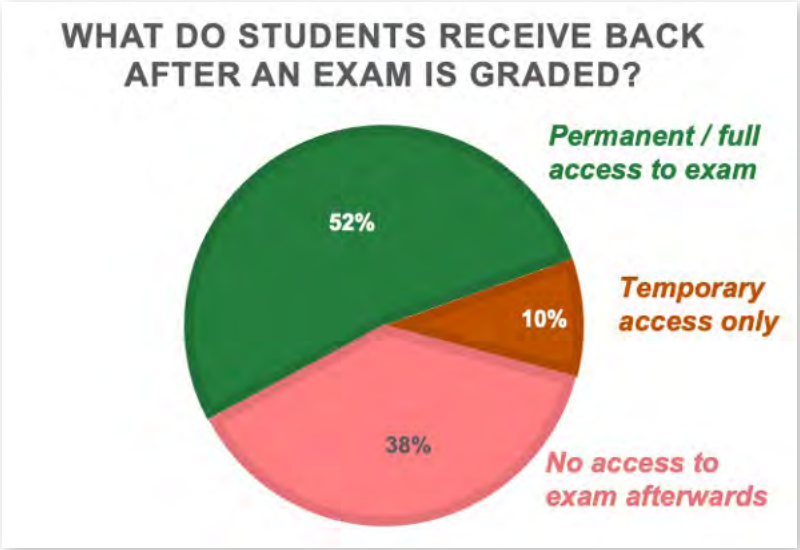

Figure 2. *A&P instructors' responses on whether students receive their exams after they are graded.*

Percentage of course grade determined by exams	Frequency of instructors in this category who DO return exams
20-40%	8 out of 10 (80.0%)
50-70%	26 out of 42 (61.9%)
80-90%	4 out of 9 (44.4%)

Table 4. *Likelihood of instructors returning exams to students is inversely related to exams' weight in overall course grade.*

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The relatively limited granting of access to graded exams (Fig. 2, Table 4) could, in theory, be explained by extensive reuse of exams from term to term, which would be less feasible if exams were kept by students. Consistent with this hypothesis, only ~5% of instructors (3 of 63) reported writing each exam from scratch (i.e., without reusing old questions), with all others (95%) reporting the reuse of some or all questions from previous exams.

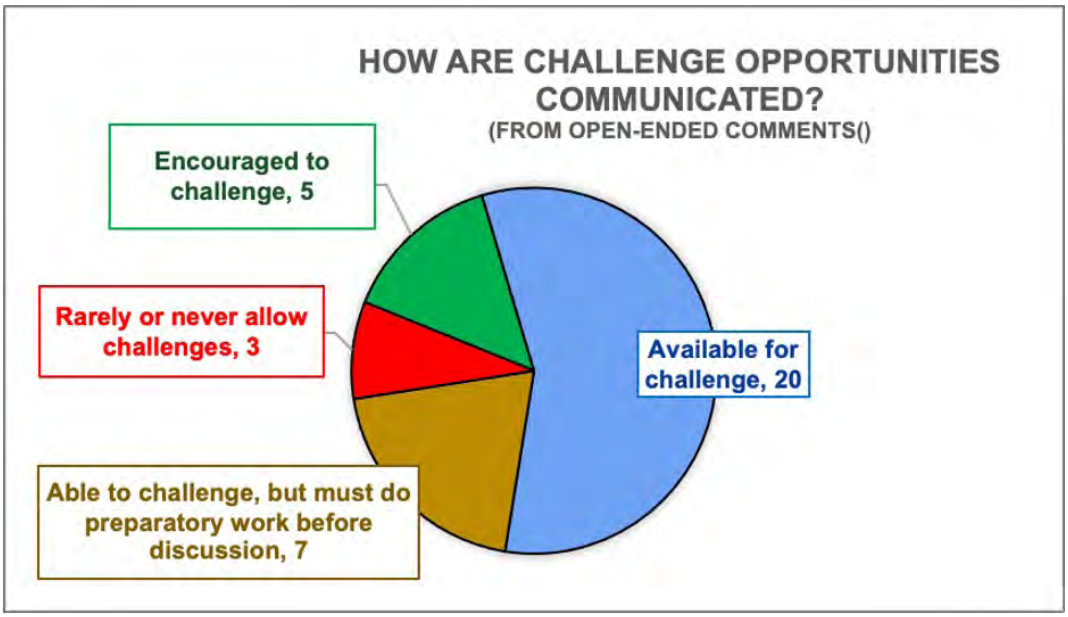

Figure 3. *Whether and how opportunities to challenge exam grades are communicated to students. Numbers shown are out of 35 respondents who answered the optional free-response question on this topic.*

Student Challenges to Exam Grading

Finally, we asked instructors whether students can challenge the grading of their exams. 86% (54 of 63) said that students could make such challenges; however, in most cases, instructors accept challenges on an informal ad-hoc basis rather than via an explicit procedure (Figure 3).

In addition, of the respondents who provided free-form answers about the nature of exam-grade challenges in their classes, only 14% (5 of 35) explicitly encouraged students to challenge questions that seemed questionable, with the remainder either simply allowing challenges or expressing some resistance or skepticism regarding challenges (Table 5).

Validity of "Choose-All-That-Apply" Data

For the seven questions that asked respondents to "choose all that apply," a possible concern is that, if some respondents misunderstood the question format, they might select only one answer per question, which would artificially lower the frequencies of individual selections (i.e., in Table 1, Table 2, etc.). To assess this possibility, we checked all 63 respondents' patterns of answers; only one respondent selected only one choice for each of the seven multi-select answers, thus alleviating the general concern of artificially low selection frequencies.

How can students challenge exam grades?	***Number of instructors***
Not allowed to challenge exam grades	2
Can challenge **informally** (e.g. during office hours, email, or individual conversations)	41
Can challenge through a **formal**, publicly described mechanism	12
Can challenge, but unclear whether through a formal or informal process	8

Table 5. *If and how students are allowed to challenge exam exams, from combined non-overlapping results of surveys and comments.*

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Discussion

This study addressed the relative paucity of information about college-level STEM exams by surveying a well-defined subgroup of STEM instructors, i.e., teachers of anatomy and/or physiology (A&P) courses. Our data suggest that each instructor creates relatively unique exam experiences in the sense that they tend to prioritize personal and course-specific issues more often than broader departmental, institutional, or national guidelines (Table 1). Instructors also devote considerable effort to helping students with exams (Table 2). However, this effort often does *not* extend to giving students detailed feedback on exams, access to their own graded exams, or clearly articulated student-friendly procedures for challenging the grading of exam questions (Figs. 2-3 and Tables 3-5). As discussed below, these results collectively raise important questions about whether exams can be administered equitably without making instructors' workloads completely unmanageable.

Limitations

Even for the limited goal of characterizing exam practices within the biology subfield of A&P, this study had sampling limitations that are common to most studies of uncompensated volunteers. Perhaps most notably, while about half of all college faculty are part-time (Culver & Kezar, 2020), our recruitment strategy targeted a professional society (HAPS) that (like most professional societies) consists largely of full-time faculty. Therefore our data are not necessarily representative of the A&P exam practices of part-time instructors, whose schedules may further limit the support they are able to provide to students. Relatedly, the pool of mostly full-time instructors who completed our survey might have been skewed toward those with especially stable and secure (i.e., tenured) positions. Therefore, due to under sampling of less secure faculty, our results may present an overly optimistic picture of exam practices.

In addition, our desire to limit the survey to less than 15 minutes also prevented us from interrogating some potentially important aspects of exam practices. For example, issues of time elapsed from initial content coverage to corresponding exams, exam question formats (e.g., multiple-choice vs. short-answer), exam retakes, and "curving" distributions of grades may all impact exam equity (Crowther & Wiggins, 2024), but the survey did not ask directly about these issues.

Secrecy Versus Sustainability

While we did not directly ask instructors about balancing service to students with maintenance of a manageable workload, our data are consistent with the hypothesis that finding such a balance is challenging for many. Arguably, our most alarming finding was that almost half of instructors do not give students full access to their graded exams (Figure 2). Such secrecy is problematic for equity (Crowther & Wiggins, 2024) and may promote perceptions that instructors are trying to weed students out, rather than trying to support them (Holland et al., 2019). Moreover, without good access to their graded exams, students may not get the feedback they need to iteratively navigate the cycle of performance, feedback, and improvement that underlies all significant learning (Clark & Talbert, 2023). The implication, as we see it, is that increasing the transparency of exam methods is likely to have both learning and emotional positive impacts for students.

Lest anyone accuse these instructors of laziness or ignorance, we find that they devote considerable creative energy to many aspects of exams. The participants in this survey reported their efforts to support students through a) utilizing ~3 sources for exam material, b) creating ~4.8 opportunities and documents for students preparation, c) supporting students in exam-based accommodations and rearrangements, and, in 42.8% of cases, and d) undertaking significant professional development related to exam methods. While this report is only an initial look at the experience of exam-based assessments, it is clear that these efforts to support students are taken up not as a tacked-on afterthought but as a complex core responsibility. Based on these data and other personal experiences, we propose that the constraints of instructors' schedules prevent them from further optimizing exams in ways that they (instructors and students) would prefer and that would maximize student learning. The implication, as we see it, is that efforts to make exam practices better for students must also be sustainable for instructors effort-wise.

This proposed tension between the support of students and the maintenance of some exam secrecy is not only suggested by the quantitative data but also by the comments of individual instructors. For example, one instructor described their exams as:

> *Students receive their exam back, their answers, and the correct answers. They can ask questions and challenge questions in class at that time (it is rare that a student will do this, but I wish they did!). They do not get to keep their exam.*

This instructor is clearly focused on creating pathways for student learning and for openness in the process of assessment. From this and other written comments, we assume this instructor cares deeply for their students' well-being and learning. At the same time, students might interpret the fact that they must hand back their graded exams, and that they are only allowed to challenge grading at one particular moment, to mean that the instructor does not trust them and/or prioritizes personal (i.e., instructor) convenience over student learning and growth.

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A similar conclusion can be reached for an instructor of 50-student classes, who wrote:

> *I meet with each student individually. They sit with me, their exam, and the exam key. They can ask me questions, challenge how I scored them, etc. Students do not get to keep old exams.*

Again, exam secrecy is not simply the result of laziness. Rather, we perceive it as a symptom of the push and pull of busy lives that must somehow be balanced between saving time and negatively impacting students.

The Importance of Exams

The data reported here reinforce the centrality of exams in the college STEM experience, both as a professional practice for instructors and as a crucial hurdle for students to surmount. The specific act of producing a written assessment for an individual student in STEM is not only happening in all or nearly all of these courses, but goes beyond the historical stereotype of "one midterm and one final" to be happening 4.8 times per term. Students are likely to perceive these exams, constituting an average of 61% of their course grade, as the dominant arena in which they must both display their understanding of A&P and demonstrate their fitness for future STEM professional training. While the rough calculation of 51,000 exams collectively taken by our respondents' students in a single academic year is notable, our data also underscore the complexity that exists in giving each one of those assessment experiences. Several methods for assessment that diminish or remove the need for exams (Clark & Talbert, 2023; Kohn & Blum, 2020; Krajcik, 2015; Pate et al., 2019), and we see significant value in these approaches, but the constraints and norms of college STEM (as well as the increasing focus on preparation for STEM fields) suggest to us that the outsized importance of exams is likely to remain.

Exams as "Conversations," for Better and Worse

The simplest model of assessments is as a purely extractive instrument for collecting student-generated evidence of learning (G. Wiggins, 1998). As exemplified in many large-scale testing situations, information is thought to flow in one direction from students to evaluators and is packaged into simplified grades or marks that approximate student learning (Pellegrino, 2001). However, we find this simple model insufficient for capturing the risks and opportunities of exams in STEM courses. Students constantly collect data from their environments about the nature of science (Stroupe et al., 2024), the values held by experts in the fields, the likelihood of their own future successes, and their own changing identities and questions, and this data collection continues as they encounter exam-related artifacts ranging from study guides to scores and feedback (Malcom et al., 2016). For example, an exam with extremely difficult questions may be an excellent instrument for collecting data about learning, but may also convey erroneously to students that their prior preparation is insufficient for future success. Cues in exams may also signal to students that they should learn and study in certain ways (Couchman et al., 2016; Tanner, 2012; Zhao et al., 2014) and/or that the content is or is not relevant to their desired careers. Thus, a more realistic view of exams is that they lead to bidirectional information flow (both to and from students) and represent a basis for a kind of "conversation" between students and instructors.

Our view of exams as substrates for two-way conversations is consistent with many open-ended comments from instructors who seem to use exams to instill values or norms of their classroom or scientific field. Various instructors stated or implied that exams are chances for them to help students think metacognitively, develop better study habits, and/or contribute to exam-taking practices (e.g., via pre-editing; Wiggins et al., 2023).

Like any important conversation, exams carry opportunities and risks depending on how the conversation is handled. Especially for students in large classes, the feedback around exams is likely to be the most personal and meaningful communication that individuals have with an authority figure to whom they spend a great deal of time and effort listening. However, such communications are at risk for being truncated prematurely, with cognitive and emotional consequences. For example, consider the act of a student challenging a grade on their exam. Even in a best-case scenario, a student who has recognized an error in grading must approach their instructor, constrained by perceived course norms and perceived risks of offending an authority figure who as a scientist/teacher is generally highly respected (Buffett, J, 2022) and, in challenging a score, must show understanding of complex material and offer reasoning for an alternative, just outcome. Now consider the additional burden on the student if the instructor has not explicitly welcomed such challenges or presented a protocol for making them. What could potentially be a fruitful exchange on nuances of content, instructor fallibility, and the limits of objectivity might never get off the ground due to student anxiety or uncertainty about where to begin. Alternatively, instructors that skillfully signal their openness to critical, evidence-based dialogue are actively representing how science at its best can be done. How much more about our values can we instill in the process of the exams that already have our students' attention?

The impacts of exam-related conversations are likely to be profound far beyond the graded scores on that exam. We know that persistence in STEM is largely determined by factors other than grades per se, and these impacts are exacerbated for students who intake messages (often implicit and/or unintentional) from their instructors and institutions that they do not belong (J. Allen et al., 2021; Chen et al., 2021; Penuel et al., 2023). We suggest that exam-related conversations -- accidental or planned, truncated or extended, cryptic or direct, sympathetic or aloof -- may

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critically affect whether students feel disenfranchised from college or professional STEM fields and how they persist over barriers to their success (Dika & D'Amico, 2016; Estrada et al., 2016; Graham et al., 2013). These conversations may be a key source for personalized beliefs around growth mindsets to take hold (Canning et al., 2024). Methods for improving exam experiences for students without increasing instructor workloads are, in our eyes, crucial to addressing this problem of persistence in STEM.

Future Research

This exploration of the ecology of exam methods within the subfield of A&P is by nature preliminary; we chose this subfield as a useful entry point for broad, shallow data collection to better inform the deeper research needed for true understanding. We hope that this future research can better describe the demographics of students and instructors alike. It will be important to go beyond rote percentages of points for indicating the grade importance of exams and instead collect data on the proportion of grade variation, as well as linking that variation to success in later professional school. Separation of the experiences provided by different types of challenges (e.g., multiple choice exams versus written exams) will be important. We hope that richer qualitative methods can be applied to help understand the thought processes (both for scientific content and emotion) that exams promote for students, and, similarly, that the goals and mental frameworks of exam-writing instructors can also be described. While we have personally undertaken studies of exam methods we believe may contribute to improving conversations and eventually persistence (Evans et al., 2023; B. L. Wiggins et al., 2023), change and improvement will be best informed by a combination of these data types from a wide range of classrooms.

Author Biographies

Ben Wiggins is an instructor in biology at Shoreline Community College, where he teaches human anatomy and physiology. Ben developed the methods collectively known as the Public Exam system during fifteen years of large courses at the University of Washington. He continues to focus on transforming college science exams from punitive barriers into the kind of complex challenges that motivate and drive personal growth.

Greg Crowther is a tenured biology instructor at Everett Community College north of Seattle, where he teaches human anatomy and physiology to pre-nursing students and others. Greg is the lead developer and researcher of the Test Question Templates (TQT) framework for making summative assessments more transparent, rigorous, and equitable.

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Supplemental Materials

- The "A&P Exam Methods Survey" can be found on the next pages.
- The survey results, in excel form, are available upon request from the corresponding author.

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A&P Exam Methods Survey

Writing science exams is hard. Exams soak up free time, test our communication skills, and provide stress for everyone involved. In this survey, we want to better understand the methods that A&P faculty are using to maintain quality, inform students, and (perhaps most importantly) stay as efficient as possible.

For the 9 multiple-choice questions here, and for the optional written questions afterwards, we want to hear about your experiences with writing, giving and grading exams. What do you do? What works? What are the challenges?

Please take this exam with your own classes in mind, and focus on the course(s) in which you write exams the most.

0. The course(s) I have in mind while taking this survey is/are: [open-ended]

The choices here are all based on existing college STEM courses.
For each question, you'll be able to explain more on the next page if you want.

Q1) How do you help students to prepare for your exams?
[Choose all that apply]

- Publish learning objectives for each class session
- Publish learning objectives for each exam
- Provide study guides that summarize the material on each exam
- Provide practice questions
- Provide information about the format of each exam
- Provide old exams for students to practice with
- Provide a partial or full copy of the actual exam
- Encourage students to study together
- Encourage students to study creatively
- Encourage students to study daily or regularly
- Encourage students to work with Teaching Assistants or Peer Learning Assistants
- Facilitate study group formation
- Facilitate a particular method of studying
- Give class points for doing a particular method of studying
- Give class points for studying in groups
- Give class points for feedback from students on the exam
- I don’t help students to prepare for exams.

Q2) I choose material for my exams based on…
[Choose all that apply]

- …nationally- or internationally-standardized learning goals
- …college- or departmentally-standardized learning goals

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A&P Exam Methods Survey

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- Give class points for studying in groups
- Give class points for feedback from students on the exam
- I don’t help students to prepare for exams.

Q2) I choose material for my exams based on…
[Choose all that apply]

- …nationally- or internationally-standardized learning goals
- …college- or departmentally-standardized learning goals

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- ...learning goals that are specific to my course
- ...questions provided by a textbook or learning management system (LMS)
- ...what I see as important for students in possible careers
- ...the ideas I get from people in relevant careers
- ...what will make the most difficult exam questions
- ...what will make the most interesting exam questions
- ...areas that students traditionally struggle with
- ...random selection from course material

Q3) How do you edit your exams?
[Choose all that apply]

- I edit my own exams.
- I have colleagues who teach the same course edit my exams.
- I have colleagues who do NOT teach this same course edit my exams.
- I have staff (like TAs or other non-faculty) who edit my exams.
- I compensate an outside professional specifically to edit my exams.
- I involve students in the editing of my exams.
- I reuse exams so they do not need editing.
- My exams are not edited.

Q4) After my exams, students receive...
[Choose all that apply]

- ...their own exam score
- ...the class average and/or median
- ...their scores on each individual exam problem
- ...their own exam (or a copy of their exam)
- ...a key to the exam with correct answers
- ...a rubric or rubrics for exam answers
- ...individual verbal feedback
- ...individual written feedback

Q5) Can students challenge their grade on the exam?
[Choose all that apply]

- Yes, they can challenge the grading of any parts of the exam.
- Yes, they can challenge but are limited to challenging a small part of the exam.
- Yes, they can challenge but only one part of the exam.
- Yes, they can challenge through a formal procedure within the class.
- Yes, they can challenge through a formal procedure outside of the class.
- Yes, they can challenge on an informal or case-by-case basis.
- Yes, they can challenge verbally during office hours.
- No, students cannot challenge exam grading.

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Q6) Feedback on the difficulty of an exam that would impact course grades includes...
[Choose all that apply]

- ...my own sense for the difficulty of the exam
- ...informal feedback or complaints from students on the difficulty of the exam
- ...formal, graded feedback that I require from students on the difficulty of the exam
- ...the class average or median on the exam grade
- ...the class distribution (including the high or low scores) of the exam grade
- Once an exam is written, I do not adjust grading based on difficulty.

Q7) If a student is unable to attend an exam due to illness, then I typically...
[Choose all that apply]

- ...give a different version of the exam as a later makeup
- ...give the same version of the exam as a later makeup
- ...allow the student to complete a makeup exam from home
- ...allow the student to do an oral exam in person
- ...don't allow for makeup exams, because I drop one or more of the exam scores from the final grade
- I don't allow for makeup exams in my class.

Q8) After I give an exam...
[Choose the single best answer] *

- ...I never use the questions again (I write all my exams new)
- ...I reuse all of the questions on future exams
- ...I reuse a few of the questions on future exams
- ...I reuse the entire exam for a future class
- My exams are the same in each iteration of the class.

Q9) Roughly how much of the final grade in your course is determined by exams?
[Choose the single best answer]

- ~100% of the final grade is from exams
- ~90% of the final grade is from exams
- ~80% of the final grade is from exams
- ~70% of the final grade is from exams
- ~60% of the final grade is from exams
- ~50% of the final grade is from exams
- ~40% of the final grade is from exams
- ~30% of the final grade is from exams
- ~20% of the final grade is from exams
- ~10% of the final grade is from exams
- None of the final grade is from exams

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If you would like to explain any of your prior answers, you can do so on these follow-up questions. **These are completely optional; answers are NOT required,** but we wanted to provide a place to explain your methods if you want. Anything you write here will be read (many times!) by our team as we try to understand the myriad of exam methods that exist across college A&P courses.

10. How do you help students to prepare for your exams? *[Optional, open-ended]*
11. How do you choose material for your exams? *[Optional, open-ended]*
12. In what way(s) do you edit your exams? *[Optional, open-ended]*
13. What feedback do students receive after your exams? *[Optional, open-ended]*
14. Can (or, how do) students challenge the grading on your exams? *[Optional, open-ended]*
15. What feedback (if any) do you use to decide if the exam was too easy or too difficult? *[Optional, open-ended]*
16. For illnesses, do you allow makeups for your exams, and if so: how? *[Optional, open-ended]*
17. How much of your exams do you reuse from course to course? *[Optional, open-ended]*
18. How do exams contribute to the final course grade? *[Optional, open-ended]*

This last section is for information that will help us to better understand the context of exam methods. As a reminder: All data in this survey will be anonymized before any summary is generated, and no individual data will be made public outside of summary.

19. At what type of institution do you primarily give exams?
[Choose the single best answer]
- R1 or research university
- Private liberal arts college
- Regional or comprehensive college
- Community or technical college
- High school
- Graduate school
- Other: *[open-ended response]*

20. Do you typically teach a schedule on quarters or semesters?
[Choose the single best answer]
- Quarters
- Semesters
- Asynchronously outside of a term schedule
- Other: *[open-ended response]*

21. Roughly how many exams do you give in a typical course?
[Choose the single best answer]
- 0

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- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

22. What level of students do you primarily teach?
[Choose all that apply]

- 1st-year college students
- Undergraduates in their 2nd or 3rd year
- Undergraduates in their last year
- Graduate students
- K-12 students
- Other: *[open-ended response]*

23. Where did you learn the most about exam writing?
[Choose the single best answer]

- I have taken coursework in exam writing methods
- I have done professional development for exam writing
- I have researched exam writing on my own
- I use knowledge from past instructors that I taught with
- I use knowledge from courses in which I was a student
- I use knowledge from observing the courses of other instructors
- I have only used my own ideas for exam writing
- Other: *[open-ended response]*

24. For the course you had in mind on earlier questions: What is your typical number of students per course?
[open-ended response]

25. Which of these is closest to your academic title?
[Choose the single best answer]

- Full-time (tenure-track or equivalent)
- Part-time or adjunct faculty
- Staff instructor
- Graduate student
- Post-doc

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- Other: *[open-ended response]*

26. Are you a member of HAPS?
[Choose the single best answer]
- Yes
- No
- Other: *[open-ended response]*

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