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Quantitative research artifacts as qualitative data collection techniques in a mixed methods research study

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ABSTRACT

The creative use of mixed methods is one way in which research designs can embrace and support the use of complex theoretical frameworks, such as those often used in psychology research. This manuscript explores a mixed methods engineering education study that leveraged artifact-based interviewing to elevate data collection. Artifacts from the quantitative phase of the mixed methods research were visually represented in follow-up interviews. The use of quantitative artifacts as visual aids in interviews improved the quality of interview data, as they gave participants language and imagery to dynamically create data in the interview. This integration aligned interview discussions with the theoretical foundations of the study while maintaining an engaging interview environment.

1. Introduction

Psychology research, a field of study focused on human minds and behaviors (James, 1890), is riddled with complexities. While the history of psychology has become increasingly studied and documented in the last decade from multiple scholarly perspectives (Hilgard et al., 1991), what is consistent across historical accounts is that psychology is a field of continuous discovery and growth. Psychology research has grown and expanded significantly from its start in the late 1800s, designing and conducting new research, developing new theories, and revising past theories to better explain humans' experiences, thoughts, and behaviors in the 21st century. The growth and expansion of research in the field of psychology has created an increasingly urgent need for research methods that can capture and highlight the complexities and nuances of human thoughts and behaviors.

Qualitative research methods are one such way in which people can be studied that preserves individuals' experiences and perspectives at a level of depth that is highly detailed and nuanced for each participant (Creswell and Poth, 2017). As the field of psychology has grown and evolved in breadth and complexity, so have the methods used by psychology researchers to keep pace in creative and innovative ways. Examples include in-depth analysis of YouTube video content to learn more about the health psychology of social media influencers who share healthy lifestyle content (del Río Carral et al., 2021) and the comparison of strengths and weakness of both human vs. computer-led analysis of online discussion forums to more accessibly research small, hard-to-reach communities (Carter et al., 2021). Both of these methods leverage pre-existing data to study those who created the shared content in forms of public communication, but these studies focused on small, specific populations rather than exploring broad trends and relationships.

While qualitative research methods do excel in capturing deep, detailed data of individual participants through words and observations, the contributions of quantitative research can also be valuable. Broadly, quantitative research is particularly useful in testing the existence and strength of relationships amongst variables, and even making predictions based on those relationships (Creswell and Guetterman, 2019). Mixed methods research is one way in which researchers can leverage both methodological strategies. Mixing methods increases the breadth and depth of the research conducted by allowing for multiple approaches to explore and develop complex theories and produce findings that are both generalizable and capture human intricacies and individual experiences (Creswell and Plano Clark, 2017). The advantages afforded by using mixed methods strategies are incredibly beneficial in research studies from psychology or other domains that explore the complex and highly variable subject of human ways of thinking and doing. Mixed methods research is relatively young by comparison to the more traditional silos of quantitative and qualitative research, but

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leading mixed methods scholars have established conceptual frameworks (e.g., Greene et al., 1989), typologies (e.g., Teddlie and Tashakkori, 2006), quality frameworks and considerations (e.g., Onwuegbuzie and Johnson, 2006), and written textbooks (e.g., Creamer, 2018; Creswell and Plano Clark, 2017) to guide researchers in leveraging mixed methods to its full potential.

Building on the groundwork laid by foundational scholars in the field of mixed methods, this manuscript details our development, our use, and the insights afforded by an innovative approach to mixed methods in an engineering education research study. Through this manuscript, we hope to further expand the ways in which researchers who conduct work within psychology-based theoretical frameworks expand the robustness of their research methods. Specifically, we will describe how a mixed methods research study leveraged artifact-based interview techniques to give participants language and imagery to dynamically create data using a quantitative artifact as a visual aid in an interview setting.

2. Background

This research is from a larger study that used a mixed methods approach to study the impacts of feedback on engineering student motivation and classroom engagement in an engineering mathematics classroom. Participants were given a survey and that survey was followed by a virtual interview based on the participants' survey responses. The surveys informed the development of quantitative artifacts that were used in interviews to elevate the quality of the responses and member check survey results.

2.1. Artifact-based interviews

Artifact-based interviews involve including an artifact – such as a picture or image, item or object of interest, etc. – in an interview to add a concrete or tangible dimension to research that is not entirely text-based (NYU Libraries, 2021). Qualitative studies have found artifacts and visual imagery useful in collecting data in qualitative interviews by allowing the interviewer and interviewee to more directly align when speaking about broad or complex topics (Douglas et al., 2015), increasing the quality of knowledge sharing (Eppler and Burkhard, 2007; Isenberg et al., 2011) and aiding in communication through images rather than solely words (Bryans and Mavin, 2006), thus reducing challenges and improving alignment in conversations around complex constructs or topics. Qualitative researchers have praised the use of visual imagery aiding in qualitative data collection for many years and have documented strategies so others can leverage these techniques as well.

The book "Seeing is Believing? Approaches to Visual Research" documents ways in which visual imagery has been used in data collection and analysis methods (Pole, 2004). The specific chapter "Images, Interviews, and Interpretations: Making Connections in Visual Research" (Felstead et al., 2004) describes artifact-based interview techniques where visual aids and images were displayed in interviews with participants. Comi et al. (2014) discuss two categories in which these visual aids can be used: projective techniques and facilitative techniques. Projective visual techniques are used to prompt answers and evoke responses from the participants (Comi et al., 2014). Many pieces of literature document the use of visual stimuli in interviews as projective techniques to stimulate thoughts and prompt comments to encourage research participants to speak on specific topics (e.g., Crilly et al., 2006; Kearney and Hyle, 2004; Wheeldon, 2011). While these projective techniques have been shown to be useful in qualitative data collection, literature also discusses visuals as facilitation techniques. Facilitative techniques are not meant to prompt or evoke answers from participants, but instead they are visual aids that are used to meaningfully organize and visually represent the participants' responses and thoughts in real time (Comi et al., 2014). Comi et al. (2014) advocate for the use of visual aids that function as both projective and facilitative techniques to elicit deeper qualitative data.

2.2. Member checking

Member checking has been well established in methods-related literature as important when conducting trustworthy qualitative research and establishing credibility with a researcher's peers and participants (Creswell and Miller, 2000; Jones et al., 2014). Member checking has been identified as a way to establish communicative validation when collecting and creating data (Walther et al., 2013). Candela (2019) also calls for member checking to serve an additional purpose – a positive reflective experience for research participants. Candela (2019) offers a perspective of member checking beyond that of the researcher and into the world of the subjects and their positive and negative experiences with the member checking process. She calls for qualitative researchers to be mindful of their member checking protocols and interactions by creating a space for positive reflection by the research participants and opportunities for their own growth and development as a result of the reflection (Candela, 2019).

2.3. Theoretical underpinnings

The research study we describe in this manuscript to demonstrate the development of a quantitative artifact and its utility in qualitative interviews integrated ideas from three different domains. First, feedback was the primary construct of interest. Students were receiving feedback in their engineering mathematics classes, and the goal of the research was to investigate how it impacted their learning processes, not outcomes. Next, we used motivation and engagement as theoretical frameworks to define and operationalize the impacts of feedback on participants' learning processes.

Independent of one other, motivation and engagement as theoretical frameworks are broad and complex – both deeply rooted in an individual's thoughts and behaviors. For example, the Causality Orientation Theory of motivation models an individual person's motivation as influenced by three orientations (autonomous, control, and impersonal). Deci and Ryan (1985) designed the orientations to model a person's motivation at a personality level, so results are highly variable from individual to individual (Hagger and Hamilton, 2020). Additionally, engagement contains multiple dimensions and spectrums on which each dimension can exist (Fredricks et al., 2004; Trowler, 2010). Fredricks et al. (2004) argue the importance of equally considering and weighing all three dimensions when exploring engagement as they are related to one another and may be influenced by one another. Integrating these two complex theoretical frameworks into a single research study proves even more challenging, as both theoretical frameworks are said to be highly contextually dependent and have the potential to change across time (Deci and Ryan, 1985; Fredricks et al., 2004; Hagger and Hamilton, 2020), making them increasingly hard to measure and track for research purposes.

When justifying the use of mixed methods, a valid justification is the complexity of the constructs and theories of interest (Creamer, 2018; Creswell and Plano Clark, 2017), as complexity often calls for the need for more data and having multiple strategies for approaching a data set or research questions. This justification, found in recently published textbooks on mixed methods, closely aligns with (and may have stemmed from) an early conceptual framework of mixed method evaluation strategies published by Greene et al. (1989). In this foundational article, the authors propose and define five reasons for using mixed methods, one of which being a complimentary mixed methods design in which the two data types and analysis strategies are used to clarify, illustrate, or elaborate on each other to ultimately "increase the interpretability, meaningfulness, and validity of constructs and inquiry results" (Greene et al., 1989, p. 259). Leveraging mixed methods to research complex topics such as human thoughts (e.g., motivation) and actions (e.g., engagement) can bring structure and clarity to research that seeks to

further understand how people navigate these complexities in their unique contexts and realities, and the methods we describe in this manuscript demonstrate just that.

2.4. Purpose

The purpose of this manuscript is to detail the integration of and the insights afforded by a quantitative artifact used to enhance the quality of qualitative data collected in an interview. More specifically, we present how an artifact from an initial quantitative phase of research collected by way of a survey was used as a dynamic data collection tool in the qualitative phase of the research that followed to improve the quality and complexity of the data collected in the interviews. With this manuscript, we will answer the research question:

How can practices from mixed methods research and artifact-based qualitative interview practices be combined to enhance the process of data collection and quality of data collected in an interview?

3. Methodological approach

This sequential explanatory mixed methods research study, as defined by Creswell and Plano Clark (2017), had two data strands: Phase 1 – a quantitative data strand and Phase 2 – a qualitative data strand. While the data collected and the order in which it was collected aligns with Creswell and Plano Clark's sequential explanatory classification of mixed methods research, our mixed methods research study can also be classified as an equal priority fully integrated design as defined by Creamer (2018). The quantitative and qualitative portions were equal in importance, and the two data strands were intentionally mixed throughout all stages of this research (research questions, data collection, analysis, and resulting recommendations). Fig. 1 depicts the two sequential data strands represented across time as they were completed for this research, as well as the points of mixing throughout the method-implementation portions of the research. Instance of mixing (1) is the development and use of the quantitative artifact in participant interviews – which is the focus of this manuscript. Instances (2) and (3) of mixing indicate points at which quantitative results were used throughout qualitative data analysis, and qualitative results were used to inform the need for additional exploration and tests for significance in the quantitative data, respectively.

We recruited students enrolled in an engineering mathematics course at two institutions for the quantitative data collection in the Fall 2020 semester. The first institution was a medium-size public midwestern university, and the second was a large public southern university. From these two institutions, 149 students provided complete survey responses, approximately 43% of all students recruited. We collected the quantitative strand's data through a three-part survey. The first part included demographic information (e.g., age, gender, race) and the second asked participants to identify their feedback preferences using a Likert-style scale (Likert, 1932). The third portion of the survey collected responses to the General Causality Orientations Scale (GCOS) (Deci and Ryan, 1985).

We began the qualitative strand in February of 2021 and its analysis continued through July 2021. We recruited selected participants (intentionally selected to represent a variety of genders, races, and motivations levels) who completed the survey to participate in 1-hour, artifact-based, semi-structured, virtual interview using the Zoom platform. A total of 17 participants completed these interviews.

We used a hybrid approach for data analysis (Fereday and Muir-Cochrane, 2006) with multiple phases of interview transcript analysis. In the first phase of data analysis, we employed provisional coding (Saldaña, 2016) in which we created codes from the constructs of interest of the original research design and applied them to each of the transcripts using the software Dedoose. After coding each transcript with the provisional codes, we created an analytical memo. Lee et al. (2019) describe using analytical memos to facilitate analysis and begin to identify complex relationships between concepts and constructs of interest. Similarly, in the memos for this research, we summarized the participants' responses to questions and any additional thoughts or experiences from the participants regarding feedback that the provisional codes did not capture entirely. After coding all of the transcripts with provisional codes and writing memos, we compiled the memos and reviewed them to identify salient experiences or ideas shared by participants. We used these experiences and ideas to create inductive codes, meaning codes that emerged from the data set (Saldaña, 2016). The final phase of qualitative data analysis consisted of us re-coding the transcripts with the additional inductive codes.

3.1. The integration of artifact-based interview strategies into a mixed methods study

This research design used mixed methods practices as well as qualitative research and artifact-based interview strategies in an intentional and novel way. When a participant accepted an interview invitation, we assigned that participant a pseudonym and created two quantitative artifacts in preparation for their interview. The first was a quantitative artifact that visually represented their Likert-style responses to the survey's feedback preference questions. An example of this quantitative artifact can be found in Fig. 2.

As a part of the interview, we asked participants to further explain or adjust their survey responses. Throughout this portion of the interview, we displayed the participant's unique quantitative artifact resembling Fig. 2 using screen sharing capabilities in Zoom. We intentionally designed the interview protocol to encourage participants to consider the visual aids when responding and to engage with the artifact in whatever ways seem most appropriate. Examples of interview protocol questions for this portion of the interview are shown below.

- *"Your survey indicated that your feedback preferences looked like this, tell me more about these preferences"*
- *"Would changing the class you are in or what you are learning/submitting lead to any changes to these preferences?"*

The second quantitative artifact visually displayed the participant's three motivation orientations according to their GCOS responses normalized against each other in a pie chart - three components of their

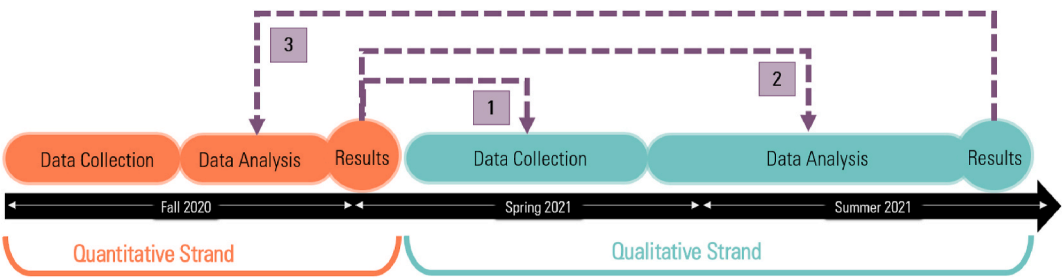

Fig. 1. A visual representation of the fully integrated mixed methods research study.

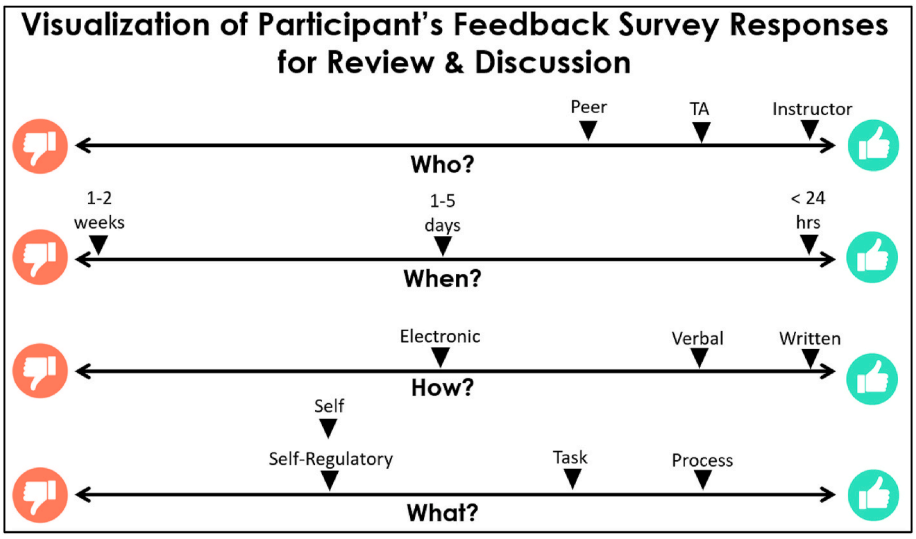

Fig. 2. Example of the artifact shown to an interview participant when discussing their feedback preferences that visually depicts their responses to a Likert-style survey in which they indicated their feedback preferences.

whole motivation as person. An example of this quantitative artifact can be found in Fig. 3.

In a later portion of the interview, we asked participants to review and reflect on their motivation orientation scores and elaborate on how their motivation is impacted by feedback. Throughout this portion of the interview, we again displayed the participant's unique quantitative artifact resembling Fig. 3 using screen sharing capabilities in Zoom. We designed the interview protocol for this portion of the interview to encourage participants to consider the visual aids when responding. Examples of interview protocol questions for this portion of the interview are shown below.

- *"This shows the scores of your motivation as a person based on the survey you took – what about these pie slices of your motivation do you agree and disagree with?"*
- *"When you get good feedback (and bad feedback), how might these different pie slices come into play?"*

Here we discuss these methods in the context of our own research study; however, the underlying methodological strategy of turning quantitative self-reported survey data into visual quantitative artifacts for use in qualitative data collection can be applied to any research that seeks to allow participants to further elaborate on survey responses for any reason. Similarly, any research study that aims to encourage participants to describe their own thoughts and behaviors in a way that can directly translate to one or more complex psychology-based theoretical frameworks could leverage simple and accessible quantitative artifacts to encourage responses that participants themselves align with the framework through their responses in the interview by leveraging the visual aid provided.

4. Demonstration and discussion of the utility of integration

Leveraging and integrating qualities of mixed methods research designs, qualitative literature on visual artifact usage in interview settings, and reflective member checking practices, we were able to create quantitative artifacts of each participant's survey results from the quantitative data strand. Creating an interview protocol around those artifacts, we were then able to use those artifacts as a data collection tool throughout the qualitative interviews to allow for detailed, reflective,

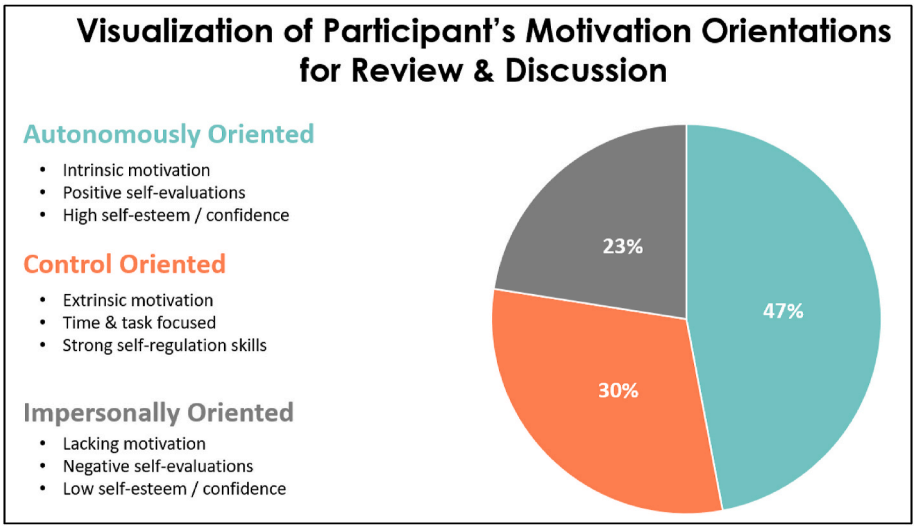

Fig. 3. Example of the artifact shown to an interview participant when discussing motivation as it relates to feedback and engagement that visually depicts their GCOS scores based on their responses to that portion of the survey.

and insightful participant responses.

4.1. Common language & specificity

Fig. 2 displays an example of what participants saw when asked to elaborate on the feedback preferences they had indicated the previous semester. Participants used this opportunity to explain their choices, and more importantly, give insight into how they interpreted and thought about the questions when they read and answered the survey the previous semester. Quantitative survey research relies on participants to interpret the question as the researchers intended and self-report their responses accurately. Reliance on these two ideas can be problematic though, as research has shown that participants' interpretation of survey questions relies on many factors such as the number range or wording used in Likert-style questions (Schwarz et al., 1998). Additionally, various biases are introduced when self-reporting information on surveys, such as cognitive bias, hindsight bias, or motivation-related biases (Quinio and Lam, 2021). Using follow-up interviews to further explain quantitative data helps address issues of survey question interpretation and self-reporting biases and is a defining quality of a sequential explanatory mixed methods design (Creswell and Plano Clark, 2017). The use of the data from the quantitative phase serving as the artifacts in the artifact-based interviews reminded participants of the quantitative data they were explaining and illuminated misaligned understandings of what the survey questions meant. When describing their survey responses, participants commonly referred to example feedback fitting those descriptions, giving more context to the response. An example of three different participants describing what they considered to be an 'electronic' mode of feedback delivery is shown below.

> "Even if someone is grading paper homework, they can circle where you made your mistake, versus when you're doing it completely online where a computer is grading it." – Blake

> "I've noticed less feedback because of [virtual learning]. If it is feedback, it's like really small. You got to search for it, like a little PDF note or whatever." – Alex

> "Electronic [feedback] is probably office hours, stuff like that." – Jesse

Notice the differences in these quotes the three participants shared in how they conceptualized what 'electronically' delivered feedback meant to them. One participant meant a computer program grading their submitted homework, another meant leaving notes on a PDF, and the third considered electronically delivered feedback as happening during virtually held office hours. While the survey results indicated how much participants agreed or disagreed with preferring electronically delivered feedback, the survey did not include ways to identify what the participants defined as electronically delivered feedback. This member checking allowed participants to further explain their response and their interpretation of the survey they completed and therefore improved the accuracy of the data and communicative validation of the research (Walther et al., 2013). The member checking also identified areas of improvement for future use of this survey, as the instrument could undergo revision and additional testing to ensure interpretation of survey items improves in consistency.

In the interviews, participants were asked to further explain their choices of feedback preferences coupled with the visual artifact reminding participants of the language in the survey. Their responses allowed them to more readily provide deeper insights into what they preferred with regards to feedback practices. The use of the quantitative artifacts in this way aligns with the visual aids being used as a projective technique to elicit more detailed responses from participants (e.g., Crilly et al., 2006; Kearney and Hyle, 2004; Wheeldon, 2011).

Mixed methods proved useful in comparing the preferences of one participant to another not only based on their quantitative survey results but also on their qualitative descriptions of their interpretations of the survey options, exploring their experiences more holistically. Without opportunities for further explanation of quantitative survey responses, these nuanced understandings of how participants interpreted the survey questions and answered according to their interpretations would have gone un-identified and the level of detail gained through these explanations would have been lost, further justifying the case for the utility of explanatory mixed methods research as defined by Creswell and Plano Clark (2017). Kajfez et al. (2021) describe and justify their use of mixed methods in a study of undergraduate researchers' identity similarly, allowing qualitative data from participants' interviews to add context and clarity to quantitative survey responses that led to a more complete understanding of participants' experiences and numeric survey responses. The methods described in this paper built upon those described by Kajfez et al. (2021) by creating multiple dynamic quantitative artifacts for graphic elicitation in the interviews rather than using one numeric item to prompt interview dialog.

4.2. Dynamic for active data generation

Not only was the quantitative artifact shown in Fig. 2 helpful in comparing participants based on their interpretations of survey items, but the artifact also elicited comparisons from participants themselves in conversations about their chosen preferences. For each characteristic of feedback (source, mode, timeliness, and content), participants were asked to rank their preference of multiple possibilities for feedback within that characteristic (e.g., participants gave their ranked preferences for three options of the "source" of the feedback: instructor, teaching assistant, and peer). When participants were shown their own responses as represented in Fig. 2, they were asked if they would like to elaborate on their responses or amend them due to experiences they may have had since they completed the survey. Many participants found themselves comparing different options in each characteristic of feedback line. Blake did just that in their quote in the previous section, comparing 'written' feedback delivery vs. 'electronic' feedback delivery. Fig. 4 provides an additional example of a participant justifying their survey responses through comparisons.

In Fig. 4, Alex explains their preference of who the feedback comes from through a comparison with the other options, specifically noting why they still like peer feedback even though their survey indicated they liked peer feedback less than instructor or TA feedback. These comparisons of feedback's different characteristics gave rise to the driving forces behind these participants' motivation related to feedback and ultimately provide more insights into thoughts and feelings that inform their feedback preferences.

While some participants, like Alex shown in Fig. 4, discussed the static placement of their feedback preference rankings through the use of comparisons, others adjusted the location of their preference placements through dynamic comparisons. Fig. 5 shows an example of a participant discussing the movement of their preferences along the 'agree' to 'disagree' scale in comparison to other preferences. This movement of the participant's answers is indicated by arrows and additional markers corresponding with the feedback they are speaking about.

In these instances, participants were actively evaluating their feedback preferences and moving them on the scale of 'agree' to 'disagree' in the interview based on the context the feedback is being given in. Specifically, in the example provided in Fig. 5, Payton considers their feedback preferences outside of the engineering mathematics course and demonstrates the dynamic component to their preferences, noting that they change respective to one another based on the content being taught and the context it is taught in. The quantitative artifact allowed for not only discussion of their previous survey answers but also proved us an opportunity for dynamic data collection of additional and revised quantitative data throughout the interview through the movement of feedback preferences across this scale.

The quantitative artifact being used as a visual aid in interviews gave

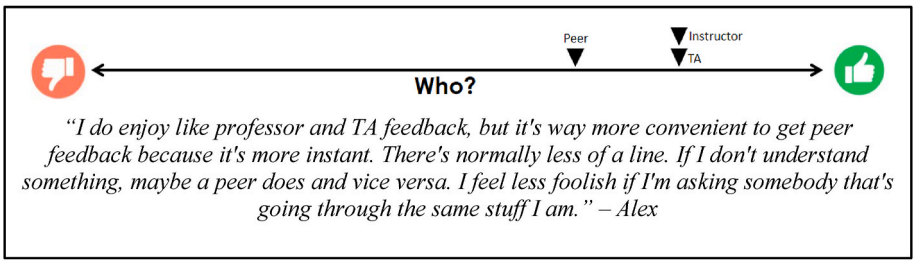

Fig. 4. Participant Alex describes their feedback preferences.

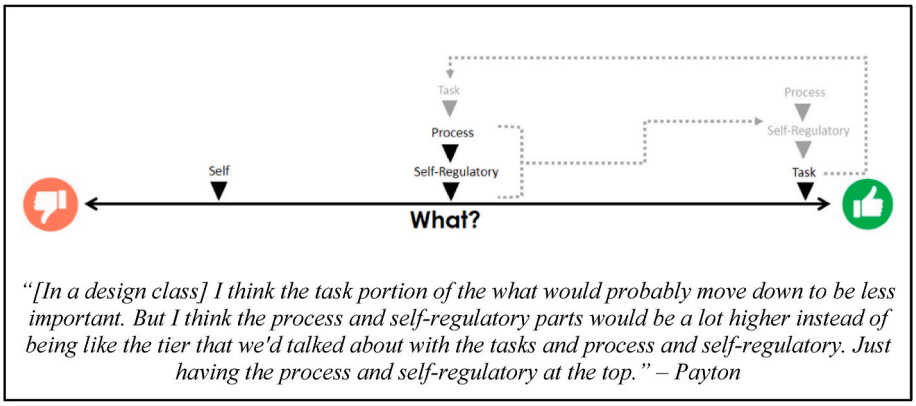

Fig. 5. Participant Payton describes their feedback preferences.

participants a visual representation and common language that we could use to discuss the complexities and nuances of feedback characteristics and participant preferences in a way the survey did not capture. The way in which participants leveraged the quantitative artifact to make comparisons between contexts and feedback characteristics is a strong example of how this strategy worked as a projective interview technique by way of a visual aid (e.g., Crilly et al., 2006; Kearney and Hyle, 2004). Similarly, it also proved useful as a facilitation technique as demonstrated by Fig. 5. We leveraged the dynamic nature of the visual aids to reorganize and document the participants' updated preferences as they spoke about the context of feedback and their interpretations of the survey questions (Comi et al., 2014; Huff and Jenkins, 2002).

The quantitative artifact served as a discussion guide to feedback characteristic preferences, how they relate to one another, and how they relate to the learning context. The dynamic nature of the artifacts allowed for these discussions to result in active and collaborative data generation in the interviews. The complex and dynamic nature of students' feedback preferences was a unique finding of our research. Without the use of this quantitative artifact, this may not have been as prominent of a result of our research focused on students' perceptions of feedback and the influence those perceptions have on student motivation and engagement.

4.3. Simple visual descriptions of complex theoretical foundations

Fig. 3 displayed an example of what participants saw when feedback's impact on motivation was discussed. This figure includes participants' GCOS score in each orientation, normalized to their total score. Before participants were asked any questions about the impact of feedback on motivation or how motivation informs their engagement in a course, they were presented with these results. We explained each orientation to them as well as the limitations of the GCOS. We then asked participants to speak to how much they agree or disagree with the GCOS results. While this artifact was screen-shared with participants during the interviews, we also asked them questions related to how feedback impacts their motivation and how motivation informs their next actions or steps in a course. Many participants used Fig. 3's quantitative artifact for common language and visual analogies when talking about their own motivation, as demonstrated by the quotes below.

> "That's kind of interesting to see, because it really just depends on the day for me sometimes. Sometimes I'm just not feeling it. Especially last semester, honestly, it was just very difficult with online school. But I would agree that all of these come into play. I definitely am motivated by getting good grades and wanting to excel in what I do … those both come into play." – Cameron

> "So I feel like the impersonally-oriented part, it's like, 'Oh, my goodness, what is even going on?' Like, 'I don't want to be doing any of this.' But then that kind of like plays into the control-oriented part where it's, 'Okay, you need to get this done, you need to get the degree.' And so being able to get it together and really understand it, but then doing it for yourself, like I'm a perfectionist, but I feel like doing it for myself." – Ezra

Cameron and Ezra both recognize the complexity of motivation and the interactions between these three orientations through their instances of reflection demonstrated in the quotes provided above. Cameron recognizes how context influences the motivation orientations and how multiple orientations can contribute to informing thoughts and actions. Ezra also recognizes the complexity of motivation by pointing to how each orientation manifests itself through how they engage emotionally or behaviorally in a course and its content. The quantitative artifact's (shown in Fig. 3) use of the metaphor of 'pie slices' that make up participants' own personal 'motivational pie' allowed them to better understand the construct of interest and gave them language for communicating the complex feelings and thoughts related to how they are motivated and how these three orientations interact with one another to inform their classroom engagement. Cameron and Ezra used the language and imagery to reflect on the roles these motivation orientations play in their engagement in their classes. Others used the quantitative artifact to describe the impact of feedback on motivation

more specifically.

> "If I can see what I'm doing wrong and they tell me what I'm doing wrong and what I need to do to improve, that – I think – intrinsically motivates me, because I'm like, 'Okay, I know how to do this now. I can apply it now.' That's what I'm going to do." – Jordan

> "I mean bad feedback may make me feel not motivated to do anything, like that gray slice of the pie, and versus good feedback might activate high self-esteem or whatever, and make me want to regulate myself and actually put effort toward my goals." – Cameron

> "Well, good feedback would definitely influence the blue section because, okay, I know I did wrong. I know how I can fix it. There's something I can do about it. I can improve. The bad feedback would fall into the gray section. Okay, I know I did it wrong, and that's it. I don't know how I did it wrong or how I can improve, so what now." – Hayden

Jordan, Cameron, and Hayden all use words and colors presented to them in the quantitative artifact to communicate the impact of feedback on their motivation and their actions after receiving feedback. Cameron and Hayden also both offer comparisons, contrasting the impact of 'good' feedback and 'bad' feedback on their motivation and regulating thoughts that inform their next actions. All three participants clearly spoke to good feedback motivating a form of positive engagement with course content. They noted being motivated to display positive emotional engagement (feelings of higher confidence to make improvements or improved self-esteem) as well as the positive behavioral engagement (putting in effort, making corrections). These insights that participants were able to provide using the imagery and language from Fig. 3 more clearly situated their answers within the theoretical framework. Instead of asking participants how they felt about feedback and applying the theoretical framework to their responses in hindsight to make educated inferences as to how motivation may be at play in their responses, we were able to give them words and an image to help them describe these feelings with the theoretical framework of motivation already applied. The use of the quantitative artifacts elicited data that was directly aligned with the theoretical framework, which could then be more readily used to best answer the research questions. Our experiences of collecting data that were well-aligned with the theoretical framework mirrors what others who have used artifact-based interview techniques have reported in literature – an improvement in the quality of data collected when discussing complex topics (e.g., Douglas et al., 2015; Eppler and Burkhard, 2007; Isenberg et al., 2011). Additionally, seeing a visual of their types of motivation displayed for them encouraged participants to share their thoughts and feelings related to how they are motivated and elicited deep discussion around where that motivation comes from, which aligned with the visual aids serving as a projective interview technique (Comi et al., 2014).

Displaying the participants' own scores as they relate to a complex construct such as motivation allowed for the participants to member check their motivation score from various perspectives to strengthen the procedural validation and ensure their reality aligns with the motivation theory being leveraged (Walther et al., 2013). Many spoke to how they felt it related to them in the broader context of being an engineering student, and others reflected on themselves and their own thoughts, feelings, and experiences related to how motivation is directly impactful to them as a student and their engagement in specific courses. The use of the pie chart with specific colors and descriptions also gave participants language and visual aids to aid in their explanations of thoughts, feelings, and experiences. This specific methodological choice enriched conversations between ourselves and the participants around the motivational impacts of feedback and elicited more descriptive insights. It also provided participants with information about themselves and asked them to reflect on how their motivation and engagement are reflective of the feedback they receive and how these constructs may be impacting their learning of content or their broader learning experience. An instance of not only reflection but also realization of needs and personal growth is demonstrated below.

> "Honestly, I kind of learned a lot from going through this, and being able to identify. So this [interview] call was actually pretty beneficial to me, because I feel like I'm going to be able to look at my feedback in a totally different way now. It was really great, and it wasn't until you asked me about the one-size-fits-all, to be able to reach out to a professor and say, 'Hey, your feedback doesn't make sense.' And I've never done that. I've never thought of doing that." – Ezra

Ezra explained that they found the interview helpful, as they now have a new outlook on the feedback they receive and gained the realization that they could better communicate their feedback needs to instructors or teaching assistants. This example is a demonstration of how the use of the quantitative artifacts also fulfilled Candela's (2019) call for member checking to serve as a positive reflective experience for participants.

4.4. Limitations

A benefit of using mixed methods is that traditional limitations associated with a solely quantitative or qualitative methodological approach or a single data type are generally addressed, commonly called weakness minimization (Onwuegbuzie and Johnson, 2006). Our research has both generalizable results from the quantitative strand and in-depth and detailed results from a diverse group of participants in the qualitative strand. However, there are limitations to this research as they relate to the context, the timeline of the complete mixed methods study, and the theoretical lens and framework used.

First, the data collection for this research took place during Fall 2020 and Spring 2021 semesters. Due to the COVID-19 global pandemic, many components of courses being offered had moved to a virtual environment, if not being entirely online. Instructors and students alike were learning how to create, facilitate, and function within virtual learning environments, which includes the likelihood that feedback practices in place had to be adjusted. These adjustments may have played a role in the feedback instructors, teaching assistants, and peers were able to offer as well as how that feedback was received by students. Second, this data collection occurred across an extended timeline. Quantitative data was collected in Fall (2020) and qualitative data in Spring (2021). Within interviews, participants talked about updating their preferences based on more recent class experiences. Those updates, while documented in the interview transcripts, were not reflected in the quantitative data set used for quantitative analysis. Finally, the theoretical framework of this work is informed by a theory of motivation. While the purpose was to understand the experiences of students at all extremes of each orientation's spectrum, it is likely that self-selection bias was introduced. Students that exhibited higher levels of motivation were likely more inclined to participate in this research, either for their own interest or learning, or for the interview incentive (Heckman, 2010).

Aside from our own research's limitations, there exists general limitations to the specific methods presented in this manuscript that should be considered before selecting this as an approach to mixed methods research. First, only 13 questions appeared on the survey asking participants about their feedback preferences, and those questions were related such that they could be clearly sorted on the quantitative artifact. If a research study requires extensive quantitative data collection, it is possible that not all data can be visually represented clearly and accessibly through a data visualization that could be used as a quantitative artifact in interviews. Also, the discussion of a theoretical framework (in our case, participants' motivation orientations) does take time and is a mini-lesson with a one slide diagram to aid in your explanation. If a research study employs one or more highly complex theoretical frameworks, consider how the framework can be simplified and explained to participants in an accessible way. Alternatively, if the

research is being done within a theoretical framework focused on implicit thoughts or behaviors, explicitly discussing your theory with participants may unintentionally pre-condition participants to align with (or alternatively, avoid) your theoretical framework more than they originally would have in the interview.

5. Implications & conclusions

In a mixed methods research study that aimed to explore the impacts of feedback on student motivation and classroom engagement, we leveraged artifact-based interview techniques traditionally used in qualitative data collection. We did this by creating quantitative artifacts that visually represented a participant's quantitative survey results and used those artifacts in virtual interviews with that participant. The artifact served to both elicit responses from the participant as they reflected and further elaborated on their survey responses in the interview, as well as dynamically create data as participants discussed and sometimes disagreed with or amended their original quantitative data.

Studying the impact of feedback on *how* it is impactful to student learning using theoretical frameworks of motivation and engagement proved difficult given the complexity of the constructs and theories of interest. The quantitative artifacts acted as incredibly useful mixed methods data collection tools in interviews as they gave participants language and imagery to describe their feedback experiences, preferences, and the highly variable and individual process that occurs between when participants receive feedback and achieve learning. This rich and insightful data set was made stronger by the common language and imagery used to describe and discuss complex constructs such as feedback, engagement, and thoughts and feelings related to participants' motivation.

Reflecting on the insights we gained from the methods described in this manuscript, we feel we should end with noting that the intentional coupling of traditional mixed methods research elements with qualitative interviewing practices related to artifacts elicitation and visual imagery has implications beyond this research. We encourage others to explore and push the boundaries of the 'safe' and 'comfortable' methods to new and unique strategies in the search for richer and more meaningful data. Not only were we able to leverage multiple method techniques and insights to best answer our research questions and achieve the broader purpose of our work, but we were able combine method techniques and insights in a way that ensured the data set was well aligned with the research questions through data transparency. We allowed participants to be fully immersed in the research by openly sharing the language and ideas informing the theoretical framework and constructs of interest. Participants were then able to use that knowledge to genuinely and thoughtfully reflect on their own experiences and needs as learners while also serving our own research purpose, which made for an incredibly rewarding data collection experience. These methods benefited the research, while participants were also able to benefit in their own unique way as well. We would recommend a similar integration of artifact-based interview techniques to any researchers exploring research questions related to a complex phenomenon or through a complicated theoretical lens. This combination of methods ensured alignment throughout this research by ensuring the theoretical framework would be applicable to the qualitative data in a way that is directly from the voices of participants as they described their experiences rather than their experiences being filtered through our understanding, interpretation, and potentially influenced by our own positionalities. This approach can be translated to a variety of research contexts, resulting in more trustworthy and authentic data sets.

Credit author statement

This methods paper was written from the methods used in the first authors PhD dissertation study advised by the second author. **Dr. Cassie Wallwey:** Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing – Original Draft, Visualization, Writing – Review & Editing, Project Administration. **Dr. Rachel Kajfez:** Conceptualization, Resources, Writing – Review & Editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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