Investigating Students' Perceptions of Resources and Positive Experiences in Introductory Physics

Jovan Corrales

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University of Pittsburgh

Frederick Honors College

This thesis was presented by

Jovan Corrales

It was defended on

April 12, 2024

and approved by

Dr. Brian Galla, PhD, University of Pittsburgh Psychology Department

Dr. Tessa Benson-Greenwald, PhD, University of Pittsburgh Psychology Department

Dr. Melanie Good, PhD, University of Pittsburgh Physics and Astronomy Department

Dr. Eric Kuo, University of Illinois Physics Department

Thesis Advisor: Dr. Timothy Nokes-Malach, PhD, University of Pittsburgh Psychology Department

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We use the biopsychosocial model of challenge and threat in an effort to better understand how the types of resources and experiences students draw upon to navigate the demands in an introductory physics course. We attempt to quantify students' open-ended responses from a survey to find what experiences they find positive and what resources they use to try to succeed in an introductory physics course at four different timepoints across a semester in two different cohorts. The categories for positive experiences were *achievement and competence, working with others*, l*earning about the subject*, *other good,* and *no good and negative*. The resource categories were *individual, classroom, outside,* and *other people*. We found that students' experiences emphasize *achievement and competence* in a course above *working with others* and *learning more about the subject*. For resources, students use more *classroom* and *social support* than *outside* and *individual* resources, with instances of *classroom* resources increasing over the semester and *outside, social support,* and *individual* resources were reported less often over the same time period. This research has implications for future research into students' learning in STEM subjects.

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1.0 Introduction

1.1 The Necessity of STEM Education

As the demand for Science, Technology, Engineering, and Math (STEM) occupations increases globally, so does the need to better understand the challenges students face in obtaining education and training in STEM as well as the factors that aid students in overcoming those challenges (STEM Education, 2013). Students pursuing training in STEM can face many challenges including having to take courses that have competitive, high-stress environments (Omarji et al., 2018; Massey et al., 2022) that often consist of high stakes tests and requiring significant time and effort for homework and study (Jones et al., 2021; Kalender et al., 2020). These environments may be particularly stressful for students with historically excluded identities in STEM (e.g., students of color, women) who often face additional barriers such as cultural stereotypes of who succeeds in STEM, discrimination and bias, and hostile educational environments, among others (Massey et al., 2022). Prior work has shown that stress, anxiety, and accompanying worry can negatively impact student learning, performance, and motivation (for a review, see Nokes-Malach et al., 2023).

In the current work, the focus is on developing a better understanding of some of the factors that may support student success in a gateway STEM college course -- introductory physics. To explore this issue, an examination and analysis of survey data collected from students in two introductory physics courses. The survey included open-ended questions about students' perceptions of resources and positive experiences in the course and was given at four points throughout the semester. A primary objective of this work was to develop a reliable coding rubric of these open-ended questions in order to develop a descriptive understanding of students' perceptions of the course's resources. These descriptions may provide insights into

what aspects of the course provide support to students and future work could further investigate their potential contribution to student success.

In the next section, there is a description of the biopsychosocial model of challenge and threat stress appraisals that serves as a helpful theoretical framework from which to explore students' perceptions of resources and positive experiences in the course (Jamieson, 2017). In the following sections, there is an elaboration on the types of resources that students may draw on based on past research on student learning and motivation in achievement-oriented classroom environments.

1.2 The Biopsychosocial Model of Challenge and Threat

The biopsychosocial model of challenge and threat states that, when motivated to perform a task, an individual will make a stress appraisal based on the relation between the demands of the situation and the resources available for coping with those demands (Jamieson, 2017). An introductory physics course is a good example of a situation where one may be motivated to perform well because it serves as a gateway (required) course for many engineering or health sciences pathways and many STEM majors. The model states that one aspect of the appraisal is determining the demands of the situation and what is needed to succeed (e.g., completing a homework assignment, solving a problem on an exam, answering a question in class). A second aspect of the appraisal is determining what resources are available -- prior individual experiences and competence (e.g., prior knowledge, skills, self-beliefs), tools (e.g., examples, instructions), and social support (e.g., peers, instructors) -- that can help meet the demands of the situation and task.

According to the model, if the resources are perceived as equal to or exceed the situation's demands, then the student will appraise the situation as a *psychological challenge*. The

state of psychological challenge is theorized to lead to a desire to pursue the task and subject and to do well within it (Jamieson, 2017). In contrast, if resources do not meet the perceived needs of the situation, it is perceived as a *psychological threat*. In a state of psychological threat, it is theorized that one will avoid a task, leading to procrastination and disengagement from the task.

This model can be helpful to apply to how students might engage and react in a given course. Students that are struggling with their coursework may be in a state of psychological threat and thus feel greater stress and anxiety, which may lead to avoiding doing the work whenever possible, leading to worse academic performance (Beilock & Maloney, 2015). In contrast, a student who thinks that they have all that they need to succeed will focus on dealing with the task at hand and engage in structuring the material in a way that allows them to deal with it in a productive manner (Engle & Conant, 2002). A critical aspect of the model focuses on how a student perceives themselves or the task and how those perceptions can impact subsequent thinking and behavior regardless of the student's prior achievement or competence in the domain. For example, although students may have strong prior training and experiences they can still perform poorly when faced with a stressful situation and task if their perceived self-efficacy is low (Kalender et al., 2020). Further elaboration on the importance of students' self-perceptions can be found in a later section.

In addition to the impact of self-perceptions, there are also social factors that can impact stress appraisals and student success in the classroom. Social support, be it peers or faculty, can be considered a resource and thus can possibly help increase feelings of belonging to the physics community and support engaging in learning activities (Li, & Singh, 2023).

Having resources that meet the needs of a task, such as sufficient time or relevant sources of information, has been known to increase productive disciplinary engagement in the subject, as

well as student authority, accountability, and perceiving the content as a series of problems to solve (Engle & Conant, 2002) as well as reduce psychological threat (Jamieson, 2017). But different resources may provide different levels or types of support depending on the student's background and perspectives. One major goal of the current work is to better understand students' perceptions of the resources available to them in an introductory physics course. Our first step is to document students' perceptions of the amount and types of resources students report such as individual knowledge and skills, tools available inside and outside the class, and social support. In the next section, there is an elaboration on different possible resources that students may have based on prior work in the learning sciences.

1.3 Types of Student Resources

With the focus being on what students use in their studies, it is worthwhile to discuss what resources students might report using and how those resources could relate to their performance in an academic setting. In this section, the focus is on prior experience and skills as resources related to the individual student (e.g., prior knowledge, skills, and motivation), physical / virtual tools available inside and outside the class (e.g., lecture materials, videos), and social support as a resource (e.g., peers and instructors).

1.3.1 *Individual Prior Knowledge and Skill*

Previous domain learning of the subject is likely a benefit to subsequent learning and success in academics. It gives one an initial starting point for learning and can make a college course more of a review or an opportunity to re-learn material rather than learning entirely new material. For example, some students could have taken physics courses in high school or another course that they found a way to connect to the topic, such as calculus.

Prior learning may also be beneficial to future learning, even when the material is not directly related to the subject being learned (Vidal-Abarca et al., 1994). This seems to happen through macrolevel learning strategies, such as by constructing different mental representations of the text by connecting to previous experiences or focusing on the details of the text, though said strategies are more effective if developed by learning the same subject (Vidal-Abarca et al., 1994). In short, previous experience allows a student to best tackle the material through building upon already existing knowledge and the development of learning strategies.

1.3.2 *Individual Motivation*

Motivation is relevant to perceptions of resources because if a participant does not feel the desire to pursue the course, they may fall behind, and falling behind can lead to a feeling of being overwhelmed or disengagement (Fong et al., 2023). This can mean that they may not be utilizing all the resources available to them, which can contribute to both a perception that they lack resources and can further contribute feelings of psychological threat. It should also be noted that a participant's motivations to pursue the course can influence their performance, as it can be seen as a resource that contributes to their perceptions of handling the course (Jamieson, 2017).

Motivation in psychology and education research has often been defined broadly to include people's beliefs about themselves and others, their goals, and behaviors in accomplishing those goals. The definition of motivation used in this study is personal factors that increase the odds of engaging with the subject. Examples of this would be expressions of interest and value for activities of the class, goals to understand the materials, or confidence in one's skill and knowledge in the course.

A student's self-perception of their ability to perform well in an academic setting or on a particular task, also sometimes referred to as academic self-efficacy, can be an important

predictor of academic success. Self-perception of competence and ability in a subject is often positively correlated with persistence and a willingness to challenge oneself (Bandura, 2012; Philips, 1984). Meanwhile, low self-efficacy is associated with the avoidance of challenging materials, even when actual academic performance is high (Philips, 1984; Kalender et al., 2020). In brief, self-perceptions of competence and ability to perform are a relevant factor for students when it comes to performance in the classroom, even when accounting for what a student is actually capable of.

1.3.3 *Physical and Virtual Domain Relevant Materials*

Resources found in the classroom are a major part of success in academics. Students often rely heavily on the resources provided in a course to succeed in it. For instance, in Torres-Díaz et al. (2016), students who directed their focus on using materials provided in the course were the ones with the lowest rates of failing any courses. These materials are also some of the easiest to access and require no additional effort to verify that they are reliable for learning about the subject they are learning about. Thus, they are incredibly relevant to students' success in academics. The resources provided in a course can vary from the textbook to the lectures, and to practice materials.

However, students do not only use resources found in the classroom, as they will often use resources that are found outside the classroom. The most notable source of these resources is the internet. Be it looking for alternate explanations of the material or ways to test their knowledge of the material, the internet is a source for many students to find information on the subject they may be struggling with. While not as effective as focusing on course materials, students who did use the internet as a source of information had fewer issues with failed courses than students who did not do additional work (Torres-Díaz et al., 2016). As such, usage of the

internet for academic purposes is a relevant resource in a student's experiences with their education.

1.3.4 *Social Support*

Social support from both faculty and peers are an important resource in how students learn. Faculty support is often the initial source of information for students, as the one who initially presents the information. This initial introduction to the information is then brought even more to the forefront with how it relates to engaging with the material. Students who have a high sense of support from faculty are frequently more engaged with the material, leading to better learning outcomes as they engage with what is presented to them more and may even seek out other sources on the subject (Wilson et al., 2020; Engle & Conant, 2002). As for peers, their social support often results in students becoming similar to their peers. Close peers have similar academic performances, along with developing similar beliefs on motivation and self-perceptions of competency (Altermatt & Pomerantz, 2003). While this applies to close peer relationships, students do often seek other students' perspectives on the material to learn from someone who is closer to them in understanding the subject. Given that both are relevant to how students learn, they are part of understanding this study. In addition, these interactions can foster feelings of belonging to the subject, which can help improve academic engagement (Li & Singh, 2023).

Previous research has identified multiple resources—such as individual, course related, and social—that have been associated with student success in a variety of educational contexts. The current study seeks to build upon this prior research by using these categories to examine how much and which types of resources are reported by students in an introductory physics class over the course of a semester.

1.4 Present Study

The present study investigates the types of resources and positive experiences reported by students in an introductory physics course. College students across two different semesters were given access to a mindfulness resource and a survey about their experiences at four times over the course of a semester.

Research questions include:

Q1. What resources do students report using for the course, and how does that change over the semester?

Q2. What positive experiences do students report in the course, and how does that change over the course of the semester?

2.0 Methods

2.1 Participants

A sample of 142 students participated in the study. They were recruited from a mid-Atlantic public research university who were in an introductory physics course. Of these, 54 were in cohort 1 and 88 were in cohort 2. Demographic data was not collected at timepoint 1 for cohort 1, which meant the four participants who only answered then did not have their demographic data collected. In addition, one participant did not answer for their age, gender, or racial identities. The average age was ~19, with a standard deviation of 2.29, with 100 (72.5%) participants in their first year of study, 24 (17.4%) in their second, 10 (7.2%) in their third, and 4 (2.8%) in their fourth or more. Out of the 137 participants who answered, 42 (30%) self-identified as woman, 94 (68%) self-identified as man, 1 (1%) self-identified as non-binary, and 1 (1%) who did answer but chose to not specify. Out of the 137 participants who answered, 1 (0.69%) self-identified as Middle Eastern or North African, 2 (1.39%) self-identified as Native

Hawaiian or Other Pacific Islander, 3 (2.08%) self-identified as Hispanic or Latinx, 4 (2.78%) self-identified as Black or African American, 21 (14.58%) self-identified as Asian, 112 (77.78%) self-identified as white, and 1 (0.69%) chose "prefer to not answer"". In addition, seven of the students self-identified as two racial identities and 130 only self-identified with one identity.

2.2 Materials

2.2.1 *Surveys*

The surveys were hosted on Qualtrics and consisted of both forced choice, Likert scale items, and open-ended questions. The constructs that were measured using Likert scale items in the broader survey included mindfulness, affect, stress appraisals, demands and resources, cognitive appraisals, physics motivation, and proactive mindset. Overall, the surveys for the two cohorts were highly overlapping though there were some differences in the specific items used or when a construct was added or dropped across cohorts. For the current work's purposes, the focus is on the open-ended questions one and two described below. The first question about students' resources was collected for just cohort 2 whereas students' responses of positive experiences was collected for both cohorts.

2.2.2 *Open-Ended Coding Rubrics*

Open-ended questions allow participants to best explain what they feel and create an opportunity to observe a wide variety of answers that are not restricted by the researcher's a priori conceptions or biases. However, this also means additional effort is needed to use these responses as part of a quantitative analysis. Thus, a method to interpret the data is needed in order to be able to look for patterns of responses. Due to gaps in the literature on this subject, one such rubric did not exist and so had to be made for this study. The steps to do so were largely

taken from Chi (1997), though there were a few deviations, such as the decision to have a rubric as the format before looking at a sample of the data.

The beginning of the process consisted of brainstorming initial ideas for the rubric based on the open-ended questions. This top-down activity occurred before looking at any student responses and was based on the first author's and advisors' experience and prior knowledge. This step allows for some initial concepts to be generated that could be modified or replaced as the data is considered and examined, functioning as an initial framework to help guide further work.

The next step was to sample the data to create a rough draft of the rubric (Chi, 1997). Ten percent of the data was used to see how well the framework from the previous step fit and if adjustments were needed in converting the framework into the rubric. Doing this allowed for examples for each of the categories used in the rubric based on the entries provided by the participants.

We then took a larger sample of the data, alongside the rough draft of the rubric, and coded the sampled entries (Chi, 1997). Twenty percent of the data was used as a sample. The sample was coded by four coders and an analysis of interrater reliability was conducted revealing significant variation in agreement (i.e., Fleiss' Multirater Kappa ranged between .21-.83 across the categories for the two questions). The coders then met to look over any inconsistencies in the coded data and discuss what potentially caused the inconsistency. For example, a student response could be ambiguous and hard to categorize or there could be confusion around the definition of some part of the rubric. We then discussed whether the rubric needed to be modified to account for the inconsistency. This was typically the case and resulted in refining a definition in the rubric or clarifying particular instances or examples of the code or category. A

new coder then used the revised rubric to code the sample data and Cohen's Kappa was calculated for the new coder and one of the previous coders, resulting in substantial agreement (Cohen's Kappa ranged between .78-1.00 across all categories for both questions).

The open-ended coding rubrics were then used by the two coders to categorize the rest of the student responses in the surveys (see Appendix A for the final coding rubrics). The first rubric was designed to categorize student responses to the question: "*What resources did you use to help you with your physics work?*". See Table 1 for an overview of the categories and subcategories of student responses.

Table 1

Resource types and definitions for the coding rubric for question one.

Resource Type	Subcategory	Definition
Individual	Prior knowledge	Knowledge one had before the course, or gained earlier in it
	Skills	Some cognitive or behavioral skill a participant has
	Motivation	Beliefs, goals, and emotions related to competence, identity, success in physics, schoolwork, or life
Classroom		Resource that is found in the classroom or on Canvas
Outside the classroom		Resource that is from outside the classroom and the individual.
Social support	Faculty	Member of the university's faculty, teaching assistant, or staff at the tutoring center
	Peers	Fellow students or peers
	Other	Person outside the university

The first category is *individual resources* that is based on one's prior experience and competence and consists of three subcategories: prior knowledge, skills, and motivation. *Prior knowledge* is defined as knowledge that the individual had before the course or had gained earlier in the course, such as experience in high school or a calculus class. *Skills* are defined as some learned cognitive or behavioral ability a participant has, such as note-taking or analytical

thinking. *Motivation* is defined as beliefs, goals, and emotions that may increase the odds of engaging with the subject, such as a positive attitude or confidence.

The second category is *classroom resources* which are materials and information provided in the course, such as the textbook or the lecture. The third category is outside the *classroom resources*, defined as resources the student identifies on their own outside the class, such as YouTube videos.

The final category is *social support* which is defined by other people that helped the student work on the material. This category includes the subcategories of the *faculty* of the school, such as the professor, TA (Teaching Assistant), or staff at the tutoring center. *Peers* include other students regardless of whether they were also part of the course or not. *Others* refers to people outside of the university, such as family or other professionals.

The second rubric was designed to categorize student responses to the question: "*What positive experience did you have with Physics recently?*". See Table 2 for an overview of the categories and subcategories for classifying student responses. Subcategories include: achievement and competence, interacting with others, and learning/understanding, other positive experience, and no good or negative experience.

Table 2

Experience types and definitions for the coding rubric for question two

Experience Type	**Definition**
Achievement and Competence	Participant responds with an experience about doing well by some standard
Interacting with Others	Participant's experience involves another person
Learning and understanding	Participant mentions learning or understanding
Other positive experience	Participant has a positive experience that does not fall into the above categories
No good or negative experience	Participants states they did not have a positive experience or brings up a negative experience

Achievement and competence is for when a participant brings up either a standard of some kind that they either set for themselves or the course or felt a sense of competency as a student. *Interacting with others* is when a participant brings up a time they interacted with someone else. *Learning and understanding* refers to when a participant describes either learning something new (e.g., a concept, skill, or mindset) or understanding how to apply that knowledge, skill, or mindset. *Other positive experience* consists of when a participant brings up a positive event that does not fall into one or more of the previous categories. *No good or negative experience* is when the participant either says nothing or brings up an explicitly negative experience.

2.3 Procedure

Students could elect to participate in the study as a part of their class in which they could earn extra credit for filling out surveys at their own pace. The students were given access to the surveys four times during the semester: during week four, seven, ten, and fourteen for both cohorts. The mindfulness resource was included as a part of the classroom resources. The survey was expected to take about ten minutes to complete and was available for 5 days.

For the cohort 1 survey participants were first asked multiple choice and Likert scale questions about mindfulness, affect, stress appraisals, demands and coping, and motivation. The next question was an open-ended where the participant is asked about a recent positive experience relating to physics. The next questions were related to the mindfulness resource. The same survey was given at each timepoint. After a participant completed their first survey (regardless of timepoint) they were linked to another series of questions about their demographic data that they filled out once.

The revised survey for cohort 2 included multiple choice and Likert scale questions about mindfulness, affect, stress appraisals, demands and resources, motivation, and proactive mindset. This was followed by the open-ended questions about the resources and recent positive experiences the participant had in the class. The open-ended resources question was asked at time points 2, 3, and 4. The next questions were about the mindfulness resources. After a participant completed their first survey (regardless of timepoint) they were linked to another series of questions about their demographic data that they filled out once.

3.0 Results

Participants answered the two open-ended questions about what resources they used to help them with their physics work and about their positive experiences in physics. Table 3 presents the number of participants who answered the survey at each timepoint. Because participants could elect to complete all or none of the surveys the data is cross-sectional with some variation as to who completed at each time point. We also report the number of participants who responded to the positive resource question at all four timepoints since both cohorts completed the question. The majority of students from both cohorts completed all timepoints.

Table 3

Number of participant responses at each time point for positive experience question

	Timepoint				*Finished All*
Cohort	*1*	*2*	*3*	*4*	*Timepoints*
1	42	47	42	36	$n = 32$
2	72	74	74	77	$n = 55$

For each question their responses were examined for the number of instances of each category and subcategory according to the rubrics. A single participant response could include multiple mentions of a subcategory and therefore contribute multiple instances for that category. Below is the report of the number of total observed instances for a given (sub)category divided

by the number of responses for a given time point. This measure helps to control for the different time points having slightly different numbers of participants completing the responses.

3.1 Physics Resources

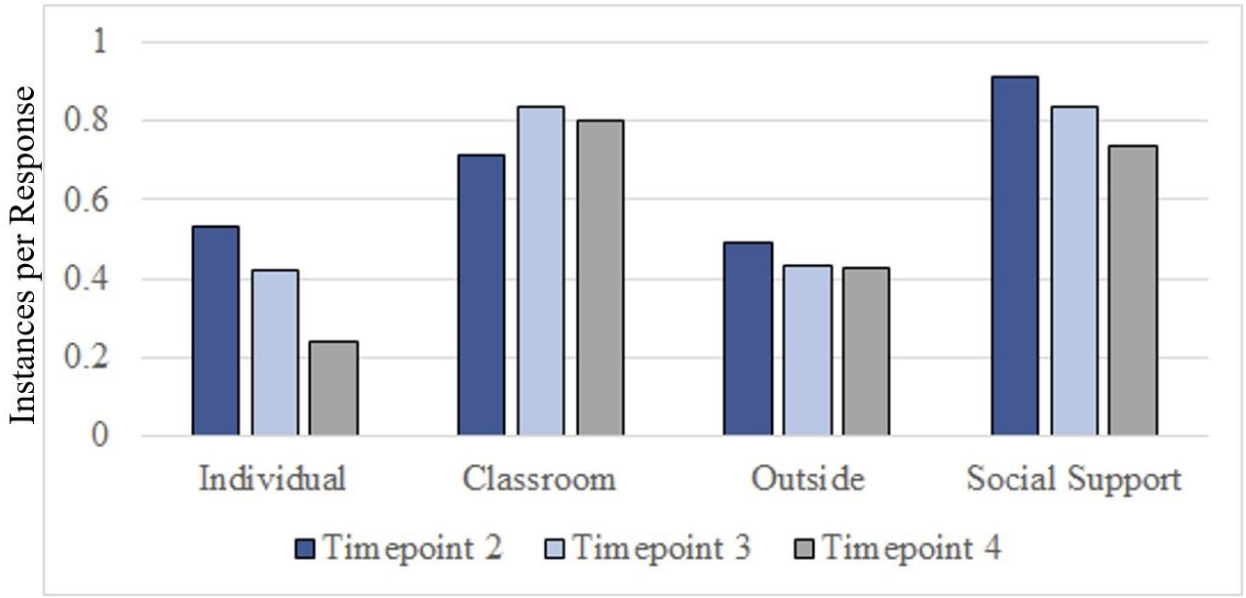
This section begins with the descriptive statistics of the overall number of instances of each general resource category (i.e., individual, classroom, outside, and social) as well as the instances per response. The subsequent sections report the descriptive statistics and visualizations for the subcategories within each general category. Figure 1 is a histogram of the instances per response of each category at each timepoint. Instances per response were obtained by dividing the resources in a category reported at a timepoint by the responses at the same timepoint. There were 41 (~0.53 per response) instances of individual resources observed at timepoint 2, 31 (~0.42 per response) instances at timepoint 3, and 19 (~0.24 per response) instances at timepoint 4 with the number of instances decreasing across timepoints. There were 55 instances of classroom resources (~0.71 per response) reported at timepoint 2, 62 (~0.84 per response%) at timepoint 3, and 64 (~0.8 per response) at timepoint 4 with the number of instances slightly increasing over time. There were 38 instances of outside resources (~0.49 per response) reported at timepoint 2, 32 (~0.43 per response) at timepoint 3, and 34 (~0.43 per response) at timepoint 4, showing largely similar number of instances across timepoints. There were 70 instances of social support (~0.91 per response) reported at timepoint 2, 62 (~0.84 per response) at timepoint 3, and 59 (~0.74 per response) at timepoint 4 decreasing slightly across timepoints.

Comparing categories across timepoints, individual and outside resources were observed at lower numbers than classroom and social support. In total, there were 204 resources reported for the 77 responses provided at timepoint 2, 187 resources for 74 responses at timepoint 3, and

176 resources for 80 responses at timepoint 4. The responses in timepoint 2-4 in cohort 2 are different from those in Table 6 due to not all participants answering all questions and the empty responses being excluded from the positive experiences.

Figure 1

All Resource Categories



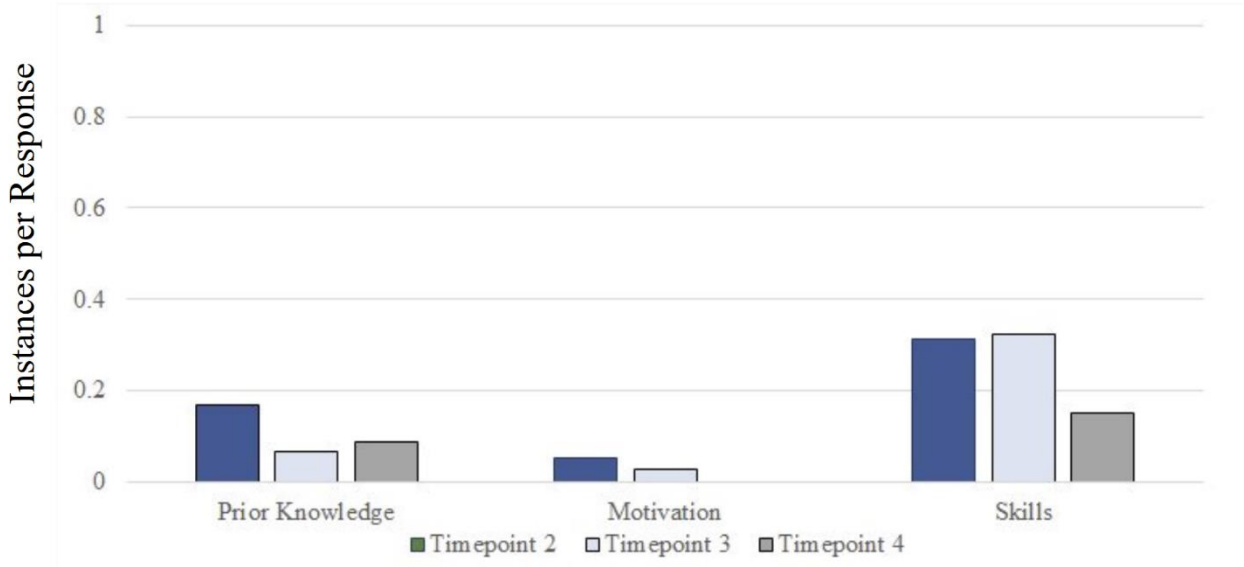
3.1.1 *Individual Resources*

The number of instances of individual resources for a given student response ranged from 0-3. The number of observed instances for each subcategory were divided by the number of responses at that timepoint. We observed 13 instances of prior knowledge at timepoint 2 (~0.17 per response) , timepoint 3 had 5 instances (~0.07 per response) reported, and timepoint 4 had 7 (~0.09 per response), dropping a lot in timepoint 3, but picking up at timepoint 4, at least proportionally. Motivation had 4 (~0.5 per response) at timepoint 2, 2 (~0.3 per response) at timepoint 3, and 0 at timepoint 4, decreasing over the timepoints. Skills had 24 (~0.31 per response) reported at timepoint 2, 24 (~0.32 per response) at timepoint 3, and 12 (~0.15 per response) at timepoint 4, largely consistent in terms of proportions. In terms of total reported, all

subcategories decreased over time, but this is consistent with the trends in total Individual resources. Figure 2 shows the data for each subcategory at timepoints 2, 3, and 4.

Figure 2

Individual Subcategories



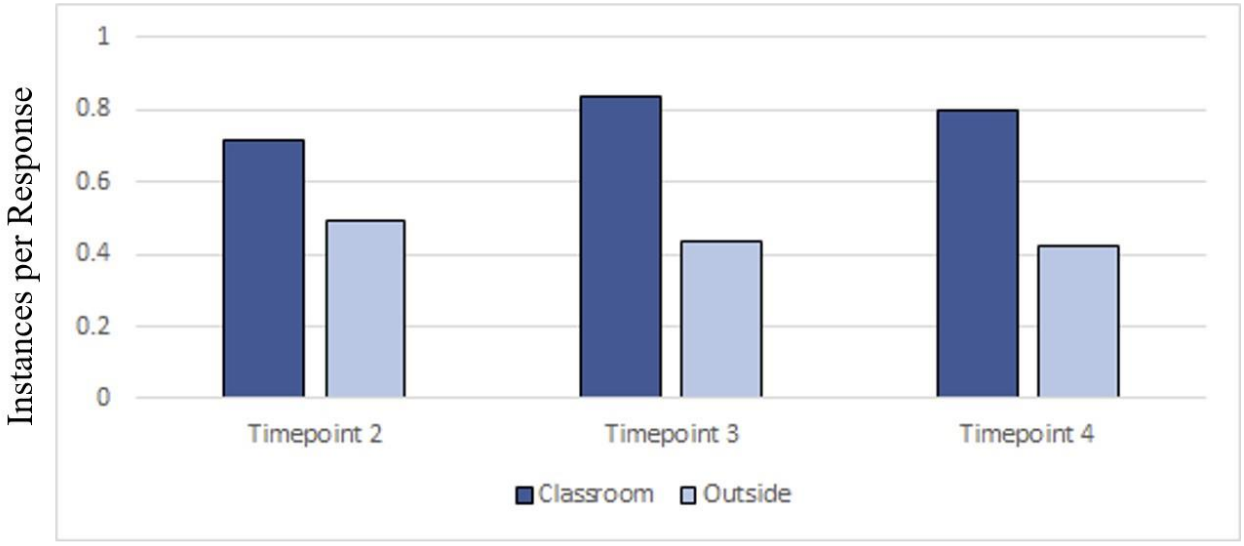
3.1.2 *Classroom and Outside Resources*

The number of instances of classroom experiences for a given student response ranged from 0-5 and the number of outside classroom instances ranged from 0-2. Classroom and outside resources initially had two subcategories each however we decided to collapse across these subcategories in reporting the results because for the classroom subcategories there was some instances where it was difficult to differentiate the two. For the outside resources one of the subcategories, technology, was only observed one time so we collapsed across the two. However, comparing the two to one another is relevant due to how they may relate to how students try to learn, as one is what the student is provided in the course, while the other is what the student seeks out to use. As reported above, classroom resources were higher at all timepoints and increased over time, while outside resources decreased over the timepoints. Figure 3 shows the data for both categories at timepoints 2, 3, and 4 (these are the same results as

presented above in Figure 1 but just focusing on these two categories).

Figure 3

Comparing Outside and Classroom



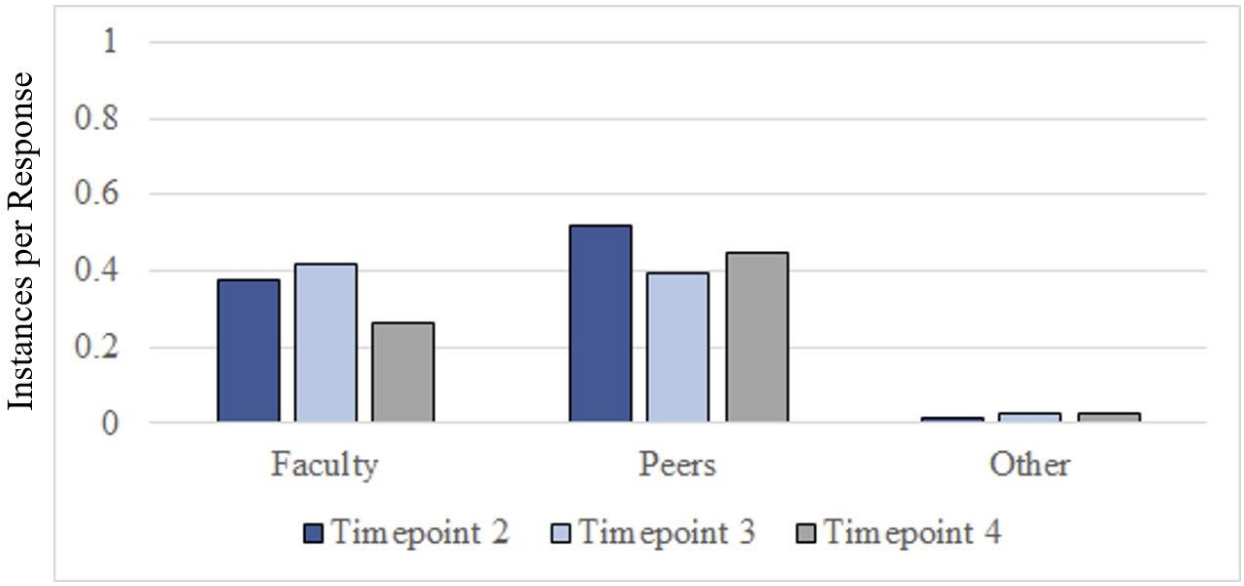
3.1.3 *Social Resources*

The number of instances of social support for a given student response ranged from 0-4. The total resources reported for each subcategory were divided by the total responses at that timepoint. We observed 29 instances of faculty at timepoint 2 (~0.38 per response), timepoint 3 had 31 (~0.42 per response), and timepoint 4 had 21 (~0.26 per response), peaking in timepoint 3 before going back down in timepoint 4. We observed 40 instances of peers (~0.52 per response) at timepoint 2, 29 (~0.39 per response) at timepoint 3, and 36 (~0.45 per response) at timepoint 4, dropping in timepoint 3 before going back up again in timepoint 4. We observed 1 instance of other (~0.01 per response) at timepoint 2, 2 (~0.03 per response) at timepoint 3, and 2 (~0.03 per response) at timepoint 4, consistently low. Figure 4 shows the data for each subcategory at

timepoints 2, 3, and 4.

Figure 4

Social Support Subcategories



3.2 Positive Experiences

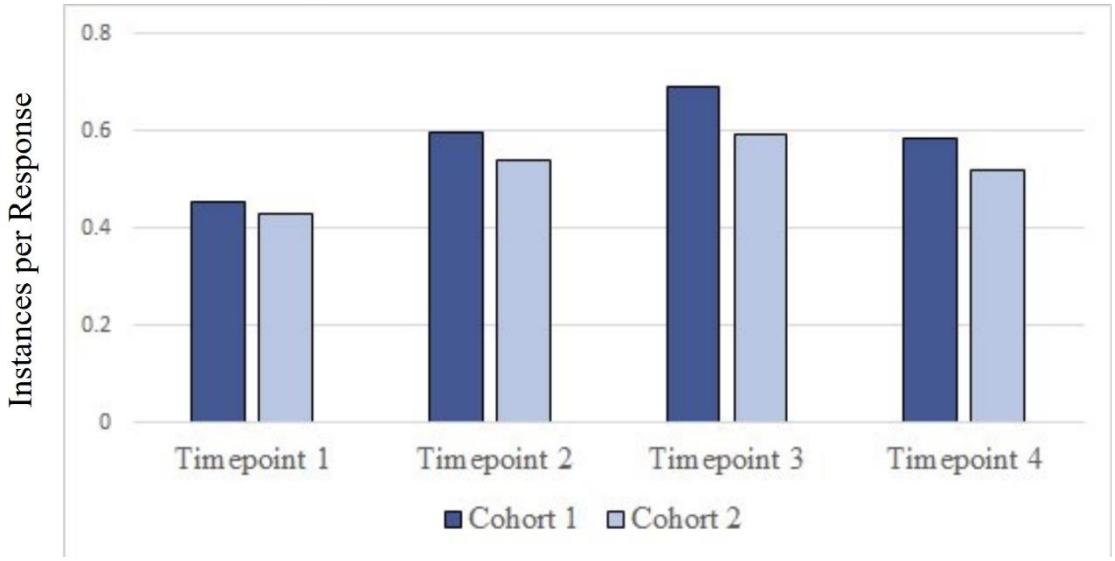
Participants were asked what positive experiences they recently had with physics. Their responses were categorized with the question two rubric. Similar to question one proportions are reported in paratheses and were calculated by dividing the total instances of a category at a certain timepoint and cohort by the total number of responses at that timepoint and cohort. It should be noted that all proportions will exceed a hundred percent due to the categories not being mutually exclusive and that students can mention more than one instance in a response.

Responses from participants were marked as achievement and competence if they matched the criteria of the rubric. For achievement and competence in Cohort 1, there were 19 instances (~0.45 per response) observed for timepoint 1, timepoint 2 had 28 (~0.6 per response) instances, timepoint 3 had 29 (~0.69 per response) instances, and 21 (~0.58 per response) responses for timepoint 4. For Cohort 2, Achievement/Competence had 31 (~0.43 per response)

responses in timepoint 1, 40 (~0.54 per response) in timepoint 2, 44 (~0.6 per response) in timepoint 3, and 40 (~0.52 per response) in timepoint 4. Achievement and competence was consistently high in terms of instances and instances per response at each timepoint and across timepoints. Figure 5 below shows instances of achievement and competence in Cohorts 1 and 2 at different timepoints relative to the overall number of responses.

Figure 5

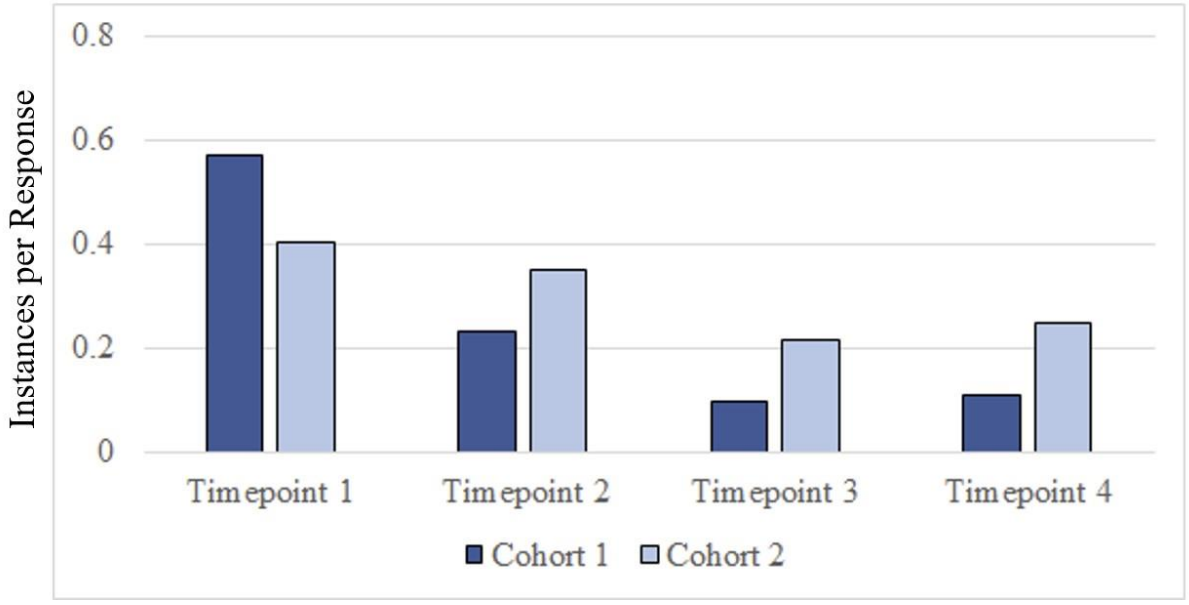
Achievement and Competence



Responses from participants were marked as working with others if they matched the criteria of the rubric. For working with others in Cohort 1, there were 24 (~0.57 per response) responses marked for timepoint 1, timepoint 2 had 11 (~0.23 per response) responses, timepoint 3 had 4 (~0.1 per response) responses, and 4 (~0.11 per responses) responses for timepoint 4. For Cohort 2, working with others had 29 (~0.40 per response) responses in timepoint 1, 26 (~0.35 per response) in timepoint 2, 16 (~0.22 per response) in timepoint 3, and 19 (~0.25 per response) in timepoint 4. In both cohorts, instances of responses involving working with others went down over time, eventually went down over the semester, though did see a slight increase in timepoint 4. Figure 6 shows this data relative to the total responses at that timepoint.

Figure 6

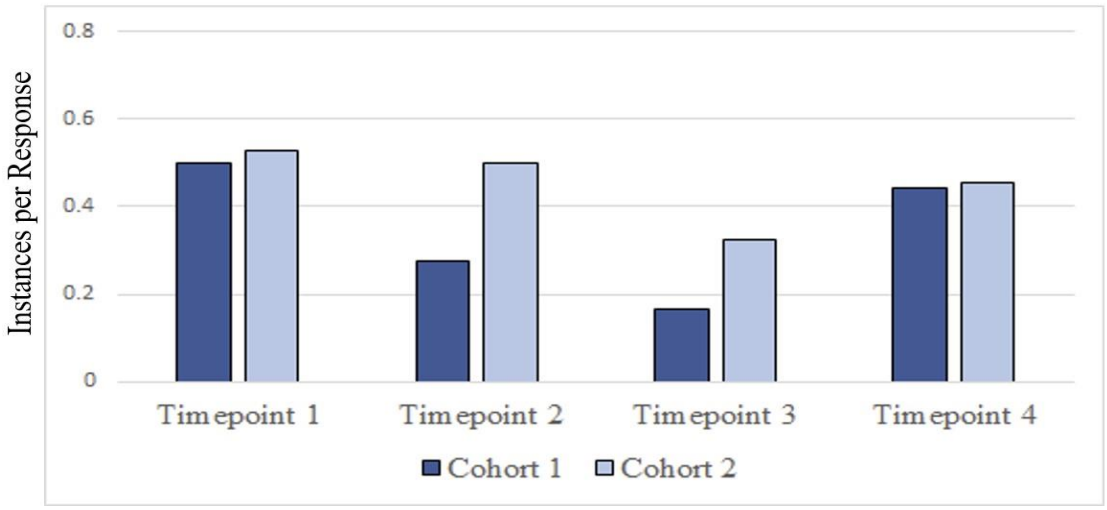
Working with Others



Responses from participants were marked as learning about the subject if they matched the criteria of the rubric. For learning about the subject in Cohort 1, there were 21 (~0.5 per response) instances observed in timepoint 1, timepoint 2 had 13 (~0.28 per response) instances, timepoint 3 had 7 (~0.17 per response) instances, and 16 (~0.4 per response) responses for timepoint 4. For Cohort 2, learning about the subject had 38 (~0.53 per response) instances in timepoint 1, 37 (~0.5 per response) in timepoint 2, 24 (~0.32 per response) in timepoint 3, and 35 (~0.46 per response) in timepoint 4. This category saw the biggest differences between cohorts, with Cohort 2 not seeing as much of a decrease from timepoint 1 to timepoint 2 and having a greater decrease from timepoint 2 to timepoint 3, though still remaining higher and then being similar in timepoint 4. Figure 7 shows this data relative to the total responses at that timepoint.

Figure 7

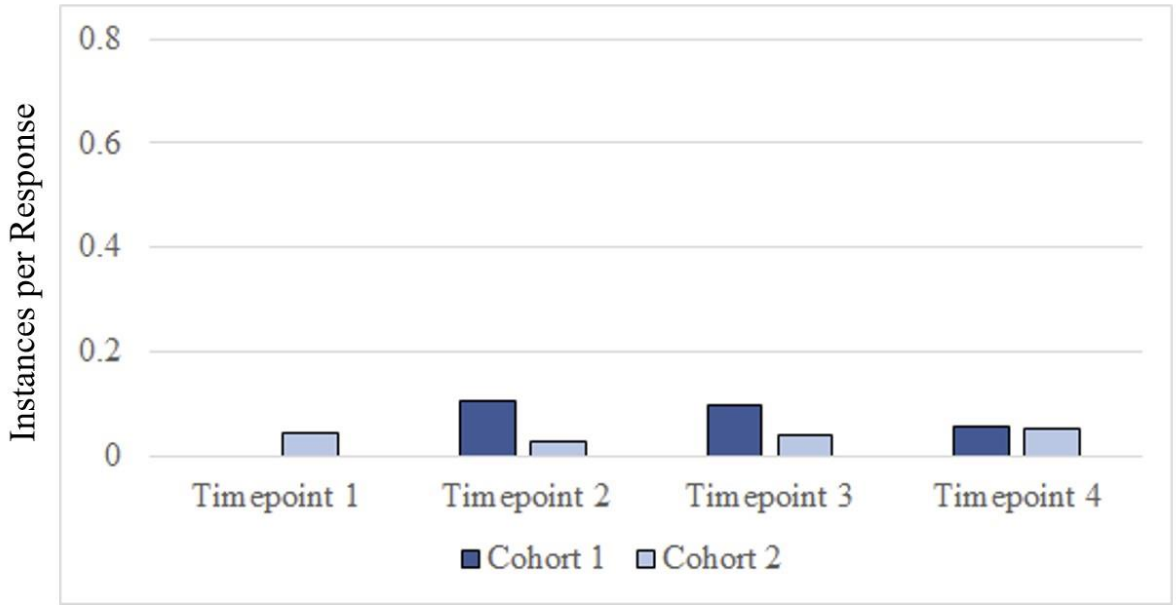
Learning About the Subject



Responses from participants were marked as other positive if they matched the criteria of the rubric. For other positive in Cohort 1, there were 0 instances observed in timepoint 1, timepoint 2 had 5 (~0.11 per response) instance, timepoint 3 had 4 (~0.1 per response) instances, and 2 (~0.06 per response) instances for timepoint 4. For Cohort 2, other positive had 3 (~0.04) instances in timepoint 1, 2 (~0.03 per response) in timepoint 2, 3 (~0.04 per response) in timepoint 3, and 4 (~0.05 per response) in timepoint 4. Instances of this category were low across all of Cohort 1, while being a more notable data point in timepoints 2 and 3. Figure 8 shows this data relative to the total responses at that timepoint.

Figure 8

Other Positive

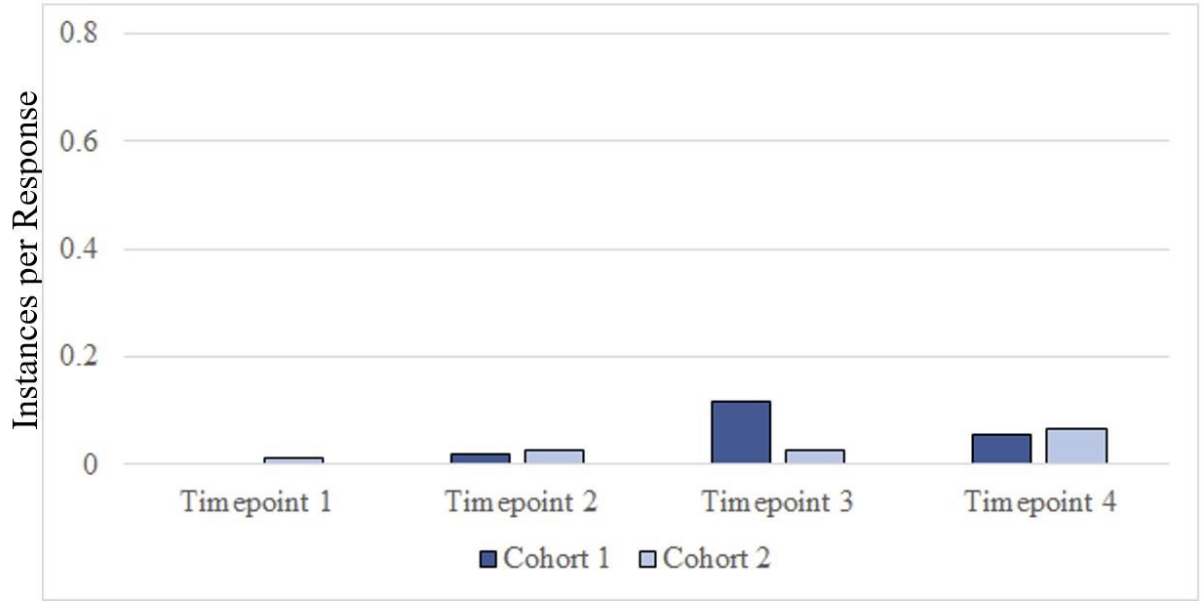


Responses from participants were marked as no good and negative if they matched the criteria of the rubric. For no good and negative in Cohort 1, there were 0 instances observed in timepoint 1, timepoint 2 had 2 (~0.02 per response) instances, timepoint 3 had 5 (~0.12 per response) instances, and 2 (~0.06 per response) instances for timepoint 4. For Cohort 2, no good and negative had 1 (~0.01 per response) instance in timepoint 1, 2 (~0.03 per response) in timepoint 2, 2 (~0.03 per response) in timepoint 3, and 5 (~0.07 per response) in timepoint 4. There was a major increase in the number of instances of this category in Cohort 1 at timepoint 3, along with a general jump at timepoint 4 for both cohorts. Figure 9 shows this data relative to

the total responses at that timepoint.

Figure 9

No Good and Negative



For total statements at each timepoint, for Cohort 1, there were 42 for timepoint, 47 for timepoint 2, 42 for timepoint 3, and 36 for timepoint 4. For Cohort 2, there were 72 for timepoint, 74 for timepoint 2, 74 for timepoint 3, and 77 for timepoint 4. There were also two answers for Cohort 2; one in timepoint 3, one in timepoint 4, that were simply N/A.

4.0 Discussion

Individual resources decreases over timepoints is possibly the result of how participants think of those resources and their relation to academic work. Looking specifically at the subcategories, instances of prior knowledge largely fell from timepoint 2 to timepoint 3, possibly due to covering more unfamiliar material, and thus prior experience is not particularly helpful at that point (before the course). Motivation was low across all timepoints, which may be due to how motivation not being commonly seen as a physics resource. It may also be due to time, as

students may lose their sense of motivation as the course goes on. Skills were the most frequently reported individual subcategory, which could relate to students' beliefs about what is helpful for successful course performance. Because physics requires problem solving skills to perform well on exams and other assessments in the course this may be a very salient resource for students. The decrease in timepoint 4 may be the result of the finals coming up. In brief, participants reporting of individual resources may have an association with how students perceive the demands of the course, most notably exams (Jamieson et al., 2022; Jones et al., 2021).

Comparing classroom and outside resources to each other, instances of classroom resources went up across timepoints 2, 3, and 4, while outside resources slightly decreased during that time, resulting in classroom having roughly double the instances compared to outside resources. With classroom resources, this may reflect participants becoming more familiar with the course and where to find and use materials, which when combined with previous research suggests that these resources are sought out and used by students. Meanwhile, outside resources going down across timepoints could be due to a few reasons. One might be that students might use external resources to compensate for a particular topic's complexity, as they begin to better understand the course and how to do well in it over time. This may also explain the increase in classroom resources, as students' increased familiarity and experience could lead to higher usage of classroom resources. It could also mean that students may shift to classroom resources after settling into a routine, while outside resources are used when participants are beginning the semester and unfamiliar with what classroom resources work best for them. Ultimately, more resources being added to courses may be one of the best ways to help students do well (Engle &

Conant, 2002), along with giving an idea of where to find reliable outside resources to help students transition into the course or to deal with more complicated subject matter.

Looking at social support resources, we see a general decrease across Cohort 2's timepoints 2, 3, and 4. This might suggest that students, over time, move away from social resources. As to why, it might be due to additional work that needs to be done as the semester progresses, and as such, time that might be spent working with others is directed elsewhere and effort that would be used to maintain that relationship is used on assignments. It could also be the result of the course becoming easier over the course of the semester, and as such not needing the additional help that social support provides. However, given that this course encourages cooperation as a part of the recitation, peer resources remain high across all timepoints, while faculty only ever exceeds listed peer resources at timepoint 3 by 2. This follows previous research that suggests peer support is a major aspect of doing well in academics, increasing a sense of belonging to the field (Cook et al, 2012; Massey et al., 2022).

Achievement and competence was the positive experience that had the highest number of instances in both cohorts, often double or even triple the number of instances of the other categories. The low number of instances in timepoint 1 is potentially related to some participants not feeling as though some of the work they had done met some standard or was worth noting as an achievement. The first exam was taken during the fifth week of the course, meaning it was one week after the first survey, and exams can be seen as the biggest obstacle to success in a course. Meanwhile, timepoints 2, 3, and 4 occur sometime after the first, second, and third exams of the course, respectively, possibly meaning students are using that as the basis for how well they are doing (Jones et al., 2021). As a result, it may help students to develop a better academic self-concept and self-efficacy in the subject, which can lead to better performance in future work

in STEM (Salimi et al., 2022, Kalender et al., 2020). Timepoint 3 having more instances than timepoints 2 and 4 may be due to Spring Break, which occurred the week before timepoint 3's survey was sent out, and thus may have improved students' moods towards the course as a result.

For working with others, the trend was downwards across both cohorts and a small increase at timepoint 4, with a lower number of instances overall in Cohort 1. The overall lower number of instances across Cohort 1 compared to Cohort 2 is possibly due to the number of students in Cohort 1 being lower than Cohort 2. As for the trend, a possible explanation is that due to interactions with peers and faculty are a part of the course—peers are encouraged to work with each other during recitation—this becomes a standard part of the course and not something that is uniquely positive and thus not worth reporting. There is also the possibility that students see the ability to independently complete the tasks as a positive quality, thus meaning that as they get more familiar with the course, they do not have to rely on others to do well.

The patterns of instances for learning about the subject have a downward trend from timepoint 1 to 3, then going up again at timepoint 4, though this pattern is more pronounced for Cohort 1 than Cohort 2. Given that this pattern is the opposite of what we see in achievement and competence, this may be reflective of the reason students have for studying the subject; such as if the motivation is intrinsic or extrinsic, or if the student is a physics or a related major. Alternatively, students may be emphasizing their academic success as they see it connected to long-term outcomes due to GPA (Sheldon & Kasser, 2008). As for the decrease from timepoint 2 to timepoint 3, and the increase from 3 to 4, this may be due to Spring Break, as participants may be only thinking of the last week when asked for a recent experience, especially if they answered the survey before the first class of the week. In addition, the increase may be due to the relevance of the material in-between timepoints 3 and 4 to students' lives, namely electromagnetism.

Overall, this category will probably require additional information, such as why participants were taking this course and how well they were doing.

Other good and no good and negative experiences had very few instances reported. For the latter point, this is likely due to the question asked, meaning participants who did have negative experiences did not report them. The increase in instances of no good and negative experiences in timepoint 3 in Cohort 1 could be the result of students not remembering due to Spring Break being the previous week and that the question is asking for a recent positive experience, which students may think of as within a week. The instances of other good experiences were low across timepoints, with the small increases at timepoint 2 and 3 in Cohort 1 being largely indicative of participants being vague about positive experiences and how they felt, possibly connected to the question not asking for why the experience was positive. Timepoint 3 may, like no good and negative at the same point, be somewhat the result of Spring Break being the previous week and participants recalling what happened that week.

The resource students responded to the most was with classroom, with their usage going up across the semester. While in the framework of psychological threat, this may suggest that these resources are the most important while coping with demands of the class, it is worth noting that the beginning of the semester is when students are the least familiar with the course, which would instead suggest that students primarily rely upon classroom resources when not in a state of psychological threat. Meanwhile, the decline in social support and outside resources may be more indicative of what students rely upon with more unfamiliar demands and, due to the additional effort needed to seek these resources out, students may not use them when they do not feel the need to. The decline in individual resources is hard to relate to feelings of psychological threat, though it may be that students emphasize their own abilities when overcoming demands.

For experiences, achievement and competence can be seen as students' feelings of overcoming the demands they face, possibly representative of a state of psychological challenge. If true, this would mean when students are faced with less difficult tasks, they may be more likely to succeed and more likely to bring up their success. This can be seen by the increase over time and that the lowest point may reflect the most difficult or uncertain time of the course. Spring Break's increase may be an instance of free time allowing students to take a step back and do a reassessment of their performance, which may mean that they may have seen that the demands they had were not as high, or that when demands are perceived as distant, they may be deemed as less demanding. The decrease in learning about the subject is possibly due to a change in priority over the course over the semester to better grades. The increase in timepoint 4 could be a consequence of the material covered around that time, electromagnetism, is relevant to their lives, that being how phones and the internet work. Working with others likely has a similar explanation to social support resources, that the additional effort to work with others was not needed due to the decreasing difficulty of the course, since the additional effort to work with others was not needed, as well as becoming less noteworthy given students were able to freely work with one another as part of recitation.

4.1 Practical Implications

For possible practical implications of this work for professors, a possibility to look at how the social support for students is structured. Allowing students to freely associate with the faculty (outside lectures and recitations) and peers may be helpful; such as with a discord server, as it allows students to get help when needed, but still allows them to work on their own if they want to do so. It may also be helpful for students to help them find reliable outside resources, such as through a document that gives them an idea of where to find and evaluate the accuracy of

an outside resource. Professors should also take note of how they structure and introduce classroom resources, as well as also providing what they used in lectures to students to allow them to review it, such as by recording lectures or uploading the slides to a course website. Professors may also want to pay attention to the motivations of their students and to what is driving students over the semester. It may also be worth examining the structure of the course and seeing where students struggle the most and where they may feel that they understand or have accomplished the most.

4.2 Limitations

This study is restricted to just the resources and positive experiences of the participants, meaning demands and negative experiences are left out, possibly missing out on what may cause problems at what points. In addition, the resources question is available for less than half the available data, meaning it is harder to utilize and make conclusions with. Also, the positive experiences question only asks about what the experience was and not why it was positive. This has led to issues for distinguishing between categories; namely achievement and competence, learning about the subject, and other good; and while it can be obvious why most experiences are positive, this meant vagueness for some participants who did not elaborate on the experience, as well as if it had some additional reason that is not obvious.

4.3 Suggestions for Future Research

There are additional variables that can be helpful for finding out more about what works for students. As brought up earlier, why participants are taking the course would be helpful for the possible associations with achievement and competence and learning about the subject. Similarly, questions about how complicated the material is could relate to learning about the subject and if how complicated the material increases or decreases the number of instances of

this occurring, as well as what resources a student may use to deal with a confusing topic. Following that, it may be helpful to ask what a student does when they don't understand the material, which can also indicate what resources a student considers most important or what resources are seen to help with what issues. Conducting an analysis that focuses on how resources are used in relation to students' identities, such as race and gender, could also be helpful for seeing how it intersects with resource usage. Another thing would be to account for breaks, as they can influence the results due to changing the attitude of the participant and limiting how much they are thinking about the course. The final suggestion for this section would be to ask about recent negative experiences in a course, seeing at what causes students to struggle and when it occurs could relate to the previous suggestion of how students tackle these issues and what issues are most common at each point in the semester.

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7.0 Appendix A: Rubrics for Open-Ended Coding

7.1 Open-Ended Question 1

What resources did you use to help with your physics work?

Measure the frequency of a response mentioned in an open-ended category. Tally how many are found in each answer and what category they fall into. If the response does not fall into one of the categories, mark it. If it falls outside of a sub-category, mark it as part of that category, but other for the sub-category. Each instance of a resource falls into one category, but an answer can contain multiple resources of a category. A slash indicates that the two resources are just one instance of a resource, not multiple.

Category	Definition	Sub-Category	Description	Examples
Individual Resource	A resource that is based on an individual's prior experience and / or self-generation	Prior Knowledge	Knowledge one had before the course (preparation for physics – math, physics, science) or acquired earlier in current course (before current survey)	High school classes, Physics or Math knowledge, Concepts from earlier chapters
		Motivation	Beliefs, goals, and emotions related to competence, identity, success in physics, school work, life -- characteristics or skills	Drive to succeed, Goals to do well, Previous interest / value in topic, Beliefs that one can do it, Identity in science Working Hard
		Skills	Some cognitive or behavioral skill a participant has	Test-taking skills, Analytical thinking, Study techniques, Time management, Organization, Easily works with others, Taking good Notes (Unless provided by another)

Classroom resource	Resource that is found in the classroom or on Canvas		Lecture slides Textbook Worksheets Mindfulness resource Wiley Exam Prelecture Videos Doc Schuster Homework	
Outside the classroom resource	Resource that is from outside the classroom and the individual. Typically requires additional effort to find or use (i.e., having to look it up or fill a form).		YouTube ChatGPT Chegg Computer Calculator	
Social Support	Participant brings up another person as a resource and implied that they gained something from it	Faculty	Member of the university's faculty	Professor TA Tutoring Center
		Peers	Fellow students from the university	Friends Roommates Other students
		Other	Other people from outside not in the university	Family members Engineers

7.2 Open-Ended Question 2

What positive experience did you have with Physics recently?

Measure the frequency of a response mentioned in an open-ended category. Tally how many are found in each answer and what category they fall into (max. 1 of each category). If the response does not fall into one of the categories, mark it.

Category	Definition	Examples
Achieve a standard / performed to a level of competence	Participant has reached a standard, be it self-generated or class specified, or has felt that they showed competency as a student	Doing homework on time or without relying upon a particular resource, Getting either a good grade, be it without comparison, comparing to others, or comparing to a past assignment Did well overall in a course Believed they did well on a test
Interacting with Others	Participant brings up an interaction with someone else	Friends or family, Professor or TAs, Classmates or roommates,
Learning / understanding more about the subject	Participant cites that they learned something (concept, skill, mindset) or that they can now understand how to apply something (concept, skill, mindset) or felt that they displayed competency in understanding the subject	I now understand Gauss' law I was able to apply my calculus knowledge I overcame a challenge to learn about the subject
Other positive affective / emotional experience	Participant is not specific in what they are positive about, or said positivity falls outside of categories so far (do not use if it falls into one of the previous three categories)	I felt good about the project (Note: Grade is either not brought up or is expressly negative or not specific about how well the participant did) I like this class, I felt relief after the project (Again, grade is not brought up or is negative or not specific about how well they did)
No good / negative experience	Participant brings up that they have had no good experiences or even only had negative experiences with the	I didn't have any good experiences, I am failing this class

	class. (Use only if answer does not fall into any of the previous four categories)	