

# Content Coverage as a Persistent Exclusionary Practice: Investigating Perspectives of Health Professionals on the Influence of Undergraduate Coursework

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## ABSTRACT

STEM undergraduates navigate lengthy sequences of prerequisite courses covering volumes of science content. Given that these courses may contribute to attrition and equity gaps in STEM, research is needed to test the assumption that prerequisite content benefits students in their future studies and careers. We investigated the relevance of prerequisite course content for students' careers through semistructured interviews with practicing nurses regarding their undergraduate anatomy and physiology (A&P) courses. Nurses reported that A&P content does not align with the skills and knowledge needed in the nursing profession. Interviewees averaged 39% on a brief A&P assessment, suggesting A&P prerequisites failed to impart a high degree of long-term A&P knowledge among nurses. Further, practicing nurses perceived overcommitment to A&P content coverage as an exclusionary practice that eliminates capable individuals from the pre-nursing pathway. These findings challenge assumptions surrounding the justification for prerequisite course content and raise questions of whether content expectations actively exclude individuals from STEM or healthcare careers. We aspire for this study to stimulate conversation and research about the goals of prerequisite content, who is best positioned to articulate prerequisite content objectives, and the influence of content coverage on equity and justice in undergraduate STEM education.

## INTRODUCTION

Consider, for a moment, the last time you taught a new course. How did you decide what content to include and what content to omit? Perhaps you referred to a colleague's syllabus, a textbook table of contents, a departmental course outline, or a list of core concepts advocated for by professors in the field (e.g., Michael *et al.*, 2009; AAAS, 2011). Perhaps you had flexibility in planning the course to focus on “enduring understandings” you aimed to promote (Wiggins and McTighe, 1998; Allen and Tanner, 2007). Whatever your sources, who ultimately contributed input about what content was taught? At any point, did professionals working in the fields students aspire to enter, or students themselves, contribute to course content decisions? And what evidence was available to suggest that the included course content was indeed the content students would most remember, need, and use in their future professional careers?

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### A Gap in the Literature Regarding Content Coverage

Numerous lines of scholarship have contributed evidence surrounding *how* we teach (e.g., active learning, Freeman *et al.*, 2014; Theobald *et al.*, 2020) and *who* we teach (e.g., how science education impacts different groups of students, Dewsbury and Brame, 2019). However, the research literature is less developed in terms of systematic investigations into *what* we teach; for example, what and how much course content is necessary and for whom. Many biology education scholars have developed key concepts, learning objectives, and principles to guide curricular development. For example, *Vision and Change* (AAAS, 2011) has provided instructors with several overarching core concepts that biology students should harness by the time they graduate. This has guided instructors to focus on central principles of biology in their courses. Similarly, many researchers have focused on the roles of faculty-generated learning objectives (e.g., reviewed by Orr *et al.*, 2022) to guide assessment and lesson development in the spirit of backwards design (Wiggins and McTighe, 1998; Allen and Tanner, 2007). However, these efforts have generally stopped short of providing systematic research evidence that the recommended content is learned, retained, and used by students in their futures. Further, these recommendations have primarily centered the viewpoints of course instructors, who may or may not have expertise about the fields their students hope to enter, and who generally have narrow experiences in the larger landscape of the life science workforce.

The above limitations in the research literature demonstrate the need for studies that collect systematic evidence to evaluate course content decisions about *what* content we teach. Such efforts might be especially important in relation to prerequisite courses, as significant attrition occurs at this critical launch-point in students' careers (Seymour and Hewitt, 1997; Seymour and Hunter, 2019). Persistence issues in entry level and prerequisite courses still remain for students who do not identify with the dominant culture in STEM (Seymour and Hunter, 2019). To complement research that has investigated *how we teach* and *who we teach*, we focused our investigative lens on the influence of *what content* and *how much detail* is included in prerequisite courses and how this may reveal malleable barriers related to student persistence in biology. A more evidence-based approach to selecting course content in prerequisites might additionally relieve educators of the "tyranny of content," such that they adopt more innovative, evidence-based teaching practices (Petersen *et al.*, 2020; Kraft *et al.*, 2023).

### Purported Benefits of Prerequisite Content Coverage

Prerequisite courses are highly integrated into higher education, but the rationale for including these courses has been somewhat nebulous. Undergraduate biology courses are typically organized into sequences with prerequisite courses leading to more advanced areas of study (Shaffer *et al.*, 2016). Some have asserted that prerequisites assist with issues of enrollment, resource allocation, study skill development, and aid in student success in later courses (e.g., Griffiths *et al.*, 1995; Hull *et al.*, 2016; Shaffer *et al.*, 2016). Despite the variation in reported benefits of prerequisites, a central purpose for this sequencing of curricula is to "provide students with targeted exposure to new information" to set a foundation for future courses (Shaffer *et al.*, 2016, p. 2). To test this claim,

several studies have aimed to examine the value of prerequisite courses. Shaffer and colleagues (2016, 2018) conducted a series of studies examining the relevance of prerequisite courses across anatomy, physiology, and molecular biology. Findings revealed that prerequisite course content may not be academically advantageous to students' performance in subsequent courses. Similarly, a study conducted by Richardson (2000) discovered that students entering upper-division science courses performed equally well without completing the prerequisites. These findings raise questions about instructors' perceptions of prerequisite content aligning with skills and knowledge needed for future coursework.

Another asserted benefit of prerequisite courses, and arguably one of the purposes of higher education, is to prepare students for the workforce (Arum and Roksa, 2011). However, studies conducted by Arum and Roksa (2011) revealed that undergraduate students only marginally increased their critical thinking, analytical reasoning, written communication, and problem-solving skills after prerequisite course completion, suggesting this was one of the reasons students enter the workforce unprepared. These findings raise concerns about the relevance of prerequisites, whether meaningful learning is occurring, how well students remember what they do learn, and which aspects of prerequisites are actually useful for students' future careers.

### Content Coverage and Efforts to Diversify STEM

Given the above research findings and emerging questions about the relevance and utility of prerequisite course content, additional concerns arise regarding whether issues of content coverage might exacerbate problems related to exclusion in STEM generally and in the life sciences more specifically. Many critical scholars have noted the liberatory power of education (Freire, 1970; Giroux *et al.*, 1989; hooks, 1994) – education can lift individuals out of poverty and close gaps between different socioeconomic classes. According to the USA Bureau of Labor Statistics (2023), the top highest paying careers reside in STEM disciplines, particularly medicine and engineering. But unfortunately, we can predict who leaves STEM majors within the first 2 y of college based on demographic characteristics (Seymour and Hewitt, 1997; Seymour and Hunter, 2019). Prerequisite courses often serve as "gatekeepers" and may disproportionately contribute to equity gaps in STEM (Alexander *et al.*, 2009; Matz *et al.*, 2017; Forgey *et al.*, 2020; Harris *et al.*, 2020). Students from populations experiencing marginalization in STEM report many exclusionary factors in their STEM courses, including content overload, as a reason they chose to leave STEM majors (Seymour and Hunter, 2019). As such, there is a need for research that examines the extent to which content coverage itself might be a key exclusionary practice in undergraduate STEM education, particularly if that content is not even retained or used by students that persist and successfully pursue careers in STEM fields.

### The Nursing and Anatomy and Physiology (A&P) Prerequisite Context

Introductory A&P, which is a yearlong undergraduate prerequisite course series, represents a promising environment in which to investigate gaps in the literature regarding the impacts of prerequisite content on the careers of life science professionals. In comparison to other STEM prerequisites that lead to a wide

variety of careers in research, teaching, medicine, industry, and beyond, A&P content is more narrowly aimed at preparing students for transfer to nursing and allied health programs (Scott *et al.*, 1995; Schmidt and MacWilliams, 2011). A&P content might, therefore, have a higher chance than other prerequisites of being immediately relevant to individuals in their subsequent schooling and careers. Yet, initial reports suggest current A&P course content in nursing programs and core concepts in physiology might not align with the needs of nurses (Davis, 2010; Mahaffey, 2023) and might not be well retained in subsequent nursing program coursework (Narnaware and Neumeier, 2019; Narnaware, 2021). These prior efforts, which have focused on a subset of A&P concepts or a nursing school population, suggest a need for broader investigations of the relevance of A&P content for working nursing professionals.

The nursing/A&P context might additionally represent an optimal starting place for investigating the relationships between equity, justice, and prerequisite content coverage. Diversity and equity are particularly salient issues in nursing. Less than 20% of nursing professionals identify as Black, Hispanic, or Native American in the United States, yet individuals from those groups collectively represent over 30% of the working age population (Salsberg *et al.*, 2021). This is particularly troubling, since a lack of racial concordance between patients and healthcare providers has been associated with disparities in medical care (Cooper-Patrick, 1999; Nelson, 2002). Prior work suggests A&P courses and other undergraduate prerequisites could play a role in generating these healthcare workforce disparities (e.g., Forgey *et al.*, 2020).

A&P, therefore, represents a prerequisite with clear career connections and with important implications for who is included in or excluded from life science careers. In consideration of these factors, we focused the present study on connections between introductory A&P course content and nursing careers. Although we focus on this specific profession and prerequisite sequence, we posit that inferences drawn from this study will have implications across STEM disciplines and prerequisite courses in a variety of fields.

### Research Questions

We aimed to address the following research questions:

1. To what extent do nursing professionals perceive A&P content as aligned with their nursing careers?
2. How do nursing professionals perform on a sample of A&P assessment questions?
3. To what extent do nursing professionals perceive A&P content as influencing who persists in their profession?

## METHODS

### Author Positionality

Our team comprises individuals with numerous identities of relevance to this study, including A&P instructors, community college faculty, nursing school attendees/graduates, nursing school faculty/administrators, and education researchers.

B.T. is a white, neurodivergent, woman-identifying professor who has first-hand experience as a medical professional and nursing student. Over the past 6 y, she has taught A&P courses across an array of institutions, from community college to R1 and R2 institutions, and continues to witness a mismatch

between knowledge needed in nursing and prerequisite A&P content. S.C. is a white woman-identifying professor who has almost 40 y of nursing experience and almost 30 y as a nursing faculty. She has taught several adult nursing theory and clinical courses, and was Assistant Director of Nursing for an Associate of Science Degree granting Registered Nursing program. Her interest in this study stems from observing evidence of the apparent disconnect between application of nursing students' prerequisite knowledge and their critical thinking and clinical judgment at the bedside. C.H. is a white woman who has been a nurse for over 40 y and a nursing professor for almost 30 y. She has taught courses across several specialties in nursing and served as the Director of Nursing for an Associate of Science Degree granting Registered Nursing program. She recognizes the challenges that current presentation of prerequisite courses present for admission to and success within nursing programs. K.D.T. is a white, woman-identifying, first-generation college graduate in her family. She grew up in a hospital setting around nursing, as her parents were trained as health professionals. Over almost two decades, she has taught aspiring nurses in general biology courses, often supporting them in recharting their career paths after unsuccessfully navigating A&P courses and/or nursing school admissions. J.N.S. is a community college biology professor and identifies as a white man. He has taught introductory A&P for prenursing and preallied health students for over 16 y, frequently coordinating efforts with nursing and allied health faculty during that time. His education research has focused on inclusive curricula and science identity in A&P course settings. We approach this work with a sense of cultural humility, given that we racially identify with the dominant culture in our fields.

### Internal Review Board Approval

This project was approved by San Francisco State University's Internal Review Board under exempt status (Protocol #45 CFR 46.101b).

### Participant Population and Recruitment

To explore nurses' perceptions of how undergraduate A&P courses influence nursing careers, we interviewed currently practicing nurses who had graduated from an accredited community college nursing program on the west coast of the United States. We selected this context because the majority of nurses complete training at community colleges (Ashford, 2017). We collaborated with nursing faculty at the college to recruit alumni nursing professionals who had graduated in the past 7 y from their institution ( $n = 178$ ). This timeframe allowed us to collect data from nurses who would likely have some recollection of their undergraduate A&P courses. S.C. sent a recruitment email to this population of nurses, inviting them to participate in a 45-min interview exploring their perspectives about which aspects of undergraduate A&P courses most directly connect to professional nursing practice. The email included a Qualtrics survey link for individuals to sign up to be interviewed by providing their name, contact information, schedule availability, and a variety of self-identified characteristics (gender, race/ethnicity, member of the LGBTQIA+ community, highest level of degree, institution type where they completed, and years since completing, their undergraduate A&P coursework, and years as a practicing registered nurse; Table 1).

**TABLE 1. Self-identified characteristics of nursing professional participants**

Characteristics		Participants % (n)
Highest Level of Education	ASN	23% (7)
	BSN	70% (21)
	Graduate Degree (MFA, MSN)	7% (2)
Institution of A&P Completion	Community College	97% (29)
	4-y	3% (1)
Years as Practicing Nurse	1–3 y	60% (18)
	4–6 y	40% (12)
Years since A&P Completion	5–7 y	60% (18)
	8–10 y	40% (12)
Gender	Women	93% (28)
	Men	7% (2)
Race/Ethnicity	People of Color (Asian, Black, Latinx, Filipino)	47% (14)
	White	53% (16)
Member of the LGBTQIA+ community	LGBTQIA+	23% (7)
	non-LGBTQIA+	77% (23)
Total participants		n = 30

### Sampling Method

We selected interview participants by employing a random, stratified sampling technique based on two factors: highest level of education (associates or bachelors/masters) and years of experience as a nurse (1–3 or 4–6 y). We initially chose to stratify by these factors to establish comparable representation across education levels and experience. Next, we randomly constructed five samples of potential interviewees. We then chose the sample that had the most balanced representation based on gender, race/ethnicity, and member of the LGBTQIA+ community. We excluded individuals who were not currently practicing or had less than one year of experience as a practicing nurse to ensure that results reflected insights from current nursing professionals who had work experience in the field.

### Participant Recruitment

After constructing the interview sample, we individually emailed the list of 30 nursing professionals with one of their preferred availabilities to schedule an interview. To obtain rich and thoughtful interview responses, we invited participants to review an abbreviated list of interview questions that were embedded in the email. We waited five business days for these individuals to confirm their availability and willingness to participate. For those who were non-responsive to our initial email, we followed up with a reminder email requesting participation and waited another three business days for individuals to respond. Any individuals who did not respond or declined the interview after this timeframe were replaced with other potential participants who held comparable levels of education and years of experience, as well as similar demographics to maintain maximal representation. We followed this protocol until 30 interviews were scheduled. All participants were compensated with a \$100 Amazon gift card for their participation in this study upon completion of the interview.

### Interview Protocol Development

B.T., K.D.T., and J.N.S. developed an interview protocol that aligned with the research questions to elicit participant perspectives about the influence of undergraduate A&P coursework on nursing careers (see Supplemental Material A for interview questions). B.T. piloted these questions with six nursing professionals and four education researchers unaffiliated with this study to face validate and clarify the wording of the interview questions. We followed a semistructured format in which B.T. asked a set of identical interview questions to all participants while allowing space for follow-up questions and discourse to further explore ideas not listed in the interview protocol. Interviews were conducted via Zoom and were audio recorded.

### Three-part Interview Protocol

To probe participants' recollection of undergraduate A&P coursework, the interview consisted of three parts: part one (preassessment); part two (assessment); and part three (postassessment). Open-ended interview questions in part one (preassessment) explored participants' general recollection of A&P and how the amount of content and level of detail in A&P was helpful in their current nursing profession. The second part of the interview (assessment) invited participants to take a short, A&P assessment containing 17 multiple-choice questions that were developed by the Human Anatomy and Physiology Society (HAPS; HAPS, 2020a). These questions were listed on the publicly available HAPS website as examples of their standardized A&P exam that instructors may use to evaluate students' A&P knowledge (HAPS, 2020b; see Supplemental Material B for questions). Thus, the researchers of this project did not develop these questions. The purpose of this 17-question assessment was to gain insights about how much A&P content practicing nurses currently recall (RQ2), as well as to provide a reminder for participants mid-interview about the nature of undergraduate A&P content. B.T. sent the participants a survey link to the assessment through the chat function on Zoom. Participants were asked to draw on their own knowledge to answer the questions and were asked not to look up answers. Once participants completed this assessment, part three (postassessment) contained interview questions similar to those in the pre-assessment section to investigate any changes in participants' perceptions of their undergraduate courses after revisiting some A&P content through the assessment. We also probed nurses' perceptions about how A&P influenced persistence in nursing and sought their advice on how undergraduate A&P courses could be improved to best align with the nursing profession. Pseudonyms were assigned to deidentify participants, and audio files were sent to a third-party company for transcription.

### Qualitative Data Analyses

Using our research questions as a guide, we performed deductive content analysis (Patton, 1990) to investigate nursing professionals' perceptions of A&P courses. Researchers (B.T., J.N.S., and K.D.T.) independently read through interview responses of three separate interview transcripts looking for evidence that addressed Research Question 1 (RQ1). This covered 30% of total transcripts (three different transcripts per researcher, or nine total transcripts). We independently placed our respective preassessment quotes that aligned with RQ1 into one shared document. Next to each quote, we added categories

to capture the essence of our participants' perspectives. We then reconvened and came to consensus regarding the emergent categories and created associated subcategories that surfaced from this initial 30% of interviews. Each quote was assigned to one subcategory (no double coding occurred). Using these categories and subcategories, researcher B.T. repeated this process for the remaining interview responses pertaining to RQ1 while obtaining inter-rating reliability (IRR) on 20% of quotes with K.D.T. We continued the same data analysis protocol from RQ1 for RQ3. IRR ranged from 93–100% throughout this entire data analysis process. In instances of IRR below 100%, B.T. and K.D.T. discussed differences and reached consensus.

## RESULTS

In this section, we present findings from interviews with professional nurses to investigate their perceptions about the relevance of A&P courses on nursing careers. Of note, there were no apparent differences between the stratified subpopulations of the interview sample. As such, all results are reported in aggregate. Results are organized into subsections by research questions, following descriptions of the interview participant population and the results of the mid-interview assessment.

### Participant Population

Of the 178 nurses that were initially contacted, 71 nursing professionals agreed to participate in this study (40% response rate). After constructing the interview sample population (see *Materials and Methods*), 30 nursing professionals participated in hourlong interviews. The self-identified characteristics of these participants are listed in Table 1. Some characteristics were overrepresented in our final group of participants due to the demographic and educational characteristics of the nursing profession generally.

### RQ1: To what extent do nursing professionals perceive A&P content as aligned with their nursing career?

Nurses across our sample reported misalignment between A&P prerequisite courses and their professional careers both pre- (77%,  $n = 23$ ) and postcompletion (93%,  $n = 28$ ) of a sample of A&P assessments during the interview. As there were minimal shifts in their perceptions regarding misalignment between pre- and postassessment, Table 2 shows evidence of total misalignment, instead of demarcated as pre- or postdata. Two salient assertions emerged from the majority of interviewed nurses: 1) they view much of undergraduate A&P course content as irrelevant to their professional work (93%,  $n = 28/30$ ), and 2) they have retained little of that A&P course content (70%,  $n = 21/30$ ).

Nearly all nurses (93%,  $n = 28$ ) asserted that the detail and breadth of undergraduate A&P course content was irrelevant to professional nursing careers. For example, Denner and Finley expressed how grasping the bigger picture of A&P content is more aligned with day-to-day nursing practice:

*I don't think [A&P] was really helpful, honestly. All those little details and all that content. I just remember the big picture. Because you don't really need to know those details. You just need to know the bigger picture. Like when you inhale your alveoli expand and you're able to take in more air. You don't really need to know, when you inhale your alveoli expand and there's a CO<sub>2</sub> exchange and these channels open up and lot of little molecules*

*go this way and that way, you don't really need to know all that, I guess. So, I don't know that all those details really helped me. Even doctors, I see them always looking things up, too. –Denner*

*I don't think that level of detail is needed because your job is going to be more, depending on where you end up, you're going to get more training, you're going to get more education. That level is not useful because you'll get more specialized training later in your career. You don't need to be exposed to that detail if you won't end up using it. –Finley*

Others commented on the memorization involved in A&P as unhelpful in retaining the material for their job:

*Well, trying to memorize everything was not helpful at all. It wasn't learning. It was more like for an exam. "I want to memorize all this thing for my exam." You have to memorize so much and then they'll ask you for four or five questions. So, I think that's the part that's hard, because expecting to memorize all that material for a test and cramming is not the same as learning it for the job or for life. –Alfa*

Furthermore, almost three-fourths of practicing nurses (70%,  $n = 21$ ) asserted that they did not remember the A&P content that they experienced in undergraduate A&P courses (Table 2):

*I guess it's hard for all of us [nurses] to remember and recall all that information, because like I said, it was just so much, in a very short period of time. I mean the structure of A&P really isn't [conducive to my learning]. I just feel like you learn it and then you remember it for the test, but then it's like, "Okay, you have to start learning about something else now." So, it's hard to recall all that information. You kind of just learn it for the exam and that's it. –Jamie*

Many participants reflected on their experiences completing the A&P assessment (RQ2 findings below) during latter parts of the interviews:

*Ollie: I've heard of those terms in A&P in that exam once upon a time ago, but it's never used, so I don't remember any of it, like really none of it. I vaguely remember some of the muscles, brachioradialis, and such, but as to where they...I don't even remember what the term was, start and end or whatever.*

*Interviewer: Origins and insertions?*

*Ollie: Yeah. There you go, origins and assertions. I couldn't tell you.*

Reflecting on their assertions about the overload of A&P content, 73% ( $n = 22$ ) of interviewed nurses volunteered suggestions for bringing undergraduate A&P courses into better alignment with their professional work that are summarized in four categories (Table 3). First, half of interviewed nurses (50%,  $n = 15$ ) suggested that decreasing content coverage in A&P courses could increase alignment of the courses with the professional knowledge required of a practicing nurse. These interviewees (50%,  $n = 15$ ) also concomitantly recommended increasing the inclusion of clinically applicable scenarios (e.g., case studies, etc.) in undergraduate A&P courses:

**TABLE 2. Emergent subcategories and example quotes from nursing professionals regarding misalignment of A&P with their professional nursing careers.**

Subcategory % (n) Description	Example Quotes
<b>Contains irrelevant content:</b> 93% (28)  <i>Describes A&amp;P course content as detailed, fast paced, requiring memorization, and ultimately irrelevant to nursing</i>	<p>“I think [A&amp;P is] really difficult and irrelevant, because I don’t feel...I don’t think your ability to pass those A&amp;P courses is indicative of your ability to make it as a nurse or make it a nursing school. I’m not saying nursing school is easy. It certainly wasn’t. You certainly had strict...I mean, our program had strict guidelines. In terms of grades in terms of the work they expected, but it wasn’t quite so like...It was more of an understanding of concepts, rather than these minute details that really can get...That get lost and really in my nursing practice I’ve never used.” –<i>Devan</i></p> <p>“I feel like my day-to-day responsibilities as a bedside nurse, I don’t utilize all the material that we learned from A&amp;P. I definitely think that A&amp;P goes into a lot more detail that nurses use on a day-to-day basis. Because I feel like my responsibilities now are more task based, like passing meds or sending my patients off to and from procedures. So, the times that I do use my A&amp;P the most, it’s when I’m assessing my patients or trying to figure out what exactly might be going on with them. So yeah, I don’t use all the information that I learned in those courses.” –<i>Charlie</i></p> <p>“I did think it was a little ridiculous having to memorize all the protuberances and all of that. Even now, I can say, “Why did I need to know that?” I could see where a lot of [A&amp;P content] wasn’t necessary.” –<i>Aiden</i></p> <p>“I wouldn’t say that it was important. It wasn’t very useful. Because even in our practice right now, even the doctors still have to look at diagrams just because they need to remember something. And they’re doctors, so you would expect for them to have memorized everything, but even they need help. Sometimes the amount of detail is very discouraging.” –<i>Marion</i></p> <p>“I remember anatomy just being super overwhelming, and just kind of plowing straight ahead, overload of information, just, “Memorize this material in a week, take a test and move on to the next material that had nothing to do with material you did previously,” like a different system, I think. You don’t need to know all of that.” –<i>Remy</i></p> <p>“My role as a nurse is to identify when things are out of the norm, concerning. Do I need to know that it’s the posterior horn of this or the left tubercle on that? Nope.” –<i>Monroe</i></p>
<b>Not currently remembered:</b> 70% (21)  <i>Unable to retain knowledge from A&amp;P</i>	<p>“So, I guess it’s just the amount that you have to learn, but at the same time, for me at least with A&amp;P, it was kind of just recall and retain and then forget, but you kind of can let go of a lot of things you learn. I don’t remember a lot of what I learned in A&amp;P.” –<i>Kai</i></p> <p>“So, the amount of content I probably [understood at the time] is like 100%, let’s say, and the amount I remember and is needed for nursing it like 10%.” –<i>Alfa</i></p> <p>“The memorizing aspect of A&amp;P actually is not helpful as a nurse because, I don’t remember any of the bones of the hands unless someone came in for hand surgery and I’m like, “Okay, well this sounds familiar, but I’ve got to look it up. So straight up memorization does not help, unfortunately.” –<i>Ollie</i></p> <p>Well, there’s definitely a lot of stuff I don’t remember. I was just like, “Oh gosh, I have no clue.” A lot of times you study so hard for the test and then as soon as you take the test, it’s over and the information is gone. –<i>Jace</i></p> <p>“We don’t use that detailed A&amp;P stuff. We don’t use it at all. We all traveled to different departments. In hospice, it’s more like, like I said, psychology. But even other branches of nursing you don’t need that level of detail. I can’t think of a field that would. Unless they’re teaching. I can’t really think of a job...In ICU we’re dealing with labs, and how do you treat this patient. Maybe we don’t use A&amp;P as much as we thought we do.” –<i>Peyton</i></p> <p>“That kind of detail – I don’t remember any of that shit. We aren’t diagnosing something. I have to understand how the body works in order to know with medication that I’m giving, is it safe? Is it okay? Is it contraindicated for different disease processes and stuff like that. But all those tiny little details are just not remembered.” –<i>Pat</i></p>

*I do think that the A&P courses, the way they are so much detail oriented into every single thing...they can cut down a little bit. So, it can be not too general and not too detailed. It can be somewhere in the middle so that the students can follow easily, and they can remember more. Instead of just remembering the little details [because] those details can never be applied to an actual nursing career. Not in the day-to-day life of a nurse. –Lincoln*

*If [A&P content could] apply to a real-life scenario, do more case studies on it, more interactive scenarios, then I think that would have been much more helpful. I would like more labs and more simulation and case studies and that sort of thing. –Jamie*

Over a third of nurses (37%,  $n = 11$ ) suggested that integrating physiological systems, instead of presenting them as separate and independent of one another, could be more beneficial for learning and retention of A&P course material and preparation for health professions careers:

*You could incorporate all the things into the teaching. You could use the anatomy of, “Here, these vessels,” the physiology part of how they contract, and what they do in the body, and then, pick an actual specific medication that does that and incorporate all three together, would make more sense than spending a whole*

TABLE 3. Emergent categories, subcategories and example quotes of nursing professionals' advice on how to improve undergraduate A&amp;P courses to be more aligned with nursing.

Subcategory % (n) Description	Example Quotes
<p><b>Decrease amount of content covered</b> 50% (15)</p> <p><i>Explain how reducing details would improve A&amp;P courses</i></p>	<p>“To me, it felt like there’s a lot crammed in together. And I felt like I was trying to...It sucked because it’s genuinely interesting because it’s what I’m going to school for, but I felt like I was trying to crank stuff out to pass tests. You know what I mean? We’d learn all this stuff and the teacher would be like, “Okay, you need to read these chapters.” But it’s like, “Okay, what do I need to know for the test? Because I literally don’t have time to learn all of this and retain it. So, what do I need to pass this class?”</p> <p>So that was frustrating because a lot of it was, I would’ve liked to look more into it, but it’s like we really don’t have time because of all the details.” –<i>Reed</i></p> <p>“Maybe structuring [A&amp;P courses] differently where you don’t have to have a doctor’s level of understanding, I think would be beneficial for our healthcare system and patients. –<i>Ashton</i></p>
<p><b>Include clinically applicable scenarios</b> 50% (15)</p> <p><i>Specifically mention case studies, real-life scenarios, or clinical nursing application as ways to increase A&amp;P’s relevance to nursing</i></p>	<p>“Knowledge stuck with me when instructors would incorporate real life stories they experienced in nursing. It helped us better absorb the material. –<i>Billie</i></p> <p>“Maybe just change [A&amp;P] into what nurses actually can use. Like labs and stuff, or going through the electrolytes, that kind of important stuff. We use stuff like that a lot, or maybe looking at the nursing program and saying, this is what’s going to happen in the program, maybe if we can make the course more tailored to the nursing field. Stuff that’s actually useful and taking all the other crap out. Because premed will have to take A&amp;P again anyway. They can get all the extra stuff there.” –<i>Peyton</i></p>
<p><b>Increase systems integration</b> 37% (11)</p> <p><i>Describe how integrating physiological systems, instead of siloing systems, would be more conducive to learning</i></p>	<p>“I do remember for example since the cardiac and respiratory system are so intertwined, we did overlap those two systems. And so, by overlapping those two systems it was a lot easier to learn, seeing how they work together. So yeah, now that I’m thinking about it, maybe if we were able to connect more systems together instead of one by one, it would have made a whole lot more sense.” –<i>Charlie</i></p> <p>“If you embedded the systems together versus them being standalone, it ties it in validity and why it’s important. You can’t see why I need to know the ocular nerve, because I’ve never done a neuro check in a stroke unit. But I do think that I truly believe it has to be integrated. It can’t be separated out now as a unique, oh, I need to know this system separately from this system. I believe it has to be integrated, and it’s not.” –<i>Dallas</i></p>
<p><b>Implement varied teaching strategies</b> 30% (9)</p> <p><i>Articulate how methods other than a textbook will help improve A&amp;P</i></p>	<p>“Having more experience with models and cadavers. Because when you see it on the book, everything looks perfect and beautiful. But it’s not like that in real life. Not even close. So, it does help to see it live. Of course, you have the models also perfect, but still I think they do help a lot with the retention of the information. Because you can see them and touch it. Same with cadavers. So, not just reading from a textbook.” –<i>Alfa</i></p> <p>“At [redacted university], it was a lot more of, “Here’s a textbook, read these chapters. You’re expected to know these concepts.” And then you go to class, you don’t really learn that much. It’s more of just them going over broad topics, not really helping you understand it. So, you would end up going to class, go back home, reread the chapter again, just because that’s the material that’s given for you. It needs to be a lot more interactive, as opposed to just straight up memorization. But instead it’s, “Here’s a textbook, learn it,” kind of thing.” –<i>Ollie</i></p>
<p><b>Decrease pace</b> 13% (n = 4)</p> <p><i>Explain how changing pace could be beneficial</i></p>	<p>“I mean, as far as the content maybe, it could be broken up more just to dive deeper, I mean, maybe physiology could be stretched out so it can actually stick.” –<i>Kai</i></p> <p>“It’s just, basically what it is, it’s too much information for the time that you have to do it, right? So, if you want to keep that information, fine, then make it three different classes and allow people to absorb it. Instead of slamming everything into one quarter, make it two, and just to be able to talk about this information.” –<i>Quinn</i></p>

quarter learning this, and then spending a whole quarter learning this, and then this. Because if they’re so far apart, then you don’t really connect them together as well. It would make more sense to combine them altogether. –*Remy*

A similar percentage of nurses (30%, n = 9) suggested that courses should be delivered through more varied teaching strategies:

*They should incorporate different modalities of learning. Don’t just use the book. Yeah. So, one of my favorite instructors for nursing, she didn’t give a lot of assignments, but her things she chose, I still, I mean, I pass them to my son and his teacher. It*

*was pretty profound. It just had a lot of impact. Videos, audio. A&P should also be like that. –Mikey*

Thirteen percent (n = 4) of nurses indicated that a reduced pace of content coverage might make A&P courses more memorable and impactful.

*“I feel like if it was maybe spaced out, it would be more helpful because it was just crammed, there was just so much and I felt like maybe if they gave students more chances on passing, then yes, it would be fair. I’d like to learn more about the stuff that... Have the A&P courses, for example, like the cardiac system, the renal system, the central nervous system, or even the reproductive*

*system, maybe learn a little bit more about that stuff and not have it be as rushed.* –Jamie

Four nursing professionals (13%) felt no changes are needed for A&P courses:

*I don't think I would change anything. I enjoyed them.* –Riggs

### **RQ2: How do practicing nurses perform on a sample of A&P assessment questions?**

After initial open ended questions about their perspectives on alignment between A&P course content and their work as a practicing nurse, participants were asked to take a short, A&P assessment containing 17 multiple-choice questions to gain insight about their current A&P knowledge, as well as to provide a reminder about the nature of undergraduate A&P content for participants mid-interview. The 30 interviewed nurses had an average score of 39% ( $\bar{x} = 6.6 \pm 2.14$ ) on this sample of A&P assessment questions.

### **RQ3: To what extent do nursing professionals perceive A&P content as influencing who persists in their profession?**

The vast majority of nurses viewed undergraduate A&P as a gatekeeping course that negatively impacts persistence in pursuing a nursing career and is exclusionary (83%,  $n = 25$ ). These interviewed nurses identified four factors that contribute to A&P's negative influence on students' ability to persist from prehealth to a nursing career (Table 4). The majority (53%,  $n = 16$ ) of nurses described A&P as containing an overly detailed curriculum that requires heavy memorization and, as a result, “weeds out” students who could have been great nurses:

*I think they are weeding people out of nursing with all that detail and memorization. I think that's what they're doing. I think they know that every student who wants to become a nurse has to take them. And they're...I just think that they...I don't know if the nursing schools don't want to get impacted with like a large number of applicants that they have to weed through. So, they say, "Let's have the prereqs weed them out. I don't know what their processes are for doing that." But there were plenty of people who I was in those classes with who I think would have made fine nurses and didn't make it through.* –Devan

Thirty-seven percent ( $n = 11$ ) of nurses provided general statements related to A&P's exclusionary tendencies, reporting these courses as inequitable and exclusionary:

*I don't think [A&P courses are] equitable. I think they're, I mean, borderline abusive in some ways. As a gate keeping kind of barrier. It definitely negatively impacts the potential field of nurses. I do think it's definitely knocked out otherwise great qualified nursing school candidates.* –Angel

Roughly a quarter of nurses (27%,  $n = 8$ ) described the structure and time commitment of A&P courses as impeding persistence in a nursing career for some students due to other life obligations, such as family and job commitments:

*I think [A&P] is fair for the people who can completely dedicate their time. But most people have certain obligations that they need to fill in life and that takes up their time. I had to work while I was in my undergrad, so I didn't have as much time as a lot of other people did. And when I got home from work, I was just exhausted. So, I had to pick and choose my battles, and memorizing, I don't know, 30 small bones of the hands is not exactly on my priority list.* –Ollie

Importantly, some nurses expressed, often through their own experiences as nurses of color (Table 4) or from an observer's perspective, how A&P courses are specifically designed to exclude students of color or those from low-income, multilingual, or refugee backgrounds (13%,  $n = 4$ ):

*These [A&P] classes are not equitable. Based on age, culture, learning styles, poverty versus White, upper-middle-class. I think that's huge. I think what it does is it creates a less diverse working group of nurses. So, if you're a Latino or African American, Laotian, or South Asian, or you're a refugee...you come from El Salvador or say Ethiopia. You are not going to have as much of a chance of survival in this as an older returning middle-class White girl. They're just simply not going to have those opportunities. They're not going to make it. It doesn't draw on their basic cultural learning styles or methodology. You might call it the bicep, but they may have another word for it or another way of understanding it, and you're never going to reach them. And they're going to quit.* –Dallas

Counter to these findings, there were four nurses who perceived A&P as important in weeding out “incapable” peers, such as Zion and Oakley who stated:

*If you're not up to par [in A&P], you need to get up to par because you need to be at that level to be a good nurse. So, I wouldn't say make it easier per se, but you need to function at that level. You need to be able to go through that course. Last thing we need is less smart nurses. That can't happen.* –Zion

*I think A&P is fair. you just need to study harder until you make it, and if you can't that's on you. We want to make sure we have capable nurses.* –Oakley

## **DISCUSSION**

The field of biology education has conducted extensive research on *how* instructors teach (e.g., evidence-based instructional practices, think-pair-shares, clickers, etc.; Freeman et al., 2014, Theobald et al., 2020). While there is widespread agreement that these techniques show promise toward reducing attrition rates and increasing inclusion in undergraduate biology classrooms, reasons for *what* we teach, *why* we commit to certain content, and *who* gets to decide which content is taught is under-conceptualized and under-researched. Through interviews with nursing professionals who reflected on their experiences in previous prerequisite A&P courses, our results demonstrate how content decisions in prerequisite courses may negatively impact students from entering their desired careers. Additionally, our results suggest that nurses do not remember the content covered in A&P due to an overabundance of material presented. Lastly, we found that nurses perceived much of

TABLE 4. Emergent categories, subcategories, and example quotes of how nursing professionals perceive undergraduate A&amp;P influencing who persists in the nursing profession.

Category % (n)	Subcategory % (n) + Description	Example Quotes
A&P is a gatekeeper course that negatively impacts persistence due to... 83% (25)	...overly detailed curriculum 53% (16)	<p>"I know people who left the program because it was too challenging in a specific way, because of how detailed...I mean, one of my classes in particular, my favorite A&amp;P class, was taught by this professor who was just very detail oriented and very systematic. It was very effective for a student like me. But her exams were very challenging, very detailed. I would say more detailed and more challenging than the quiz you just gave me. It felt like it was at an even deeper level. And a lot of students just failed out because they couldn't do that. And so, it makes me realize that those classes could be a detriment to actually having a healthcare workforce that's good and effective." –Casey</p> <p>"I think a lot of people who could be really good nurses are skipped over. I think a lot of people who have a brain can memorize things, can get through and get into nursing programs. And I will tell you that there were plenty of really smart people in my nursing program who didn't make it past the first or second quarter because they could do the work, they had the highest grades in the class, but when it came down to being in a clinical setting or they couldn't do it. So, it's...You're taking one group of people and allowing it...Allowing them to go on and you're taking another group of people who would probably be very competent great nurses, and you're saying, "Because you can't do this memorization is difficult for us, we're writing you off from the whole profession." –Darian</p>
	...general gatekeeping tendencies 37% (11)	<p>"The program I went to, I thought, and I still think the anatomy, the A&amp;P, courses were weeders [...] I get teary-eyed saying this, I'm super passionate about being a nurse. I love it. I am so grateful that I have the opportunity to become one. And the thought that there are so many people who don't have that opportunity to find a career that they think would be filling is a shame. Because it really...It fills my cup every day." –Devan</p>
	Mention A&P generally weeding people out	<p>"I feel like all the prerequisites are just kind of more like a... I don't want to say an obstacle course, but kind of more like a gate keep into a program to get to actually finish it up." –Lincoln</p>
	...other life commitments 27% (8)	<p>I had the time available, even though I worked full time through school, but I still was able to...I didn't have children and I had otherwise lots of time and attention to spend on the classes. But there's other people who had to juggle full-time jobs or family while doing this. And yeah, I think those kinds of factors definitely played into them not being able to become a nurse. –Quinn</p>
	Articulate how family and/or job commitments interfere with persistence	<p>"I could see that's scaring people off. It's a lot and it's very life-consuming if you have any other classes. I think I got to the point where I only took.... Oh, I was only taking two classes a quarter when I was doing those. And before, I was taking four or five, but it just wasn't possible. And that's not really fair because you can't do that. They don't have time to do that. And I was able to work part-time, if I hadn't been...It wouldn't have been fair because I probably wouldn't have been able to pass. Or those who have kids. I can't imagine having had kids and trying to take those courses." –Reed</p>
	...disadvantaging particular populations who aspire to be nurses 13% (4)	<p>"[A&amp;P], it makes you fail because English is not my first language. I was about to fail the class. I don't think it is equitable. I think it not a good model. Have everyone to memorize every single thing. But still I think the memorization part is not the best model of education. For me personally, it's really hard, the memorization part. Because as an ESL student, there's a lot of things that have different names, so the memorization. Mostly not the name, but the spelling of the word is the most difficult part for me." –Alfa</p>
Express how A&P is not designed for certain populations	<p>"I mean, I definitely do think patient populations suffer by not having representation. And nursing is, traditionally, a middle-class white woman's field. I mean, most of my fantastic, exceptional colleagues are not from that background, and they have more of a personal connection to the patients, they have just a different life experience. And even when you work with them, you see there's no reason that they shouldn't be there. They're great nurses, they're great people. And yeah, there are definitely unnecessary barriers in the current state of nursing education that do detract from the equitable representation." –Frankie</p>	
A&P weeds out incapable peers 13% (n = 4)	<p>No subcategories</p> <p>State that A&amp;P is important to weed out individuals who are not committed</p>	<p>"I feel like if people can't get through that level of detail...I've taken a lot of hard classes in my lifetime. If they can't get through that level of detail, then maybe they shouldn't go on to nursing. You need to have a certain amount of science ability or ability to do hard things, to be able to be a nurse. And if you're not the type of person that can pass those courses, you're not going to be a good nurse." –Riggs</p> <p>"There were people in my A&amp;P class that were like, "I want to do nursing, but if this is the stuff we have to deal with, no way." This is the most basic thing. So, A, it gives those who are serious, a serious grounding in what we need to know before nursing. B, it helps start weeding out those who are just like, "Oh, nursing's glamorous, let's be a nurse." –Sammie</p>

what was taught in prior A&P courses as irrelevant to the professional career of nursing. Collectively, these findings call for reconsideration of what is taught in these courses that would best prepare students for and retain them in their career pathways, as well as who has the best insights and professional authority to decide what content would be professionally relevant. Below we explore the implications of these findings for undergraduate A&P courses, as well as undergraduate STEM education more broadly.

### **Practicing Nursing Professionals Perceive Overcommitment to Content Coverage as an Exclusionary Practice**

In our investigations, practicing nurses described undergraduate A&P courses as negatively impacting who persists in the nursing profession. These findings align with those of Seymour and Hewitt (1997), which indicated an overabundance of content is a factor that leads to attrition of disadvantaged student populations in STEM. Our nursing participants similarly suggested that content expectations in A&P act as a contributing factor in “weeding out” students in the career pathway. And although we did not interview those who left the prenursing pathway, those who persisted were highly dissatisfied with the volume of material covered in their A&P courses. These findings are striking, as many conversations regarding persistence in STEM have centered on how we teach, such as through active learning strategies, with less emphasis on examining the amount of content covered in a course.

Some nursing participants also expressed a more specific awareness that A&P content coverage might contribute to the lack of racial, refugee, multilingual, and low-income representation among healthcare workers and subsequently drive health inequities among disadvantaged patients. Although 47% of our interviewees identified as nurses of color, this is not representative of the racial demographics of nursing professionals across the USA. According to the National Council of State Boards of Nursing, 80.8% of nurses are white and nurses of color represent only 19.2% of the profession (American Associate of Colleges of Nursing, 2019). Just over two decades ago, a highly influential report by the Institute of Medicine outlined several reasons why a lack of representation in the healthcare workforce may lead to disparate health outcomes across patient demographic groups (Nelson, 2002). For example, racial concordance (same race) and discordance (different race) between patients and their providers significantly impacts patient experiences and trust of the medical community (Cooper-Patrick, 1999; Nelson, 2002). These are among a wealth of studies that support the reflections from our nursing participants who cited patient-centered care as a factor contingent on diverse representation across nursing professionals, and that might be impacted by exclusionary forces in the prenursing pathway.

### **Prerequisite Courses Failed to Impart a High Level of A&P Knowledge Among Working Nursing Professionals**

In addition to providing evidence that course content might be exclusionary, our findings suggest that, even for those individuals who do persist in the nursing field, A&P course content may not have been learned or retained. Nursing professionals in this study appeared to have little content knowledge when probed with a short, multiple-choice A&P assessment conducted during

the interviews. Nurses’ average score of 39% on the assessment was only moderately higher than what would be expected if randomly guessing at the answers on an assessment with five multiple-choice options. Further, the majority of nurses asserted during interviews that they did not retain much information from their prerequisite A&P courses. These findings add to existing evidence that retention of A&P knowledge wanes shortly after students finish class (Narnaware and Neumeier, 2019; Narnaware, 2021). This raises the question “if professional nurses are unable to recall prerequisite A&P content, why are we teaching it?” While our findings are centralized around A&P, the inability to learn and retain information across all domains of knowledge has been central to conversations regarding reform efforts in undergraduate education for decades. Arum and Roksa (2011) explored the concern that, despite the benefits college education brings, students may be learning far less than we think. Through the administration of a survey assessing students’ educational gains at two time points, results revealed that, from students entering freshman year to the completion of their sophomore year, they only improved critical thinking skills by 7% on average. One can infer from these findings, coupled with results from this and other studies, that most students – even those persisting in higher education and successfully navigating these courses – are not acquiring skills to the degree educators might hope. And although this study is focused on a small number of individuals in the context of the nursing profession, these findings may raise broader questions about the exclusionary nature of the breadth and depth of introductory course content and the extent to which that information is relevant to students’ futures. Finally, these findings might motivate deeper reflection and research into the purposes of prerequisites more broadly. For example, A&P prerequisites have sometimes been justified as a nursing school admissions requirement due to their correlation with success in nursing school (Gilmore, 2008). However, if students recall relatively little A&P content, one wonders what mechanisms underlie this association and what that implies regarding the rationale for prerequisite courses.

## **IMPLICATIONS**

### **Assumptions Surrounding Content Aligning with Professional Careers May be Inaccurate**

This study points to a potential misalignment between undergraduate A&P content and nurses’ professional work, based on the detail and breadth of material covered in A&P. Nurses noted that much of this content was irrelevant to the practice of nursing. Rather than teaching overwhelming amounts of content, they suggested that basic foundational knowledge of the human body was more apropos to the skills and knowledge needed in nursing. If working professionals do not find value in prerequisite courses and there is misalignment between what is taught and what is needed in the workforce, why do we teach what we teach? What evidence do we have that what we are teaching is relevant? This further calls into question the driving factors behind the purpose of prerequisite courses, which aligns with questions raised by several prior studies.

In 2000, Richardson compared student grades in an advanced physiology course between “experienced” students who had completed an elementary physiology course versus “naïve” students who did not have this prior experience. Scores

on both the pretest and posttest were not significantly different between prerequisite completers and noncompleters. Consistent with this, Wright *et al.* (2009) found that an organic chemistry prerequisite course had little impact on students' performance in a nonmajors introductory biochemistry course. Shaffer *et al.* (2016) conducted a study that challenged the assumption that content in prerequisite courses improves learning in later coursework across molecular biology and human anatomy science courses. The study examined the degree to which tested concepts had been covered in prerequisite courses. Compared to novel topics, there was no difference in scores between previously covered material and novel material. This suggests that covering topics in previous courses does not improve students' future performance. In a subsequent study, Shaffer *et al.* (2018) examined the impact of a prerequisite human physiology lecture course on a follow-up human physiology lab course and molecular pharmacology course. Findings revealed limited student performance gains in the subsequent courses despite the overlap in content coverage. These studies suggest that prerequisite knowledge may not impact students' performance in later courses as much as instructors often presume. This supports our findings that, even beyond undergraduate courses, nursing professionals continue to find the details in A&P prerequisites as irrelevant to their careers. As noted in the *Introduction*, A&P courses represent one of the more specifically career-oriented STEM prerequisites where we might expect to have the best chances of observing an alignment between content and careers. Given the lack of alignment we observed in this context, one wonders whether more dramatic misalignment might emerge for other STEM prerequisites that are less directly connected with students' future careers.

If growing bodies of research, and nursing professionals themselves, attribute detrimental impacts on patient care to a lack of representation among healthcare workers, and if we are teaching overwhelming amounts of content that further contributes to this lack of representation, a systemic reconsideration of content in prerequisite courses is not only recommended but essential. Given the potential consequences of excessive course content on the persistence of aspiring nurses, one may wonder why we, as a biology education research community, often overlook problems surrounding the breadth of content and detail in prerequisite courses. How can we choose content for prerequisite courses that fosters diversity in healthcare fields and in the broader STEM workforce? In this light, we invite instructors and researchers to reflect on the ways course content decisions may represent a persistent exclusionary practice in undergraduate STEM education that disadvantage students based on vast amounts of content that is disconnected from professional goals.

### Moving Away from the “Banking” Model of Education

If content coverage in prerequisite courses runs the risk of being exclusionary, unmemorable, and irrelevant, then who is responsible for determining course content goals, and how might this need to change? Why are science instructors often in the exclusive position of determining content goals when they may have little to no experience across the myriad of jobs that undergraduate STEM students eventually pursue? These questions may be linked to the work of Paulo Freire, a Brazilian educator and philosopher who founded and advocated for critical pedagogy

(Freire, 1970; Giroux *et al.*, 1989). Critical pedagogy is a teaching philosophy that invites educators to deliberately influence what knowledge is introduced in a classroom by centering the voices of those in less powerful positions, specifically students (Giroux *et al.*, 1989). Freire described that when educators choose to teach copious amounts of information, or “narrate”, without considering the perspectives of students who are absorbing such information, this reinforces systems of power and oppression (Freire, 1970). Freire describes this “banking” system of education as a system where...

*“Narration (with the teacher as narrator) leads the students to memorize mechanically the narrated content. Worse yet, it turns them into “containers”, into “receptacles” to be filled by the teacher. The more completely [the teacher] fills the receptacles, the better a teacher [they] are. The more meekly the receptacles permit themselves to be filled, the better students they are... This is the banking concept of education, in which the scope of action allowed to the students extends only as far as receiving, filing, and storing the deposits.” (Freire, 1970, p. 72)*

Freire proposed that one way toward liberation from this system of oppression involved educators learning through ongoing dialogue with their students. He posited that this action allows students to have agency over their learning. We realize that students may not always know what information will be useful to them in the future, but allowing space for them to dialogue about their experiences and what they value may support them in developing agency over parts of their education that could help align curricula with students' and working professionals' needs. Bernal-Munera (2023) called for a Freirean approach specifically in the pre-nursing curriculum at community colleges, suggesting that educators “reject the idea of teaching topics in isolation from the historical, social, cultural, and political phenomena that circumscribe students' lives” (Bernal-Munera, 2023, p. 44). This aligns with nurses in this study who described how the inclusion of real-life scenarios may be a more impactful teaching strategy to increase the relevance of A&P content to the nursing profession. Implementing what Freire refers to as *problem-posing curricula* (Freire 1970; Morales-Doyle, 2023; Salinas *et al.*, 2023) that center current social concerns in the context of science, such as healthcare disparities, may be one technique that draws a connection between aspiring nurses' lived experience and relevance of course material in memorable ways. Importantly, this may be an avenue that supports future healthcare professionals to advocate for change in reducing health disparities and increasing representation among healthcare providers.

Existing frameworks provide further guidance on what a Freirean approach might look like in practice. For example, Diekman *et al.* (2020) describe a “goal congruity” framework based on the idea that “individuals seek to enter and engage in roles that fulfill their valued goals.” Applying this analytical lens led to the discovery that many individuals, and especially women and minoritized individuals, valued communal goals (e.g., using their work to help others), but that students do not perceive such communal goals as central to many STEM fields (Boucher *et al.*, 2017). The researchers noted that “complementing lessons of STEM concepts and skills with specific ways that these abilities and knowledge can improve the quality of

lives or save lives can have great benefits for students” (Boucher *et al.*, 2017). Indeed, their studies suggested that emphasizing communal goals in STEM curricula can increase interest in STEM courses and STEM fields (Belanger *et al.*, 2017). Royse *et al.*'s (2020) investigation of student success in A&P courses further bolsters this recommendation. In finding that science identity most strongly predicted A&P grades, they suggest that “capturing who students believe themselves to be and to which communities they feel that they belong may be an efficacious avenue for motivating and retaining students” (Royse *et al.*, 2020, p. 294). Might it be that restructuring course content to emphasize connections to communal goals, which minoritized populations of students value (Boucher *et al.*, 2017), would increase learning and content retention in addition to interest and persistence?

### LIMITATIONS

The present study investigated the perspectives of a diverse group of 30 nursing professionals that completed nursing education at a community college on the west coast of the United States. This context was selected in anticipation that it would engage professionals who had navigated a common academic trajectory toward a nursing career. However, nursing programs and workplace responsibilities can differ within and between regions and job types. As such, the results reported here might not be generalizable beyond our specific context and geographic region. Further, we used only a small selection of publicly available A&P questions generated by HAPS to investigate nurses' current A&P knowledge. Although nurses in our study indicated that the questions mirrored similar content to their A&P classes, more detailed assessments would be needed to understand the full extent of nursing professionals' A&P content knowledge. Importantly, we did not assess nurses' A&P understanding immediately following their prerequisite courses. Therefore, we are unable to examine if information from these prerequisites was ever learned in the first place. We can assert, however, that all the nurses interviewed in this study succeeded at A&P to the extent that they earned admission into a nursing program. Perhaps most importantly, although we draw conclusions about content being exclusionary, we did not collect data from students who were unsuccessful in completing their A&P prerequisite courses. Considering the above, additional work is needed that warrants future investigation.

### FUTURE DIRECTIONS & CONCLUSIONS

This study points to the urgent need for new approaches to deciding what content is included in prerequisite courses, both for A&P courses and perhaps for all prerequisite and introductory courses in STEM more generally. Decisions about the content in prerequisite courses should ideally be guided by empirical studies that investigate the relevance of the content for students' future lives and careers and the extent to which students remember course content for any length of time. Collecting direct evidence of short-term and long-term content retention and relevance may seem daunting. However, our results raise concerns that failing to collect such evidence may be perpetuating longstanding inequities by excluding qualified individuals from certain career tracks. Given persistent disparities in student success and persistence in STEM (Seymour and

Hewitt, 1997; Seymour and Hunter, 2019), researchers should be motivated to undertake such lofty studies.

In calling for these future studies, we also seek to shift the lens away from including course content “just in case” it is needed by certain students (Rushby, 2006). For example, prerequisite A&P courses serve students pursuing many different careers and subdisciplines, such as radiologic technologist, physician assistant, dental hygienist, and more. Some contend that, even if certain content is not remembered or used by individuals in nursing, perhaps it is critical to include just in case it is needed by students pursuing another career track. However, this sidesteps the possibility that the content might also be unmemorable or unused by students entering those careers, and thus, similarly acting as an exclusionary force for those pathways as well. As such, we suggest shifting the burden of evidence to those that advocate for the inclusion of a particular content area in prerequisite courses, as opposed to including content based on untested assumptions surrounding its importance. This shift would be justified, given the potential for systemic exclusion from STEM or healthcare careers due to an unnecessary excess of content.

Short of collecting direct evidence regarding course content decisions as described above, numerous other steps might contribute to the development of less exclusionary and more evidence-based approaches to deciding prerequisite course content. Collecting comparable data sets to those in the present study, but from other prerequisite STEM courses, such as introductory biology, chemistry, physics, and math, could shed light on how we can better align undergraduate STEM content to reflect knowledge needed by students. Future work exploring faculty's perceptions of content in prerequisite courses would be a valuable contribution in examining what propels an overcommitment to content coverage. Recent work by Kraft *et al.* (2023) indicates that “contextual factors” (e.g., “being part of a course that runs in a series, standardized exams, the course textbook,” [p. 18]) are at the root of the pressure experienced by chemistry faculty to cover a wide breadth of content. The authors suggest that STEM instructors might be motivated to cover less content if provided with opportunities to navigate internal conflicts between their values as educators and the external pressures they experience (Kraft *et al.*, 2023).

Scholars in other fields have additionally suggested models of curriculum development that bring together current and former students, teaching faculty, and working professionals to collaboratively develop curricula meeting the needs of all stakeholders (Macik *et al.*, 2017). This could represent a more evidence-based approach compared with current models in biology education that predominantly center the viewpoints of faculty in curricular decisions (Michael *et al.*, 2009, 2017; AAAS, 2011; Michael & McFarland, 2020; Orr *et al.*, 2022).

Another area of exploration that would bring these findings full circle involves investigating the experiences of those individuals who do not persist in their desired academic and career pathways. This could involve, for example, interviewing individuals who aspired to nursing, but left the prenursing pathway during their prerequisite courses. Future studies would benefit from this exploration to more concretely examine how content is inequitable by those who have directly experienced this exclusion.

Finally, future work might explore the extent to which prerequisites represent an example of “discriminatory design” in undergraduate STEM. Michalec and Haferty (2022) investigated aspects of the premed pathway that represent discriminatory design, which they described as “the fashioning and fabrication of physical and social entities that can (intentionally or not) negatively affect particular groups of people, and in turn, sustain power and status differentials nested within social hierarchies” (Michalec and Haferty, 2022, p. 4). They identified discriminatory design in the curricular structure, among other parts, of the premed pathway (Michalec and Haferty, 2022). If similar conclusions are reached regarding the content coverage in STEM prerequisites, one may wonder, “Do we need introductory prerequisite courses at all?” What alternative mechanisms, instead of prerequisites, could be implemented to assist all students in higher education, irrespective of demographics, to gain the skills and knowledge needed to succeed in their futures?”

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