Electronic Supplementary Information (ESI)

Understanding the Reasons and Cues that Guide General Chemistry Students' Studying Decisions

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Codebook of Inductive Student Reasons

Note: Some reasons were present for both using and not using strategies.

Reasons for **Using** Strategies

Table S1. Decisions based on understanding/learning

Reason Code	Description	Representative Quote
Seeking clarification	Describes using a resource because they want clarification on an idea/want to validate if they are correct or not (both human and not a human).	Minerva: “So that way I can understand certain topics because some of them I understand right away but some of them I don't really understand so I'll watch videos [online] so that way I can actually understand what I'm learning.”
Knowing connections helps understanding	Discusses using a resource because it helps them make connections across multiple ideas. Also, may mention that you need to know the connections between the concepts and the practice problems to be able to fully understand it. Response is generic.	Dean: "If I’m working through a problem and I can’t figure it out…I’ll look online [for] like real life examples of this happening and this works with mathematics as well…[when] given material you want to relate it to what you see on a daily basis, and it makes it easier to grasp…it makes you want to grasp it, thus giving you a drive and motivation to learn it. "
Supplemental learning	Discusses seeking out additional instructional materials outside of what happens in the course/is available in the course (e.g., YouTube).	Albert: " [The YouTuber is] a great great person to like-channel to like just watch and he goes through like- he explains stuff very easily for you to understand…It’s more of like an addition because sometimes like if I get the general idea of what I'm trying to learn I- and I want to go into like more specifics I then go to like find videos and stuff like that and they can help me explain that. "
Building understanding through teamwork	Building on one another's strengths to understand a topic (two-way street) and may describe it as bouncing off ideas from each other or comparing perspectives.	Lily: "…I study with umm a couple of friends. We go to office hours, and it really helps me because [my friends] might ask questions that I don’t know how to word or they might have questions on things I haven’t even thought about asking. And it really helps to bounce ideas off of [them] because a lot of times when you’re talking to someone who’s well versed and has a lot of education in chemistry or science, a lot of the times it’s harder to kinda understand what they’re trying to get at, whereas if you have a friend that’s also in your class that’s in the same boat and knows just as much as you do, they can put it into words that

		might click better or…might be easier for you to understand from a peer because how they're wording it isn't big science-y, it's not big vocabulary."
Wants a model/example	Participant discusses wanting a model for how to solve a problem/an example.	Lily: "I watch videos online because sometimes there are questions that I just do not know how to start…I used to watch them for stoichiometry until I grasped the hang of it. I would just watch it to just see the setup, the process so I could take their example and I can input my own numbers and then calculate it and see if what I'm getting makes sense based on what they're saying to do. "
Social learning	Describes the generic ideas of social learning as the reasons they use a resource.	Ruby: "I like social interaction so like that's nice but it's also like you're verbally talking about the materials that helps reinforce it and then like if you're stuck you're problem solving together so that helps you learn the material more."
Wants to understand why problems are solved certain ways	Tries to understand why problems are solved certain to make sense of problems they are struggling with.	Hermione: [I ask questions about how things work because] sometimes if I don't know like the steps to solve a problem I'll be like why do they do that like and then try to work backwards..." Lily: "I connect [practice problems to concepts] just so I can understand why I choose to solve a problem this way or what's the point of solving a problem like…what does it mean that I'm getting this answer…in lab for example…I was able to connect the dots and say, 'oh so if I get a negative delta H then it means this or if I get a positive then it means that.'" (Also coded as Wants to understand why the content is important)
Wants to understand why the content is important	Tries to understand why they are doing things to help better connect the content together and make sense of the concepts they are struggling with.	Minerva: "[I ask questions about how things work] so that way I can better understand it. Some of the things I'm like okay why am I learning this and then I will like review my notes and then Google certain things and then find a credible source ummm and then it kind of explains like why it's so important."
"I'm not simply doing math"	Wants to understand the chemistry/concepts behind the math problems they may be asked to do. May mention that this will help them	Albert: "[I connect practice problems to conceptual material] cause I guess it just doesn't make it simply a math class you just ya'know if you know the chemistry behind it then I feel like you're all set and it just helps

	prepare for the problems they will see on the exam.	because I know I'm not simply doing math. I know why I have to do it and when it comes time to [take] a test and they ask me a certain question I know why, what I need to do, what kind of math I need to apply to that problem to like get the right answer...Uhh I feel like sometimes hearing stuff from other people kinda can help you understand ya'know cause some people just can not explain something you need to know in the right way so having that resource kinda makes it just easier. And something that I got into the habit of doing during online classes yeah so."
Wants to understand the most important thing/conceptually understand material	Participant discussing wanting to understand the most important thing/see how everything in the course relates together (conceptual understanding). This motivates them and dictates how they study.	Millicent: "Because the instructor's notes are what they want you to take away from their lectures. Umm and that's really the most important thing, you don't want to get muddled in everything they said- more like what they were trying to teach you...and even if it isn't on the exam you're gonna need it just to understand the material as a whole."
Uses a model/example	Participant discusses uses a model for how to solve a problem/an example. Model/example could be used to help plan out how to do the problem.	Rose: "I relate the problems to the problems [the instructor] has on like examples, and see which ones kind match with one another, and the notes also and see which ones, and then plan out how to do the problem. I think that makes sense."
Active engagement supports learning	Participant discusses using strategies that require active involvement/engagement as that leads to better learning/success.	Lily: "Especially in textbook notes, I take notes of examples because a lot of the times pictures and graphs will help me to better conceptualize something. Whereas just hearing it while I'm in lecture doesn't really do anything to me. I have to physically write it down to see it."
"Make concrete examples that foster understanding"	Mention that using the study strategy while studying helps make concrete examples that fosters understanding	Neville: "[I ask myself questions while studying about how things work and try to find out the answer] [be]cause it helps make concrete examples that foster understanding...[And I relate materials to real-life to] Fosters understanding. You can like picture it, and understand why it works, it's better than just being told why it works."

Table S2. Decisions based on idiosyncratic/personal reasons

Reason Code	Description	Representative Quote
Individualized/personal learning	Discusses considering the level the resource is at (e.g., is it using terms they understand, suggestions are tangible or specific to their mistake, etc.). Could be used to describe why they would use the strategy (it is at their level).	Charlie: "…[I study with peers because] there's a very good chance that if you don't know something somebody else does and they can explain it to you from like a student perspective too. And like chances are they've struggled on it too and they know how to get through it."
Supports repetition/memorization	Participant describes using a resource because it supports repetition and memorization of material.	Dean: "I would use flashcards for more memorization actually. I use them for the compounds or if I needed to remember oxidation numbers, or where things are located on the periodic table. What I'll write on the flashcards is a very very simple question that shouldn't take longer than like 5 seconds to answer…I don't try to put too much work into the flashcards…"
Personal preference	Generic or idiosyncratic reasons for using a strategy.	Hermione: "[I rewrite my notes because] my handwriting is very bad so its kinda just like makes more sense for me."
Aligns with their "learning style"	Participant discusses using a strategy/resource because it is in line with their "learning style".	Percy: "I create visuals to represent the material cause I'm as I said I'm a hands on learner and so a visual like a balloon or like some- like a doodle will help me better." Lily said "I'm much more of…a visual learner than an auditory learner so hearing it helps but I kinda need that thing to look at to just really understand it to like confirm that what I'm hearing is what I'm writing…"
Time constraints	Participants describe time when discussing their reasoning for using a resource.	Dean: "I'm gonna say I only [go to a tutor] when I need help. Just because my major and my workload is very extensive and excessive so I don't have too much free time, but if I need to prioritize my time with tutor, I will make that time for it."
Prefers in-person/physical	Describes preferring in-person/physical resources (e.g., using a resource because it is in-person/physically available, and not virtual).	Neville: "Generally, I do more office hours than the tutor, umm, because it's available immediately after class, but I like to talk to people. As much as videos online and stuff are nice, it's nice to be able to like pose your own questions. If I don't understand something, ya'know google can help me- point me in the right direction but someone that's skilled and knowledgeable in the field is the person I trust

		the most."
Want a relationship with instructor	Participant describes using a resource because they want to develop a relationship with their instructor as it helps them be successful/be a better student.	Ariana: "[I go to the professor's office hours because] it helps me have a better connection with the- the like teacher so then they if I need to go to them and like get like a better understanding of something they're just more willing to do that so it helps."
Prefers virtual	Discusses preferring virtual resources (e.g., using a resource because it is virtual and easy to access).	Albert: " Our TA is like in person. She's like in [University Chemistry Building]. She's on the bottom floor and our umm professor she's on zoom so I feel like it's kind of harder a little. I guess it's just dow-down to the fact that I want like a physical like someone like right by-right beside me like telling me what I need to do instead."
Motivated by peers	Participant discusses using resources/approaches as being surrounded by like-minded individuals/peers supports/encourages success (both in class with similar majors and in a living-learning community).	Hannah: "Studying with other people it kinda of encourages you to study to-to keep to stay motivated and to help each other out."
Formal instruction	Describes using a resource because they learned about it in a formal classroom experience (e.g., university 101 course), a workshop, and/or a meeting with a staff member or the resource itself instructed on how to study (e.g., consultation with the university academic enhancement center helping them improve their academic habits).	Ariana: “[I watch] the amoeba sisters…[my University] 101 like advisor told me to watch them and it actually really helps.”
Research supported	Describes using a resource because literature/research supports using it for success. Must explicitly say that they know it is research-supported.	Albert: "[I wrote my notes] [be]cause I-I see a lot people like doing notes on laptops. It just doesn't work for me. So I just like the old fashioned way I guess just write it down and I guess like research have found out that writing stuff down makes it easier for you to remember so."
Helps them focus	Discusses using a resource because it helps them	Minerva: "[I take notes while reading the textbook/lecture notes] so that way I

	focus/stay on topic.	understand what I'm reading because sometimes I'll just read and kind of zone out but if I take notes on it I'll actually like remember everything that I read."
Convenient time	Describes using a resource because it operates at a time convenient for the student (e.g., drop-in tutoring hours during the day).	Ariana: "[University tutoring has] have like good drop-in hours and they also like always have someone there that can like that understands the topic..."
Motivated by future use/need in program/major	Motivated by future use/need in program/major to learn the concepts during their current chemistry course.	Millicent: "...learning objectives are what they want you to take away from it and its kinda what the course is meant to teach you. And you're gonna need to take all of that away from the course in order to move- like progress."
Academic coaching	Describes using a resource for academic coaching purposes (e.g., consultation on how to better manage their time).	Ruby: "I was having a hard time doing like time management. I know I met with [I] think [the University academic skills development and community outreach coordinator who] help[ed] me plan out and think about how I can manage my academic umm stress and then I was also able to connect with someone to help me plan out my finals schedule which was helpful."

Table S3. Decisions based on assessment

Reason Code	**Description**	**Representative Quote**
Alignment with assessments	Discussing the idea that the content of exams/assessments dictates what students choose to use or not use/prioritize based on the strategy aligning with the exam/assessment. Example - instructor uses a textbook exam question database, so students value studying the book because questions come directly from the book.	Rose: "[I use the instructor's practice problems] [be]cause I feel like from what I've seen in…the problems that he has on his problem set, it's kind of similar to the way it's structured on the exams and quizzes."
Resource/studying method recommended to be used by instructor	Discussing the idea that a resource/studying method recommended to be used by the instructor would be valuable for the exam.	Ariana: "[The instructor] likes it like when people do her practice problems [be]cause she basically says….'Do these [problems] cause then you'll know what's on the test and you know you know how to do it'..."

Generic assessment-guided studying	Generic discussion that the exams/assessments dictates what students choose to use or not use/prioritize when studying.	Lily: "[I make a study guide] so that I can get a good grasp on what should be expected on the exams or quizzes or whatever is expected of me just so that I feel more prepared...I- first of all I break it down by unit or chapter. I write down any definitions of words that I haven't heard of before that I would think might come up. I write down formulas, I write down processes, examples of umm questions that might require me to do drawings or math so. Just like a broad- a very broad study guide."

Table S4. Decisions based on instructor

Reason Code	**Description**	**Representative Quote**
Value because resource is provided by instructor	Expressing the idea that any resource provided by the instructor or recommended by the instructor is valuable. DOES NOT include because instructors control exam material -- that's assessment-guided studying.	Charlie: "[With the instructor's study guide]…I try to use all the resources that are provided to me…like if they're created by an instructor for sure umm they're gonna have information that's useful to me."
Instructor's resource is more simplified and straightforward	Discusses that the instructor's resources are a useful resource because they are more simplified and straightforward.	Hermione: "I read the instructor's notes [be]cause I feel its like summarizes the textbook in a way so it's more like the simplified version of the textbook. So sometimes that's helpful."
Instructor is "expert" so I value it/them	Expressing the idea that students respecting the instructor's expertise.	Dean: "If it was the lecture problems I would say, yes 100% do those [again as part of studying] because…my professor…write[s] notes and explain[s] why she's doing certain steps. Not only would she explain them in class a little differently, [be]cause she knows it like the back of her hand…and when she explains it to you in a lecture it's much easier to understand then the textbook, which would give you the full blunt of all the information and sometimes without explaining why the steps would be taken."
Values what instructor emphasizes	Discusses valuing what material the instructor emphasizes, and this may be found through the use of instructor provided resources (e.g., the instructor notes).	Millicent: "Because the instructor's notes are what they want you to take away from their lectures...and that's really the most important thing, you don't want to get muddled in everything they said- more like what they were trying to teach you."

Resource/studying method recommended to be used by instructor	Discusses choosing to use a strategy because it was recommended to be used by the instructor.	Lily: "[The instructor was] the one who told me that there are practice problems in the book because it's online I did not know that. I was unaware there were like extra questions at the end cause most textbooks have them but I wasn't sure where I could exactly access by paying the online fee versus buying the textbook. So I just started doing that recently because she just told me a few days ago that they were there which I'm thankful for because I was- I'm a little nervous for this next exam so."

Table S5. Decisions based on reflection/metacognition

Reason Code	**Description**	**Representative Quote**
Supports reflection	General category of reasons that are all about reflection.	
-self-assessment	*Participants trying to "see how far they can go" -- identifying the boundary of their understanding, recognize if they understand the content. Need to explicitly talk about testing themselves in some way.*	Millicent: "Ummm because it allows you to see where- like the limit of your knowledge [is] and it allows [the other student] to kind of check you. Like if you are super confident about it and you're explaining it to them, and they are well I'm not a 100% sure about this but I know that that's not right at all…It's kind of like a way to fact check yourself and also other people." Ariana: "In chemistry I would <u>make flashcards</u> for the vocabulary and…most likely like having someone quiz me on them...if someone like quizzes me it helps hold me accountable for like knowing the definitions instead of just thinking that I know them."
-prioritizing what to study	*Participants identifying areas to focus on/prioritize topics or skills. Can be based on previous exam performance, going through their notes, etc. - focus needs to be on what to do next/focus on next.*	Luna: "[I make an outline] because if I like to know the general idea and if I'm good with certain like sections of the chapter …then I'll just go focus on the ones that I'm struggling on."
-having a growth mindset	*Participants discussing wanting to improve from mistakes, grow, get better.*	Lily: " I reached out to my chem professor and I had her walk me through some of the problems I missed on the last exam with similar concepts so that way if it was something like dimensional analysis or oh you need to remember to do this with a periodic

		table or this is how you find molecular charge, something that's a basic concept I just wanted to make sure that for my next exam I wouldn't make that same mistake so I had- I did that with her."
-breaking info into smaller chunks	*Participants focusing on reflection to help breakdown information into smaller, manageable chunks.*	Percy: "I take notes while reading the textbook because Uhh that's all the information and I wanna break down the information which seems like the most important or what seems like the most pivotal it will be on the exam and most important to learn."
Prior Knowledge	Uses prior knowledge when looking at new material.	Albert: "[I ask myself questions and] I kinda use my pre-knowledge of what I've learned before to see if it applies to what I'm learning now. And if it does then it makes it stick a whole lot more and if it doesn't then I just try my best to find resources that can explain it to me. Like I search up Google, stuff like that, go to my professor."

Reasons for **Not Using** Strategies

Table S6. Decisions based on not valuing the strategy

Reason Code	**Description**	**Representative Quote**
Time constraints	Participants describe time as a reasoning for not using a resource, including it is a waste of their time	Hannah: "I think making practice test would take way to long so it feels like it's like a... why would you do it if it's going to take that much time"
Student-created material may not be done well	Participant describes the sentiment that if they created a resource, it may not be correct, as good as what the instructor would make, not complete enough to be useful, etc. This can include not being confident in the materials they make or thinking their materials would be inadequate. This can also include that they would make questions that are easy, or they may focus only on what they know and not what they don't know.	Rose: "I can't make [a practice test] of my own because I will just put easy questions, or really hard questions...and then I have no idea if I get it right or wrong then. Just leave it be, just [leave making a practice test] for someone else."

Not helpful to them/the way they learn	Discuses not using a strategy because they consider it not helpful to them and/or the way that they learn.	Minerva: ""I know [the instructor will] post like 'I can' statements, but for me I don't learn that way. Like I learn by actually seeing examples and seeing the notes that she does…not really just [from] statements."
Not worth the effort	Discusses not using a strategy because the work/effort required is not worth it (cost-benefit analysis) or may overcomplicate their studying/learning.	Neville: "[I do not make a practice test] [be]cause I don't want to…Because, I (pause) am lazy…It's more time than I'm willing to put into it." Albert: "…I [made an outline] for another class recently and it takes quite a while, like a lot of people don't realize how much work needs to be put into that."
Resource does not work well for chemistry	Describes not using a resource because it does not fit general chemistry learning outcomes. These reasons can include the problem solving/math focus of chemistry (not seeing it as concept based) or generic that chemistry is difficult.	Rowena: "[I do not use a study guide because]…for chemistry I think it's mostly on like math problems [than] like the concepts so then I kind of focus more on like solving problems than trying to memorize like everything."
Individualized/personal learning	Discusses considering the level the resource is at (e.g., is it using terms they understand, suggestions are tangible or specific to their mistake, etc.). Could be used to describe why they would not use the strategy (it is not at their level).	Albert: "It was an option to get [a textbook] but…they don't keep in mind that the people that are reading it don't know…the topic of what they're trying to like read about so they just use words that you don't feel like you know and people just tend to like read through them thinking they know what they're reading but majority of the times you don't."
Supports repetition/memorization	Participant describes not using a resource because it supports repetition and memorization of material. They may mention that memorization does NOT help with conceptual understanding.	Lily: "[Flashcards are] not really helpful for me personally. I tend to just not really remember the concepts, I just remember what's on it. So, I could easily just be ya'know here's a problem, solve it but…I just I feel like I memorize the answer, I don't memorize why it's the answer. I'm somebody that needs- that's always gonna ask why, why is it this, why is it that. I can't just get the answer and be satisfied. I would rather have somebody walk me through like a four hour experiment to let me know why these bonds do that then just say because they do or because it's a law."

Strategy is redundant	Discusses not using a strategy because it is redundant/already completed/do not want to duplicate efforts	Charlie: “[I do not redo homework questions because]…I've already done them…I just try to look up more…Something that I haven't [completed] like- I'm not just gonna know the numbers just cause I remember them, I'm gonna know them cause I know them.”
Prefers Individual/Independent Learning	Participant describes not using a resource because it supports repetition and memorization of material. They may mention that memorization does NOT help with conceptual understanding.	Rose: "I don't like studying with other people because...I would compare myself, and because I don't like that. And also because...I feel very impatient when I'm studying with someone else because I might be going ahead, but they're not ahead..."
Prefers peers over tutors/TA/instructor	Discusses not using a resource because it is from a tutor/TA/instructor, prefers interacting with peers.	Rowena: "...if I find a friend that in my class who knows how to solve this question I usually prefer like asking my friend because I'm more comfortable with her than like tutor."
Not worth the money	Describes not using a resource because it is not worth spending their money on	Albert: "It was an option to get [a textbook] but I don't feel like it's worth the money…"
Personal preference	Generic or idiosyncratic reasons for not using a strategy.	Neville: "[I do not create visuals because] I'm not artsy."
Too impatient to use strategy	Describes not using a strategy because it requires too much patience	Hannah: "...I get bored with videos I can't like- for some reason I can't do videos, that's why I like notes cause I can read them on my own speed, whereas if I'm watching a video their taking like 10 minutes to explain two things, I'm like 'oh my god can we speed it up please'."
Distracting/ does not help them focus	Discusses not using a resource because it is distracting and/or makes it hard to focus.	Marietta: "[I do not study with a peer/group because] I get distracted when I like when I'm with people."
Does not question information/facts provided to them	Mentions that they do not ask questions due to their trust that the information provided for them is correct and they do not question that fact.	Rose: "[I do not ask questions about how things work because]...I think they work. [The TA] say[s] they work, I trust [their] word." Interviewer: "You don't try to think about how, like yourself and like try to think about for yourself, you just kinda follow- you just trust what's being told to you?" Rose: "Yes, it's not a good thing but I still do it."

Not valuable/relevant	Does not find the task valuable or relevant to chemistry.	Charlie: "[I do not connect concepts to practice problems because] it just doesn't seem relevant to me at the time."
Hinders motivation	Discusses a resource not being worth their effort/makes them unmotivated/not wanting to learn.	Dean: "I don't make a study guide because...I find that doing this, it exhausts and kind of pulls me away from even wanting, to like desire to learn about it, and I kind of like will take a break for a few days and I'm like I don't want to even think about it because making that test was exhausting..."
Prefers in-person/physical	Describes preferring in-person/physical resources (e.g., not using a resource because it is not in-person/physically available and is virtual).	Marietta: "I'm kind of person who don't like online like com- to use computer for reading. So small like you don't highlight." Interviewer: "Oh you have an online textbook?" Marietta: "Yes..So I like to read slides cause I print them and it's hard to print a book (laughs)."
Prefers virtual	Discusses preferring virtual resources (e.g., not using a resource because it is not virtual).	Percy: "[I do not make flashcards] [be]cause I Uhh I just digitalized everything so I suppose I use like quizlet for ce-certain examples so it's be like online flashcards but a lot of the times I'm just us- opening a google doc and creating something in there."

Table S7. Decisions based on not knowing how to use the strategy

Reason Code	**Description**	**Representative Quote**
Never considered it before	Participant describes never really considering using a specific approach -- they know what the approach is, but it never crossed their mind to try it themselves.	Lily: "Why don't [I] make a practice test? Honestly [be]cause I've never thought of it." Millicent: ""I just forget that [the textbook practice problems are] there to be honest."
Do not know how	Participant describes not doing something because they do not know how (e.g. they don't know how to questions for a practice test or now knowing how real-life examples would help them study).	Ruby: "I've never [made flashcards] before so I don't how I would use it for chem."

Lacking expertise in content	Participant describes not doing something because they lack the necessary expertise (e.g., they don't know how to make real life examples because they don't have the knowledge in that content to make those connections). May also describe not being able to think of chemistry on that level whether it be because they are "not a chemistry person" or their "brain doesn't go there". The focus is more on themselves rather than chemistry itself (that would be Resource does not work well for chemistry).	Millicent: "[I do not think of real-life examples because]…I just can't really think of chem[istry] on that level like I think of chem[istry] as something I just need to know…I think of it as numbers and it's hard for me to see numbers in the world…"
Not aware of resource	Did not use a resource/approach because they were unaware of its existence (e.g., did not seek out a tutor because they did not know tutors existed on campus).	Hermione: "I didn't really know [the university resources] were a thing to be honest with you."

Table S8. Decisions based on not needing the strategy

Reason Code	**Description**	**Representative Quote**
Resource is not necessary/needed	Discusses not using a resource because they "don't need it"	
-Have alternative strategy instead	*Distinguished by having another resource that takes the place of the suggested resource (e.g., don't go to the tutor because office hours are "enough"). Does not specify where they would get the alternative resource.*	Charlie: "[I do not] make a practice test because I-I can find practice tests that are provided to me or can- I can find them online." Hannah: "[I don't go to professor's office hours because]…I just haven't felt the need to, so I found other things that work for me before going to office hours…that's almost like my last resort…"
-Instructor provides/gives alternative strategy	*Distinguished by having another resource that takes the place of the suggested resource that is specifically provided for them by the instructor (e.g., don't make a study guide because a practice test is provided by the instructor).*	Rose: "I feel like [the instructor] already has everything, and I just go into the textbook to see like the tables [the instructor] shows in class…like solubility rules…or like the strong bases and strong acids…But I don't exactly read it as much as I should cause I feel like he already has the [instructor's] notes, and kind of a rough summary of everything."

- I'm doing well in class/confident in understanding	*Distinguished by feeling that they are doing well in their class performance and/or confident in understanding the material.*	Minerva: “I don't [see a tutor] just because I'm doing well in chemistry. So I don't feel as though I need to.”
-Confident in current study strategies	*Distinguished by a confidence in their currently used study strategies (e.g., "I'm confident enough with all the other things I use." A bit more generic and may not mention specific study strategies that are used.*	Ariana: “[I do not use the university’s academic resources because] I think my studying habits are pretty good so I don't I've needed it yet.”
Resource does not match classroom instruction	Discusses not using a resource because it differs from what they were taught.	Rowena: "If I have time usually I will try to find the [practice problems from outside of the textbook] that are related to the topic but then usually just searching straight from Google doesn't bring like the exact same thing as the professor was."
Reviews from peers	Describes not using a resource because they have received reviews from other students which makes them not want to use the strategy. The reviews may also be mixed with some positive and some negative.	Lily: "...I've heard various things [about the university resources]. I've heard oh they're super helpful or oh they didn't even pay attention to me or didn't help my questions so I'm just sticking with what's working at the moment...

Table S9. Decisions based on strategy not available

Reason Code	**Description**	**Representative Quote**
Resource not available	Did not use a resource/approach because it was not available as an option to them/not an available resource (e.g., a study guide was not provided by instructor)	Lily: "[I don't redo my homework questions] because they lock after we do them. They lock completely so we can not get access to them." Rowena: “For my chemistry lecture class we don't really have [a] textbook. We just have like the PowerPoints that the professor made.”
Lack of social network	Describes not using a resource because they lack the network/community/friends	Albert: “[I do not study with peers because] I guess because I'm not really like formulated those bonds yet.”
Not enough of the resource	Discusses a resource being limited/too crowded/not enough of it to be useful so they do not use it.	Rowena: "I only went to tutor like twice or but then most of the time it was really crowded and if I find a friend that in my class who knows how to solve this question I usually prefer like asking my friend because I'm more comfortable with her than like tutor."

Table S10. Decisions based on assessment

Reason Code	Description	Representative Quote
Alignment with assessment	Discussing the idea that the content of exams/assessments dictates what students choose to use or not use/prioritize based on the strategy aligning with the exam/assessment. Example - instructor uses a textbook exam question database, so students value studying the book because questions come directly from the book.	Ruby: "…I've look through some of the [practice problems from the textbook] and it's like not worded like how my exam is or like it seems like I haven't learned that material so it's just more confusing."
Resource/studying method recommended to be used by instructor	Discussing the idea that a resource/studying method recommended to be used by the instructor would be valuable for the exam.	Dean: "I'm not really big on the textbook. I rather just go off of what my professor does, because she will do certain problems that aren't in the textbook. Some of them, are obviously cause it's from the course, but most of the stuff that she puts on the exam is only from the lecture, so I don't usually look in the textbook often. I'd like to try it in the future just to see how it works, but I don't do it."
Generic assessment-guided studying	Generic discussion that the exams/assessments dictates what students choose to use or not use/prioritize when studying	Rose: "[I don't make real life examples because]...I just don't try to overcomplicate something. So like even if I do compare to something in real life, I can't- it might come here and there, I just can't really relate to it." Interviewer: "It might not be, say put in that format for the exam so it might be a little bit more confusing to you?" Rose: "Yeah, and I just don't want to go through the hassle of comparing to real life examples."

Table S11. Decisions based on instructor

Reason Code	Description	Representative Quote
Values what instructor emphasizes	Discusses valuing what material the instructor emphasizes, and this may be found through the use of instructor provided resources (e.g., the instructor notes).	Rowena: "[I don't take notes while reading the textbook/lecture notes because] I just write like the notes like on top of like what [the instructor] already has cause I don't wanna like focus on something else than what [the instructor] wants."

Deductive Cues

The learning/content cue was applied when students discussed the appropriateness of the study strategy for the course content or their learning. The effort cue was applied when students discussed the time and/or effort the strategy required or the difficulty/ease of using the strategy. The previous experience cue related to most student explanations as they relied on their previous experiences to make choices; as such, it was only applied when a student mentioned an explicit previous experience (e.g., the student said they used the strategy for another class). Given that reasons and studying beliefs are personal, it is not shocking that a variety of unique reasons were elicited; an idiosyncratic cue was created to capture responses that did not rely on any of the three framework-informed cues.

Student Cues For **Using** Studying Strategies:

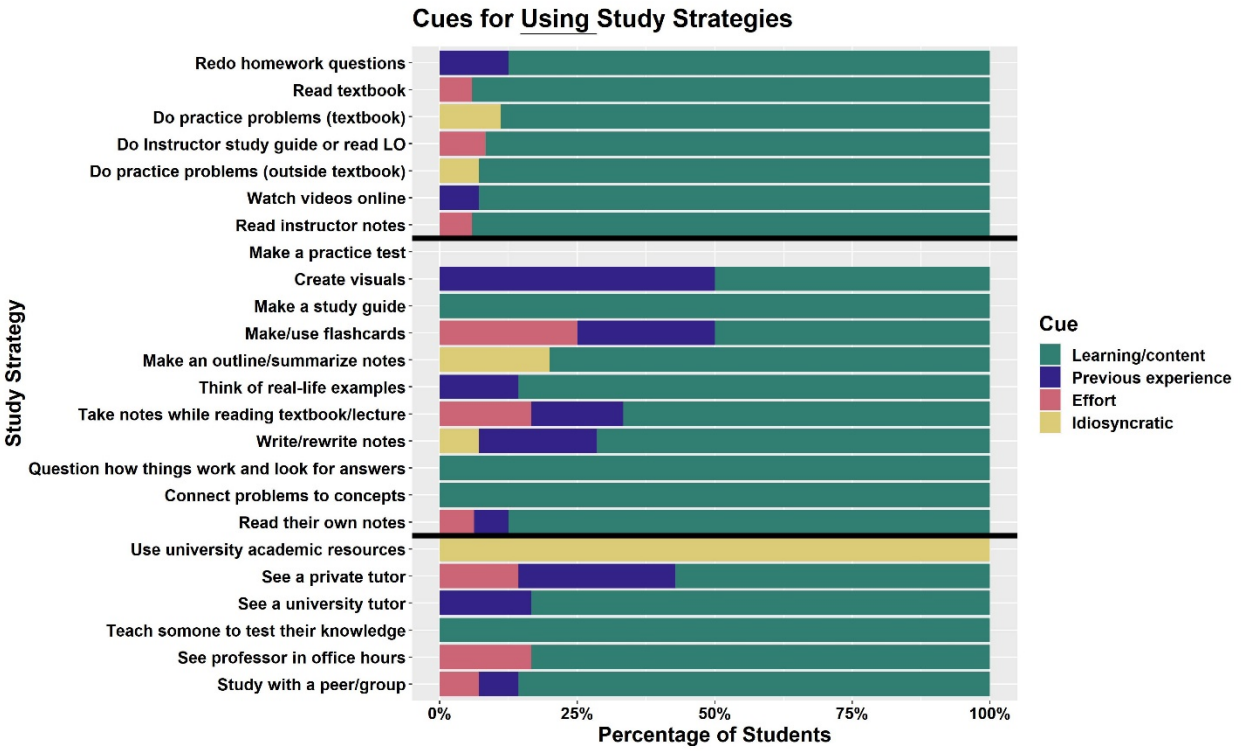
In line with our theoretical frameworks, deductive coding was used to determine which cues students relied on in their reasoning: learning/content, previous experience, effort, and idiosyncratic (see Table S12 for exemplar quotations). This deductive analysis complements the inductive analysis presented in the manuscript as it provides a more holistic interpretation that can easily be compared to previous literature. The cue of *learning/content* was identified when the students believed that a study strategy was appropriate for the course content or was beneficial to their learning, such as Ruby discussing that studying with peers helps her understanding by gaining the insight of another student's perspective (Table S12). The cue of *previous experience* underlies most students' explanations as they rely on their prior experiences to make their choices, influencing their learning/content, effort, and idiosyncratic cues. Therefore, only ideas that were explicitly discussed as previous experiences were coded as such. For example, Millicent mentioned that she uses flashcards occasionally but does not like using them (see below). The cue of *effort* was present when the student discussed the time/effort it took to use the strategy or the difficulty/ease of the strategy, such as Rowena describing the professor's office as an easy resource to obtain help. As discussed previously, with the reason category of **decisions based on idiosyncratic/personal reasons**, it is unsurprising that some of the ideas discussed by students did not fit into the framework cues; this necessitated an idiosyncratic cue to capture these unique ideas. For example, Hermione discussed rewriting her notes because her handwriting is bad, not mentioning any other cues in her reasoning.

Table S12: Cues students relied on for using specific studying strategies with exemplar quotes. *Note: Bolding is used to focus the reader's attention, while underlining is used to provide context and identify the specific study strategy(s) discussed.*

Cue	Example Quote
Learning/content (*N* = 16)	Ruby: "[Studying with peers] helps me cause sometimes I like having people **explain stuff to me cause if I get stuck on the problem they usually know how to do it** and then **if they're stuck I know how to do it so it's like a different perspective**.
Previous experience (*n* = 9)	Millicent: "**I do use [flashcards] occasionally, but I just don't like using them**."
Effort (*n* = 5)	Rowena: "[I got to professor's office hours] because for my chemistry professor…has her office hours like [at a] set time and like she has it through

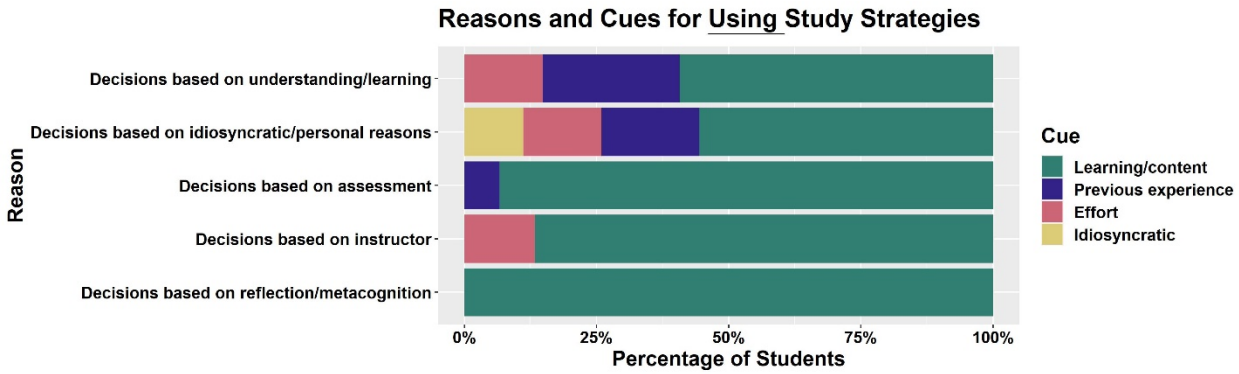
	zoom which is **more easier for me to like get help from her than like some of the other professors** then when I'm stuck with questions that most people can't solve it I just go ask her."
Idiosyncratic (*n* = 5)	Hermione: "My **handwriting is very bad** so its kinda just like makes more sense for me [to rewrite my notes]."

Figure S1: Percentage of students using specific studying strategies by cues. *Note: Horizontal lines are used to differentiate the three types of study strategies -- Externally Provided Strategies on top, Student Created Strategies in the middle, and Social Learning Strategies at the bottom. Note: Each study strategy was used by different numbers of students and some students discussed more than one cue.*



Throughout all the types of study strategies, the cue of learning/content was most commonly discussed as part of why students use specific strategies, with all participants discussing it (Figure S1). This suggests that students rely more on their perceptions of learning benefits or the appropriateness of the strategy for the content as to why they select a strategy. Unsurprisingly, this cue was prevalent because the most common inductive reason category was **decisions based on understanding/learning**, showing an already identified importance of learning considerations for students. The cues of previous experience (*n* = 9) and effort (*n* = 5) were relatively evenly distributed across the three types of strategies, but were more commonly relied on when discussing why they did *not* use a study strategy.

Figure S2: Percentage of students who discuss each cue by reason categories for why they use study strategies.



To better understand the cues students relied on for their reasoning, the overlap between the inductive reason categories and the deductive cues is shown in Figure S2. Unsurprisingly, the ***decisions based on understanding/learning*** reasons relied on learning/content cues (*N* = 16) as they were already recognized as focusing on understanding and learning. Along with the learning/content cue, many students relied on their previous experience (*n* = 7) to explain why the study strategy benefited their learning. For example, Ruby discussed seeing a tutor because one-on-one interactions helped reinforce the material previously in high school: *"[Seeing a tutor] helps me get my homework done…cause I'm use[d] to like a one-on-one interaction [be]cause I came from a small high school. So having that like walkthrough if needed helps like reinforce the material."* Ruby provides an example of students using their previous experience to inform their studying choices, suggesting that the lack of formal training on effective strategies requires the students to use their previous experiences to form their own understanding of what works for their learning (Kornell and Bjork, 2007). The effort cue (*n* = 4) for **decisions based on understanding/learning** were all for social learning strategies and discussed their choice for help seeking based on the ease of the strategy. Compared to the view presented by Rowena (Table S12) that the professor's office hours were an easier resource, Luna believes that her friends are quicker: *"Because I do have friends who are more confident in chemistry. And umm if I'm struggling than they're advice is a lot helpful and they're kinda just- it's a quicker resource and it's faster than going to the professor."*

Decisions based on idiosyncratic/personal reasons had various unique reasons; however, the most prevalent cue was learning/content (*n* = 15). Similar to **decisions based on understanding/learning**, some students used their previous experience (*n* = 5) and effort (*n* = 4) cues to explain why the study strategy benefited their learning. For example, Albert discussed rewriting his notes because his experiences with taking notes on laptops did not work for him, and he used research to inform his belief that writing information down is easier to remember:

> *[I rewrite notes] [be]cause I-I see a lot people like doing notes on laptops [and] it just doesn't work for me. So, I just like the old fashioned way I guess just write it down and I guess like research have found out that writing stuff down makes it easier for you to remember.*

In contrast to the other reason categories, **decisions based on idiosyncratic/personal reasons** was the only category in which students relied on idiosyncratic cues (*n* = 3). This is unsurprising as they were

already recognized as relying on an idiosyncratic reason, such as Hermione rewriting her notes because her handwriting is bad (Table S12).

Decisions based on assessment predominantly relied on learning/content cues (*n* = 14), as many students focused on aligning the study strategy with the assessment to determine that it would benefit their learning. For example, Charlie believed that if he could do practice problems from outside the textbook, then he would do well on the exam: *"My professor umm she posts umm practice problems and I usually just go through that and if I can do all of that confidently then I- I think I'm in good shape for an exam."* The focus of learning the material for the exam follows a performance goal orientation and not solely a mastery goal orientation, which is not the recommended mindset for student success and learning (Pintrich, 1999; Muis, 2007; Naibert *et al.*, 2024). Only one student relied on previous experience cues to support why the study strategy was beneficial for their learning, and effort cues were not mentioned for this category.

Similar to **decisions based on assessment**, **decisions based on instructor** mainly focused on using learning/content cues (*n* =13). The reliance on learning/content cues for strategies provided/recommended by the instructor suggests that instructor-provided/recommended strategies may be considered good strategies for learning. This belief was held by Charlie, who discussed that all resources provided by the instructor have helpful information: *"[With the instructor's study guide]…I try to use all the resources that are provided to me. Umm and those are like if they're created by an instructor for sure umm they're gonna have information that's useful to me."* There were only two students who relied on effort cues to support why the study strategy was beneficial for their learning, and there was no mention of previous experience cues for this category.

In contrast to the other reason categories, **decisions based on reflection/metacognition** only relied on the cue of learning/content (*n* = 12). It is reasonable for students to focus only on the learning cue due to the reflective nature of this reason category. For example, Ariana used flashcards to self-assess her learning: *"In chemistry I would make flashcards for the vocabulary and…most likely like having someone quiz me on them...it helps hold me accountable for like knowing the definitions instead of just thinking that I know them."* The learning focus of self-assessment suggests that some students recognize the benefits of self-assessment and view it as helpful for learning and studying rather than just as a method used for assessment (Kornell *et al.*, 2009; Bjork and Bjork, 2014; Blasiman *et al.*, 2017).

Student Cues For **Not Using** Studying Strategies:

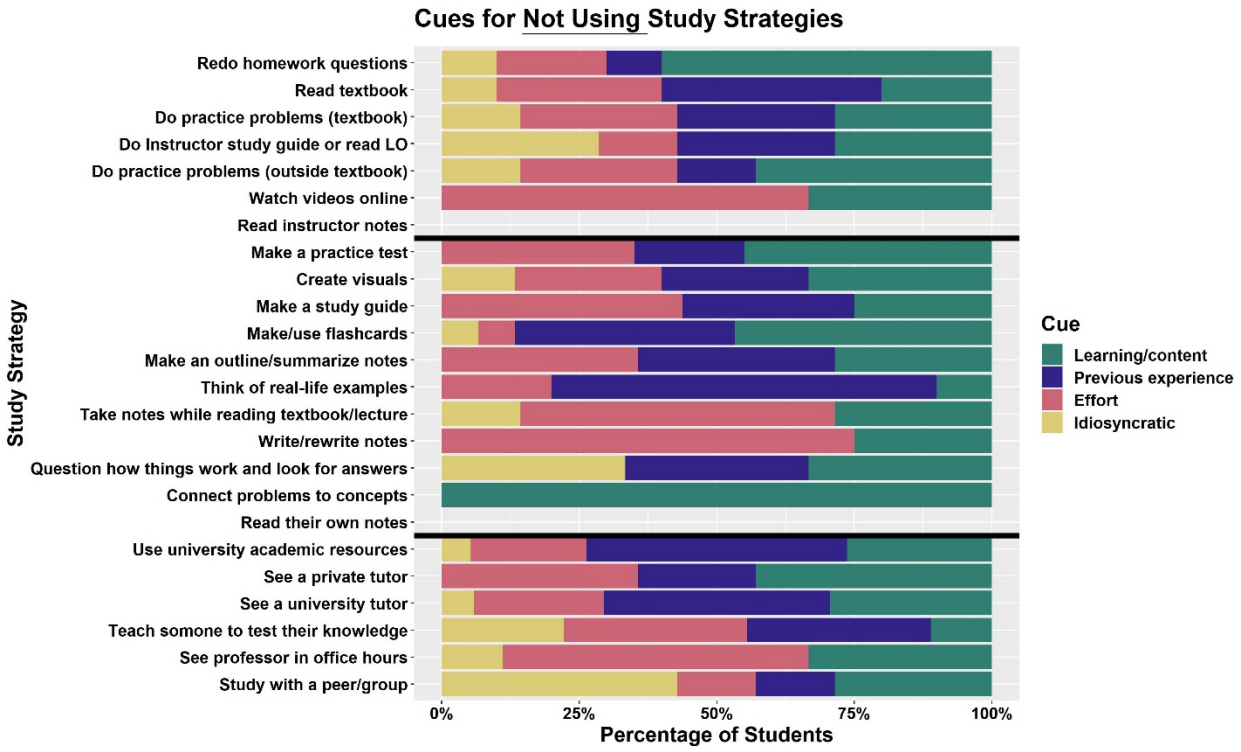
The same cues students relied on for using strategies were present for their reasons not to use study strategies (see Table S13 for exemplar quotations). As discussed above, the cue of *previous experience* was only coded when ideas explicitly mentioned a prior experience or lack of experience. For example, Percy lacks experience in making practice tests as he has never considered them before and would not know what to do. The *learning/content* cues focused on the study strategy not being appropriate for the course content or not beneficial to their learning, such as Lily discussing that flashcards are not helpful to her based on their promotion of memorization rather than forming a deeper conceptual understanding. The cue of *effort* was identified when students discussed the time/effort it took to use the strategy or the difficulty/ease of the strategy, such as Dean viewing making a study guide as more work than it is worth. The *idiosyncratic* cue captures unique ideas presented by

students that do not fit into the framework cues. For example, Neville would share knowledge that he felt was cool rather than test his knowledge by teaching someone. He also would not create visuals because he does not view himself as artsy.

Table S13: Cues students relied on for not using specific studying strategies with exemplar quotes. *Note: Bolding is used to focus the reader's attention, while underlining is used to provide context and identify the specific study strategy(s) discussed.*

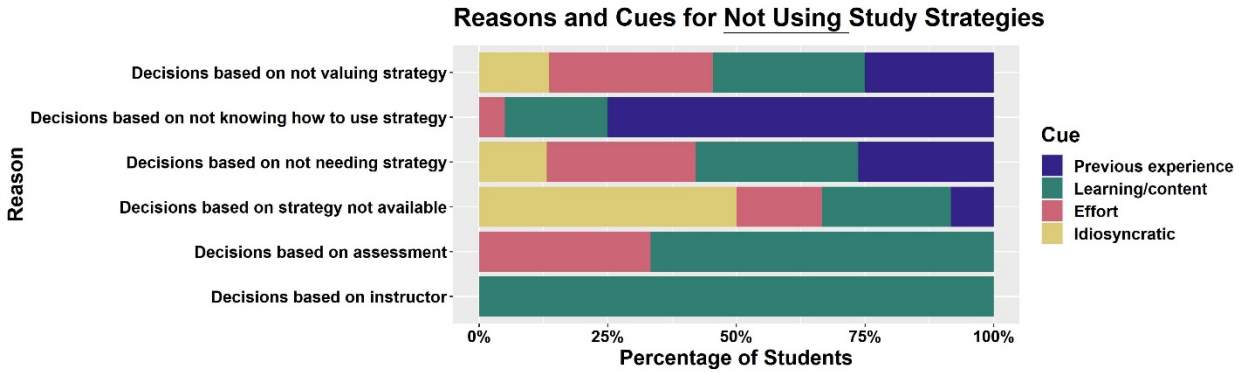
Cue	Example Quote
Previous experience (*N* = 16)	Percy: "I don't make a practice test because…**I like never like really thought about it**…**I would not know what to do**."
Learning/content (*n* = 15)	Lily: "[Flashcards are] not really helpful for me personally. **I tend to just not really remember the concepts, I just remember what's on it**. So, I could easily just be ya'know here's a problem, solve it but…**I just I feel like I memorize the answer, I don't memorize why it's the answer**. I'm somebody that needs-that's always gonna ask why, why is it this, why is it that. I can't just get the answer and be satisfied. I would rather have somebody walk me through like a four hour experiment to let me know why these bonds do that than just say because they do or because it's a law."
Effort (*n* = 15)	Dean: "I don't make a study guide because, again **it's more work on myself.** I find that I end up exhausting myself and I've tried in the past where I'll try to make like a practice test…about chemistry or other courses, and I find that doing this, it **exhausts and kind of pulls me away from even wanting, to like desire to learn about it**…and I'm like this really **wasn't worth it to me in the end**."
Idiosyncratic (*n* = 10)	Neville: "[I do not teach someone to test my knowledge] [be]cause by the time I'm teaching someone, who's generally my wife, it's just because they think it's clever. **It's not even about testing my knowledge at that point, I just want to share something I thought was cool**." Neville: "[I do not create visuals because] **I'm not artsy**."

Figure S3: Percentage of students not using specific studying strategies by cues. *Note: Horizontal lines differentiate the three types of study strategies -- Externally Provided Strategies on top, Student Created Strategies in the middle, and Social Learning Strategies at the bottom. For each study strategy, there is a different number of students that make the total of each percentage and some students discuss multiple cues for a study strategy and are counted more than once.*



Compared to the heavy reliance on learning/content cues for using study strategies, students used a greater variety of cues when deciding not to use a study strategy (Figure S3). The most common cue discussed by all students was previous experience. With Student Created Strategies, many students (*n* = 15) discussed lacking experience with a strategy and believing that a strategy was not helpful to them or that they did not need it. This lack of experience is in line with the need for formal training discussed in previous findings (Zimmerman, 1998; Kornell and Bjork, 2007; Bjork *et al.*, 2013) and was present in the reason category **decisions based on not knowing how to use the strategy**. Unsurprisingly, this cue was mentioned more for Student Created Strategies than other strategies based on the need for previous experience to know how to make the strategy effectively. Like Student Created Strategies, previous experience cues (*n* = 13) when discussing Social Learning Strategies focused on lacking experience (e.g., with the university resources and teaching someone to test their knowledge) and believing that the strategy is not helpful. Externally Provided Strategies relied less on previous experience (*n* = 7) as they were provided to students and focused on believing that the strategy was not helpful or that they did not need it. Learning/content and effort cues were discussed by most of the students (*n* = 15 each) and were relatively evenly distributed across the three types of strategies. Externally Provided and Social Learning Strategies were both described as help-seeking strategies; therefore, it is reasonable that students would evaluate the perceived learning they would obtain from the strategy. More students used idiosyncratic cues for why they do not use a strategy (*n* = 10) compared to why they use a strategy (*n* = 5).

Figure S4: Percentage of students that discuss each cue with the reason categories for why they do not use study strategies.



The overlap between the reason categories and cues help better understand the cues students relied on for their reasoning (Figure S4). **Decisions based on not valuing the strategy** relied mostly on effort (*n* = 14) and learning/content (*n* = 13) cues. Unsurprisingly, the effort cue was present for this reason category, as some of the ideas shared by students were focused on the study strategy not being worth the effort and the time to use it. For example, Percy views summarizing his notes as a waste of time: *"…I see [summarizing my notes] as a waste of time…why summarize my notes when…I write them down I simplify them as much as possible…and why would I rewrite it when I could just like reread it…"* The consideration of effort by Percy and other students suggests that formal study strategy instruction needs to focus on the learning benefits of the strategies and explicitly explain why desirably difficult strategies are worth the high effort.

Similar to the effort cue, the learning cue was not surprising due to the learning-focused reasonings discussed by students related to valuing a strategy (e.g., study strategy not being helpful to the way they learn, the strategy not working well for chemistry and student-created material may not be done well). Millicent described her concerns with making a practice test: *"Because I feel like if I make a practice test I'm only going to ask myself questions that I know. And I can't ask myself questions…on what I don't know because…I can't think about what I don't know."* The inability of Millicent to think about what she does not know influenced her choice not to use a practice test as she does not view it as a valuable learning experience. Compared to Millicent, Marietta focused more on the appropriateness of using flashcards for chemistry: *"…I just feel like the chemistry I'm taking now it's all math so flashcards is not like for math."* The value of the strategy, as discussed by Millicent and Marietta, lies in the learning benefits they can obtain from it and its appropriateness for the content. Using the previous experience cue (*n* = 11) often supported them not valuing the strategy based on the learning/content and effort cues. The less prevalent cues were idiosyncratic (*n* = 6). They focused on their unique preferences, such as Rose feeling pressure when studying with peers, so she does not: *"I feel too pressured to do well if I'm studying with someone else."*

Decisions based on not knowing how to use the strategy relied predominantly on previous experience cues (*n* = 15). It is unsurprising that this category was already recognized as focusing on a lack of prior experience with the study strategy. For example, Hermione was unaware that teaching someone was a study strategy: *"I never really thought of [teaching someone to test knowledge] as a*

study habit to be honest with you." The student's explicit reliance on previous experience echoes the importance of previous experience in Self-Regulated Learning (Zimmerman and Moylan, 2009). The less prevalent cues used with decisions based on not knowing how to use the strategy were learning/content (*n* = 4) and effort (*n* = 1).

Similar to **decisions based on not valuing the strategy**, **decisions based on not needing the strategy** relied on various cues, with learning/content (*n* = 12) and effort (*n* = 11) being most prominent. The connection between effort and learning/content was seen with Percy as he believed that he did not need to put in the effort to go see a tutor because he was doing well in the class: *"I don't see a tutor because I don't feel the need to see a tutor at this moment in time cause uhh I'm doing quite well and yeah so I don't see a tutor."* The students considering their perceptions of their learning for dictating how much effort they put into it emphasizes the importance of metacognition development. Metacognitive development is needed to make accurate judgments of learning, leading to appropriate decisions on the amount of effort spent on help-seeking or other studying strategies. The effort cues were also commonly discussed when students described using alternative strategies to explain why they did not need specific study strategies. For example, Ruby does not make a practice test because she is provided one by the instructor: *[I do not make a practice test] [be]cause a teacher provides it...if I don't have the time, I won't do it…I would maybe redo the homework or like the problems I've done that the professor has provided.* The evaluation and comparison of effort between study strategies described by Ruby are in line with findings that students will choose less effortful study strategies (Zeegers, 2001; Dye and Stanton, 2017; De Bruin *et al.*, 2023; Wang and Lajoie, 2023).

The other prevalent cues that overlapped with **decisions based on not needing the strategy** were previous experience (*n* = 10) and idiosyncratic (*n* = 5). Among the previous experience cues, some students discussed that they were generically confident in their studying strategies without providing more details on why they felt confident. For example, Ariana described not using the university's academic resources because she felt that her studying habits were good enough: *"[I do not use the university's academic resources because] I think my studying habits are pretty good so I don't [think] I've needed it yet."* Confidence leading students to continue using their study strategies is reminiscent of findings that suggest students choose strategies based on their strategy's usefulness to achieve a specific performance, and if they are successful, students will maintain the same study habits (Harrison *et al.*, 2015; Stanton *et al.*, 2019; Nayyar *et al.*, 2024).

Decisions based on strategy not being available were distinct from the other reason categories by the most common cue being idiosyncratic (*n* = 6) rather than relying on learning/content (*n* = 3), effort (*n* = 2), or previous experience (*n* = 1). Understandably, these would have more idiosyncratic cues based on the individual dependence on the accessibility or availability of specific strategies, such as those provided by the instructor or strategies dependent on the student's social network. The least common reason categories of **decisions based on assessment** (*n* = 1) and **instructor** (*n* = 4) relied mainly on the learning/content cues, following the reliance on learning/content cues for these reason categories when describing why students choose to use study strategies.

Interview Protocol

- Please walk me through how you would generally study for an exam in **chemistry**.
    a) I have a list of study habits and resources that people have said that they use. Please read each habit or resource out loud as you go down the list and say if you use the habit or resource when studying for an exam in **chemistry**.
        - **Why do you use __(checklist study methods used)?**
        - **Why don't you use __(checklist study methods not used)?**
    b) Are there any study habits that you think are not helpful? What do you think are the most helpful study methods? **Why?**
    c) How did you learn how to study (i.e., how did you acquire your study habits)?
        - Has your instructor suggested ways to study?

<u>List of Known Study Habits</u>

☐ Read textbook

☐ Read instructor's notes

☐ Read my own notes

☐ Make a study guide

☐ Make an outline/summarize notes

☐ Use Instructor study guide or learning objectives

☐ Watch videos online

☐ Write/rewrite notes

☐ Do practice problems from the textbook

☐ Do practice problems from outside of the textbook

☐ Redo the homework questions

☐ Take notes while reading the textbook/lecture notes

☐ Flashcards

☐ Make a practice test

☐ Study with a peer/group

☐ See a tutor

☐ Go to the professor's office hours

☐ Think of real-life examples/concrete examples

☐ Create visuals to represent the material (example: infographics, cartoon strips and diagrams)

☐ Teach (or pretend to) someone to test your knowledge

☐ [University Academic Enhancement Center] tutoring resources (drop-in peer tutoring, weekly tutoring groups, occasional tutoring)

☐ [University Academic Enhancement Center] academic skills resources (consultations, study strategies course, study strategies workshops and online study tips)