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Tensions between Depth and Breadth: An Exploratory Investigation of Chemistry Assistant Professors' Perspectives on Content Coverage

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Abstract

Content coverage is frequently identified by faculty as a barrier to the implementation of student-centered instructional strategies. This need to cover content may be a personal belief faculty hold and/or an external requirement imposed (or perceived to be) on them (e.g., by their department, institution, accreditors, etc.). Studies have shown improved learning outcomes for instructors that adhere to depth (as opposed to breadth) approaches. This study sought to characterize chemistry assistant professors' perspectives on content coverage and the reasoning supporting these perspectives. Nine chemistry assistant professors were interviewed, and constant comparative analysis was used to reveal patterns in faculty thinking. Most of the faculty participants appeared to lean to one side in "the debate" of content coverage and generally expressed that they were acting in the best interests of their students. For some their personal beliefs mainly drove their preference while for others, contextual factors contributed to their choice.

Introduction

Teaching and learning reforms in higher education have called for a shift toward student-centered learning. Despite this, university science, technology, engineering, and mathematics (STEM) faculty practices have been slow to change (Stains et al., 2018, Durham et al., 2017, Borrego et al., 2010, Henderson and Dancy, 2009). To address this slow uptake, studies have explored barriers and drivers that impact STEM faculty members' implementation of student-centered instructional strategies (e.g.,Shadle et al., 2017, Sturtevant and Wheeler, 2019). A common barrier to instructional reform raised in these studies is content coverage (Shadle et al., 2017, Andrews and Lemons, 2015, Michael, 2007, Turpen et al., 2016, Henderson and Dancy, 2007, Sturtevant and Wheeler, 2019). Content coverage refers to all of the material that instructors perceive they need to teach in a particular course. For example, a study conducted across 10 STEM departments at one institution reported that over half of the 169 faculty participants indicated instructional challenges, which includes content coverage, as the second most prominent barrier to implementing student-centered instructional strategies (Shadle et al., 2017). Similarly, a study of physics faculty found that nearly half of the 35 interviewees thought that the use of Peer Instruction (PI, Mazur, 1997) would make it difficult to cover the content they felt should be covered in a course (Turpen et al., 2016).

Tension exists surrounding the notion of content coverage, as there are conflicting views and influences on how it should be carried out. At the heart of discussions on content coverage is the so-called 'debate of depth versus breadth' where one must be chosen at the expense of the other (Schwartz et al., 2009). At one end of this debate, a breadth or "full coverage" approach is a "view that students are best served by encountering a great number of topics relevant to a particular science discipline" (Schwartz et al., 2009, p. 799). The way textbooks are written is an example of a breadth approach to content coverage, as they contain a wide array of content within a discipline. On the other side of the debate, a depth or "deep coverage" approach emphasizes that "there are certain fundamental concepts that are more important or beneficial to master than others and that spending focused time, at the expense of covering many other topics, is a far more productive strategy" (Schwartz et al., 2009, p. 799).

A depth approach built around a few core ideas is advocated for by The National Research Council in The Framework for K-12 Science Education(National Research Council, 2012b). Additionally, several reformed chemistry curricula in higher education have adopted a similar approach. Examples include Chemistry, Life, the Universe and Everything (CLUE, Cooper and Klymkowsky, 2013, National Research Council, 2012a) and Chemical Thinking (Talanquer and Pollard, 2010). The two primary reasons why these reformed chemistry curricula and The Framework for K-12 Science Education advocate for the depth approach are alignment with the theories on how people learn and the potential to enhance student outcomes.

The depth approach aligns with the theory on how people learn

The theory of constructivism posits that learners play an active role in integrating and connecting new knowledge into already existing knowledge frameworks inside their minds (Driscoll, 2005). Developing these frameworks is a critical goal for instruction as their structure (or lack thereof) affects one's ability to meaningfully learn new concepts. Indeed, studies have shown that experts have interconnected frameworks of knowledge that build off the principles or core ideas in their discipline whereas novices seem to have more isolated chunks of knowledge (National Research Council, 2000). When solving problems, experts are able to see more than the surface value of the words/figures and draw upon the underlying principles from their robust mental framework (National Research Council, 2000). The National Research Council's Framework cited this novice/expert difference in knowledge organization as one reason to structure the organization of content around core ideas (National Research Council, 2012b). Curricular depth can help students develop more organized, connected knowledge frameworks since reducing content allows for more focus on the selected concepts and the relationships between them. The focus on core ideas provides opportunities for deep exploration of important ideas and allows students the time to develop meaningful understanding, practice the science, and reflect upon it (National Research Council, 2012b).

The depth approach enhances students' outcomes

Studies that have investigated the relationships between approaches to content coverage (depth versus breadth) and student learning outcomes have demonstrated an advantage for the depth approach (Schwartz et al., 2009, Murdock, 2008, Luckie et al., 2012). For example, Schwartz and colleagues (Schwartz et al., 2009) surveyed over 8,000 students from 55 universities across the United States of America in introductory college STEM courses about their experience with content coverage of fundamental topics in high school science. They found that students who covered at least one topic in depth (defined as a month or longer in this study) in their high school science course achieved higher grades in introductory college science courses (Schwartz et al., 2009). This finding held true even when they controlled for differences in student background variables that could contribute to performance in a college science course (Schwartz et al., 2009). In contrast, this study found a breadth approach to be a significant disadvantage for biology student outcomes, and no advantage was reported for a breadth approach in either chemistry or physics (Schwartz et al., 2009). In addition, a study of physics high school students across 13 countries showed that in-depth coverage of physics topics (defined as the degree to which the curriculum focused on or emphasized a topic) throughout primary and secondary education lead to higher average achievement on an international physics assessment (Murdock, 2008).

The support for depth extends to the laboratory curriculum as seen in the findings of a ten-year study of a biology department's transition to an inquiry-based laboratory curriculum (Luckie et al., 2012). The findings of Luckie and colleagues support depth over breadth in content coverage specifically for developing a strong foundation of knowledge that students can draw upon in their future (Luckie et al., 2012). Relatedly, studies have compared chemistry student learning outcomes for traditional versus a reformed curricular approach which is centered around core concepts (Chemistry, Life, the Universe and Everything; CLUE) and have shown that students in the reformed courses have greater learning gains at both the high school and undergraduate levels (Stowe et al., 2019, Underwood et al., 2016, Cooper and Klymkowsky, 2013). Additionally, a comparison of American Chemical Society (ACS) exam scores from two groups of students taught by the same instructor, one group with a traditional curriculum and the other with a reformed curriculum that emphasized thinking about rather than knowing chemistry (Chemical Thinking), performed at the same level (Talanquer and Pollard, 2010). Taken together, these studies demonstrate that the depth approach leads to equal, if not enhanced student learning outcomes.

On the other end, a breadth approach has been reported to have no advantage to student learning and it has contributed to negative outcomes and loss of students in STEM fields (Schwartz et al., 2009, Seymour and Hunter, 2019). Referred to as 'problems with STEM curricular design' in Talking About Leaving Revisited, content overload, the pace of delivery, and poor alignment between course elements have contributed to the decision of many students to leave STEM majors (Seymour and Hunter, 2019). In fact, this problem has increased since their first report in 1997 and was cited as affecting both students who switched majors and those who persisted in STEM fields (Seymour and Hunter, 2019).

In summary, research has shown that a depth approach (reduction in content coverage with more focus on foundations/core concepts) results in greater student learning outcomes and retention compared to a breadth approach (the coverage of a wide range of topics/concepts/skills).

Influences on instructors' perspectives on content coverage

The Teacher-Centered Systemic Reform model (TCSR, Gess-Newsome et al., 2003) describes factors influencing faculty's teaching practices and was leveraged in this study to explore potential factors impacting faculty's perspective on the tension between depth and breadth approaches of content coverage. Broadly speaking these influences can be both concerning an individual personally and their perceptions of the environment/community (context) of which they are members.

The TCSR model identifies contextual factors as one category of influencers on teaching practices. Contextual factors include the structural and cultural contexts of both the local and global environments and communities in which faculty work. These include for example the greater community (e.g., professional organizations), institution, department, discipline/subject area, and classroom. As an example, a department-level factor that can have an impact on decision-making around content coverage could be the use of exams created by the American

Chemical Society (ACS) Examinations Institute. A national survey of chemistry departments' assessment efforts showed that two-thirds of the 1,120 departments that were required to engage in assessment efforts (such as preparing reports) used the ACS exams to fulfill this requirement (Emenike et al., 2013). Indeed, these exams were by far the most widely used assessment type (Emenike et al., 2013). ACS exams have been developed for each chemistry subdiscipline and are constructed by a committee of instructors who teach the course in that subdiscipline. The content coverage on these assessments thus reflects the content valued by expert chemists in the subdiscipline (Raker and Holme, 2013, Reed et al., 2017, Srinivasan et al., 2018). National norms are computed for each of these exams and students' performance in a course are reported based on these norms. Thus, for faculty members required to use these assessments, there can be pressure to demonstrate high performance. One way to pursue high performance is to ensure that every topic on the exam is addressed during the course. Indeed, standardized exams have been reported in the literature as influential to instructors' instructional decisions. For example, 35 physics faculty were asked to provide reasons for not aligning their instructional practices with Peer Instruction and almost a quarter of these faculty indicated that external requirements such as the Medical College Admission Test (MCAT) constrain their pedagogical choices as they feel pressure to cover content to prepare their students for this exam (Turpen et al., 2016). Another contextual factor linked to content coverage identified in this study was at the institutional level. A fifth of the interviewees expressed concern about using PI because of the institutional expectations of content coverage. For example, one physics faculty, who was implementing PI, mentioned that their colleagues advocated against the use of this strategy citing their observations that content coverage was limited in courses in which PI was implemented (Turpen et al., 2016).

A second factor within the TCSR model that affects faculty practices is teacher thinking. This includes knowledge and beliefs about teaching and learning (Gess-Newsome et al., 2003). One study indicated that faculty members' perspectives on content coverage might stem from personal beliefs they hold. Padilla and Garritz investigated the beliefs about teaching and learning of experienced chemistry faculty (20+ years of experience, Padilla and Garritz, 2015). They found that six out of the ten faculty interviewed placed a higher priority on the curriculum than on their students, meaning that the majority of these faculty valued getting through all of the material over focusing on students and their learning needs, whether that be to slow down, repeat, or skip some material (Padilla and Garritz, 2015). However, another study indicated that chemistry faculty members perceived depth as an essential component of conceptual understanding. Holme and colleagues' large-scale study involving nearly 1,400 general chemistry faculty sought to explore chemistry faculty members' definition of conceptual understanding (Holme et al., 2015). The consensus definition that emerged consisted of five constructs, the second most prevalent being depth with over 500 faculty expressing this view. They defined depth as "reason about core ideas using skills that go beyond mere rote memorization or algorithmic problem-solving" (Holme et al., 2015, p. 1480). This definition of depth implies both reduction of content by focusing on "core ideas" and understanding at a deeper level. These values align with the intentions behind student-centered instructional strategies and current curricular reforms in chemistry (Cooper et al., 2017, Talanquer and Pollard, 2010, Talanquer, 2016, Cooper and Klymkowsky, 2013) in that they all desire a conceptual understanding of fundamental (core) topics of the discipline.

There are thus various and perhaps conflicting influences on chemistry faculty members' decisions about the content coverage they employ in their courses. This study aimed to shed some light on these influences by explicitly probing chemistry assistant professors' perspectives on content coverage and the reasoning used to justify these perspectives. We focused on faculty in their early career stage since it provides a prime opportunity to investigate instructors' teacher thinking and practice as they are being established. The research question explored was:

> What are chemistry assistant professors' perspectives on content coverage and what reasoning do they use to support these perspectives?

Methods

The study design and participant recruitment were approved by the Institutional Review Board at the University of Nebraska-Lincoln (IRB Number: 20151115802 EX).

Participants

For this exploratory study, a convenience sampling approach was used. The research team had access to forty-seven chemistry assistant professors from higher education institutions in the United States of America, who had participated in a national pedagogical workshop(Baker et al., 2014) two and a half years before this data collection. The Corresponding author (M.S.) was the lead evaluator for this workshop. All forty-seven professors were invited to participate in the study. Nine agreed to participate. It is important to note that data saturation was not expected as this was a small, convenience sample. Each participant was assigned a numerical label and identifying information was removed from the data to protect participants' identities. Participant characteristics and course contexts are reported in Table 1.

Table 1. Participant Characteristics. G stands for a graduate-level course, UL for a lower-level undergraduate course, and UU for an upper-level undergraduate course. The chemistry subject taught reflects the course each participant taught at the time of data collection.

Participant ID	Year Teaching	Chemistry Subject Taught	Course Level	Institution Carnegie Classification
16201	3	Bioanalytical	G	Doctoral: Very High Research
16202	4	Inorganic	UL	Doctoral: Very High Research
16203	4	Biochemistry	UU	Doctoral/Professional Universities
16204	5	Biochemistry	UU	Master's: Larger Programs
16205	4	Analytical	UL	Doctoral: High Research
16208	5	General	UL	Doctoral: High Research
16209	3	Biochemistry	UU	Doctoral: Very High Research
16220	3	Organic	UL	Doctoral: Very High Research
16226	4	Analytical	UU	Master's: Larger Programs

Data collection and analysis

The faculty's perspectives on the debate were explored through interviews, which lasted about one hour. These interviews were collected as part of a larger study investigating faculty beliefs about teaching and contextual influences on their instructional practices(Popova et al., 2021, Popova et al., 2020). The interview protocol consisted of the Teaching Beliefs Interview(TBI, Luft and Roehrig, 2007) protocol and a set of self-developed questions. All questions were asked within the context of one particular course the participants were teaching at the time of data collection (see Table 1). For this study, we focused our analysis on questions within the interview protocol that probed interviewees' perspectives and reasoning behind their preference for depth versus breadth of content coverage:

1. In the classroom, how do you decide what to teach and what not to teach?
2. How do you decide not just what content to teach, but how you teach that content?
3. How do you decide when to move on to a new topic in your classroom?
4. Do you generally keep to that schedule (as outlined in your syllabus)?
5. Which scenario is worse: getting through all of the topics while only a minority of students understand them or getting through only some of the topics while a majority of students understand them?

The scenario (question 5), which was inspired by another study(Padilla and Garritz, 2015), makes explicit to faculty members the outcome of each approach on student learning and forces the interviewees to place themselves on the depth-breadth spectrum. The additional four questions were part of the TBI protocol and were presented earlier in the interview protocol before the scenario. They were used to triangulate and compare the consistency of interviewees' thinking and reasoning across their responses to the presented scenario and their description of content coverage in their course. The interviews were audio-recorded, transcribed verbatim using Temi.com, and checked for accuracy.

The interview protocol utilized in this study had already been employed in a previous study. The first (A.K.) and second (M.P.) authors had leveraged data collected in this previous study to develop an initial coding scheme for question 5 above. In this initial coding scheme, the themes were the faculty members' general perspectives to the question 5 scenario (breadth or depth) as the question was phrased to place them on the depth-breadth spectrum (Table S1). However, emphasis was paid to the categories (groupings of related codes that share a broader idea) within each theme as these explain the reasoning behind their views (i.e., the "why"). This initial scheme was used by the first (A.K.) and fifth (M.S.) authors to conduct the first round of independent coding of all interviews collected for this study across all five questions. Upon review and discussions of this initial round of coding, the research team made two significant changes. First, they found that a new perspective was described in this data set, which had not been identified in the previous data set. This new perspective was labeled *Theoretically depth, but in practice breadth*, in which faculty members expressed some value of depth followed by statements such as "but" or "however" with rationale of why that wasn't the practice they used in their courses (Table S2). Second, questions 1-4 provided more insight into the reasoning faculty provided for their perspective on the scenario (question 5 above) as well as the reasoning behind their approach to content coverage in their own courses. A new section of the codebook was created to capture these reasoning (Table S3). This new section was organized by overall factors influencing their perspective (i.e., individual and contextual) and the sources of reasoning within these factors.

The following aspects of our analytical approach contribute to the trustworthiness of the results and findings from this study. A detailed description of the context, participants, and data collection is provided to ensure transferability of the work. Throughout the analytical process, members of the research team engaged, independently and together, in critical reflections of the data set and the emerging coding schemes thereby contributing to the credibility of the findings. Data was reviewed and analyzed in an iterative process involving multiple cycles of independent coding of responses followed by discussions between the first and fifth authors. Through this iterative consensus-making process, 100% inter-rater agreement was achieved on the coding for each participant and categorization of reasoning (Creswell and Poth, 2018). These steps contribute to the confirmability of the work presented here.

Results

Depth-Breadth two-dimensional spectrum

Four different perspectives emerged from the analysis of the interviews (see Figure 1 and Table S2). We divided these four perspectives along two continua: individual preference on content coverage and content coverage in practice.

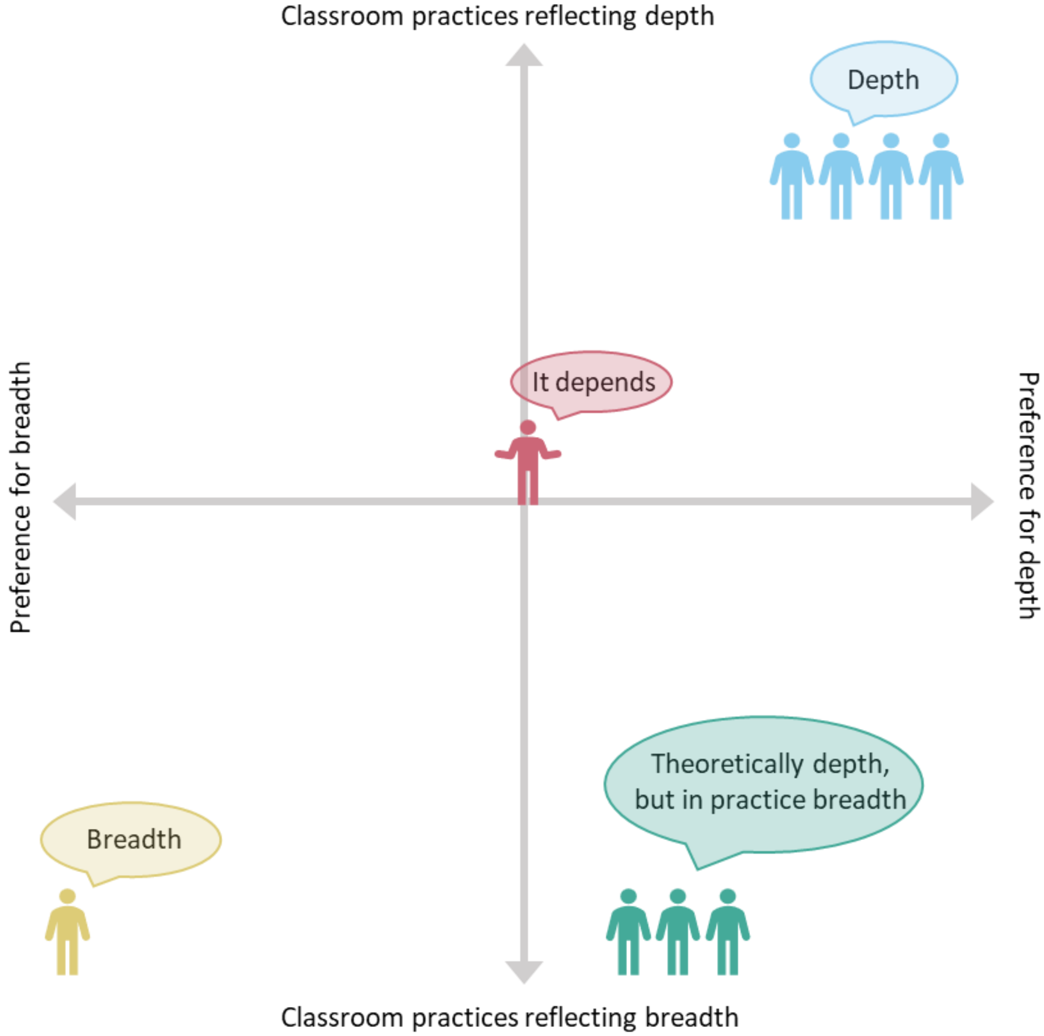

Figure 1. Content coverage quadrant showcasing chemistry assistant professors' perspectives and expressed practices on content coverage

Table 2 summarizes the faculty's reasoning behind each perspective (see Table S4 for representative quotes for each reasoning). The sections below introduce each perspective and describe the associated reasoning.

Table 2. Chemistry assistant professors' reasoning that supports their perspective on content coverage

Type of factor	Source of reasoning	Description of reasoning	Breadth (n = 1)	Theoretically depth, but in practice breadth (n = 3)	It depends (n = 1)	Depth (n = 4)
Individual	Conception of Breadth	Students will get bored if covering a minority of topics therefore need to cover topics quickly	1			
	Conception of Depth	Focus on core/foundational topics		1		3
		Students get lost in breadth coverage without depth, therefore there is no point to it		1		3
		Application of core/foundation material			1	3
		Adjusted pace based on students not the syllabus/schedule				3
		Emphasis on application of material		1		1
		Focus on why content is important		1		1
	Personal considerations	Reflected on their own learning, how they were taught, or observation of others teaching of the subject			1	2
		Felt need to add introductions to additional content to prepare students for research in graduate school/their career		2		
		Expressed tension in what the instructor wants students to understand versus the content the instructor anticipated to cover				1
Contextual	External Pressure	Syllabus dictates the content that has to be covered	1	2		
		Felt expectation of content coverage based on course series (ex. Gen Chem 1 & 2)		2		
		Expectation of content coverage in course based on textbook chapters and/or instructor relies on textbook for pace of content		1	1	
		Have to cover what is on the ACS exam		1		
	Department	Felt pressure from senior colleagues to cover topics		2		
	Course Level	Perspective varied between course level taught (i.e., undergraduate vs. graduate)			1	
	Structure of Course	Aimed for alignment of content between lecture and lab				2

	Shared schedule and exams for all sections of course	1

Depth is more important than breadth

Four faculty members indicated preferring a *Depth* approach when presented with the scenario. Common reasoning for this perspective was the need to provide students with adequate foundational knowledge and skills to support students' learning and experiences with future concepts within the same course or in future courses (see Table 2 and see Table S5 for coding breakdown by participant). For these faculty members, the characteristic of an adequate foundational knowledge and skills was one that focused on core concepts and/or skills. Participant 16204 best embodied these reasoning:

> *"I'm hoping that those core concepts that we've covered, when they [students] have to encounter that material that we missed, that because they've internalized that hopefully they can apply that learning to the new scenario. Whereas if we just have blanket coverage, I'm afraid that the learning is clearly more scattered and superficial overall, most students didn't get it. And then it doesn't seem like it really matters to me that we had that coverage if no one understood what was going on and didn't retain it at all after the semester is over." [P#16204, Q1]*

Triangulation of responses between the scenario and the other interview questions that focused on faculty members' description of content coverage in their course provided for a deeper insight into faculty thinking. Three of the four faculty members who indicated *Depth* in the scenario question also indicated that they alter their schedule on their syllabus to accommodate for student learning and understanding of the material. In other words, they would slow down and be comfortable skipping topics; topics skipped were often those planned near the end of the semester. They placed their value on students' understanding rather than on the teaching of as many topics as possible. The following quote from participant 16204's answer to the question about how they decide to move on to a new topic in their course further demonstrated their preference for depth of content coverage:

> *"So usually I've already decided like what I want to cover and then the amount of time that it takes to do that is the amount of time that it takes… there's some room [in the syllabus] for things to be a little bit longer, a little bit shorter, which can just be dependent on the group of students. And if there's something that's particularly like confusing, I would rather stop and make sure that they get that sorted out before we move on, versus just pushing through the material to push through the material." [P#16204, Q3]*

While the primary reasoning from this group stemmed from the individuals themselves, they were not exempt from contextual influences. For two faculty members (16201 & 16204), their department's discussions of the curriculum had some influence on the content they taught:

> *"So broadly speaking, some of the major topics we talk about as a department or at least as a biochemistry subdivision about what we want to cover and then there's some wiggle room I guess beyond that."* [*P#16204, Q1*]

The two other *Depth* faculty members (16202 & 16205) generally aimed to align content between their lecture and the associated laboratory schedule:

> *"There's also an associated lab course to the class, so I do have to kind of keep track to make sure the topics being covered in lecture are relevant to the lab." [P#16202, Q3]*

One *Depth* faculty member even explicitly recognized that it was a struggle for them to balance their target for content coverage while ensuring students were learning:

> *"I still feel like... I want to cover more, but I want them to understand more. So I feel like sometimes I'm personally challenged by figuring out what, what we should really make sure they understand versus what I had anticipated to get through by the end of this past year." [P#16205, Q1]*

Overall, the *Depth* faculty members mentioned some parameters they were working under, yet student understanding was their personal priority and, therefore, they chose a *Depth* approach in their courses.

Theoretically depth, but in practice breadth

Three faculty members indicated that although depth was their preferred perspective in theory, when it came to implementation they followed a breadth approach. Similar to the previous group of interviewees who indicated a preference for depth, these faculty members also emphasized the desire for students to succeed in their future as a reason behind their perspective. However, their thinking of student success was defined by external expectations such as preparing students for the second course in a series (e.g., General Chemistry I and II), following the textbook, and ACS exams. These faculty members expressed the need to cover everything and that topics could not be skipped. These external pressures imposed a breadth approach to content coverage. Participant 16209 illustrates the pressure for preparing their students for the next course in the series:

> *"The first one [breadth scenario] would be worse if we're just throw, you know, flying through the material, but nobody's getting it; we're not teaching. However, like I was mentioning before, because I teach the first semester of a two-semester series, I do feel some pressure to make sure that the students aren't going to be behind when they start the next semester." [P#16209, Q1]*

In addition to pressure related to a course series, Participant 16220 identified the textbook as well as university description of the course in their response to how they decide what to teach and what not to teach in their course:

> *"The syllabus is pretty much standard. Um, so we'll have certain content that we need to teach the class. Right. Um, so it's pretty much determined by that. I've acquired lecture notes from previous instructors just to get a sense of what are things that are important and how much leeway do I have in terms of incorporating new knowledge… Um, but I still try to stick to this textbook that we use, um, finish the first 14 chapters because it's the first semester to second semester, right. So it's pretty much determined by the scope the class that the school defines, but I try to incorporate some new stuff in there as well." [P#16220, Q2]*

The following quote from participant 16226's response to the same question further demonstrated their description of breadth in their practice because of the use of ACS exams:

> *"So that's just based on the ACS exam, so there are certain topics that they require to teach so we just follow it. And then I talk to other senior faculty in our department all from the same division and then they say, oh yeah, so there are certain topics that um it is a must, so we have to cover all the topics." [P#16226, Q2]*

Interestingly, in addition to external pressure felt to cover content, two participants (16226 and 16220) in this group mentioned adding more topics to their course in order to prepare students for research/graduate school. For example, participant 16226 responded to question 4 in the interview protocol in the following way: *"Of course I will give them some other introductions about the modern techniques, for example Raman spectroscopy, which are not covered in ACS, but they're used a lot in research."*

This group of faculty members thinks differently about depth because their perspectives, contrary to those from the *Depth* group, do not align with the definition of a depth approach to content coverage described in the literature. While the majority of the faculty members with a *Depth* view were focused on developing core concepts and/or skills needed for students to be successful in current and future courses, only Participant 16226 from the *Theoretically depth, but in practice breadth group* had this view. Participant 16220 expressed another view of depth in wanting to “make it a story”, make connections, and explain why the content is important. The last participant in this category, 16209, did not elaborate extensively in their interview to capture their thinking of depth.

This group displays some tension in individually wanting depth and understanding for their students (though not as robustly expressed as it was by the *Depth* group), but external pressures and expectations seem to have a larger influence in the content coverage in their courses.

Breadth is more important than depth

One faculty member chose *Breadth* as their approach to content coverage. Their thinking behind this perspective appears to be a combination of an external constraint as well as a personal belief (Table 2). Participant 16208 points to shared exams (external constraint) and the belief that a quick pace of content coverage is necessary to keep the students engaged:

> *“Yeah, so I'm kind of in a bind. I can't get through a minority of topics because we have shared exams. And so in the case of shared exams, I have to get through the majority of the topics even if a minority of students understand them. I think also that, uh, instructors tend to think that they are very useful when lecturing, but I don't think that that's true. I think that students tend to learn what they need to from the books and from each other. And so covering the topics quickly is better because most of the students will get bored if you are covering a minority of topics I guess.” [P#16208, Q1]*

Similar to those coded as *Theoretically depth, but in practice breadth,* Participant 16208 described their practice as focused on content rather than students in their response to the question about how they decide when to move onto a new topic in their course:

> *“Um, when I've covered it, [chuckles] I don't know. I think I just I get to the end of the material that I have for that and I keep going. And at this point, I know like what day I have to end so, I guess I stick to a schedule. I don't stick to students and their need to stay on the topic. I stick to the schedule and what we have to cover. So it's, it's schedule-led not student-led.” [P#16208, Q3]*

It depends

Finally, one faculty member chose *It depends* as their approach to content coverage. Their explanation was based on the different needs of students in different types of courses:

"It should be the latter one, the majority of students should understand, but maybe it depends on the setting. I think in the lecture class, uh, that's what I'd pick, but the undergraduate and graduate and those more specialized topic versus broader topic, it varies. I think my baseline is majority of them understand … graduate course sometimes I'm fine to push them and if they don't study, it is their responsibility at that point. And so I believe baseline still most of them can understand… I don't think my intention is left someone behind, but I try not to give opportunity for someone to go far, far, far ahead … I mean undergraduate course in principle I do feel in the same way, but in reality I can't really find very good way to make this happen. There is no efficient way to make that happen. I think reading textbook it's one of the things I push, but uh, it's not very easy." [P #16203, Q1]

Participant 16203's response to how they decide what to teach and what not to teach provided more insight into their thinking in that they base content selection heavily on their own experience as well as thinking of connections to subsequent material using the textbook as their pacemaker:

"I think it's based on my experience. And if I have never heard about it, it's maybe too much… I would say each chapter, if I'm covering 80% I'm probably okay, if I feel I taught less than 50% probably I have to study. So I use the textbook as my pacemaker and other part if I never heard about it up to this point, I tend to lower the priority I would read and rethink. But most of the time I think my experience is affecting quite a bit. Another consideration is if we need that idea, to understand other chapters, so if we need that little bit of that topic in other chapters obviously they have to cover. So connection with subsequent chapters. Uh, so it's some way subjective [and] someway objective and uh another part is a correlation, an alignment with other course… It's, it's very much my decision." [P#16203, Q2]

Discussion and implications

Prior research has shown that STEM faculty members often point to the need to cover content as a reason for not integrating more student-centered instructional strategies into their teaching (Shadle et al., 2017, Andrews and Lemons, 2015, Michael, 2007, Turpen et al., 2016, Sturtevant and Wheeler, 2019, Henderson and Dancy, 2007). Yet, few studies have focused on characterizing STEM faculty members' perspectives on content coverage. It is thus challenging to address productively this perceived barrier in a professional development setting without a better understanding of faculty members' approach and reasoning on content coverage. This study is one of the few to date that aim to provide such insight. Analysis of the interviews conducted with nine instructors revealed four different perspectives on content coverage and variation in the factors influencing these perspectives.

The majority of the faculty members valued the *Depth* approach. However, not all faculty members described this approach in a similar manner. Faculty members within the *Depth* group focused their description on the need for students to master core concepts and skills; this description is in alignment with the literature. However, faculty members within the *Theoretically depth, but in practice breadth* group had different descriptions, including one with equating depth with structuring content as a story. Depth is also measured in different ways in the literature (see introduction). These mixed descriptions and ways of measuring a depth approach clearly highlight the need for the community to better operationalize its meaning. One of the anonymous reviewers for this manuscript (Reviewer 2) raised these interesting questions: "What does it mean to teach a topic or an idea 'in depth'? Is dedicating more time to teaching a topic equivalent to teaching it 'more in depth'? Is organizing a course around a core set of central ideas equivalent or enough to ensure that we are teaching more 'in depth'?" Further exploring the various approaches and understanding of a depth approach from the perspective of faculty members, curriculum developers, and discipline-based education researchers) is essential to help propagate this approach and characterize its impact on students.

Faculty members who aligned with a *Depth* approach were primarily driven to this perspective by their personal belief that students will be more successful in their current and future courses if they master a set of core concepts and skills. The thinking of these faculty members aligns with research on how students learn and instructional reforms, which advocate for the understanding of fewer, core concepts (Schwartz et al., 2009, Murdock, 2008, Luckie et al., 2012, Dewsbury et al., 2022). Contextual factors, although experienced by some of these faculty members, were not strong enough to influence their preference for and use of a *Depth* approach in their courses. The role of personal belief in their preference for the *Depth* approach aligns with prior research, which had shown that faculty members' perspectives on content coverage may be seen as a personal belief (Padilla and Garritz, 2015, Turpen et al., 2016). However, contextual factors overshadowed personal beliefs on content coverage and determined the approach to content coverage for the group of faculty members classified as *Theoretically depth, but in practice breadth*. These faculty members indicated valuing depth, but felt constrained to use a *Breadth* approach in their courses. Contextual constraints they experienced included being part of a course that runs in a series, standardized exams (i.e., ACS), the course textbook, as well as the type of course (i.e., undergraduate versus graduate-level course). Taken together, these findings demonstrate the importance of characterizing contextual influences while investigating faculty members' thinking about teaching, in this case, the approach to content coverage. This is in line with the TCSR model which highlights that context impacts both instructor's thinking and practice (Gess-Newsome et al., 2003).

Faculty participants in this study felt direct and indirect expectations for content coverage from various chemistry communities: textbook authors, ACS exam authors, and colleagues within their own department. Overwhelmingly, the faculty members in this study felt that these entities pressured them to take on a breadth approach to the content coverage in their courses. Whether this is actually the intention of all of these entities is unclear. However, this study illustrates that this is how faculty members perceive these pressures. In order to enhance student learning in chemistry courses, chemistry faculty members could benefit from having conversations about the undergraduate chemistry curriculum with colleagues in their chemistry departments, across institutions, and within chemistry professional organizations. These conversations should be informed by the latest research on how students learn, and thus should focus on a depth approach to the curriculum. An initiative in the United States of America provides a model for how such conversations could be organized and the impact they could have. The American Association for the Advancement of Science with support from the National Science Foundation organized a series of conversations around the curriculum in undergraduate biology. These conversations included administrators, faculty members, students, and other stakeholders. This work led to the identification of a set of core biology concepts and science practices that all science students should master. These core sets of concepts and skills were published in a report called *Vision and Change: A Call for Action (American Association for the Advancement of Science, 2011)*. Since its publication, this report has been used as a guide for curricular transformation (Aguirre et al., 2013, MuSante, 2013, Branchaw et al., 2020). One could envision that a similar endeavor could be undertaken in chemistry. A report such as this could then drive the content that textbook authors and exam developers prioritize. A shift in the approach to content in textbooks and standardized exams would influence faculty members' perspectives and approach to content coverage in their courses, as we saw these external pressures had greater influence when it came to some faculty members expressed classroom practices.

The results of this study can inform and assist professional development facilitators to better craft their sessions to help faculty recognize and work through any dissonance/tension they may hold and confront reasonings, especially contextual factors, behind this need for content coverage and the effects it may have on student learning. Our findings show that personal values and beliefs seem to guide faculty members' decisions in the classroom rather than evidence from educational research or assessment results from their students. This is in alignment with prior studies which have shown that instructors' decision making and instructional practices are derived from personal empiricism (Andrews and Lemons, 2015).

As this was an exploratory study further research should investigate chemistry faculty members' perspectives of content coverage and factors (such as those indicated in the TCSR Model) that may influence faculty members' thinking and practices with a larger, more diverse sample (in particular, investigating a specific sub-discipline of faculty or those teaching the same course). It would also be interesting to explore more seasoned instructors and compare their rationale for their choice of content coverage approach to those more novice instructors that were the sample in this study. Additionally, exploring the extent to which evidence (be that from educational research, action research conducted by the faculty members themselves in their courses, or engagement within their department in developing learning outcomes for courses and an academic program) contribute to or guide faculty members' decisions about content coverage. The findings from such studies will help researchers and professional development facilitators understand faculty members' perspectives on content coverage and assist them in overcoming this content coverage barrier to the implementation of student-centered instructional strategies. Instructors experiencing the tension between the need to cover content and the desire to promote student learning of core concepts can leverage a recent study that provides strategies to address and overcome this when implementing student-centered instructional strategies (Petersen et al., 2020).

Limitations

As emphasized in the title, this was an exploratory investigation of chemistry assistant professors' perspectives on content coverage. Identifying patterns in faculty members' thinking was limited due to the sample size and composition as all were from research institutions. A second potential limitation of this study might be that participation in the workshop may have had an impact on faculty members' beliefs. However, there was no direct programming addressing the tension of content coverage. Moreover, the data for this study was collected two and a half years after participation, so we believe that the beliefs were representative of the faculty members' views at the time of data collection. As these faculty members voluntarily participated in the aforementioned workshop, they may not reflect the broader population of chemistry assistant professors. Thus, we do not claim the generalizability of these findings to chemistry faculty members as a whole. In addition, faculty members' practices and student learning outcomes were outside the scope of this study, but further research should be conducted for a deeper insight into the intersection between chemistry faculty members' beliefs and practices concerning content coverage.

Authors' contributions:

The first and fifth authors conducted data analysis and drafted the manuscript.

The second author conducted the interviews and helped with the development of a coding rubric to analyze the data.

The third and fourth authors contributed the scenario question to the interview protocol.

The second, third, and fourth authors provided edits on drafts of the manuscript.

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Appendices

Table S1 – Initial codebook

Indicated perspective	Description of reasoning
Breadth	Particular course restraint with mixture of students – wanting to provide a proper foundation for students who will work in the field
It Depends	Context dependent (course level undergraduate or graduate)
Depth	Concern for students' future *-Focus on foundations for students to apply in future* *-Breadth focus sets students up for failure* Student learning is instructor responsibility Concern for students' learning *-Need to balance student level of understanding "poor" vs. "strong"* *-Don't want to overwhelm students, leaving them feeling lost/didn't learn anything* Constraints on content coverage (Culture of department/institution) Feeling uneasy about leaving students behind No clear explanation

Table S2 – Chemistry assistant professors' perspectives on content coverage

Perspective on content coverage	Participants, *n*	Subject and course level taught
Depth is more important than breadth	4	Bioanalytical - Graduate Inorganic – Lower Undergraduate Analytical – Lower Undergraduate Biochemistry - Upper Undergraduate
Theoretically depth, but in practice breadth	3	Biochemistry - Upper Undergraduate Organic – Lower Undergraduate Analytical - Upper Undergraduate
Breadth is more important than depth	1	General Chemistry – Lower Undergraduate
It depends	1	Biochemistry - Upper Undergraduate

Table S3 – Final codebook section on factors and reasoning behind faculty's perspectives on the depth-breadth spectrum

Type of factor	Source of reasoning	Description of reasoning
Individual	Conception of Breadth	Students will get bored if covering a minority of topics therefore need to cover topics quickly
	Conception of Depth	Focus on core/foundational topics
		Students get lost in breadth coverage without depth, therefore there is no point to it
		Application of core/foundation material
		Adjusted pace based on students not the syllabus/schedule
		Emphasis on application of material
		Focus on why content is important
	Personal considerations	Reflected on their own learning, how they were taught, or observation of others teaching of the subject
		Felt need to add introductions to additional content to prepare students for research in graduate school/their career
		Expressed tension in what the instructor wants students to understand versus the content the instructor anticipated to cover
Contextual	External Pressure	Syllabus dictates the content that has to be covered
		Felt expectation of content coverage based on course series (ex. Gen Chem 1 & 2)
		Expectation of content coverage in course based on textbook chapters and/or instructor relies on textbook for pace of content
		Have to cover what is on the ACS exam
	Department	Felt pressure from senior colleagues to cover topics
	Course Level	Perspective varied between course level taught (i.e. undergraduate vs. graduate)
	Structure of Course	Aimed for alignment of content between lecture and lab
		Shared schedule and exams for all sections of course

Table S4 – Representative quotes for chemistry assistant professors' reasoning that supports their perspective on content coverage

Source of reasoning	Description of reasoning	Quote
Conception of Breadth	Students will get bored if covering a minority of topics therefore need to cover topics quickly	"I think also that instructors tend to think that they are very useful when lecturing, but I don't think that that's true. I think that students tend to learn what they need to from the books and from each other. And so covering the topics quickly is better because most of the students will get bored if you are covering a minority of topics I guess." 16208
Conception of Depth	Focus on core/foundational topics	"Well, so particularly for this class, a lot of the topics we cover is, as I already mentioned, some of them are an extension of Gen chem, but a lot of the other topics are things that they will need to move into their future classes and be successful. Um, and so even if we cover less, making sure that they have a very firm understanding of those topics should assist them as they move into their more, um, like their higher level chemistry courses." 16205
	Students get lost in breadth coverage without depth, therefore there is no point to it	"The first one would be worse [*scenario*]. if we're just throwing, you know, flying through the material, but nobody's getting it, we're not teaching." 16209
	Application of core/foundation material	"These ideas like equilibrium activity, acid base chemistry because they are so prominent in the rest of the curriculum as well that I think it's extremely important that they have a good foundation in them. So they may have gotten a brief intro in gen chem, but they really need to be able to utilize these concepts, these ideas both in my class and as they take things like biochem, organic chemistry, et cetera." 16205
	Adjusted pace based on students not the syllabus/schedule	"I will say my schedule was pretty broad. It was like week one slash two this topic, week three slash four this topic … I probably kept to it reasonably well though I did get behind at the end of the semester again, because I saw that there was challenges, understanding certain equilibrium topics that I wanted to make sure we're clear."16205
	Emphasis on application of material	"We still think the learning, especially for a graduate level course, for learning it should be have a function or application. If you just learn the knowledge but without using it, I think it's useless." 16201
	Focus on why content is important	"I'm trying to fit in with what we decided the core curriculum should be, but then also to connect not only to, like I said, organic chemistry, but also other, um, I think topics to help students understand why metabolism is important to learn about or why it might be interesting to their day to day life, things like that." 16204
Personal considerations	Reflected on their own learning, how they were taught, or observation of others teaching of the subject	"So I think I reflect on probably how I was taught those subjects or classes that I've observed, how they were taught there. And I'm trying to reflect on that. And then since this class is the third time I've taught it, I also have taken, you know, notes every semester and try to reflect on things that worked, things that didn't work and trying to continually update and refine things. Um, so that, I think that we're continuing to hopefully improve the course for the students." 16204

Source of reasoning	Description of reasoning	Quote
	Felt need to add introductions to additional content to prepare students for research in graduate school/their career	"I still try to stick to, you know, we have this textbook that we use, um, [inaudible] finish the first 14 chapters because it's the first semester to second semester, right. So it's pretty much determined by, the scope the class that the school defines, but I try to incorporate um, some new stuff in there as well." 16220
	Expressed tension in what the instructor wants students to understand versus the content the instructor anticipated to cover	"I still feel like... I want to cover more, but I want them to understand more. So I feel like sometimes I'm personally challenged by figuring out what, what we should really make sure they understand versus what I had anticipated to get through by the end of this past year." 16205
External Pressure	Syllabus dictates the content that has to be covered	"I guess I stick to a schedule. I don't stick to students and their need to stay on the topic. I stick to the schedule and what we have to cover. So it's, it's schedule-led not student-led." 16208
	Felt expectation of content coverage based on course series (ex. Gen Chem 1 & 2)	"I won't skip any chapters, um, for this class because I think everything is important. Um, especially when you have a second semester to take, if you miss one chapter it's gonna probably cause some issues in second semester, um, or even down the line, in the class. Um, so what I'll try to do is we have some, uh, I, I would intentionally leave out things and then I will have, we have review sessions, so I'll have my TA cover that in the review session." 16220
	Expectation of content coverage in course based on textbook chapters and/or instructor relies on textbook for pace of content	"The syllabus is pretty much standard. Um, so we'll have certain content that we need to teach the class. Right. Um, so it's pretty much determined by that. I've acquired lecture notes from previous instructors just to get a sense of what are things that are important and how much leeway do I have in terms of incorporating new knowledge… Um, but I still try to stick to this textbook that we use, um, finish the first 14 chapters because it's the first semester to second semester, right. So it's pretty much determined by the scope the class that the school defines, but I try to incorporate some new stuff in there as well." 16220
	Have to cover what is on the ACS exam	"So that's just based on the ACS exam, so there are certain topics that they require to teach so we just follow it. And then I talk to other senior faculty in our department all from the same division and then they say, oh yeah, so there are certain topics that um it is a must, so we have to cover all the topics." 16226
Department	Felt pressure from senior colleagues to cover topics	"Based on, uh, the ACS exam so there are certain topics that they require to teach so we just follow it. And then, uh, I talk to other senior faculty in our department all from the same division and then they say, oh yeah, so there are certain topics that um it is a must, so we have to cover all the topics." 16226
Course Level	Perspective varied between course level taught (i.e. undergraduate vs. graduate)	"It should be the latter one, the majority of students should understand, but maybe it depends on the setting. I think in the lecture class, uh, that's what I'd pick, but the undergraduate and graduate and those more specialized topic versus broader topic, it varies." 16203
Structure of Course	Aimed for alignment of content between lecture and lab	"In class I also tried to align some of those lab topics with class, like timing. Um, so I'd say that's another thing I kept thinking about throughout the semester. Like how much time do we spend on each topic. I was trying to align it with what was being covered in the lab simultaneously." 16205

Source of reasoning	Description of reasoning	Quote
	Shared schedule and exams for all sections of course	“Yeah, so I'm kind of in a bind. I can't get through a minority of topics because we have shared exams. And so in the case of shared exams, I have to get through the majority of the topics even if a minority of students understand them.” 16208

Table S5 – Chemistry assistant professors' reasoning that supports their perspective on content coverage

Type of factor	Source of reasoning	Description of reasoning	Breadth (*n* = 1)	Theoretically depth, but in practice breadth (*n* = 3)	It depends (*n* = 1)	Depth (*n* = 4)
Individual	Conception of Breadth	Students will get bored if covering a minority of topics therefore need to cover topics quickly	16208			
	Conception of Depth	Focus on core/foundational topics		16226		16202 16204 16205
		Students get lost in breadth coverage without depth, therefore there is no point to it		16209		16201 16202 16204
		Application of core/foundation material			16203	16202 16204 16205
		Adjusted pace based on students not the syllabus/schedule				16202 16204 16205
		Emphasis on application of material		1626		16201
		Focus on why content is important		16220		16204
	Personal considerations	Reflected on their own learning, how they were taught, or observation of others teaching of the subject			16203	16201 16204
		Felt need to add introductions to additional content to prepare students for research in graduate school/their career		16220 16226		
		Expressed tension in what the instructor wants students to understand versus the content the instructor anticipated to cover				16205
Contextual	External Pressure	Syllabus dictates the content that has to be covered	16208	16220 16226		
		Felt expectation of content coverage based on course series (ex. Gen Chem 1 & 2)		16209 16220		
		Expectation of content coverage in course based on textbook chapters and/or instructor relies on textbook for pace of content		16220	16203	
		Have to cover what is on the ACS exam		16226		
	Department	Felt pressure from senior colleagues to cover topics		16226		

Type of factor	**Source of reasoning**	**Description of reasoning**	**Breadth** (*n* = 1)	**Theoretically depth, but in practice breadth** (*n* = 3)	**It depends** (*n* = 1)	**Depth** (*n* = 4)
	Course Level	Perspective varied between course level taught (i.e., undergraduate vs. graduate)			16203	
	Structure of Course	Aimed for alignment of content between lecture and lab				16202 16205
		Shared schedule and exams for all sections of course	16208			

Appendices

Table S1 – Initial codebook

Indicated perspective	Description of reasoning
Breadth	Particular course restraint with mixture of students – wanting to provide a proper foundation for students who will work in the field
It Depends	Context dependent (course level undergraduate or graduate)
Depth	Concern for students' future *-Focus on foundations for students to apply in future* *-Breadth focus sets students up for failure* Student learning is instructor responsibility Concern for students' learning *-Need to balance student level of understanding "poor" vs. "strong"* *-Don't want to overwhelm students, leaving them feeling lost/didn't learn anything* Constraints on content coverage (Culture of department/institution) Feeling uneasy about leaving students behind No clear explanation

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Theoretically depth, but in practice breadth	3	Biochemistry - Upper Undergraduate Organic – Lower Undergraduate Analytical - Upper Undergraduate
Breadth is more important than depth	1	General Chemistry – Lower Undergraduate
It depends	1	Biochemistry - Upper Undergraduate

Table S3 – Final codebook section on factors and reasoning behind faculty's perspectives on the depth-breadth spectrum

Type of factor	Source of reasoning	Description of reasoning
Individual	Conception of Breadth	Students will get bored if covering a minority of topics therefore need to cover topics quickly
	Conception of Depth	Focus on core/foundational topics
		Students get lost in breadth coverage without depth, therefore there is no point to it
		Application of core/foundation material
		Adjusted pace based on students not the syllabus/schedule
		Emphasis on application of material
		Focus on why content is important
	Personal considerations	Reflected on their own learning, how they were taught, or observation of others teaching of the subject
		Felt need to add introductions to additional content to prepare students for research in graduate school/their career
		Expressed tension in what the instructor wants students to understand versus the content the instructor anticipated to cover
Contextual	External Pressure	Syllabus dictates the content that has to be covered
		Felt expectation of content coverage based on course series (ex. Gen Chem 1 & 2)
		Expectation of content coverage in course based on textbook chapters and/or instructor relies on textbook for pace of content
		Have to cover what is on the ACS exam
	Department	Felt pressure from senior colleagues to cover topics
	Course Level	Perspective varied between course level taught (i.e. undergraduate vs. graduate)
	Structure of Course	Aimed for alignment of content between lecture and lab
		Shared schedule and exams for all sections of course

Table S4 – Representative quotes for chemistry assistant professors' reasoning that supports their perspective on content coverage

Source of reasoning	Description of reasoning	Quote
Conception of Breadth	Students will get bored if covering a minority of topics therefore need to cover topics quickly	"I think also that instructors tend to think that they are very useful when lecturing, but I don't think that that's true. I think that students tend to learn what they need to from the books and from each other. And so covering the topics quickly is better because most of the students will get bored if you are covering a minority of topics I guess." 16208
Conception of Depth	Focus on core/foundational topics	"Well, so particularly for this class, a lot of the topics we cover is, as I already mentioned, some of them are an extension of Gen chem, but a lot of the other topics are things that they will need to move into their future classes and be successful. Um, and so even if we cover less, making sure that they have a very firm understanding of those topics should assist them as they move into their more, um, like their higher level chemistry courses." 16205
	Students get lost in breadth coverage without depth, therefore there is no point to it	"The first one would be worse [*scenario*]. if we're just throwing, you know, flying through the material, but nobody's getting it, we're not teaching." 16209
	Application of core/foundation material	"These ideas like equilibrium activity, acid base chemistry because they are so prominent in the rest of the curriculum as well that I think it's extremely important that they have a good foundation in them. So they may have gotten a brief intro in gen chem, but they really need to be able to utilize these concepts, these ideas both in my class and as they take things like biochem, organic chemistry, et cetera." 16205
	Adjusted pace based on students not the syllabus/schedule	"I will say my schedule was pretty broad. It was like week one slash two this topic, week three slash four this topic … I probably kept to it reasonably well though I did get behind at the end of the semester again, because I saw that there was challenges, understanding certain equilibrium topics that I wanted to make sure we're clear."16205
	Emphasis on application of material	"We still think the learning, especially for a graduate level course, for learning it should be have a function or application. If you just learn the knowledge but without using it, I think it's useless." 16201
	Focus on why content is important	"I'm trying to fit in with what we decided the core curriculum should be, but then also to connect not only to, like I said, organic chemistry, but also other, um, I think topics to help students understand why metabolism is important to learn about or why it might be interesting to their day to day life, things like that." 16204
Personal considerations	Reflected on their own learning, how they were taught, or observation of others teaching of the subject	"So I think I reflect on probably how I was taught those subjects or classes that I've observed, how they were taught there. And I'm trying to reflect on that. And then since this class is the third time I've taught it, I also have taken, you know, notes every semester and try to reflect on things that worked, things that didn't work and trying to continually update and refine things. Um, so that, I think that we're continuing to hopefully improve the course for the students." 16204

Source of reasoning	Description of reasoning	Quote
	Felt need to add introductions to additional content to prepare students for research in graduate school/their career	"I still try to stick to, you know, we have this textbook that we use, um, [inaudible] finish the first 14 chapters because it's the first semester to second semester, right. So it's pretty much determined by, the scope the class that the school defines, but I try to incorporate um, some new stuff in there as well." 16220
	Expressed tension in what the instructor wants students to understand versus the content the instructor anticipated to cover	"I still feel like... I want to cover more, but I want them to understand more. So I feel like sometimes I'm personally challenged by figuring out what, what we should really make sure they understand versus what I had anticipated to get through by the end of this past year." 16205
External Pressure	Syllabus dictates the content that has to be covered	"I guess I stick to a schedule. I don't stick to students and their need to stay on the topic. I stick to the schedule and what we have to cover. So it's, it's schedule-led not student-led." 16208
	Felt expectation of content coverage based on course series (ex. Gen Chem 1 & 2)	"I won't skip any chapters, um, for this class because I think everything is important. Um, especially when you have a second semester to take, if you miss one chapter it's gonna probably cause some issues in second semester, um, or even down the line, in the class. Um, so what I'll try to do is we have some, uh, I, I would intentionally leave out things and then I will have, we have review sessions, so I'll have my TA cover that in the review session." 16220
	Expectation of content coverage in course based on textbook chapters and/or instructor relies on textbook for pace of content	"The syllabus is pretty much standard. Um, so we'll have certain content that we need to teach the class. Right. Um, so it's pretty much determined by that. I've acquired lecture notes from previous instructors just to get a sense of what are things that are important and how much leeway do I have in terms of incorporating new knowledge… Um, but I still try to stick to this textbook that we use, um, finish the first 14 chapters because it's the first semester to second semester, right. So it's pretty much determined by the scope the class that the school defines, but I try to incorporate some new stuff in there as well." 16220
	Have to cover what is on the ACS exam	"So that's just based on the ACS exam, so there are certain topics that they require to teach so we just follow it. And then I talk to other senior faculty in our department all from the same division and then they say, oh yeah, so there are certain topics that um it is a must, so we have to cover all the topics." 16226
Department	Felt pressure from senior colleagues to cover topics	"Based on, uh, the ACS exam so there are certain topics that they require to teach so we just follow it. And then, uh, I talk to other senior faculty in our department all from the same division and then they say, oh yeah, so there are certain topics that um it is a must, so we have to cover all the topics." 16226
Course Level	Perspective varied between course level taught (i.e. undergraduate vs. graduate)	"It should be the latter one, the majority of students should understand, but maybe it depends on the setting. I think in the lecture class, uh, that's what I'd pick, but the undergraduate and graduate and those more specialized topic versus broader topic, it varies." 16203
Structure of Course	Aimed for alignment of content between lecture and lab	"In class I also tried to align some of those lab topics with class, like timing. Um, so I'd say that's another thing I kept thinking about throughout the semester. Like how much time do we spend on each topic. I was trying to align it with what was being covered in the lab simultaneously." 16205

Source of reasoning	Description of reasoning	Quote
	Shared schedule and exams for all sections of course	"Yeah, so I'm kind of in a bind. I can't get through a minority of topics because we have shared exams. And so in the case of shared exams, I have to get through the majority of the topics even if a minority of students understand them." 16208

Table S5 – Chemistry assistant professors' reasoning that supports their perspective on content coverage

Type of factor	Source of reasoning	Description of reasoning	Breadth (*n* = 1)	Theoretically depth, but in practice breadth (*n* = 3)	It depends (*n* = 1)	Depth (*n* = 4)
Individual	Conception of Breadth	Students will get bored if covering a minority of topics therefore need to cover topics quickly	16208			
	Conception of Depth	Focus on core/foundational topics		16226		16202 16204 16205
		Students get lost in breadth coverage without depth, therefore there is no point to it		16209		16201 16202 16204
		Application of core/foundation material			16203	16202 16204 16205
		Adjusted pace based on students not the syllabus/schedule				16202 16204 16205
		Emphasis on application of material		1626		16201
		Focus on why content is important		16220		16204
	Personal considerations	Reflected on their own learning, how they were taught, or observation of others teaching of the subject			16203	16201 16204
		Felt need to add introductions to additional content to prepare students for research in graduate school/their career		16220 16226		
		Expressed tension in what the instructor wants students to understand versus the content the instructor anticipated to cover				16205
Contextual	External Pressure	Syllabus dictates the content that has to be covered	16208	16220 16226		
		Felt expectation of content coverage based on course series (ex. Gen Chem 1 & 2)		16209 16220		
		Expectation of content coverage in course based on textbook chapters and/or instructor relies on textbook for pace of content		16220	16203	
		Have to cover what is on the ACS exam		16226		
	Department	Felt pressure from senior colleagues to cover topics		16226		

Type of factor	Source of reasoning	Description of reasoning	Breadth (*n* = 1)	Theoretically depth, but in practice breadth (*n* = 3)	It depends (*n* = 1)	Depth (*n* = 4)
	Course Level	Perspective varied between course level taught (i.e., undergraduate vs. graduate)			16203	
	Structure of Course	Aimed for alignment of content between lecture and lab				16202 16205
		Shared schedule and exams for all sections of course	16208			