Exploring Students' Perceptions of Contextualized Computing in an Introductory Computing Science Course for Non-majors

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Abstract: Introductory computer science courses for non-majors (CS0) aim to increase diversity and highlight the relevance of computing across disciplines. To enhance the accessibility and engagement of CS0, researchers have explored contextualized computing, where computing is integrated with another subject, to teach course content. While research has explored various designs for contextualized courses, we know less about how contextualized computing tasks impact students' learning experiences. Through the lens of metacognition and affect, we conducted a secondary qualitative analysis on daily diary and retrospective interview data from 20 students in a CS0 course that applied coding to different contexts. Our findings demonstrate that students' feeling of knowing and their perception of the task are two central themes that shape their affect and interest in the course. We conclude with design suggestions for contextualized computing in CS0 to better support students.

Introduction

Introductory computer science courses for non-majors (CS0) are designed to be accessible, to appeal to a wide variety of students, and to help students see connections between computing and other disciplines (Sax et al., 2017). Despite these intentions, CS0 courses remain challenging for many students due to the complexities of learning disciplinary knowledge (Li et al., 2019) and the influence of affective experiences (Kinnunen & Simon, 2010; Li et al., 2024). One approach for understanding experiences in CS0 is to examine how students approach homework assignments, which often make up the bulk of their coursework. Previous studies have explored student learning experiences while working on homework through the lens of *metacognition*, which encompasses the conscious awareness and active regulation of one's thinking processes, and affect, which refers to emotions and other mental states such as mood and feelings (Li et al, 2024). When working on tasks, students make subjective judgments about both the task and their ability in relation to tasks. Together, the subjective judgments and affect shape students' decisions and actions as they approach the task.

Previous work (Li et al., 2024) suggested that awareness about when and how to apply disciplinary strategies, metacognitive regulation strategies, and emotional regulation strategies contributes to students' learning experience. While previous work has explored how the strategies one knows can influence learning experiences and affect, we know less about the role of the computing task itself in shaping these experiences. Learning tasks provided in classes are designed with specific features and instructional goals in mind; however, students often construct their own subjective judgments of these tasks (Efklides, 2011; Winne, 2004). These subjective judgments are influenced by factors such as personal values and prior domain knowledge, and may diverge from the intended objectives of the tasks (Efklides, 2011). Thus, this paper investigates how the design of the task itself influences students' learning experiences and affect.

This study focuses on contextualized computing tasks—homework assignments in a CS0 course that employ *contextualized computing*. Contextualized computing is an approach to teaching computing that integrates another subject matter or discipline (Sax et al., 2017). CS researchers and practitioners have explored teaching computing content alongside or within the context of another subject, such as media (Forte & Guzdial, 2004), biology (Zuckerman & Juavinett, 2024), and law (Sloan et al., 2017), to make CS0 more enjoyable, accessible, and engaging. In this paper, we refer to these other subjects as the *applied context*. Contextualized computing homework assignments inherently involve both the computing and applied contexts, which creates unique challenges and opportunities for students' learning experiences.

Previous research has shown that contextualized computing increases student interest and engagement with computing by associating it with another field of interest, promoting personal relevance, and making it less intimidating (Forte & Guzdial, 2004). However, some evidence suggests that students may not be experiencing the expected benefits for motivation and engagement, with some students feeling overwhelmed by the additional applied context, or feeling that the course was inauthentic (Zuckerman & Juavinett, 2024; Carter, 2014; Knobelsdorf and Denenberg, 2013). Through the lens of metacognition and affect, this paper explores the ways in which students' learning experiences sometimes differ from the instructional designer's intended outcomes, and unpacks how task design influences these experiences.

We present a secondary analysis of data collected from 20 participants in a CS0 course where students worked on homework assignments in the applied contexts of music composition, graphics, games, and data visualizations (Li et al., 2024). Through a qualitative analysis of participants' daily diaries and retrospective interviews, we uncovered two key subjective judgments of contextualized computing tasks: students' feeling of knowing the applied contexts, and their perceptions of whether the contextualized computing tasks met their needs. These judgments influenced students' experiences; when students felt that they did not know the applied context or that the assignment did not meet their learning needs, they sometimes experienced negative affect, disengagement, and even a loss of interest in the class. Based on our findings, we present implications for how to design contextualized computing tasks and discuss the nature of computing.

Theoretical framework

We use the Metacognitive and Affective Model of Self-Regulated Learning (MASRL) proposed by Efklides (2011) as a lens to understand how students' learning experiences are influenced by the design of contextualized computing tasks. It is a comprehensive framework that integrates theories of both metacognition and affect to explain learners' self-regulated learning processes (Efklides, 2011). In this section, we first introduce the concepts that are relevant to our paper–metacognitive knowledge, metacognitive experiences, and affect–and then describe how they fit together in the MASRL model (Efklides, 2011).

Definition for metacognition and affect

Metacognitive knowledge refers to one's relatively stable beliefs about people (both the self and others), the task, and appropriate strategies to apply during cognitive processes (Flavell, 1979; Li et al., 2024; Efklides, 2011). This paper primarily focuses on metacognitive knowledge about people—one's awareness and beliefs about one's own or others' abilities as learners—and metacognitive knowledge about the task— one's awareness or understanding of the characteristics of a specific task (Tarricone, 2011). For instance, students might consider tasks involving recursion to be complex. This is considered *metacognitive knowledge* about the task because it reflects a relatively stable belief about all computing problems requiring recursion, rather than the feeling of difficulty experienced while actively working on a specific task, which would instead be classified as a *metacognitive experience*. Similarly, a student's belief that they are able to solve a complex problem is considered metacognitive knowledge about the self; they are aware that they have this ability.

In contrast, metacognitive experiences are momentary, task-specific subjective judgments and feelings that reflect students' evaluations of their task progress and understanding while working on a task. Efklides' (2006) definition of metacognitive experiences includes three elements: *metacognitive judgments, metacognitive feelings*, and *online task-specific knowledge*. Metacognitive judgments refer to the judgments students make about their learning, including the effort required to complete a task, estimates of how long a task will take, and judgments about the correctness of their work. Metacognitive feelings include students' feelings of knowing and feelings of difficulty. Online task-specific knowledge refers to the metacognitive knowledge about the task and relevant strategies that are actively in use while working.

Efklides (2006) argued that metacognitive experiences, especially metacognitive feelings, are closely tied to affect– subjective feelings such as emotions and positive or negative mood that arise in response to a situation (Carver, 2003). For example, feelings of difficulty are associated with negative affect, such as the frustration and confusion that students experience when the task is not running smoothly (Efklides, 2006).

The definitions of metacognitive experiences and affect are closely related and difficult to distinguish. For example, confidence could be conceived of as either a metacognitive experience or as affect. We differentiate between metacognitive experiences and affect based on their origins and scope. Metacognitive experiences are task-specific and arise from students' internal, task-related evaluations, often through monitoring their process. Affect is a broader construct, involving general emotional states and personal traits that arise from prior experiences or external feedback that influences motivation and engagement. Therefore, the feeling of confidence as a metacognitive experience refers to feeling confident in one's task processes or cognitive ability, such as feeling confident in one's answer to a question. In contrast, confidence as affect may involve feeling confident about one's future as a programmer after receiving encouragement from others.

Online task-specific knowledge differs from other metacognitive experiences because it focuses less on the subjective and affective aspects of a person's feelings. Instead, it centers on the perception of the task's features and demands. For instance, it involves understanding what the task is trying to assess and identifying the procedures needed to process and complete the task.

The Metacognitive and Affective Model of Self-Regulated Learning

MASRL identified three interconnected components, the *person level*, the *task*, and *task × person level* (Efklides, 2011). Person level refers to stable, overarching personal traits, including metacognitive knowledge, attitudes, self-concepts, motivation, and cognitive abilities that guide a learner's approach to a task. Task level includes the features of a task, such as its complexity, requirements, and instructional goal. The interaction between these two levels occurs at the task × person level, where individual characteristics meet task features during engagement. It is at this level that metacognitive and affective experiences are most active, influencing students' decisions, actions, and progress as they work through a task.

Each component in the MASRL framework has a reciprocal relationship; that is, person-level functioning can both shape how one approaches a task, and be shaped through repeated experiences with tasks over time (Efklides, 2011). *Top-down self-regulation* refers to person-level functioning shaping how one approaches tasks, and *bottom-up self-regulation* refers to how metacognitive and affective experiences during task engagement can influence one's decisions, actions, and person-level characteristics over time. For example, a student may possess a piece of metacognitive knowledge about themselves, such as "I have the ability to solve a complex computing problem." Top-down self-regulation refers to how this person-level piece of knowledge might influence the student's decision to take on a challenging computing task. On the other hand, bottom-up self-regulation refers to how students' metacognitive experiences when struggling to complete a task, such as feelings of difficulty and negative affect, shape their person-level traits over time, reinforcing their metacognitive knowledge of self as someone who does not have the ability to solve a complex problem.

This model serves as a helpful lens in our research because it emphasizes how metacognitive and affective experiences operate at the task × person level, and how they are central to learners' regulation of their engagement with tasks, influencing both immediate learning outcomes and person-level beliefs. Additionally, the model considers tasks not only as a context for learning but also as an active component that can trigger learners' subjective judgments, influence task engagement, and interact with their person-level characteristics. In this study, we focus on metacognitive experiences stemming from contextualized computing tasks, drawing upon the MASRL framework to explore how and why task design influences learners' engagement and interest. By understanding this, we aim to offer insights that can help CS researchers and practitioners design effective contextualized computing tasks and provide additional support to enhance students' learning experiences.

Methodology

This paper reports on a secondary analysis of data we collected in the fall of 2023; see our previous paper for a complete description of the data collection methods (Li et al., 2024). We present a summary of the methods for the present analysis.

Setting and participants

We collected data through a 12-week CS0 course offered at a highly-selective private university in the midwestern United States. The course assigned contextualized computing homework that used Python to support music composition via TunePad (Horn et al., 2020), graphics, games, and data visualizations using Tkinter to create a graphical user interface. Table 1 presents a summary of these assignments. We recruited 20 students from this CS0 course to participate in the study. 11 participants reported having prior experience with programming, three from CS courses in high school.

Table 1
Contextualized Computing Homework with Corresponding Computing Concepts Each Participant Worked On

Homework	Homework Description	Computing Concepts	Participants
Music Composition	Create an original 16 to 32 beat musical piece in TunePad	list, tuple, loop, variable, function	P1, P2, P3, P4, P6, P7, P8, P9
Make a Creature	Draw a creature of your own design using Tkinter	function taking input parameter	P11, P12, P15, P16, P17
Wordle	Write a text-based version of the game Wordle	dictionary, loop, conditional logic	P14, P18
Data Visualization	Create a visualization of a real-world dataset using Tkinter	data cleaning, data processing	P20, P21, P23, P25, P27

Procedure

Participants documented their experiences working on a single homework assignment (Li et al., 2024). We asked participants to complete daily diaries to capture their evolving affective and metacognitive experiences as they worked on the assignment. Participants were only required to complete diaries on days when they engaged in CS0-related tasks. The diary included questions about participants' thought process while approaching the task and their feelings if they experienced challenges while working. The diary also included questions about how participants' feelings and challenges influenced their behaviors and their beliefs about themselves and CS. In total, we received 118 diary entries from 20 participants. Retrospective interviews were conducted with each participant after the assignment. The first author reviewed all responses before the interview to identify areas requiring clarification, such as ambiguous statements or missing context. We asked follow-up questions to gain deeper insight into participants' feelings and perceptions based on their diary responses. The interview questions relevant to the present study included comparisons between different homework assignments, reflections on their assignment preferences and their feelings about applying computing concepts to various contexts, and explanations of why they felt that way.

Data analysis

We reviewed the diary and interview transcripts using the lens of student metacognitive experiences about contextualized computing assignments and their emotional reactions. The first and second authors followed a qualitative data analysis process (Miles et al., 2014) and collaboratively conducted two rounds of qualitative coding. The unit of analysis in this study is each participant's response to individual diary and interview questions about their subjective feelings about contextualized computing tasks. During the first round, the first two authors conducted inductive, open coding because we wanted to characterize students' responses and capture all reactions to the task, without the constraint of the common metacognitive experiences mentioned in Efklides (2006). Some descriptive codes include, "*feeling the need for music knowledge*" for responses mentioning that students need knowledge of music in addition to knowledge of computing, "*the feeling of practicing coding*" for responses mentioning that the applied context did not affect student's ability to learn through the underlying coding task. During the second round of coding, we categorized these initial codes by comparing them with the definitions from our theoretical framework and adopted terminology such as the *feeling of difficulty* to capture our initial codes of "*feeling simple*" and "*feeling complicated*." The two authors also categorized the type of metacognitive experience, for example an experience about the nature of the task or an experience about students' feelings about the task. Finally, the first author generated hypotheses about the relationships between different metacognitive experiences, how these experiences influence students' actions, how person-level traits influence these experiences (especially metacognitive knowledge of computing), and how these experiences further reciprocally influence person-level characteristics. These hypotheses were discussed and confirmed with all authors.

Results

Through our analysis, we identified two key metacognitive experiences—students' feeling of knowing and their perceptions of the task characteristics of contextualized computing assignments—which influenced students' affect and interest in the class.

The impact of the feeling of knowing the applied context

One of the most frequently reported metacognitive feelings while working on contextualized computing homework was the feeling of knowing. This feeling, by definition, reflects learners' subjective assessment of their familiarity or confidence regarding their ability to recall or recognize information (Nelson, 1998). In the context of our study, this feeling of knowing corresponds to students evaluating whether they believe they possess the necessary knowledge to complete the task. Importantly, since our tasks were contextualized computing tasks, this included knowledge about both computing concepts and the applied context. Our participants also brought up *familiarity* with concepts often; we consider this to be a feeling of knowing in our context. The feeling of familiarity carries a slightly different meaning than the feeling of knowing in the metacognition literature, referring to a feeling of fluency in task processing triggered by stimuli. However, in our study, students' descriptions of familiarity were consistently associated with their assessments of whether they knew the relevant concepts. Since familiarity serves as one of the criteria for evaluating the feeling of knowing by definition, we chose not to differentiate these two concepts further in our analysis.

We observed that participants' feelings of not knowing the applied contexts added to the perceived difficulty of tasks and their stress, while their feeling of knowing the applied contexts made the homework feel easier and more enjoyable. For instance, P6, while working on the music composition homework, expressed a belief that the upcoming Wordle game homework would be simpler because "*I don't do music, so I don't really know much about it [...] I'm familiar with the structure of games, but not with the structure of music. I know how* *to create statements to have a working game, but I don't know how to create statements that could make music.*" P1 found the visualization homework "*less stressful*" because "*using [the] coordinate plane, I can relate some of my math knowledge.*" P4, who has some musical training, acknowledged that knowing music made homework easier and more enjoyable. In contrast, P7 said, "*I think [the music homework] was difficult because I'm not that familiar with music.*" P9 considered music "*a foreign language,*" and said, "*I think the music is definitely influencing the difficulty of the assignment. I don't have a musical background and that was a little intimidating.*" The feeling of not knowing enough about the applied context added to the tasks' perceived difficulty for P9, and leaving her feeling overwhelmed.

We also saw P1 explicitly mentioned how not knowing enough about the applied contexts influenced her feeling of confidence. P1 reflected on her experiences working on the problem set exercises, the music composition homework, and the making-a-creature homework: "*we went from something very basic of putting in numbers ... to let's do music now ... I started losing a little bit of my confidence in coding ... now we're going into graphic ... something that I do recognize, I wouldn't say it stresses me out as much as the music one*." P1's reflection suggests that the feeling of knowing impacts her feeling of confidence and her affect in reaction to different contextualized computing assignments. Although it is challenging to determine whether the under-confidence that P1 expressed is a person-level trait or just a task-specific metacognitive experience, repeated interactions like this could over time impact her metacognitive knowledge of her programming abilities, as described in the bottom-up self-regulation process in MASRL (Efklides, 2011).

From participants' explanations of why the feeling of not knowing the applied context impacted their perception of task difficulty and their affect, it became evident that the challenge stemmed from not sufficiently knowing both the domain knowledge of the applied context and the computing concepts. For example, P3 noted that even though the course provided resources on music theory and code examples to lower barriers, "*it took a little bit of a learning curve*" as she needed to experiment to "*submit something that didn't sound like ... banging on the piano keys*." P7 remarked, "*if you had some kind of musical background, that might've been really helpful just because it would be skipping another step on your way to learning how to do all the code and stuff*." The additional domain knowledge required for contextualized computing, plus the steps needed to translate ideas into code, made the assignments challenging. P1 explained, "*having no background in music and just four weeks of coding ... It was both things. Not having the best understanding of doing both of those was where my panic or stress came in*." All these reflections from participants illustrated that the combination of not knowing enough about the applied context and computing together contributed to stress and made the homework overwhelming.

Before investigating the underlying reasons, our participants' initial responses often attributed their challenges and negative affect primarily to their lack of knowledge of applied contexts, overlooking their difficulties in understanding computing concepts. Given that this is a course for non-majors, many students will not continue CS in the future, so not recognizing the gaps in computing knowledge might not seem problematic. One could even argue that attributing struggles to the applied contexts rather than CS might avoid solidifying or forming negative attitudes toward CS. However, P6's experiences provide an illustrative case, demonstrating the potential risks of hurting student interest in the class and ultimate disengagement from tasks.

P6, who was new to computing, evaluated his understanding of computing content through his performance on the assignments: "*I'm not experienced in coding, I can't really tell myself how well I'm doing. I can just base it on how well I'm doing on the homework and exercises*." Before the music composition assignment, P6 had successfully used computing concepts such as variables, lists, and functions in exercises. He stated, "*I know how to create a variable. I know how to create a list. I know how to create functions*." However, P6 struggled to incorporate these concepts to compose the music, saying, "*I know how each one works and how to properly use them, I just have no idea how to put them into practice.*" The misalignment between his judgment that he knew these computing concepts and the fact that he could not perform well on this contextualized computing homework made him believe his struggles were due to his lack of knowledge about music. He said, "*I feel unproductive but it's not like I have any choice considering I'm struggling with music composition and not the actual content of the class*."

To learn more, the interviewer asked P6 to talk about the challenges he faced in the homework. P6 explained that he had already hard-coded notes and chords, and did not understand why the homework required him to modify the code to use certain computing concepts. This response showed that P6's problem was not only not knowing music, but also confusion about why and how to apply functions and loops for repetition and code conciseness. The combination of negative affect and metacognitive experiences led P6 to disengage. He expressed his frustration by saying, "*I might just give up or try winging the assignment and hope for partial credit.*" He also expressed that his interest in CS110 had diminished, explaining that "*I just really don't like being forced to create music when it's not something I'm interested in.*" Efklides (2008) suggested that students often struggle to accurately attribute the causes of their challenges because numerous metacognitive experiences, both conscious and unconscious, emerge throughout task engagement. P6’s experiences of misattributing his challenges with the homework to a lack of knowledge about the applied context suggest that unfamiliar contexts provide students with opportunities to externalize their struggles, especially when they do not know how to assess their learning beyond relying on homework correctness, which can hinder their engagement and learning progress.

Students’ perceptions of contextualized computing tasks

We identified another metacognitive experience, online task-specific knowledge, which refers to students’ perceptions of the tasks’ characteristics while working on their homework assignments. For contextualized computing assignments, students demonstrated differing perspectives on the nature of the assignments. In this section, we show how person-level traits shaped students’ perceptions of tasks. While some students perceived the tasks primarily as opportunities to practice computing concepts, others placed greater emphasis on evaluating the applied context of the task. We then demonstrate how students’ perceptions of task characteristics and their affect work together to shape their interests and attitudes toward the course. This dynamic aligns with the reciprocal relationship between top-down and bottom-up self-regulation described in the MASRL framework (Efklides, 2011). While our data does not provide sufficient evidence to claim that students’ person-level traits were updated, given that the data collection spanned only a single homework cycle, there is potential for such traits to evolve over time through repeated experiences (Efklides, 2008).

Person-level traits influenced students’ perceptions of task characteristics

We identified a number of person-level traits that influenced students’ evaluations of task characteristics: *personal values*, or how students see themselves, their future goals, and what interests them, *course expectations*, or what they expect to gain from the course, *metacognitive knowledge of computing,* or their understanding of what counts as computing, and their *prior experiences* in computing. The influence of personal values and course expectations on students’ affect and perception of tasks often intersect; for example, a student interested in becoming a data scientist may expect that the course introduces data analysis concepts.

Because our study setting is an introductory CS course for non-majors, our participants’ personal values and course expectations fell on a spectrum from zero interest in taking more computing classes to an interest in taking more classes and ultimately working in the field. We found that participants who expected to learn foundational computing concepts or aimed to work in a computing-related field judged the task based on how closely the applied contexts aligned with their personal interests and career aspirations, instead of viewing each contextualized computing assignment as an opportunity to practice computing. For example, P18, who wants to minor in data science (DS), found the music composition and graphic homework “*less engaging*”, noting, “*it’s just not really in line with what I want to do*.” Despite acknowledging the fun of coding for music, graphics, and games, she preferred more career-relevant contexts. Similarly, P20, who also plans to major in DS, liked the data visualization homework the most, stating, “*I finally get to do something that would be really interesting to me.*” These responses demonstrated how personal values and course expectations influenced the focus of students’ evaluations of the task characteristics, emphasizing the relevance of the applied contexts.

Another perception of the task characteristics that arose through our analysis was the belief that contextualized computing assignments overemphasize the applied context. This perception appeared to be linked to students’ metacognitive knowledge of computing. For example, P11 reflected that the graphic assignment requires “*think[ing] more mathematically and think[ing] less of it being a code*.” P17 described why she thought the graphics homework focused on math more than computing: “*You just have to manipulate the... parameter for different [shapes], which is just math.*” Though understanding how to manipulate parameters is a crucial computing skill, our participants, who are beginners in CS, did not recognize it as important.

Some participants commented that these tasks emphasized the applied contexts, and did not focus enough on actively practicing computing concepts. For instance, P6 felt that “*there's more of an emphasis on music and art and other things that aren't related to coding.*” Despite P6’s unfamiliarity with music-related knowledge, the quotes suggest that students’ understanding of computing is largely confined to the direct practice of computing concepts rather than their application in broader contexts. Although the assignments are designed to deepen students' understanding of computing concepts, both P6 and P17 said that they would prefer traditional problem sets, viewing them as a more explicit way to learn computing concepts rather than applying them in various contexts. In fact, in many real-world situations, non-computing aspects of tasks are inseparable from computing aspects. Not all of our participants share this understanding of computing.

In contrast, some of our participants who had prior experiences with programming expressed that applying computing to another context does not change nor reduce the degree of computing practice embedded in the assignment. For example, P2, who had prior experience in a high school computer science class, mentioned that “*the main objective is rather than creating the music, it's that you're creating the code behind the music … I* *don't think [music] plays a significant role.*" P27, who took a computer science class in high school, noted that, "*coming out [of this class], I've learned a lot of ways of how to use CS [...] it allowed you to use CS through different variations.*" This echoes Efklides (2001), who claimed that novices focus on surface-level task characteristics, while experts identify essential task features relevant to choosing problem-solving strategies. Consequently, while instructors can see that the contextualized computing tasks utilize important computational skills, it was challenging for most of our participants to make this connection. It is also possible that students with prior computing experience had more opportunities to reflect on and expand their metacognitive knowledge of computing than the students with less experience. As Efklides (2008) claimed, metacognitive knowledge evolves through reflection on information obtained during the process of monitoring task progress.

In summary, our participants' reflections highlight the challenges of designing contextualized computing assignments that resonate with novices and balance computing concepts with other domains. Additionally, we observed that participants, especially novices, do not always have a clear understanding of what computing constitutes, further influencing their perceptions of contextualized computing assignments.

Students' perceptions of the tasks influence their interest in the course

In this section, we show why students' perceptions of task characteristics are important. Specifically, we found that students compared their understanding of the tasks with their personal values and course expectations, and when these elements did not align, they risked losing interest in the course.

Students who are less inclined to continue in CS after this course, whether because they enrolled to fulfill graduation requirements or out of curiosity about what CS entails, tended to have positive affect around contextualized computing tasks, regardless of their perception of whether the assignments helped them practice computing. For example, P8 who had prior experiences in computing and viewed contextualized computing as computing practice, shared that she had no interest in continuing computing. Although she "*never really liked computer science*" and did not have a positive experience in her high school CS class, she found contextualized computing a "*rewarding*" way of learning computing and "*relevant in the world*" rather than practicing with the problem set that "*is very contained.*" The use of contextualized computing increased her interest in this course and changed P8's impression of coding. P14 enrolled in the course to learn foundational computing concepts but did not have an interest in pursuing a computing-related career. While working on the assignments, she expressed confusion about their connection to computing practice, remarking, "*It seems like a very simple thing to do, especially in Excel, and felt a little pointless to code for it.*" Having encountered CSV files in her psychology research but never needing to handle them herself, she valued the exposure the assignment provided and enjoyed the homework. These two representative cases showed that, despite having contrasting perceptions of whether contextualized computing is well-designed to practice computing concepts, students' personal values of not wanting to continue in CS overpower the influence of other person-level traits in students' affect and metacognitive experiences. This allowed them to develop a positive attitude toward this CS0 course.

Participants interested in taking more CS classes or pursuing careers in computing-related fields, who expected the course to emphasize computing concepts, experienced a disconnect when they perceived the contextualized computing assignments as overly focused on their applied context. This misalignment reduced their interest in the course and contributed to their negative affect. For example, P6, who believed the assignment prioritized music instead of coding, found this "*discouraging*" because it did not align with his primary interest in "*learning about coding*", commenting that "*I love coding, not music*," which ultimately "*hurt [his] interests in the course*." P18 and P20, who thought the task did not align with their personal values and course expectations, also expressed their attitudes towards the course as "*not that helpful*", and "*less interesting comparing with my other statistics class*." These reflections underscore how a mismatch between task design and students' personal values and course expectations can negatively impact their engagement and attitudes toward the class.

In contrast to most of our participants, P1's interest in the course was not diminished by the contextualized computing assignments, even though she planned to pursue a DS major. This was due to her expectations: "*I knew that it was an intro course, so I knew it wasn't going to be specialized in [data science].*" With the understanding that the course was designed for students to "*get used to coding, not necessarily in such a formal thing*," P1 appreciated the idea of contextualized computing. In fact, we found that P1 gave herself more grace when struggling with assignments that were not relevant to her career. She said, "*I know I'm not going to need to code music for my career, so I'm not too worried about this one.*" Overall, P1's case shows that when students know what to expect, they may have more positive experiences with contextualized computing.

In summary, our data reveals that when participants' evaluations of the task did not meet their personal values or course expectations, they tended to have negative affect and sometimes lost interest in the class. However, helping students set appropriate expectations before enrolling in the course, as we saw with P1, may help them better evaluate task characteristics and maintain their interest in the class.

Discussion and conclusion

We used the MASRL framework (Efklides, 2011) to understand how participants' varied metacognitive and affective experiences regarding contextualized computing assignments in a CS0 course were shaped by their person-level traits, specifically their metacognitive knowledge of computing, prior experiences, personal values, and course expectations. Some participants reported positive experiences, finding contextualized computing to be rewarding and helpful for learning different ways to apply CS, highlighting how it may support engagement among non-majors. However, for other participants, the feeling of not knowing the applied context and the misalignment with their personal values and course expectations evoked negative affect and influenced their confidence and interest in computing.

Our work contributes to CS education, particularly in the area of contextualized computing, by applying the MASRL framework (Efklides, 2011), which has rarely been used in CS contexts. We see alignments with Efklides' (2006, 2011) descriptions of the relationship between the feeling of knowing, perceived difficulty, and affect. Additionally, our findings highlight how students' perceptions of task characteristics—shaped by their metacognitive knowledge of computing, prior experiences, course expectations and other person-level traits—impact their engagement. This aligns with the MASRL framework's emphasis on the reciprocal interaction between person-level traits and person × task level interaction (Efklides, 2011). We suggest that future research in CS education can adopt MASRL further to investigate the dynamics of how different metacognitive experiences influence one another, as well as to study these reciprocal relationships on a larger scale using diverse research methods, such as survey studies.

Our findings also expand beyond existing models, revealing that students' feelings of not knowing stem from both the computing and applied contexts. However, students tend to attribute their struggles more to the applied contexts, influencing their interest in computing and their judgment of their learning. Specifically, we saw that the feeling of not knowing the applied context can lead students to misattribute their struggles. We believe these findings have implications beyond the CS context. Contextualized computing tasks reflect real-world problem-solving contexts, where tasks often involve multiple disciplines rather than knowledge from a single domain. Many previous studies of metacognition have been conducted using cognitive tasks such as verbal fluency, which do not account for the interdisciplinary nature of many real-world tasks. Our findings suggest that when studying relationships between metacognitive experiences, affect, and person-level traits, it is important to distinguish the influence of the different disciplines in which these metacognitive feelings arise.

Given the limitations of our study—our reliance on self-reported diaries, data collected from a single university course, and our limited scope of one homework per participant—we recommend future research take a broader approach. This could include longitudinal studies to examine how students engage with multiple contexts with different levels of familiarity, collecting behavioral data through interaction logs to triangulate their self-reported responses, or using survey studies to explore larger-scale causal relationships.

Our findings also provide practical insights that can help CS educators design contextualized computing assignments. Our findings support previous calls for tailoring introductory computing education to students' majors (Forte & Guzdial, 2005), and suggest that approaches like co-designing assignments alongside faculty from other disciplines may help produce tasks that resonate more deeply with students (Guzdial & Evrard, 2024). If institutional bandwidth requires a single introductory course for non-majors (e.g. CS0), we suggest offering assignment options that allow students to select contexts where they feel they have sufficient background knowledge or that are aligned with their interests. It is also important for instructors and academic advisors to help students manage their course expectations prior to enrolling. We recommend providing clear information about what to expect from contextualized computing courses to ensure students know what to anticipate. Finally, we noticed that students' metacognitive knowledge of computing may not be accurate, for instance, not recognizing parameter manipulation as a computing skill, or not realizing that non-computing concepts are often inseparable from computing concepts in real-world problems. This led some students to believe the homework lacked sufficient emphasis on computing. Instructors and homework descriptions could directly state that contextualized computing emphasizes the inseparable relationship between computing and non-computing concepts, making the learning experience more valuable to those students.

In summary, this paper explored students' experiences with contextualized computing through the lens of metacognitive experiences and affect. We found that participants' knowing of the applied context shapes their affect, confidence, judgment of learning, and engagement. Additionally, we discussed how participants' perceptions of tasks, influenced by their person-level traits, sometimes negatively contribute to their affect and interest in computing. Taken together, we identified opportunities for designing contextualized computing assignments in CS0 that enhance students' learning experiences.

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