Supporting Experiential Learning in People with Gestational Diabetes Mellitus

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ABSTRACT

Managing Gestational Diabetes Mellitus (GDM) is a significant challenge for pregnant individuals. Constant self-monitoring, emotional burden, and the short and long-term implications of GDM make the overall pregnancy experience challenging for these individuals, requiring action, learning, and lifestyle adjustment to manage the pregnancy properly. Prior literature on GDM mostly focuses on the medical and health management of the condition. However, pregnant individuals with GDM often must actively learn and adapt lifestyle strategies quickly without much support. Through semi-structured interviews with 13 pregnant individuals diagnosed with GDM, we investigate how these individuals experience, explore, learn, and reflect on ways to live with and manage GDM. Using Kolb's Learning Theory to analyze and structure our findings, we built on pregnant individuals' concrete lived experiences and uncovered the challenges as they navigate the GDM journey, managing their changing relationship with food and supporting emotional well-being while living with an often stigmatized condition in an at-risk pregnancy. Our study contributes to the discussion on the design opportunities to facilitate experiential learning of pregnant individuals' journey.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**.

KEYWORDS

Gestational Diabetes Mellitus, Pregnancy, Experiential Learning, Kolb's Learning Cycle

1 INTRODUCTION

The prevalence of Gestational Diabetes Mellitus (GDM) in the U.S. is high. The U.S. Center for Disease Control and Prevention (CDC)

reports about 10% of all pregnant women are diagnosed with GDM annually [25]. Gestational Diabetes Mellitus (GDM), often diagnosed in the second trimester of pregnancy, places the pregnant individual and unborn baby at both short-term risks (e.g., birth complications including shoulder dystocia, birth trauma, and neonatal hypoglycemia [50, 73]) and long-term risks (e.g., mothers can develop Type 2 Diabetes (T2D) several years after childbirth) [5, 44, 50]. Individuals with GDM often have to adopt lifestyle changes or medications quickly, adding to a complicated pregnancy journey. These sudden changes, such as diet modifications and monitoring sugar levels at least four times a day, often create additional burdens for pregnant individuals to maintain a healthy pregnancy and keep the unborn child safe [5, 26].

Although similar to T2D, where lifestyle changes and continuous self-monitoring are common strategies in condition management, GDM is often a more challenging and understudied condition for various reasons. First, GDM is temporal and only lasts from diagnosis to a few weeks post-childbirth [44]. Compared to other chronic conditions where patients may have a more extended period to learn and adjust their lifestyles, individuals with GDM often have to completely revamp their everyday routine in a very short time [28]. Secondly, unlike T2D, GDM affects more than one individual - the mother and the unborn child (or children) - with a risk of complications at birth for the baby and potentially developing T2D in the long term for the mother [1, 26, 44]. Therefore, individuals with GDM have to consider the health of the fetus and the short- and long-term implications for both the pregnant individual and the baby. Finally, every pregnancy is different [65]; pregnant individuals have a unique journey within each pregnancy [3]. GDM presents an extra burden of emotional stress and stigma within the reality of what becomes an at-risk pregnancy for the individuals involved.

While individuals with GDM experience many unique challenges, their needs, experiences, and potential support are relatively under-explored, compared to other forms of diabetes [55–57], such as Type 1 diabetes (T1D) [42, 47, 71] and Type 2 Diabetes (T2D) [16, 75]. In addition, while there are increasing numbers of self-monitoring tools to help individuals with diabetes manage their condition, challenges exist in making sense of the condition and learning from all the data captured with these tools. These challenges are burdensome upon individuals who already have to self-manage their condition. In this research, we contribute to research that pushes the boundaries from a biomedical approach to health to a more holistic approach [7] that accounts for lived experiences [36], social interaction [2, 36], and psychological factors [18, 22, 36]. Therefore,

this work does not attempt to further medicalize the GDM and pregnancy journey or only focus on the tools used for GDM monitoring. Instead, this research investigates the challenges individuals with GDM experience as they learn, reflect, and engage with their condition within their unique, lived experiences and environments to care for themselves and their unborn babies in high-risk pregnancies. To uncover these challenges, we adopt the lens of experiential learning and draw on the highly influential Kolb's Experiential Learning Cycle. Kolb's Experiential Learning Theory describes learning as a process in which knowledge is created from a transformation of "Concrete Experience" [61]. To create new knowledge, individuals start with observation, reflection, forming abstract concepts, and finally testing hypotheses and concepts in new situations [61]. While reflection can be helpful, simply triggering reflections does not always lead to the transformative effect. Therefore, it fails to provide individuals with a more profound understanding or knowledge to improve their actions or behavior [12, 59]. In this sense, learning occurs from creating figurative representations of an experience in one's mind and then transforming the experience into action [69].

Using Kolb's Experiential Learning Theory allows us to examine people's transformative experiences, beyond reflection, by focusing on the following research question: How do pregnant individuals with GDM learn from, reflect on, and act on their experiences managing GDM? To answer this question, we conducted semi-structured interviews with 13 pregnant individuals in the U.S. who self-reported being clinically diagnosed with GDM. Using Kolb's Experiential Learning Cycle as a lens, our findings show how participants learned about themselves, reflected on and acted on their everyday experiences living with the condition, interpreted and conceptualized these experiences into knowledge, and experimented on and adopted lifestyle changes to help them manage it. Situating the GDM experiential learning process in rich, real-life contexts, our data revealed the emotional burden, stress, and stigma that pregnant individuals with GDM encounter while managing the condition. Reflecting on these findings, we discuss potential design opportunities to provide better support to pregnant individuals with GDM. This research makes the following contributions:

- We uncover challenges and gaps that individuals with GDM encounter during pregnancy by leveraging an experiential learning model (i.e., Kolb's Experiential Learning Cycle) to characterize the experiences and challenges of pregnant individuals with GDM. Specifically, we show how adapting to lifestyle changes during pregnancy influenced their individual and familial relationships with food. We also show the emotional burden of having to constantly make sense of the stigmatized condition.
- We identify and discuss strategies to consider in technology design to support pregnant individuals in their GDM journey. These strategies include focusing on and celebrating positive aspects and changes in food activities and developing innovative ways to provide a safe emotional and educational support space.

2 RELATED WORK

HCI research in diabetes has focused chiefly on T1D and T2D [16, 42, 47, 55–57, 71, 75], with little understanding of designing technologies to support managing GDM. In this section, we highlight the risks and challenges that GDM presents and review related work on T1D and T2D management. As our study seeks to understand how pregnant individuals with GDM (with no prior diabetes diagnosis) learn and reflect on their experience in managing the condition, we adopt Kolb's experiential learning cycle as a theoretical lens to present our findings.

2.1 Gestational Diabetes Mellitus and the Pregnancy Journey

GDM is a condition that develops during pregnancy, characterized by increased insulin intolerance [1]. In the US alone, the prevalence of GDM is estimated at 5.8% to 9.2% [26]. GDM is unique because it is temporary but requires substantial lifestyle changes and care in a short time [5]. Pregnant individuals with GDM have an increased risk of maternal complications upon delivery, including increased frequency of congenital anomalies, intra-uterine death, excess fetal growth, and increased likelihood of Cesarean delivery [44]. Compared to pregnant individuals without GDM [26], they also are at risk of long-term adverse health outcomes, such as a seven-fold increased risk of developing T2D and retinal and cardiovascular conditions [5]. Their offspring have an increased risk of glucose intolerance when they become children and young adults [44]. Screening for GDM typically takes place in the second trimester, between 24 and 28 weeks of gestation [26]. Sometimes, this screening happens earlier if the pregnant person has a history of underlying risk factors, such as a previous history of GDM in a past pregnancy, or older maternal age.

During the three to four months between diagnosis and delivery, pregnant individuals experience extensive changes, bear immense burden and pressure, and have to take on drastic adjustments to ensure their own and their baby's safety. Pregnant individuals with GDM need better support to navigate the evolving condition during their pregnancy journey. GDM increases self-management burden to the already exhaustive pregnancy journey. Several HCI and health research studies have been conducted on diabetes self-monitoring. Pregnant individuals with GDM often must closely and consistently self-monitor their glucose within specific post-meals using glucose meters or blood glucose monitoring devices [62]. Research has also examined how these monitoring devices could include psychological aspects by facilitating learning and reflection [7]. Previous research highlights individuals with GDM often experience a loss of normal pregnancy, a loss of personal control, a strong emotional response, prioritizing the baby's health outcome over the mother's health, and negative experiences with healthcare information and support [62]. Pregnant individuals with GDM also experience stigma associated with their diagnosis because it is often presumed that they may be unable to have a healthy pregnancy or are faulted for developing GDM [39]. Research has also shown that this stigma is sometimes rooted in marginalizing experiences that people in larger bodies face as a result of fat shaming and

weight bias in fertility and prenatal care [27, 49]. Furthermore, researchers [27, 53] also highlight that the risks associated with fat shaming and tying maternal complications simply to "obesity", stigmatizes individuals in fat reproductive bodies, portraying them as unsuitable parents and therefore, evoke emotions of guilt, shame, and fear. Through our work, we offer considerations for designing to support and fully immerse oneself in the learning opportunity that comes with the condition. Against this backdrop, our work aims at an empirical understanding of experiential learning within the GDM condition, the challenges encountered, and how individuals with GDM can be better supported to engage with the condition.

2.2 Diabetes Management

Research has shown that GDM could be a precursor to diabetes (in particular, T2D) in women. GDM and T2D present similarities in how the disease is managed, but the context of each condition is different. GDM is temporary and occurs in pregnancy, which differs from the chronic aspect of T2D. Considering the similarities, in this next section, we review related work on diabetes management. Coping with diabetes can be taxing and burdensome. Managing diabetes involves extensive out-of-clinic management that is often burdensome on patients – these include diet management, scheduling meals, counting carbohydrates, blood pressure, exercising, and blood glucose measurement [15]. For all types of diabetes (T1D, T2D, and GDM), self-management and timely diagnosis help mitigate acute and long-term complications (e.g., ketoacidosis, diabetes foot) [15].

Researchers have explored diabetes management driven by either technology or an individual's self-management strategies. At the technology level, in recent years, many AI-enabled diabetes management strategies have been adopted in research and practice. For example, decision support systems can help patients and healthcare providers manage diabetes therapies [15]. Systems with intelligent detection algorithms can also identify critical events, such as accurate and inaccurate measurements in Continuous Glucose Meters (CGM) [51] and adverse glycemic events [15]. To support individuals managing the condition, voice-activated self-monitoring applications can enable remote sharing with providers and reduce clinical encounters [66]. While these systems have helped manage diabetes, individuals with diabetes still need to carry the heavy lifting in everyday self-management.

Individuals with diabetes often undergo an iterative process of learning how to manage and cope with their condition [72]. Sometimes, these individuals find ways to self-manage their condition with the support of their families, online forums, and support groups. Prioritizing schedules or using a household calendar can be helpful for family members to provide support, especially when there is more than one member with chronic disease [20]. Individuals could also learn how to manage their condition through adopting, testing, and modifying strategies shared in online support groups to generate individualized solutions [35]. For example, existing members on dLife.com shared a "startup solution kit" that connected new members to blogs and articles about diabetes management and strategies. These members also shared diverse strategies based on individual experiences to help other members learn and adapt to their unique situations [35]. While online support can be helpful, online health information can be misleading and problematic, adding to the emotional burden for individuals as they try to reconcile and make sense of their experiences [46]. These emotional burdens are incredibly challenging for individuals with GDM because, within a short time upon diagnosis, they may be unable to validate online information or establish supportive relationships. The stigma GDM carries can also create barriers for individuals to seek support online and offline. Therefore, it is essential to understand how individuals with GDM learn and make sense of their condition during the pregnancy journey and provide feasible support toward their unique circumstances. While there is a vast body of literature in HCI on T1D and T2D [16, 42, 47, 55–57, 71, 75], very few studies in HCI focus on GDM, potentially due to the complexity of the condition simultaneously existing with pregnancy. Therefore, we aim to fill this gap with our work by presenting empirical studies on GDM to complement the vast body of literature on other forms of diabetes. Our work highlights the challenges that individuals with GDM experience while learning in conjunction with managing the condition.

2.3 Kolb's Experiential Learning Cycle

Kolb's Experiential Learning Theory (Figure 1) [45] is an influential model to understand experiential learning – how reflective experiences lead to action and transform the experience into knowledge [60]. In HCI, prior work has studied reflection [4, 6, 13, 23] and shown that technology can be used to support reflection [13, 69]. According to Kolb's model [45], experiential learning consists of four key components: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC), and Active Experimentation (AE) [45, 60]. Kolb's framework is a cycle, with each stage feeding into the next stage, and it is possible to enter the cycle from any point. However, individuals typically enter Kolb's framework from the *Concrete Experience* aspect. An experience is considered "concrete" when the learners are involved and actively engaged participants in a real-world experience where knowledge is situated in context: place and time [60]. *Reflective Observation* is a critical reflection that serves as a mediator to making meaning of the concrete experience, where learners act in an investigative manner, consider the contextual conditions of a problem, acknowledge that they do not yet "know" how to solve the problem [60]. Sometimes, learners also begin to appreciate that the problems are not structured and may have more than one solution to the problem [60]. *Abstract Conceptualization* is a purposeful and pragmatic reflection where learners co-construct meaning, form a working hypothesis, and begin to appreciate that the context conditions may change across time and place [60]. In this reflection, all knowledge gained is interim and needs to be tested in a situated context [60]. *Active Experimentation* places the learners beyond their comfort zones, temporarily destabilized to utilize the theories formed for decision-making and problem-solving [60]. This theory has been used to develop peer support psychoeducation for post-chemotherapy breast cancer patients [17]. More recently, in HCI, it has been used to develop physical activity support structures that help individuals engage with their fitness data [69].
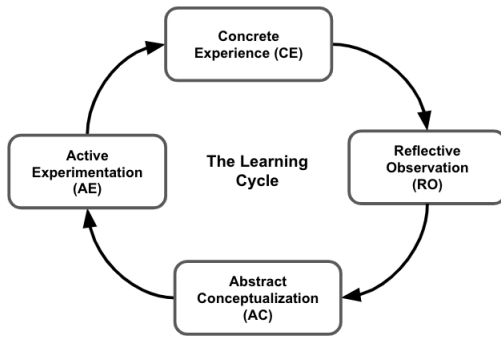
Figure 1: The Kolb's Experiential Learning Cycle: Concrete Experience (CE), Reflective Observation(RO), Abstract Conceptualization (AC), and Active Experimentation (AE)

The experiential learning theory highlights a learning process where knowledge is built from a transformative experience and driven by the combination of dual dialectics of action/reflection and experience/abstraction [19, 63]. For an experience to be considered "Concrete," the learner's participation must be central and hands-on [60]. In the context of GDM, pregnant individuals are involved, active, and engaged participants in the learning process of self-tracking and managing their condition. Therefore, the concrete and involved nature of GDM makes Kolb's model an important lens for understanding and analyzing participant experiences.

In this research, we analyze and present individuals with GDM's experience of learning and managing their conditions by primarily drawing on and engaging with Kolb's experiential learning framework. In this paper, we join the call to look beyond medicalization to a more holistic approach to illnesses [7, 18, 65]. In particular, we focus on individual experiences in active learning, support, and psycho-social factors, such as emotional wellbeing and familial support.

3 METHOD

We collected data using semi-structured interviews and analyzed our data using thematic analysis [8, 9, 11]. We conducted semi-structured interviews with pregnant individuals diagnosed with GDM. We chose the semi-structured interview as a data collection approach in order to gain a deeper understanding of their individual experiences during the GDM journey and how they think about their diagnosis, the journey, the data, the learning experience, and the challenges they encountered through learning. The entire study was conducted from September 2021 through May 2022. Indiana University, Bloomington's Institution Review Board (IRB) approved the study protocol. To support inclusivity and diversity, we use the term "pregnant individuals" in this paper as we recognize that pregnant persons may not identify as women. However, in our findings, we use the term "women" because all participants in our study self-identified as women. While we did not specifically select women for our study, we acknowledge in the limitation section

that the language we used in our recruitment materials may have contributed to the self-selection bias. We intend to be more inclusive in future study recruitment.

3.1 Recruitment, screening survey, and participants' information

We recruited participants through these three channels: GDM-related Facebook groups, subreddit groups, and a research volunteer platform designated for research recruitment processes. Recruitment postings included a screening survey link that collected basic demographic information, including how the participants manage their GDM, annual income, highest degree, weeks of gestation at the time of taking the survey, weeks of gestation at which GDM was clinically diagnosed, marital status, and whether or not they have had GDM in a previous pregnancy. We did not collect information about their medication use. We received 54 responses to the survey. To be eligible, participants had to be located in the US, over 18 years old, pregnant, clinically diagnosed with GDM (self-reported), and actively monitoring their sugar levels. Participants who completed the survey met the eligibility requirement and provided contact information were invited for the semi-structured interview. Of those contacted, 13 followed up and opted to be interviewed. Recruitment was continuous throughout the study period.

Table 1 shows the breakdown of our 13 participants, including their age, ethnicity, number of pregnancies with GDM, the highest level of education earned, and annual income. All participants were currently pregnant at the time of the interview. Three of the participants were experiencing GDM for the second time as they have had previous pregnancies with GDM. For these three participants, to distinguish between experiences related to the current experience of GD, and their past GDM experience, in our interviews, we prompted participants to specify if their recounted experiences pertained specifically to the present GDM. Often, when participants discussed past pregnancies, it was primarily in the context of comparing those experiences with their current situation. Participants interviewed had no history of either T1D or T2D. The mean age of our participants is 32.8, with a standard deviation of 2.9. All participants reported that they were either married or in a domestic partnership. The 13 interview participants were asked for informed consent over e-mail before they were scheduled for interviews. We provided Amazon e-gift cards worth 15 US dollars as compensation. All participants in our interview study identified as female. In this work and our result sections, we use she/her/hers in describing our participants.

3.2 Interviews

We conducted interviews via Zoom and recorded the sessions. At the start of the session, participants were reminded of the informed consent, and verbal consent was collected. Then, we confirmed that participants had been clinically diagnosed with GDM, inquiring about it to check that the information matched what the participants had entered in the screening survey. Then, we gathered information on the pregnancy journey and how they managed GDM. In the interview, we probed on their pregnancy experience, their gestational diabetes experience, what they tracked, how they

Table 1: An overview of the participants in the interview study

PID	Age	Ethnicity	Diagnosed at:	# of GDM preg	Highest level of education	Annual Income
P1	37	White	23 wks	2	masters	$80-100k
P2	34	White	28 wks	1	trade/vocational training	$100k and above
P3	33	White	26 wks	1	doctorate	$100k and above
P4	39	White	26 wks	1	some college credit, no degree	$20-40k
P5	33	White	28 wks	1	masters	$40-60k
P6	36	White	27 wks	1	masters	$100k and above
P7	32	White	29 wks	1	masters	$60-80k
P8	29	Asian/ Pacific Islander	26 wks	1	masters	$100k and above
P9	28	White	30 wks	2	associate	$40-60
P10	34	White	28 wks	2	masters	$80-100k
P11	36	White	28 wks	1	masters	$60-80k
P12	34	White	9 wks	1	masters	$100k and above
P13	31	White	29 wks	1	masters	$80-100k

tracked and their overall wellbeing within GDM. We also asked questions about how they revisit/think about their data, and we probed on their meal experience, and relationship with food before and during GDM. The interview ended with discussions about how they thought about or reflected on the GDM journey, its contexts, and broader implications (social, ethical, etc.) about GDM. All participants were recruited and scheduled for interviews while they were still pregnant, however, two participants participated in the interviews within days of giving birth. One participant had to reschedule her interview date as she had to give birth to her child on the day we had scheduled her for the interview. We stopped interviewing participants when we reached theoretical saturation.

3.3 Data Analysis

We recorded each Zoom interview and collected 9.5 hours of interview data. In total, interviews lasted 29 to 64 minutes (M=43.7 SD= 13.3). All interviews were transcribed for analysis. The interview data were coded using the codebook approaches, as described by Braun and Clarke's [10, 11]. The codebook approach to thematic analysis integrates the principles of reflexive thematic analysis, inherent in qualitative research, with a more structured coding system [10]. First, the first author familiarized herself with the full scope of the data we had collected during the interviews, including the data from the screening survey. Then, the dataset was cleaned to ensure that interview sentences were correctly transcribed. Secondly, the data was openly coded without a pre-existing code list to get a deeper understanding of the findings. The themes we got from open coding were then used to structure and chart our analysis to the different hierarchies of Kolb's Experiential Learning Cycle. The authors discussed the understanding of the data and quotes. Using the Kolb's model serves as the high-level construct in reporting data as Kolb's model allowed for more granularity within the themes, captured more distinction in each phase, and engaged the richness of experiences in our data. Upon discovering our granular themes, we mapped these to Kolb's Experiential Learning Cycle (Table 2). For example, themes such as *"Thinking about GDM experience"* or *"Data comparisons"* described the Reflective Observation (RO). Other themes such as *"Broader Implications"* mapped to Abstract

Conceptualization (AC). We continuously mapped and structured our granular themes to the corresponding phase of Kolb's Experiential Learning Cycle.

We chose Kolb's framework for three key reasons. First, Kolb's cycle accounts for a "concrete experience," which aligns with the complex experiences that participants in our study underwent - pregnancy and GDM. These experiences are temporary conditions lasting for a few months but can profoundly impact the mother and the unborn fetus, even beyond the pregnancy. Second, because pregnancy already involves many changes that set every day and everyone's experience apart from each other [65], pregnant individuals with GDM must constantly solve problems and make decisions in unfamiliar situations. These constant observations, learning, and experimentation are consistent with the learning circles in Kolb's framework. Finally, because of the short but urgent circumstances, GDM often requires pregnant individuals to move from a concrete experience to act quickly. Using Kolb's framework allows the research team to systematically analyze and reflect on these findings.

3.4 Positionality and Reflexivity

All authors of this paper have experience in HCI research health and technology design. All identify as female and are from multi-ethnic backgrounds and experience. One author brings a public health experience. Engaging with literature on positionality and reflexivity [24, 34], we acknowledge that none of us have experienced GDM. The study was initially motivated by the observation of the lack of extensive literature on the intersection of GDM with the CHI and CSCW community, extending beyond the medical domain. To the best of our abilities, we undertook this study with reflexivity. Two of the authors of this work constantly met to discuss our approach, pausing to reflect on the interview questions. Additionally, we strove to embody an 'empathetically neutral' approach [24] in conducting the interviews and in our analysis of the findings. However, it's crucial to recognize that some level of subjectivity will persist, as we cannot fully experience the perspectives of our participants and cannot fully represent the experiences of all individuals who experience GDM beyond our participant group.

4 RESULTS

In this section, we categorize our findings using the stages of Kolb's Experiential Learning Cycle: Concrete Experience (CE) (Section 4.1), Reflective Observation (RO) (Section 4.2), Abstract Conceptualization (AC) (Section 4.3), and Active Experimentation (AE) (Section 4.4). The summary of our findings is presented in Table 2. CE is the lived experience of pregnancy with GDM. Reflective Observation involves an individual's attempt to make meaning of their concrete experience(s). AC involves co-constructing meanings from the experience(s), producing new ideas that could be tested. AC could also create ideas that transcend one's immediate needs. AE involves utilizing the knowledge formed, moving beyond one's comfort zone to make decisions and problem-solve.

4.1 Concrete Experience (CE): The Lived Experience of GDM

As previously stated, the pregnancy journey is inherently "Concrete" for individuals embarking on this pregnancy journey, as active participation is essential. For pregnant individuals with GDM, an extra layer of CE is introduced, demanding heightened consideration for daily choices related to both food and overall health. Pregnant individuals with GDM must track their blood sugar four times a day [26]. Combined with other relevant lifestyle data, such as food and exercise, participants reported using a variety of tracking tools at the same time. They had to make sense of a substantial amount of data across multiple sources. Participants in our study reported that the change in food practices was one of the significant behavior changes they experienced when they were diagnosed with GDM. They recorded their meal plans on phone note apps, paper, or spreadsheets they had created independently. In order to illustrate the CE of GDM in the everyday lives of participants within the broader pregnancy context, we present two case studies detailing the experiences of participants.

Case Study 1: P3 mentioned that her mother had a history of GDM during pregnancy, prompting her to undergo early testing for the condition. Despite being a self-proclaimed 'data junkie' and a devoted user of various tracking apps to monitor aspects like exercise, water intake, and vitamin consumption, she found the experience of tracking GDM particularly challenging. She described it as "exhausting" and "traumatic" due to the extensive monitoring required, the stringent guidelines, and the unique context of tracking within the pregnancy experience. Given the exhausting nature of this CE, P3 highlighted that she relied upon resources such as her mother, and the subreddit community where she found support by reading other community member's stories. To balance the mental exhaustion from the CE of GDM and pregnancy, she sought additional support from a therapist.

> "It's exhausting, The amount of mental thought you have to put into it, because the guidelines are very tight for what you're supposed to keep your sugars within [...] To be perfectly honest, tracking four times a day for 30 some weeks is a little traumatic. You have to stick yourself so many times. I don't really want to do it again. I kind of really hope I don't have type two diabetes [...] At first, It wasn't overwhelming. It became

> overwhelming over the course of the pregnancy. [...] I have a therapist that I go to, just for my own mental health purposes, like I said, it gets exhausting managing the condition, so she helps a lot "–P3

Case Study 2: At 33 years old and in her first pregnancy, P5 emphasized the unique dual experience of navigating both the joys of impending motherhood and the challenges of dealing with GDM. Despite her excitement about expecting her first child, she specifically highlighted the distinct nature of managing GDM within the pregnancy context, setting it apart from other conditions associated with pregnancy. She noted that alterations in her diet also extended to shared dinners with her husband. However, she clarified that this impact did not extend to their breakfast and lunch routines, as they continued to have different meals during those times.

> "[...] with other diseases, it's like you take a pill for it and you don't have to think about it. Diabetes, especially GDM, and I'm sure regular diabetes but in my context, GDM is something you really do have to put effort into it and it's kind of a daily thing that you have to think about and manage and learn about as you go along. I think that's what makes it a little bit different maybe than some other pregnancy conditions and I think contributes to why for me it took a couple of weeks to come to terms with it and be okay with it ...It's a little jarring at first and then you adjust of course"–P5

In summary, the case studies above detail the CE of GDM and pregnancy highlighted by participants in our study. This experience is reflective of the challenging health experience that pregnant individuals with GDM have to manage. These experiences also are situated in the social contexts that pregnant individuals are in, oftentimes requiring others to provide support (e.g., seeking therapies (P3) or families adjusting diet together (P4)).

4.2 Reflective Observation (RO)

Reflective Observation (RO) involves participants consciously reflecting on a CE. As we have noted, participants in our study encountered two types of intertwined, CE: GDM and pregnancy. Participants' RO occurred in three main aspects: food-related, condition-related, and data-related experiences.

4.2.1 Food Related Reflective Observation: The most prominent aspect of reflective observation was the participant's relationship with food. This result is not surprising given that most of the lifestyle adjustment for GDM revolves around meals and blood sugar tracking (measured around mealtime). The changing relationships that participants experienced with food were sometimes negative. Individuals with GDM and their families often change their grocery shopping, meal planning, and cooking practices in response to the diagnosis. P8 and P12 described how the changing relationship affected their lived experiences. P8 was diagnosed with GDM at 26 weeks of gestation. She reported a history of diabetes running through her maternal side of the family. Upon diagnosis, she discovered that a lot of the management of the condition revolved around food and sought additional knowledge on foods from the book "Real Food for GDM" [1]. As she reflected on the experience,

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[1] Real Food for GDM: https://a.co/d/2TTkVC8

Table 2: Summary of Findings Categorized by Kolb's Experiential Learning Cycle

Kolb's Cycle	Themes/Findings
Concrete Experience (CE)	GDM and Pregnancy
Reflective Observation (RO)	Food Experiences | GDM Experience | Data Comparisons
Abstract Conceptualization (AC)	Educational Support | Tracked Data | Broader Implications
Active Experimentation (AE)	Experimenting with food

she highlighted that the food adjustments took away the fun of eating.

> *"... It's pretty intrusive, in many ways, because you have to change so much of your life habits revolving around eating. It takes the fun out of eating, so to speak."* –P8

P12 also emphasized the major challenge with GDM – it led to significant trade-offs for activities she enjoyed before pregnancy. P12 reflected on her initial relationship with food being a stress outlet because she enjoyed baking. As a result of GDM, she could not use the stress relief outlet (i.e., baking) she was familiar with. Hence, the stress build-up, in turn, negatively affected her health by inducing more stress and anxiety.

> *"...I used to love cooking and especially baking. Baking was a stress relief outlet. And that's been difficult because my pregnancy has been stressful. And so, it got to the point where it was super depressing to think about things like, "Oh, it'd be great to make baked cookies that I can't eat."... the diagnosis took away some of the joys I had... stress relief outlets that I had. And just replaced them with sources of more stress and anxiety.."* –P12

Though P12 had a negative experience with food, she also tried to consider the positive aspects of future food experiences that came from experiential learning through the condition.

> *"...So I had to change my whole diet. And that was frustrating at first. I've since come to terms with it. And I've come to enjoy having broader flavors, textures, and options in my life. And it makes some things easier, like meal planning with my husband. And you know, thinking ahead, it'll be cool to introduce some of these funky new flavors to my daughter when she gets here..."* –P12.

In some cases, the entire family adopted the GDM diet to support the pregnant individual so the latter did not feel isolated from the communal nature of eating. Here, we present two examples of family adjustment to food relationships in support of the pregnant person. P2 shared that her whole family changed to a GDM diet with her and found health benefits from doing so.

> *" We change the diet of everybody in the house. Just to make it easier, there won't be any temptation. And it made a big difference, actually, for everybody. Blood pressure went down for people [referring to family members], and my son's behaviors are much better now..."* –P2.

In P3's case, while her husband tried to adopt the same diet, both found it hard to stick to it.

> *" My husband was a champion. He mostly did the diet with me. He indulged himself periodically, mostly where I could not see him. But he changed his diet, too, because it's just hard. I had trouble when he had things in the house that I would want to eat"* –P3.

In summary, food-related RO was indicated by participants' reflections on their changing behavior around food. This form of reflection showed both positive and negative experiences around food.

4.2.2 Condition Related Reflective Observation: Participants in our study also reflected on their initial feelings associated with being diagnosed with GDM. Most importantly, they shared how the initial understanding of the GDM experience clashed with the reality of the condition. Several participants in our study expressed guilt, shame, and a sense of self-blame that they may have brought the condition upon themselves. Participants often asked the question *"What did I do wrong?"* and often mentioned the emotional response that they had towards their condition- *"...I felt sad. and I felt guilty..."* –P2. One participant, P4, mentioned that while she felt sad and broke down to tears due to GDM, she also felt very guilty that she may have brought the condition upon herself. She shared that the condition brought back childhood memories of living with her grandparents, who never invested time into ensuring that she had a good relationship with food. This memory and the fact that she continued her childhood eating habits as an adult made her feel guilty about her GDM diagnosis.

> *" I remember when I came home, I was in tears...I never had a good eating journey in my life. So I think about my grandparents who were hard on me as a kid about what I ate...it's all my fault, everything I'm doing is wrong, and now I'm ruining the next generation..."* –P4.

The condition, the pregnancy, and her childhood memories added to the overall emotional stress that P4 had. P6 similarly felt a sense of guilt but acknowledged that she considered the risk factors she had control over versus those she had no control over. She acknowledged that her genetics, which she had no control over, put her at risk for GDM. However, the fact that she chose to become pregnant later (36 years at the interview) made her feel guilty for putting herself at risk for GDM.

> *"I definitely have felt like... I did something to cause it. Some of the risk factors are not in people's control... I can't control my genetics, I can't control that...my mom had it (referring to GDM). In theory, I can control the age I choose to get pregnant. But.. this was when it was right for me to do it..."* –P6.

The guilt was also sometimes tied to the choices and decisions participants felt engaged in during the first trimester. GDM is diagnosed in the second trimester. Thus P8 emphasized how her choices in the first trimester of the pregnancy might have resulted in her GDM. She, therefore, felt very guilty for putting her baby at risk and constantly questioned herself.

> *"The biggest thing was an overwhelming sense of guilt. Because I knew I hadn't been eating particularly well in my first trimester. I was eating very carby things: baked goods, anything I could keep down at that point. And there was sort of this overwhelming feeling of, 'Did I do this? Is this my fault? What did I do?'"* –P8.

In contrast to P8, who felt her choices put her at risk of GDM, P1 felt her experience of GDM and knowledge of risk factors clashed as she considered herself to be very fit with no family history or genetic conditions that were known to put individuals at risk of GDM. Yet she was confused by the diagnosis and the reality that she had to manage GDM throughout the rest of her pregnancy.

> *" I'm probably.. one of the fittest people in my family, and nobody else has had it (i.e., GDM) in there or been diagnosed, at least in our whole family, for their pregnancy. So, I and everyone just thought, 'Oh, I wouldn't expect that.' But now that I talked to many people, I know many people that maybe didn't fit the criteria of traditional GDM patients."*–P1.

P13 highlighted that the feeling of guilt also came from her experience of stigma and the assumptions tied to their condition. This added to the emotional burden of their condition. P13 mentioned that the stigma she perceived included that people with GDM will have large babies and that individuals with GDM had not taken good care of themselves or had not maintained a proper diet before conceiving.

> *"...I do think there's some stigma around...there's this assumption that your baby will be huge because of GDM ...our baby is small. And then I think people assume that you weren't eating well beforehand or that you weren't taking care of yourself beforehand...And then when you look it up online, there's like, 'Oh, if you're overweight, or you have these other health conditions, then you're more likely to get GDM. Sure, there are statistics about that, But I think that also makes you reflect on yourself in, maybe, not in such a positive light "* –P13.

To summarize, condition-related Reflective Observation (RO) surfaced as an overwhelming sense of guilt linked to the diagnosis, especially as participants tried to make sense of the risk factors, personal choices, and stigma that may have played a role in the CE of GDM.

4.2.3 Data Related Reflective Observation: Data-related reflective observation occurred when participants observed that their sugar numbers were out of range and posed questions to make sense of the situation. Some participants also reflected on the complexity of tracking in GDM. Many participants had to use multiple tools together to monitor their blood sugar and lifestyle factors, and this data made them mindful and anxiety-inducing. For example, P9

described the multiple variations of questions she posed to herself whenever her data was beyond the normal/specified range:

> *"... over the past week, I've had three highs after breakfast, even though I'm eating the same thing, why is that?... the first day, I said, 'okay, that's weird. What happened there? What did I do wrong?'... And then, it happened again, 'What the heck is going on? And then again, what's going on here?'..."* –P9.

P3 reflected on how she used the data to decide on what foods to eat and inform future decision-making

> *"The data that I have tells me what I can and can't eat, in terms of what it's going to do to my blood sugar, which is a good piece of information to have. So I think it will inform my diet choices in the future "* –P3.

Two of the three participants who had prior experiences with GDM from their first pregnancies (P10, P9, and P1) emphasized how they used the data from their current pregnancies to compare to their previous pregnancies. P10 compared the times of diagnosis with GDM and what types of food she could eat at specific weeks of gestation without affecting her sugar level. From the comparison, she observed that her food options became limited at certain weeks in her last pregnancy.

> *" I did some basic comparison of the data over the two pregnancies... I was diagnosed at roughly the same time in both pregnancies...I had about two or three weeks in my first pregnancy where I could eat half a baked potato and a piece of bread and have it be no big deal. And then like 30 to 33 weeks hit, and suddenly, the allowable foods just got much, much narrower..."* –P10

P1 also compared her second pregnancy data with her previous GDM data from 2019. She stated that she would pick similar weeks of gestation within both pregnancies and compare the weight and trends for both pregnancies. She used the learning from this comparison to determine if she was doing okay or needed any action.

> *" So one example would be ... I would click on my weight. And.. kind of looking to see: 'Okay, throughout my pregnancy, how much weight did I gain?'. And if I'm looking back, I can see in 2019, my weight was at its highest, like 160. And right now, I'm at 155 or something like that. So I would look and see. If I start gaining a pound a week for the rest of the pregnancy, I will be in trouble... But I expect it to level off; then I'm doing the same things and doing okay."* –P1

Tracking helped P12 to realize that she experienced negative emotions and needed to seek support. P12 noted that tracking was a huge source of stress for her because it was cumbersome. She first struggled with maintaining the fasting blood sugar numbers within the allowable range. However, upon incorporating mood and stress level tracking alongside her glucose monitoring, P12 discovered an increase in negative moods, a realization brought to light through the analysis of her combined data. From her reflective observation, she realized she needed to talk to a counselor for support, given the negative emotions and burden she experienced from tracking the condition.

" It also was a huge source of stress and anxiety for me, especially ...my fasting numbers, like with many women, were more difficult to control than my post-meal numbers...so waking up early to prick my finger was kind of anxiety-inducing...And then, as I would note, my blood sugar number in there, and then my mood and/or stress level, depending on which of those things I was tracking at the time. That was very cumbersome. I felt like I was tracking a lot more negative to neutral moods than positive ones...And that was one of the things that motivated me to talk to a counselor because it was apparent that I was having some anxiety and depression issues "–P12.

Instances of data-related reflective observation surfaced in the following ways: posing questions when sugar levels are beyond the normal range, comparing data points between two pregnancies (in individuals who have been diagnosed with GDM in more than one pregnancy), and finally, realizing the burdensome nature of tracking multiple data points at the same time.

4.3 Abstract Conceptualization (AC)

Abstract conceptualization involves interpreting the reflected upon experience to form new experiences, produce new ideas, or modify existing ideas/knowledge [58]. AC in our participants resulted in an improved personal understanding of the support they need from immediate family members and providers. In addition, this type of reflection also considers broader implications around policy, society, and ethics as they relate to or beyond their own experiences of GDM. In this section, we highlight three ACs that participants in our study discussed: gaps in educational support, opportunities to improve data collection and viewing, and other broader implications, such as the financial, ethnic, and policy-related considerations of GDM.

4.3.1 Gaps in Educational Support: Participants in our study reflected on their experience and discussed the various types of educational support they needed. They highlighted the need for more knowledge about GDM and GDM diets, training on using and making sense of readings from glucometers (the device used in measuring blood sugar), and support structures for individuals with prior eating disorders.

P2 noted a need to provide more education about GDM and how to manage the condition between visits. She mentioned that between the time she received the actual diagnosis and when she got her first follow-up appointment after the diagnosis, she was left with a lot of uncertainty and emotional stress.

" My question that would be good to ask women is how much education they're getting about diet and how to use the meter like the doctor didn't teach me how to use it. And they didn't teach me anything about the actual physical use of my supplies. And the diet, they just told me I was diagnosed, and it was weeks until I had an appointment. So during that time, I wonder if women are being left to the cracks..." –P2.

P10 also mentioned the need for understanding how to interpret the numbers on the glucometer, especially when it was beyond

the normal range. Because P10 had prior experience with GDM, she mentioned that she had been actively engaged in the online Reddit community for GDM during her second pregnancy. She felt that given this was not her first pregnancy with GDM; she felt a sense of privilege in making sense of her data. However, she noted that other women may not have similar privileges, especially if it was their first pregnancy. She also shared that on the Reddit group, some individuals reported having a past eating disorder, but there was not much support for these individuals.

" a bad number (referring to the sugar level being out of range) *could do a number on someone who's not able to respond to the numbers meaningfully. There's some privilege involved in seeing the number and knowing you can do something about it, instead of just seeing the number, knowing it's bad, and knowing there's nothing one can meaningfully control about it. If you're a person who says you've had an eating disorder in the past, I think being diagnosed with GDM should trigger some sort of additional support: the counting of the carbs, the tracking of the numbers, and all that stuff..."* –P10.

4.3.2 Tracking and Viewing Tracked data: Participants realized there is no adequate consolidated mechanism for tracking and viewing tracked data. Many participants used multiple tools, from paper-based journals, note-taking apps on phones, spreadsheets, and data transmitted through the one-touch glucometer app. Sometimes participants used multiple tracking tools because glucometers did not connect to other systems. They also reported that it was easier to use spreadsheets or paper-based tools when they had to plan different meals while taking notes of meals that caused a blood sugar spike. These data points were stored across tools, making the data-tracking process complicated for later interpretation and sense-making. Based on these experiences, many participants shared a conceptual idea of how tools could better support them. P13 could not find a tracking method that suited her needs, and through her spouse's support, she created a log that worked for her and stated that she intended to share it with anyone with GDM within her network.

" I essentially have three ways of tracking. And I think they are all important... It'd be nice to consolidate all this into one place where I send everything ... And there are logs out there. But I don't feel like they're as comprehensive as this ... There were more resources or tools to help you get there. And we had to create it on our own..." –P13.

P12, whose day-to-day job as a city planner involved considering visual accessibility, highlighted the importance of infographics (charts, reports, and images) in viewing and presenting the multitudes of data points tracked during pregnancies.

"... I understand the value of organizing information that's in a way visually accessible for a lot of people. So, like, infographics make it easy, in a lot of cases, to understand more complicated data ... I think the data visualization (referring to GDM) is really where I would have needed more support, so I ended up doing some color coding for, like sleep quality and mood and that

was fine. . . but it got to the point where I didn't want to spend any more mental energy, trying to figure out how to make it work for me." – P12.

4.3.3 Broader Implications: Participants also indicated broader implications involving financial, ethnic, and policy-related considerations. These were financial burdens resulting from GDM, considerations for ethnic backgrounds in the GDM diet recommendations, and how GDM individuals are supported from a health policy perspective in other regions. P13 first reflected on the burden as it related to herself. She had been tremendously supported by her partner throughout the GDM journey. She had also carefully planned the financial side of her pregnancy. Then, she inferred beyond her immediate self into thoughts of how other pregnant individuals could be supported, highlighting the flexibility with working hours, spousal support to help create tracking spreadsheets for her GDM diet, and proper financial planning ahead of pregnancy.

> *"I don't know how people do it, financially or without support ... my appointments are typically on Wednesdays ... So that means working weekends to make up for the time or working evenings. Given my situation of saving money and having a supportive partner, I have felt pretty lucky. But I do wonder how people do this without being able to spend a week making a spreadsheet. why shouldn't this just be part of the package they give you, and not have to stress about that?... So yeah, I don't feel like doctors talk about the financial aspect...Definitely challenging financially, for anybody..."* –P13

For another participant, AC surfaced as an expanded view of the burden that GDM presented to diagnosed individuals. P8 reflected on how the burden meant that financial trade-offs must be carefully considered.

> *" In diabetes supplies alone, I've probably spent $200, which is a lot of money, especially when getting everything ready for your baby. So something that you might need for your baby: formula, diapers, that might be something that you can't have, you have to make this trade-off if you don't have enough money. And it's a terrible thing. I think that all GDM supplies should be free and easily available"* –P2

AC also included social and ethnic considerations around the GDM diet. P8 emphasized how diet recommendations for pregnant individuals with GDM were Western-centric and did not cater to individuals from different ethnic backgrounds. P8 found the diet to be different from what she would eat on a regular day in her home and wished that dietary recommendations could be more inclusive of her ethnic background. However, she emphasized that having a dietitian from a similar ethnic background helped her consider other meals that supported her condition.

> *" I met the dietitian, who emphasized that I didn't have to give up many of my cultural foods. I am Chinese, ethnically, even though I grew up here* (referring to the US). *So much of our food is carb-based. She taught me how I could balance that with more protein. She was South Asian. So she understood very well, and that*

makes a difference. A lot of the resources are aimed at the sort of Western diets, such as avocado toast, and I never eat avocado toast. So that's kind of a challenge." –P8] .

Participants also highlighted the broader considerations of GDM relating to society or policy. An instance of this occurred in our discussions with P4, a first-time mom diagnosed with GDM at 26 weeks. She explained that she had challenges adjusting to the GDM diet and found the diet to be expensive. Before her pregnancy, she had no good relationship with food and had not learned how to eat healthily. Upon reflecting on her experience and relationship with food, she thought her journey would be easier if the US adopted policy changes similar to what she had read about policies in other countries.

> *"I think it would be helpful if our health providers...didn't just provide advice, that they would provide meal services for people...I've heard about how in other countries, I think in the UK, they actually will provide you like a food stamp card or something like that, to get foods that you're allowed to have. And in America, we just go, 'Yeah, shit sucks, figure it out.' I feel like they just provide more support over the pond. So I think it'd be nice if our medical providers did something like that "* –P4.

In our study, AC in GDM was presented in identifying gaps in educational support for individuals with GDM, insights into how there are no adequate tools for tracking and viewing tracked data, and broader implications inferred from the experience of GDM.

4.4 Active Experimentation (AE)

Most participants entered Kolb's Experiential Learning Cycle from the AE phase. Upon diagnosis and confirmation of GDM, participants began experimenting with a combination of food and exercise regimens, including the timing, content, and quantities of eating/snacking and exercise as they tried to maintain their blood sugar levels within the allowable boundaries per meal. Participants in our study reported experimentation as they tried to make sense of and meaning of the condition and as they attempted to produce and/or modify existing knowledge on their CE, indicating that AE overlapped with both reflective observation and AC. P6 and P8 described how they tested and experimented with food. As P6 learned that she needed to exercise alongside dietary management, she found that people mostly exercised after meals. However, she learned that exercising worked better for her if she did it before her meals. In addition, she experimented with multiple food measurements as she attempted to keep her sugar numbers within the allowable range. P6 explained:

> *" One interesting thing is, as most people are told to exercise after they eat, and I think, based on a lot of my numbers, it's almost better for me to do it before I eat . . . last week, I tried eating some beans, and I'm like, well, I'll try a quarter of a cup. And it was like my numbers were fine. So then I was like, Okay, well, now I'm going to try a half a cup"* –P6.

In P8's circumstance, she discovered that she had been struggling with the fasting blood sugar level (a measure of blood sugar after an overnight fast). She began experimenting with snacks before bedtime and discovered that snacking before bed helped her fasting sugar levels in the morning.

> " I would say the timing I ate also changed. I realized that I was eating too early in the evenings. And that drove my fast numbers up, making me incorporate the snack at the last moment of the day. Oh, wow. Yeah, they were consistently five points higher. If I didn't snack "
> –P8.

One challenge that participants encountered during this phase was exhaustion from experimenting with different foods. One participant expressed becoming too intimidated or overwhelmed to experiment with new foods continuously. As a result, she stuck to foods that did not spike their sugar level, which led to less variety in meals throughout her pregnancy. The overwhelming nature of experimentation during pregnancy could take the fun out of food and eating.

> " I highlighted what I was willing to try or eat, which, luckily, I liked vegetables, so it wasn't super limited. But I've kept to the parameters they said in there. I've been too intimidated to try things on my own " –P8].

Participants found that experimentation with food could be made more accessible with support structures. P13 found experimentation to be easier because her husband helped create nutritional labels for food items they sourced from the grocery store, and he input values into the spreadsheet he had created to help her figure out which combinations of foods worked for her sugar limits.

> " My husband painstakingly went to the grocery store to look at everything before he bought it and then brought it home and input all that information. So looking at the nutritional labels on all of the food items. And if it was unclear... if there was anything that did not have a label, we just won't buy it...If I want to try new foods, he'll get the information, put it, and update the spreadsheet...So we got a lot of food in there, so I haven't felt the need to branch out as much " –P13

P10 gained support from others (her friend and mom), which helped ease the experimentation process. P10 turned to friends to share experimentation ideas, such as foods that worked to maintain the blood sugar level. In addition, P10 sought support from her mum, who had a wealth of nutritional knowledge, to test out new recipes that would support her pregnancy and allow for more variety in food choices.

> " Yeah, one of my good friends had had GDM in her first and only pregnancy, so she was a good source of information... our experiences weren't 100% the same, but she and I were able to talk about foods that worked out for us and like count the balance of balanced meals...she's another engineer and a close friend. So she was very supportive, which was helpful..." –P10.

P10 further highlighted the support she received from her mother through the pregnancy and experimentation phase:

> " As far as nutritional resources, my mother is a pharmacist and is really into nutrition. She didn't know a lot at first but did a lot of reading and was very helpful to me; she would find a new recipe and cook it when I came over; she just made many things easy for me. She would make that low-carb recipe, I test my sugar there, and she's like, 'alright, it's a good recipe.' I'm home with the leftovers. She's great. That was helpful." –P10

In our study, AE in GDM was presented in the form of modifications relating to food as each participant tried to manage the condition.

5 DISCUSSION

In our findings, we noted how reflection, active learning, and experimenting with lifestyle management could help pregnant individuals gain a sense of control over GDM. Our research surfaced challenges, such as stigma from the condition, the intrusive nature of dietary adjustment, taking the fun away from eating, exhaustion from actively experimenting with a variety of foods, and the western-centric nature of dietary recommendations. Situating our findings within the burdens in the pregnancy context, we use Kolb's Experiential Learning Cycle to emphasize the opportunities for designing to support the GDM journey throughout each phase of the Learning Cycle. Our findings revolve around two broad themes: supporting and managing the changing relationship with food and supporting emotional wellbeing in a stigmatized and burdensome condition as individuals navigate the different stages of the Experiential Learning Cycle.

5.1 Designing to Support Concrete Experience (CE)

Based upon the CE we learned from participants as highlighted in 4.1, we recommend design opportunities for the CE stage to support emotional wellbeing, minimizing mental exhaustion and the stigma individuals feel within the condition. Participants in our study often felt the stigma around their pregnancy and sometimes did not disclose that they had GDM to close friends. The stigmatizing views sometimes came from the participants, who felt they had contributed to their condition. This form of stigma is called 'Internalized Stigma' [54]. The sense of shame and guilt led participants in our study to seek support through social networks, especially those that offer anonymity (e.g., Reddit). This is consistent with previous work that shows anonymity and disinhibition provide social support by ensuring a safe environment for people to communicate and share questions and stories [70]. The need for social support within an emotionally burdensome and stigmatizing condition highlights the importance of the Pregnancy Ecology Framework [65]. The pregnancy ecology proposes an ecological approach to design for other facets of pregnancy beyond reinforcing medical guidelines. It emphasizes the importance of incorporating healthy emotional and social wellbeing support, informational support, and tangible support (e.g., time, money, and access) [65]. Individuals with GDM need support in reducing guilt and anxiety.

To support the emotional, social, and informational needs of people with GDM, we recommend designing a safe and interactive learning environment. This environment could involve support from those who have successfully undergone the journey and experts who

specialize in providing health and emotional wellbeing support, such as therapists and nutritionists. For example, an interactive learning environment supporting T2D [52] has shown that diabetes education in this environment helps increase women's awareness of their body and bodily reaction, leading to a sense of empowerment, trust in their embodied knowledge, and recognition that they have choices and could take back control of their lives [21]. In implementing this interactive learning environment, we advocate for researchers and designers to employ respectful language and reconsider their assumptions about weight loss [64] as a means of mitigating fat oppression and the related stigma experienced by pregnant individuals diagnosed with GDM. One of the key advantages of a virtual learning environment is anonymity – which helps lessen the stigma in social face-to-face encounters – while allowing presence and virtual capabilities [67].

Building on successful virtual learning environments in HIV [68], diabetes [76], and smoking cessation [77], implementing virtual interactive learning in the GDM context that would need four key components. First, a virtual environment allows individuals to participate in synchronous learning with diabetes educators and nutritionists, with whom they can ask questions and receive live answers. As participants in our study expressed, GDM came at a financial and time-related cost because they had to trade off working hours to attend visitations with several vital stakeholders managing their care. A virtual environment could help relieve this burden. A second key component for a virtual learning environment in GDM is educational video content, enabling individuals with GDM to increase knowledge and awareness about their disease. Participants in our study emphasized the knowledge gap in their understanding of the condition, how to use blood sugar monitoring devices, and how to make meaning for the data. Educational videos within a virtual learning environment would help pregnant individuals fill this knowledge gap, especially in the early phases of the condition, where the learning curve and adjustment to the condition are steep. The third component will help address individuals' mental exhaustion. Participants emphasized the guilt and internalized stigma in managing the CE of both GDM and pregnancy. A virtual learning environment that takes into account factors beyond physical wellbeing, such as mental and social wellbeing, and a history of disordered eating, could prompt additional assistance from therapists to aid the pregnant individual throughout the pregnancy journey, making these therapies integral to the overall experience. More research is needed to determine the financial, policy, and infrastructural support of GDM in our technologies and designs. Finally, the virtual learning environment will benefit from including a community of peers who are currently experiencing or have experienced the condition, empowering pregnant individuals with GDM to also see themselves as credible experts on their own experience [64]. The internalized stigma around the condition may prevent individuals from contacting friends and family for support. In cases where individuals find themselves isolated, a virtual community of support, such as peers, nutrition experts, and mental health therapists would be beneficial to help navigate the emotional burden of GDM.

We also encourage researchers, designers, and medical professionals supporting individuals with GDM to move away from perpetuating the medicalization of a condition by embracing a "Storied Care" approach [27]. Storied Care emphasizes the importance of believing in, respecting, and honoring the stories of individuals with GDM. As researchers and designers, in creating tools to support these individuals, we need to put Storied Care into practice by checking our biases and ensuring we listen and learn from pregnant individuals and their stigma to avoid the reinforcement of stigma in the technologies we build. Adopting this approach also has the potential to empower and recognize individuals undergoing GDM as experts undergoing a CE of GDM.

5.2 Designing to Support Reflective Observation (RO)

Based on our findings, opportunities to support the RO stage would need to focus on individuals' interactions with food, health conditions, and data aspects. In this context, we propose two avenues for support: streamlining the tracking process and implementing recommender systems that align with personalized meal plans.

5.2.1 Minimizing the Burden of Tracking and Sensemaking. Easing the burden of RO and promoting the transition to the AC phase of Kolb's Experiential Learning Cycle in GDM requires considering data consolidation and meaning-making. Prior studies in the review of behavior change apps for GDM suggested dual-processing as an essential consideration [48]. Dual-processing posits that individuals have two systems of thinking: system 1 (which is automated, habitual, and effortless) and system 2 (which is controlled, logical, and effortful) [37, 38, 40]. In designing tracking tools for individuals with GDM, there are opportunities to consider what aspects of the tracking and sensemaking process could be supported by an automatic process, requiring less of system 2. For example, if a pregnant individual discovers that blood sugar is outside of the recommended range, systems could automatically compare that data point with other sugar level data during this pregnancy and provide potential reference experiences, such as *"On this day, you had a similar sugar level when you ate a bowl of mashed potato"*. The automated feedback could help reduce the cognitive overload from making comparisons or attempting to figure out the data anomaly. Participants in our study alluded to the mental burden that arose from identifying anomalies, looking for explanations, and comparing them to prior similar data. Katz et al. [40] investigated the dual-process theory in the design to support T1D. While different mechanisms cause T1D and GDM, both conditions require the same method of monitoring blood sugar levels. Katz et al. [40] highlighted that in the design of a better diabetes support system, designers would need to consider answering the question: *"How can UI support interactions with complex data in a manner that is of low enough cognitive demand (system 2) to allow for frequent usage while still encouraging non-reflexive mindful engagement?"*. When designing blood glucose monitoring tools, automated feedback that minimizes cognitive demand would support RO, easing the transition to other phases of Kolb's Experiential Learning Cycle.

5.2.2 Adopting Recommender Mechanisms in Supporting Individual Diet Needs. Participants in our study reported that most of the clinical guidelines and health promotion recommendations they received were based on a Western diet, which might not align

with their ethnic preferences. Dietary needs could also come from personal, ethnic, or religious preferences and requirements. For individuals with food restrictions, adjusting to the GDM diet is a much steeper learning process that would impact both the RO and the AE aspects of Kolb's Experiential Learning Cycle. These challenges increase the need for pregnant individuals to experiment with foods that align with their restrictions and work for their sugar level, making the diet change potentially more intrusive to their existing lifestyle. Research in meal recommender systems has attempted to balance personal preferences and chronic health nutritional needs [30, 78]. For example, *Yum-Me* considers a user's profile and preferences to generate a set of recipe recommendations [78]. Although food recommender systems still have a few challenges with data sources, evaluations of recommendations, and accuracy [74], they could still serve as a potential direction to support individuals with GDM. To reduce the burden for pregnant individuals, improve the pregnancy experience, and ease the transition to AE, there is also a service design opportunity to adapt food recommendations to include ethnically diverse meal delivery service plans, such as freshly [2], to support the preferences and needs of pregnant individuals. Studies of meal kits that had resulted in positive changes in food intake [43] and helped reduce the risk of cardiovascular disease [41], are successful examples of how meal delivery services could lead to positive health outcomes. However, to adopt these service designs in the GDM context, it would be essential to ensure diversity in the meal options available to support individuals with diverse diet preferences, requirements, and ethnic backgrounds.

5.3 Designing to Support Abstract Conceptualization (AC)

In thinking about supporting the AC phase of the Experiential Learning Cycle, it is essential to take into account the contextual environment. Through our research and in our findings, we gained insights into situated contexts, such as the role of food in social gatherings. Food is deeply integral to social and cultural practices, allowing people to form deep connections, experience pleasure, and sustain their human bodies [29]. Therefore, we recommend designing to support food adjustments in social environments. The need to adopt and adapt to the GDM diet often influences the food choices of immediate family members. Spouses/partners and children often adapt to the restricted GDM diet to support the pregnant person. The relationship with food goes beyond one's survival needs alone. For some, food is a means of bonding with family and connecting at social events (e.g., birthday parties) or special occasions (e.g., anniversaries). Eating in social settings, especially within co-located family settings, can influence individual food choices [32]. When individuals have diet-related conditions, such as Inflammatory Bowel Disease (IBD), families often have to change food practices, such as meal planning and routine maintenance [14]. Therefore, nutritionists and healthcare professionals need to consider including the family as a unit in their dietary recommendations and nutritional guidelines [14]. Individuals with GDM and their families often change their grocery shopping, meal planning, and cooking practices in response to the diagnosis. As indicated in our findings,

in some cases, the entire family adopted the GD diet. While family-wide diet change could be straightforward to plan for some, it might not be possible when family members have conflicting needs. With the progression of pregnancy, the need for diet adjustment might evolve, too. Therefore, technology to support individuals with GDM and their families in diet choices and planning must adapt to these changing needs and family contexts. Some participants in our study also saw the practice of making food connected families and provided a sense of satisfaction. However, with the diagnosis of GDM, they no longer had the opportunity to enjoy eating or the process of making particular food. Design to support food relationships as part of the overall wellbeing, therefore, needs to consider support beyond survival and nutritional needs. For example, systems can suggest alternative recipes that are safe for GDM. Systems could also support community building where individuals with GDM could enjoy making food while others (without GDM) could enjoy consuming the food. Designing for the different human-food interactions in GDM could build on the concept of celebratory technology [33]. Celebratory technology has elaborated on how food technologies could support positive interactions, such as focusing on creativity, family connectedness, gifting, pleasure, and nostalgia. As researchers and designers approach design to support food relationships for pregnant individuals with GDM and incorporate their family context, it is essential to consider how the family interacts with and connects through food and integrate the design to support pregnant individuals and their families.

5.4 Designing to Support Active Experimentation (AE)

Participants in our studies reported that they were never taught how to measure the total calorie or required carbohydrate intake per day. This lack of guidance made AE both burdensome and complex as each individual was forced to self-learn how to keep their blood sugar level at a normal range. Unlike other health conditions (such as T1D or T2D) where dietary changes only affect the diagnosed person, for GDM, the dietary changes affect both the pregnant individuals and their unborn babies. The stress and uncertainty add an extra burden of responsibility for pregnant individuals to ensure that the proper nutritional regimen is adhered to. Therefore, creating a tailored dietary plan that fits an individual's and their baby's needs is essential. Individuals need to be empowered with knowledge of dietary management and supported in creating their dietary plans. One example could be adapted from Glasemann et al. [31], where a mobile learning game was designed to help young people with T1D learn how to manage their carbohydrate intake. Gamified learning experiences, such as the example from Glasemann et al., could be adapted to support pregnant individuals in understanding how to incorporate carbohydrate restriction alongside other dietary needs, such as calorie management and other nutritional needs unique to pregnancy. Furthermore, the pregnancy experience differs and evolves, and incorporating actionable strategies into the learning experience can support pregnant individuals to adjust their diet throughout the pregnancy journey. For example, in GDM, glucose intolerance may change at different phases of the pregnancy journey. Understanding how to adjust food intake accordingly could be helpful in training in games.

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[2]Freshly-https://www.freshly.com

Building on the same concept, systems supporting GDM management also need to consider how to decrease additional burdens required for pregnant individuals to balance their condition management needs and pregnancy needs. Further research is crucial to understand the financial, policy, and infrastructural support necessary to effectively integrate GDM considerations into technologies and designs. This includes exploring funding models, regulatory frameworks, and necessary infrastructure development to ensure equitable access and successful implementation. Toward this goal, this paper provides an empirical understanding of the experiential learning process of pregnant individuals living with GDM that serves as a first step to unpacking these challenges.

6 LIMITATIONS

Given our recruitment methods, our participant makeup was heavily influenced by the population affiliated with the social media groups and the research volunteer platform we used. All participants were from the US and primarily identified as "White." Our recruitment material included the term "pregnant women," which may have excluded pregnant individuals with GDM who did not identify as women. In future research, we intend to be more inclusive in our recruitment and study design. All participants enrolled in our study identified as female and either were married or in a domestic partnership. Therefore, our findings can only describe the experience of cisgender women. Within our participant group, we had three participants who had experienced GDM in a prior pregnancy. Our current study and findings only factored in the existing pregnancy at the time of the interview. Future studies are needed to contrast experiences between individuals with prior GDM experience versus those who experience GDM for the first time. Our participants benefited from supportive networks from friends, partners, and therapists. Therefore, additional research endeavors are needed to explore the differences between individuals with GDM who possess these supportive networks versus those without in the context of GDM. We recognize that a significant proportion of the participants in our study possess a high level of education, earned a decent annual income and that these factors potentially influenced their overall experience, shaping their approach to health management and data engagement. Therefore, considerations must be taken in applying our findings and implications to other pregnant individuals from other cultural, ethnic, educational, religious, and economic groups who are underrepresented in our study. In addition, since we focus on the experience of reflection and experiential learning on currently pregnant individuals with GDM, we did not ask the participants about their experience with health technology before their GDM diagnoses or their medication use. Thus, our participants may consist of a mixture of expert and novice health technology users. Future research examining GDM technology use could further investigate how prior health technology experience influences pregnant individuals' interaction with GDM-related technology.

7 CONCLUSION

In this research, we examine pregnant individuals' lived experience with GDM using the lens of Kolb's Experiential Learning Theory. By interviewing 13 pregnant individuals who were clinically diagnosed with GDM, we learned about how they reflected on their concrete GDM experience, how they conceptualized these experiences to form new understandings and insights, and how they actively experimented with ways to manage their condition. Based on these findings, we discuss design opportunities to support pregnant individuals in managing their changing relationships with food and improve overall wellbeing while living with the stigmatic condition.

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