

The use of recommended interviewing practices by novice engineering designers to elicit information during requirements development

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Abstract

Effective stakeholder interviewing is a critical component of a design process. However, interviewing is a complex skill that is difficult for novice designers to learn and incorporate into their design practices. Few studies have investigated how novice designers apply recommended practices for interviewing stakeholders during the development of product requirements. In this research, we studied how novice designers elicited information to inform the development of product requirements during stakeholder interviews. Results included the establishment of a coding methodology developed from a systematic literature review of recommended interviewing practices that was used to reliably evaluate the use of recommended practices in novice designers' interviews. A correlation existed between the use of recommended practices and the extent to which information gathered from interviews was incorporated into the requirements. Additionally, specific recommended practices, such as encouraging deep thinking and being flexible and opportunistic, differentiated performance among novice designers. The coding methodology could be adapted to guide the development of stakeholder interview protocols and assessment of design interview skills.

Key words: stakeholder interviews, requirements elicitation, engineering design, design education

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1. Introduction

To design effectively, one must identify and deeply integrate the needs and wants of stakeholders (including both users and others impacted by the design) into design decisions (Zhang & Dong 2009). Effective stakeholder engagement is a critical component of a design process and has been shown to lead to more useful, usable, and desirable products (Steen, De Koning & Pikaart 2004; Walters 2005; Zhang & Dong 2009). Design ethnography methods facilitate information elicitation from a variety of stakeholders and comprise interviews, focus groups, surveys, observations, participatory design workshops, and co-creative partnerships (Grudin & Grinter 1995; Crabtree, Rouncefield & Tolmie 2012). Design interviews, often in combination with other methods, are prominently used to gather stakeholder information during front-end design, as they provide opportunities for in-depth

conversations with individuals that facilitate hearing first-hand accounts of real experiences (Alam 2002; Vredenburg *et al.* 2002; Rosenthal & Capper 2006).

While stakeholder engagement has been demonstrated to improve product success, studies have documented that novice designers sometimes struggle to elicit information from stakeholders effectively (Bano *et al.* 2019; Loweth *et al.* 2020a) and to apply information from stakeholders to inform their design decisions (Sugar 2001; Mohedas, Daly & Sienko 2014; Mohedas *et al.* 2020). Further, research has shown that novice designers' engagement with stakeholders lessens as their design projects progress (Lai, Honda & Yang 2010; Loweth *et al.* 2019, 2021). Since many design processes recommend stakeholder interviews to support design decision making, and since understanding stakeholder perspectives is central to design success, this research sought to investigate how novice designers elicit information to inform the development of product requirements during stakeholder interviews.

Given the importance of design interviewing among various design approaches, it is imperative to more fully understand the practices that precipitate success. Thus, our work sought to (a) develop a methodology to evaluate the performance of novices during stakeholder design interviews based on commonly-described recommended practices compiled from design literature, (b) apply this method to data collected during a front-end design task to evaluate the performance of novice designers, (c) determine relationships between the prevalence of recommended interviewing practices and the application to requirements development of information gathered through design interviews, and (d) identify recommended interviewing practices most associated with differentiating performance.

2. Background

2.1. Front-end design and requirements elicitation

Activities associated with front-end design phases, including problem definition, requirements and specifications development, and concept generation, are often described as ambiguous and ill-defined (Cooper 1988; Sanders & Stappers 2008; Park, Han & Childs 2021). Front-end design involves developing a deep understanding of the problem, which is accomplished through iteration of both the problem definition and potential solutions, defined as problem-solution co-evolution (Murphy & Kumar 1997; Dorst & Cross 2001; Dorst 2019). During front-end design, the iterative nature of problems and solutions is evident through evolving product requirements, which define the design problem and focus designers' efforts. Research has tied many product failures to errors made during front-end design phases that could not be cost-effectively resolved during later design phases (Cooper 1988; Park *et al.* 2021). Studies have also shown that the success of new products depends in part upon how well designers execute front-end design activities during product development (Khurana & Rosenthal 1998; Markham 2013).

A key component of front-end design that impacts product success is the elicitation and development of product requirements (Cooper & Kleinschmidt 1987; Hein, Voris & Morkos 2018; Park *et al.* 2021). Product requirements are any function, constraint, or other property required for a designed artefact to meet the needs or wants of stakeholders (Pahl & Beitz 2007; Dieter & Schmidt 2021).

These requirements are then translated into engineering specifications that are both quantifiable and measurable in order to guide engineers' solution development processes. The ambiguous and iterative process of developing product requirements and translating these requirements into engineering specifications is a challenging undertaking in design work (Sutcliffe & Sawyer 2013; Ferrari, Spoletini & Gnesi 2016; Rosa *et al.* 2021). Studies have demonstrated that over half of the product requirements generated during initial problem definition are changed over the course of product development (Kobayashi & Maekawa 2001; Ramzan & Ikram 2005; Hein *et al.* 2018). Furthermore, mistakes made during the development and management of product requirements can lead to increased complexity, development times and development costs (Hein *et al.* 2018; Rosa *et al.* 2021).

2.2. Interviewing to elicit requirements

Stakeholder interviews provide key information to develop product requirements and engineering specifications. The importance of effective stakeholder interviews during design processes, particularly during requirements elicitation, has been documented in a range of fields including automotive systems (Islam & Omasreiter 2005), medical device development (Martin & Barnett 2012), human-computer interaction (Light 2006) and consumer product design (Rosenthal & Capper 2006). Furthermore, interviewing stakeholders is a practice that spans numerous design approaches and philosophies including socially-engaged design, human-centred design, inclusive design, participatory design, design ethnography and lead user approach (Steen, Kuijt-Evers & Klok 2007; Crabtree *et al.* 2012; Coleman *et al.* 2016; Luck 2018).

Existing resources on design interviewing have focused on describing a variety of interview question types and organisational strategies that support the flow of design interviews (Eris 2003; Ozgur 2004; Aurisicchio, Bracewell & Wallace 2006). For example, the IDEO toolkit (IDEO 2015) and interview materials from the d. school (2015) provide overarching strategies for interacting with stakeholders, along with example questions for various contexts. However, there is opportunity for more nuanced and specific resources that also leverage the broader literature from across disciplines (e.g., Moody, Blanton & Cheney 1998; Browne & Rogich 2001) to provide additional support structures for designers in preparing and conducting design interviews with stakeholders. For example, some strategies mentioned in the literature include ensuring that the most important topics are covered during a design interview (Burnay, Jureta & Faulkner 2014), that questions are appropriate and unbiased (Wetherbe 1991), that questions focus on uncovering stakeholders' feelings and complete perspective on a given topic (Donoghue 2010), and that interviews lead to a broader social, political, or cultural understanding of the design problem (Goguen & Linde 1993; Leydens & Lucena 2009). Recent literature in the fields of human-computer interaction (e.g., Ogbonnaya-Ogburu *et al.* 2020) and participatory design (e.g., Harrington, Erete & Piper 2019) have also emphasised that designers should reflect on how their personal and social identities may impact the types of information that stakeholders may be able or willing to share during interviews. Numerous challenges also exist in addition to executing the interview, such as planning and preparing for interviews, gathering information from multiple stakeholders, synthesising these data, and analysing the data to make design decisions.

2.3. Challenges conducting design interviews

Previous studies have described some of the struggles of novice designers as they engage in design interviewing, such as asking open-ended questions during interviews (Bano *et al.* 2019; Loweth *et al.* 2020a) and adopting interviewee language (Luck 2007; Mohedas *et al.* 2014; Bano *et al.* 2019; Loweth *et al.* 2020a). For example, Bano *et al.* (2019) observed 110 first-year graduate students studying information technology as they conducted requirements elicitation interviews for a simulated design task. The authors identified several challenges that participants encountered while conducting their interviews, including asking poorly worded questions, asking questions in an illogical order that interrupted interview flow, using language that might be confusing for the interviewee, and treating the interview more as an interrogation than a conversation. In addition, Loweth *et al.* (2020a) analysed stakeholder and domain expert meetings conducted by six novice design teams in the context of a capstone design course. They identified 11 different interviewing behaviours exhibited by their participants that did not align with recommended practices, such as asking closed-ended questions that implicitly constrained interviewees' responses and utilising overly technical language that was misaligned with interviewees' domain knowledge.

Studies have shown that novice designers may also encounter broader difficulties related to gathering and applying information from stakeholders to inform their requirements development and/or solution development processes (Sugar 2001; Mohedas *et al.* 2014, 2020; Conradie, De Marez & Saldien 2017; Loweth *et al.* 2019, 2020b). For example, Mohedas *et al.* (2014), in their study of capstone design students' use of design ethnography, found that participants struggled to identify stakeholders who could provide needed design information. Participants also struggled to navigate contradictions between stakeholders' responses. Furthermore, Sugar (2001), in their study of novice software designers, and Conradie *et al.* (2017), in their study of novice engineering designers, both described cases where interviews with users had little to no impact on novice designers' solution development outcomes. Novice engineering designers' difficulties with gathering and applying stakeholder information may stem in part from technocentric beliefs that engineering work primarily involves designing and building technological components (e.g., as described in Khosronejad, Reimann & Markauskaite 2021). Loweth *et al.* (2019) and Niles *et al.* (2020) have shown that engineering students with more technocentric mindsets struggle to engage stakeholders effectively and integrate stakeholder perspectives into their design projects.

While novice challenges with conducting design interviews have been well documented in the literature, these challenges are not uniformly encountered by all novice designers. For instance, Loweth *et al.* (2020a) observed several instances of novice designers employing interviewing approaches that aligned well with recommended interview practices. The goal of our work was to explore in greater depth the variation in how novice designers approached stakeholder interviews and determine how differences in interview approaches may relate to novice designers' subsequent use of interview data to inform their requirements development processes.

3. Methods

3.1. Research objectives

The study was guided by the following research questions:

- (i) RQ1: How can novice designer performance of stakeholder interviews be reliably assessed?
- (ii) RQ2: How does interview performance relate to the use of interview data in the subsequent development of product requirements?
- (iii) RQ3: How does the use of recommended practices during interviews vary across participants?

We posited that the breadth of recommended interviewing practices documented throughout the literature could collectively be used to assess interview performance. We also hypothesised that the presence of more practices recommended by literature would yield more useful data gathered from the interview that would be evident in participants' developed product requirements. Using the developed assessment of interview performance, we sought to identify what (if any) recommended practices were leveraged most frequently by participants whose interviews contained the most instances of recommended interviewing practices overall.

3.2. Participants

Eight students from two sections of a mechanical engineering capstone design course volunteered to be participants for the design task. Recruitment from this course ensured that all volunteers had completed or were in the final weeks of their capstone design course. Among the eight participants, five were male and three were female, and seven were mechanical engineering majors and one was a biomedical engineering major. Participants completed a pre-task survey detailing their prior design and stakeholder engagement experiences. We used the information collected through the survey and Dreyfus' model of skill acquisition (Mohedas, Daly & Sienko 2016) to classify participants' expertise. All participants were classified as novice designers because of their minimal prior design experience. All participants provided written informed consent, and the study was approved by the University of Michigan Institutional Review Board. Participants were compensated \$16 per hour for their time.

3.3. Data collection

We developed a design task to investigate the behaviours of participants as they interviewed stakeholders as a source for developing product requirements. Participants were provided the following prompt:

You are currently working for a large toy company that specializes in toys for young children (0 to 10 years old). You've just received a job assignment from your boss. The executives have decided they would like to begin to develop toys that aid young children, between 1 and 5 years of age, in developing their cognitive abilities, specifically children's ability to explore and learn about cause and effect. You have been assigned the job of investigating this idea in order to understand the design problem, develop user requirements, and translate these user requirements into engineering specifications. You will be using standardized templates that your

company has developed in order to document the user requirements and engineering specifications. In the future, you and a team will design the toy based precisely on the user requirements and engineering specifications you are developing, so be sure to include as much detail as possible. For now, your boss only wants to see the user requirements and engineering specifications.

The problem was formulated to be easily understood by all participants, but did not coincide with any of the participants' prior design experiences, a strategy consistent with other design task studies (e.g., Dally & Zhang 1993; Atman *et al.* 1999, 2007).

Participants had six and a half hours to work on the design task – three hours of design activity in the morning and three and a half hours of design activity in the afternoon. During the task, participants were provided with access to a broad range of resources: academic literature, books, Consumer Products Safety Commission guidelines, standards associated with toy development, example toys for the appropriate age range, the opportunity to observe and engage with children playing with toys, and the opportunity to interview various stakeholders. Participants were given standardised templates to document their product requirements and engineering specifications. They were also prompted to indicate the information sources that informed each requirement/specification. The stakeholder interviews (which are the basis for the study presented in this article) were individually scheduled by the participants. Stakeholders available included: two parents, two teachers, an education expert (PhD in education), a psychology expert (PhD in psychology) and a children's product safety expert. Participants were allowed to schedule as many interviews within the design task period as desired, and they were given the option to interview multiple stakeholders simultaneously (i.e., in a small group format) as well as to re-interview stakeholders if they wanted. Interviews were scheduled on a first come first serve basis; no participants expressed lack of access to interview time slots (approximately 45% of the interview time slots were used).

Data collection included audio and video recordings of stakeholder interviews, audio and video recordings of a focus group discussion with stakeholders, audio recordings of post-task interviews with participants, stakeholders' evaluations of each interview, and stakeholders' evaluations of each participant's requirements. Additionally, overhead video camera footage of the computer workstation room, screenshots (every 20 seconds) of participants' computers, computer and network surveillance data, participants' notebooks, and post-task information-use surveys were also collected, but not used in this analysis. For the study reported here, data analysis focused on the audio and video recordings of all stakeholder interviews conducted by participants and the final product requirements and engineering specifications developed by participants.

3.4. Data analysis

Data analysis consisted of three phases. First, we developed a coding methodology for recommended design interviewing practices based on academic literature, established its inter-rater reliability, and used this coding methodology to evaluate the transcripts of the stakeholder interviews conducted by participants. With this evaluation, we developed a generalised linear model to compare participants' performance in stakeholder interviews, where the dependent variable was the number of recommended practices per question asked by participants.

Next, we assessed the ‘interview effect’ for each participant, which we defined as the extent to which the information elicited during interviews was reflected in the product requirements (which included detailed engineering specifications) developed by the participants. We investigated if the interview effect metric was correlated with interview performance (measured by recommended practice usage). Finally, we examined specific recommended practices used across participants. We discuss these three phases of analysis as follows.

Phase 1 analysis

A literature search was conducted (June–July 2015), drawing from literature related to stakeholder interviews within a design context. With the overarching topic of design guiding our search, we explored a range of application areas (e.g., automotive systems, medical device development, human-computer interaction, and consumer product design) and design philosophies and methods (e.g., human-centred design, participatory design, design ethnography, contextual design, and lead user approach). The search was conducted by the first author on Web of Knowledge and included combinations of the following groups of terms: (a) stakeholder*, user* and end-user*, (b) design*, engineer*, and technology*, and (c) interview*, talk*, and inquiry*. One term from each group was used for each search (e.g., Search 1: stakeholder* AND design* AND interview*). Of the 1105 articles reviewed, 188 were found to be of direct interest because they included some reference to stakeholder interviews during design (or related tasks).

Interviewing requires a complex skillset, and the literature review highlighted the challenges in measuring the quality of an interview. However, we aimed to operationalise interviewing performance to include only the skills that could be identified within interview questions within a transcript of an interview to enable the development of an efficient tool for novice assessment and/or self-assessment. We acknowledge that a more comprehensive assessment would also include gesturing, posture, and other nonverbal behaviours. In the review of the 188 articles, 20 recommended practices were identified and 12 were determined suitable for a coding scheme because they: (a) could be identified by a coder by reading an interview transcript and (b) could be coded at the question level (i.e., is the recommended practice present or not present in the question asked by the participant). [Table A3](#) shows recommended practices that we identified from the literature that were not suitable for coding. The process for determining which recommended practices from the literature to include in our coding scheme involved multiple iterations of a two-stage process. During the first stage, the first author compiled summaries of recommended practices from the literature. During the second stage, the research team discussed the appropriateness of the recommended practice for inclusion in the coding scheme. Following each discussion, the first author gathered additional recommended practice related information from the literature, which was subsequently discussed with the research team until saturation was achieved. The recommended practices in our assessment framework needed to be independent of information that was not available to a coder (e.g., did not depend upon knowing the intent of the interviewer). An example of a recommended practice found in the literature, but not included in our coding scheme was ‘prioritise questions based on the stakeholder’. This recommended practice was not included, because it

would have required knowledge of what questions the participant thought were most important for particular stakeholders.

Once the recommended practices that were suitable for our research goals were established from the literature, three coders (members of the research team) participated in the next part of the analysis process. After an initial discussion to clarify the coding scheme, the coders independently reviewed a few transcripts at a time and then discussed the codes for those transcripts, resolving any disagreements, and clarifying the coding scheme as necessary. This coding process included evaluating each question posed by the participants during their stakeholder interviews for each of the 12 recommended practices, noting its presence or absence. Once the coding scheme was finalised, we assessed it for reliability using a subset of five transcripts that were randomly selected for comparison. We selected five transcripts to allow for substantive comparison. Inter-rater reliability was measured using Cohen's kappa (Cohen 1960); this coefficient ranged from 0.77 to 0.86 (mean 0.82) for the five interviews coded. Kappa coefficients above 0.8 are considered extremely reliable (Krippendorff 1980; Landis & Koch 2008), while values above 0.60 indicate substantial agreement. Then, coders evaluated the remaining interview transcripts (37 in total) separately using the final coding scheme. The transcripts were divided randomly across the coders. Additionally, portions of these transcripts were coded by multiple coders to ensure that the inter-rater reliability remained at or above the value established from the first five interviews (minimum of 0.77). Ultimately, 589 total questions were coded and the number of questions per participant across all their interviews ranged from 28 to 145.

We used this coding of recommended interviewing practices to represent interview performance. To understand how multiple factors potentially impacted interview performance, we developed a generalised linear model. This type of model is used to understand the level of variance associated with a dependent variable that can be attributed to a specific independent variable, while controlling for other confounding variables (Nelder & Wedderburn 1972; Coolican 2009). In our linear model, we investigated how the dependent variable 'interview performance' varied as a function of the independent variable 'participant' (i.e., interviewer), while controlling for the other variables of interviewee, question number (i.e., the first, second and third question asked in an interview), and interview number (i.e., the participants' first, second and third interview, during the day-long design task). Through our linear model, we also investigated question number and interview number as independent variables predicting the dependent variable interview performance. In the model, each question asked by a participant represented the unit of analysis.

The dependent variable, 'interview performance' was defined as the total number of recommended practices identified by the coder per interview question asked, represented as:

$$y_j = \sum_{i=1}^{12} x_i, \quad (1)$$

where x_i represents the presence or absence of a particular (i th) recommended practice (1 indicates presence of the recommended practice, 0 indicates absence of the recommended practice), y is the dependent variable and j is the question being evaluated. We assigned equal weights to each recommended practice when defining overall interview performance because the existing literature did not provide

information to more accurately interpret the relative contributions of recommended practices to overall interview performance. For example, if on a particular question (*j*), a participant (*a*) encouraged deep thinking and (*b*) used a co-creative strategy (but no other recommended practices), the value of the interview performance metric (*y*) was two. We did not aim to establish an absolute metric of interview performance (e.g., to determine the minimum number of recommended practices per question that would indicate ‘good’ performance). Rather, the generalised linear model allowed us to compare interview performance of participants in the study. The standardised metric we developed, based on recommended practices prevalent in the academic literature, allowed us to assess interview performance within the controlled laboratory design task in a consistent way across participants.

Phase 2 analysis

Next, we developed an interview effect metric to investigate the effect interviews had on the product requirements developed by the participants, that is, the extent to which participants gathered data from stakeholders during interviews that contributed to their product requirements. The interview effect metric was calculated using two variables: (a) the number of interviews that contributed to the development of a specific requirement, and (b) the number of times the product requirement was discussed during each interview. We chose these two variables for the metric to align with design literature, which emphasises the importance of (a) consulting diverse stakeholders to elicit and validate requirements and (b) diving deep into specific topics with individual stakeholders (Kaiya *et al.* 2005; Dieter & Schmidt 2021; Loweth *et al.* 2021).

The interview effect metric was calculated using all instances within interviews during which participants asked questions related to the subsequently developed requirement. For example, during one interview a participant asked ‘Do you think repetition is more important when learning a cognitive ability or...is variety [more important]?’ The interviewee’s response was later referenced by the participant as contributing to the product requirement: ‘Allow for multiple types of usage’. The number of instances when the product requirement was discussed during each interview was determined by analysing each interview question asked by participants. Every interview question that resulted in a discussed requirement was counted as an instance. Instances were assessed by two coders. All discrepancies were discussed at meetings with all authors, and final decisions were made.

We then represented instances of interview data informing requirements through branch diagrams. For example, in Figure 1, we represent a branch diagram from Participant 1. Participant 1 developed five requirements from 16 instances of interview questions across six unique interviews. To calculate the interview effect

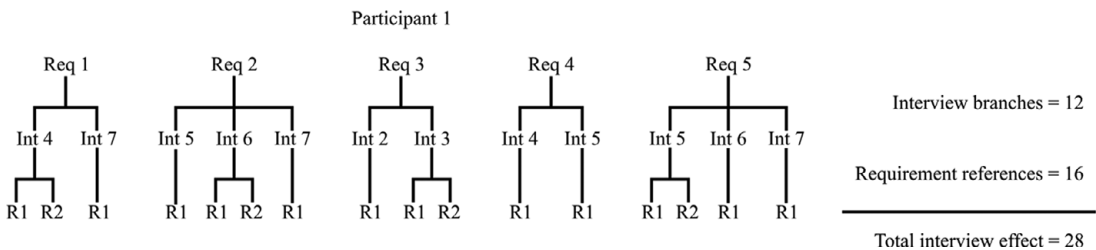


Figure 1. Example of requirements reference trees with respect to stakeholder interviews for Participant 1.

metric, we totaled the number of branches: 12 interview branches and 16 requirement reference branches for a total effect of 28.

We chose not to normalise the interview effect metric based on the number of interviews each participant conducted to avoid penalising participants that employed different interview strategies. For example, a participant who used initial interviews to gather background information and later interviews to focus on requirements development would have appeared less successful than a participant who used the internet to gather background information and interviews to focus on requirements development.

After calculating the interview effect for each participant, we then correlated it with the overall quality of the participant's interviews conducted to determine if higher quality design interviews lead to the elicitation of more relevant information (as defined by the interview effect metric). Only one participant repeated interviews with the same stakeholders (she interviewed four stakeholders twice each). These repeated interviews were not treated differently during analysis.

Phase 3 analysis

To identify what (if any) recommended practices were leveraged most frequently by participants whose interviews contained the most instances of recommended interviewing practices overall, the top and bottom three interview performers as determined by the generalised linear model were compared individually across the 12 recommended practices. Fischer's exact test was used to determine the specific recommended practices in which a statistically significant difference was observed between the participants whose interviews contained the most instances of recommended interviewing practices overall and those whose interviews contained the fewest instances of recommended practices.

4. Results

In this section, we first describe the coding scheme used to measure design interview performance and the results of the generalised linear model (addressing the first research question). Second, we show the interview effect metric for various participants and display the relationship between interview performance and the interview effect metric (addressing the second research question). Third, we present comparisons of the participants with the highest and lowest scores as determined by the design interview performance coding methodology (addressing the third research question).

4.1. Interview performance assessment and generalised linear model

The literature review of recommended design interviewing practices led to the coding scheme shown in [Table 1](#). The coding scheme consists of 12 independent recommended design interviewing practices that can each be evaluated at the question level of an interview transcript.

The coding scheme (as shown in [Table 1](#)) was then applied to all interviews conducted by the eight participants and the results are presented in [Table 2](#). Additionally, [Table A4](#) contains examples for each code found in the data. The number of interviews conducted by participants ranged from 3 to 7 and the

Table 1. Recommended practices identified within literature forming the basis for the coding structure used in later analyses.

Code/Recommended practice	Recommended practice description	Code description	References
Encourage deep thinking	Interviewers should encourage stakeholders to think deeply, defined as analytical thinking, integration of ideas, and use of logical reasoning. This approach encourages stakeholders to move beyond superficial responses and provide more in-depth knowledge on a subject.	<ul style="list-style-type: none"> • Designer asks question that requires stakeholder to <ol style="list-style-type: none"> (i) Analyse a situation: presents a situation (or multiple) and asks stakeholder to analyse, assess, make a determination, and so forth (ii) Integrate ideas: asks stakeholder to synthesise multiple ideas to establish broader understanding (iii) Use logical reasoning: asks stakeholder to reason out why something is the way it is, or how something occurs, and so forth 	Leifer, Lee & Durgee 1994; Rosenthal & Capper 2006; Scheinholtz & Wilmont 2011
Develop a rapport with the interviewee	Interviewers should strive to develop a good rapport with stakeholders. This approach facilitates a more comfortable discussion and more open and honest responses.	<ul style="list-style-type: none"> • Designer begins the interview with nondesign related questions or small talk. • Designer uses personal questions (when appropriate) to develop relationship with stakeholder: <ol style="list-style-type: none"> (i) Conversation at beginning or end; nondesign related conversation during interview (ii) Questions about the stakeholders' background to better understand them 	Tsai, Mojdehbakhsh & Rayadurgam 1997; Strickland 2001
Avoid misinterpretations	Misinterpreting a stakeholder's responses can lead to erroneous information being collected. Interviewers should document stakeholder's exact wording or the interviewer should present their interpretation back to the stakeholder for verification.	<ul style="list-style-type: none"> • Designer asks a clarifying question to ensure they fully understand a stakeholder's response 	Spradley 1979; Byrd, Cossick & Zmud 1992; Wooten & Rowley 1995; Strickland 2001; Dekker, Nyce & Hoffman 2003

Table 1. Continued.

Code/Recommended practice	Recommended practice description	Code description	References
Be flexible and opportunistic	Interviewers should not be rigidly attached to a predefined list of questions or topics. They must be able to identify relevant topics arising from stakeholders' responses and dig deeper into this newly discovered information.	<ul style="list-style-type: none"> • Designer probes into a topic area brought up by a stakeholder (tangential to the designer's original question) • Designer adjusts their interview questions/approach after learning about the stakeholder 	Agarwal & Tanniru 1990; Nguyen, Carroll & Swatman 2000; Strickland 2001; Luck 2007; Dhillon <i>et al.</i> 2011
Verify the conclusions drawn from interviews	If conclusions are drawn during analysis of interview results (or during interviews), interviewers should attempt to verify that these conclusions align with stakeholders' perceptions.	<ul style="list-style-type: none"> • Designer presents the stakeholder with their interpretation of the stakeholder's response for confirmation • Designer presents conclusions drawn from other interviews to stakeholders to determine if prior conclusions hold true • Designer verifies the requirements/specifications generated through interviews 	Nuseibeh & Easterbrook 2000; Firesmith 2003
<ul style="list-style-type: none"> • Designer begins and interviewee concludes 	At the start of the interview, interviewers should define the purpose and goals of the interview with the stakeholders. At the end, interviewers should allow time for stakeholders to discuss topics of interest that were not asked about.	<ul style="list-style-type: none"> • Designer explains to the stakeholder the purpose of the interview (e.g., their goals and the design project) • Designer leaves time at the end of interview to allow the stakeholder to offer any concluding thoughts that were not covered by questions 	Strickland 2001; Luck 2007
Use projective questioning techniques	Interviewers should use stories, metaphors, drawings, analogies, role-playing, third party projections, and so forth, to enhance the information elicited.	<ul style="list-style-type: none"> • Designer frames questions using: <ol style="list-style-type: none"> (i) Hypothetical: how would you, what would be your preference if, if you had to choose, and so forth (b) Story telling: if you had to purchase a toy today, how would you go about it 	Rosenthal & Capper 2006; Donoghue 2010
Use a co-creative interview strategy	Interviewers should encourage stakeholders to take ownership of the	<ul style="list-style-type: none"> • Designer asks questions or makes comments that would increase 	Sanders & Stappers 2008; Scheinholtz & Wilmont 2011

Table 1. Continued.

Code/Recommended practice	Recommended practice description	Code description	References
	goals of the interview; giving stakeholders a stake in the outcome can result in more useful information elicitation.	the stakeholder's sense of ownership of interview/product requirements; questions give ownership of the process to the stakeholder	
Introduce domain knowledge	Interviewers should seek to introduce domain knowledge (either from other information sources or other interviews). This approach can help elicit information about specific topics for which stakeholders may be experts.	<ul style="list-style-type: none"> • Designer uses domain knowledge from prior interview or observation or literature or any other information source to frame question 	Tsai <i>et al.</i> 1997; Strickland 2001; Bednar 2009
Have the interviewee teach you	Interviewers can profess ignorance to encourage stakeholders to explain a specific topic or break complicated subjects into component parts.	<ul style="list-style-type: none"> • Designer uses ignorance to get the stakeholder to teach them about an idea/procedure/concept/etc. 	Strickland 2001; Evnin & Pries 2008
Explore contradictions	Interviewers should seek to understand contradictions (within a stakeholder's own responses) or disagreements between different stakeholders.	<ul style="list-style-type: none"> • Designer asks about discrepancies within a stakeholder's own responses or differences between different stakeholders' responses 	Goguen & Linde 1993; Kaiya <i>et al.</i> 2005
Break down expert tasks	Experts may fail to mention all of the cognitive or physical processes required to perform a specific task or reach a goal. Interviewers should follow-up and probe experts to capture all information.	<ul style="list-style-type: none"> • Designer probes stakeholder's responses to break-up complicated cognitive processes into more manageable steps 	Davis 1982; Agarwal & Tanniru 1990; Wetherbe 1991; Inoue <i>et al.</i> 2012

Table 2. Summary statistics for coding of all participants.

Participant ID	P1	P2	P3	P4	P5	P6	P7	P8
Interviews conducted	7	3	3	3	4	7	7	3
Questions asked	145	28	50	67	60	85	115	35
Questions per interview	20.7	9.3	16.7	22.3	15.0	12.1	16.4	11.7
Recommended practices found	173	28	54	85	94	124	121	29
Recommended practices per question	1.19	1.00	1.08	1.27	1.57	1.46	1.05	0.83

Table 3. Estimates, standard error, and significance of the variables included within the generalised linear model.

	Estimate	Std. error	Sig.
(Intercept)	1.029	0.125	***
P2	-0.048	0.158	
P3	-0.093	0.127	
P4	0.215	0.122	†
P5	0.528	0.120	***
P6	0.314	0.103	**
P7	-0.122	0.089	
P8	-0.379	0.148	*
Teacher 1	0.152	0.143	
Parent 1	-0.129	0.123	
Parent 2	-0.285	0.109	**
Education PhD	-0.009	0.104	
Psychology PhD	0.142	0.108	
Safety expert	-0.189	0.133	
Interview number	0.052	0.021	**
Question number	0.000	0.005	

*** $p < 0.001$;

** $p < 0.01$;

* $p < 0.01$;

† $p < 0.1$.

number of questions asked per participant per interview ranged from 9.3 to 22.3 (interviews lasted approximately 15 minutes each). In total, 708 instances of recommended practices were identified across all 37 transcripts. Participants exhibited between 0.83 and 1.57 recommended practices per question. In addition, a cross-tabulation table (Table A1) and a table of correlation coefficients (Table A2) are shown in the Appendix; they show that no recommended practices were correlated at the question level (which would have led to redundancies in our analysis; for example, there was no evidence that some recommended practices generally came in pairs).

The results of the generalised linear regression analysis are shown in Table 3, including coefficient estimates, standard errors, and significance levels for all variables examined. The variables included: all participants (Participants 1 through 8), all interviewees (two teachers, two parents, an education PhD, a psychology PhD and a safety expert), interview number, and question number. In the model, Participant 1 and Teacher 2 were used as the reference within their respective categories. Participants 4, 5 and 6 employed a significantly greater number of recommended practices per question than the reference (all statistically significant); whereas Participants 2, 3, 7 and 8 used fewer recommended practices per question than the reference (only Participant 8 used statistically significantly fewer recommended practices than the reference participant). The model also revealed that interviews conducted with Parent 2, produced significantly fewer recommended practices than interviews conducted with other stakeholders. Additionally, the positive and statistically significant coefficient associated with interview number indicated that the participants' interview performance improved as they conducted more interviews.

4.2. Effect of interview performance on interview information use in requirements

There were key differences in how individual participants used interviews to develop requirements. For example, Participant 6 used interviews extensively to develop all of her requirements and obtained information from multiple interviewees for each requirement, as can be seen in Figure 2. In contrast, Participant 2 incorporated interview information into fewer than half of her requirements and

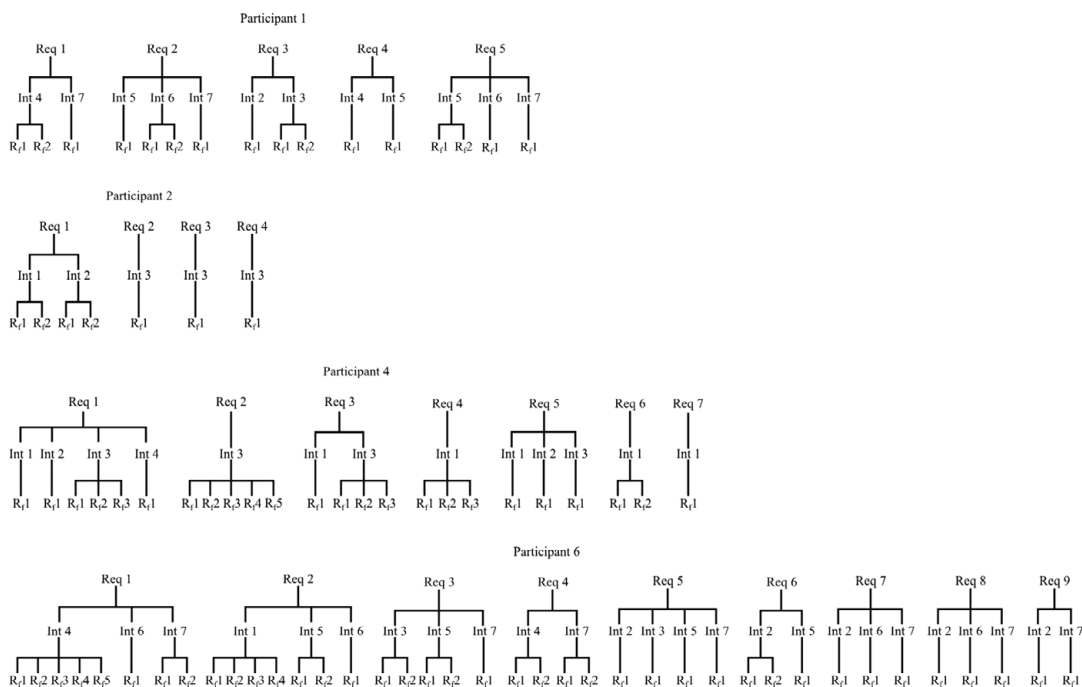


Figure 2. Interview references to final requirements developed by participants.

only obtained multiple perspectives on one requirement. Additionally, while Participant 1 did not generate as many requirements from the seven interviews he conducted as Participant 6 generated, he still displayed effective behaviour by consulting multiple stakeholders to discuss each requirement instead of relying only on a single interview to develop each requirement. These four representative examples demonstrate a range of behaviours with respect to how participants used interviews in requirements development.

Participants whose interviews contained more instances of recommended interviewing practices also gathered information that appeared more frequently in requirements developed compared to participants whose interviews contained fewer instances of recommended practices, as seen in Figure 3. The Pearson's correlation coefficient between interview performance (as assessed by the linear model) and the interview effect metric was 0.60, indicating a relatively high correlation. This finding suggests that a designer who is able to use a greater number of recommended interviewing practices (using the linear model results, this would include Participants 4, 5 and 6) may be able to elicit information that is more directly applicable to the development of product requirements. Alternatively, participants who used a greater number of recommended practices in their interviews may have ultimately employed stakeholder information at a higher rate to inform their requirements.

4.3. Recommended practice differentiation

We performed a second analysis to identify what (if any) recommended practices were leveraged most frequently by participants whose interviews contained the most instances of recommended interviewing practices overall. In this analysis, the three highest and lowest scoring (as defined by their coefficients in the generalised linear model, Table 3) participants' interview transcripts were examined to identify

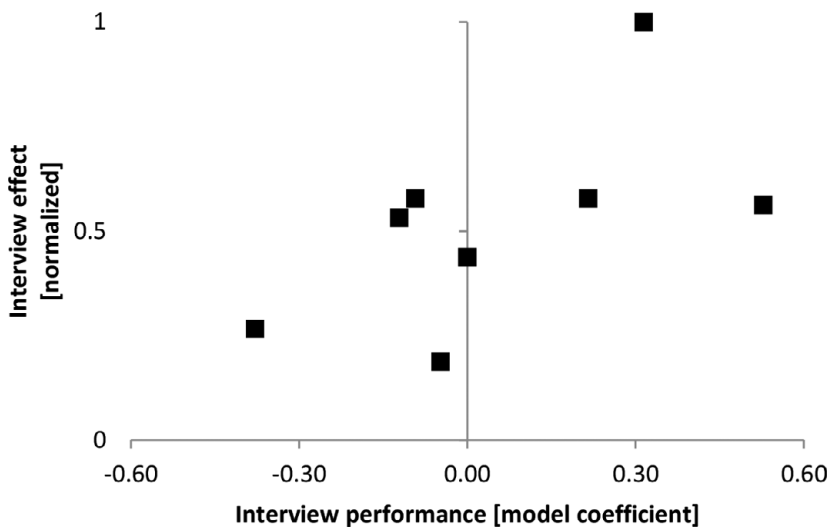


Figure 3. Relationship between participants' performance during interviews and the interview effect metric.

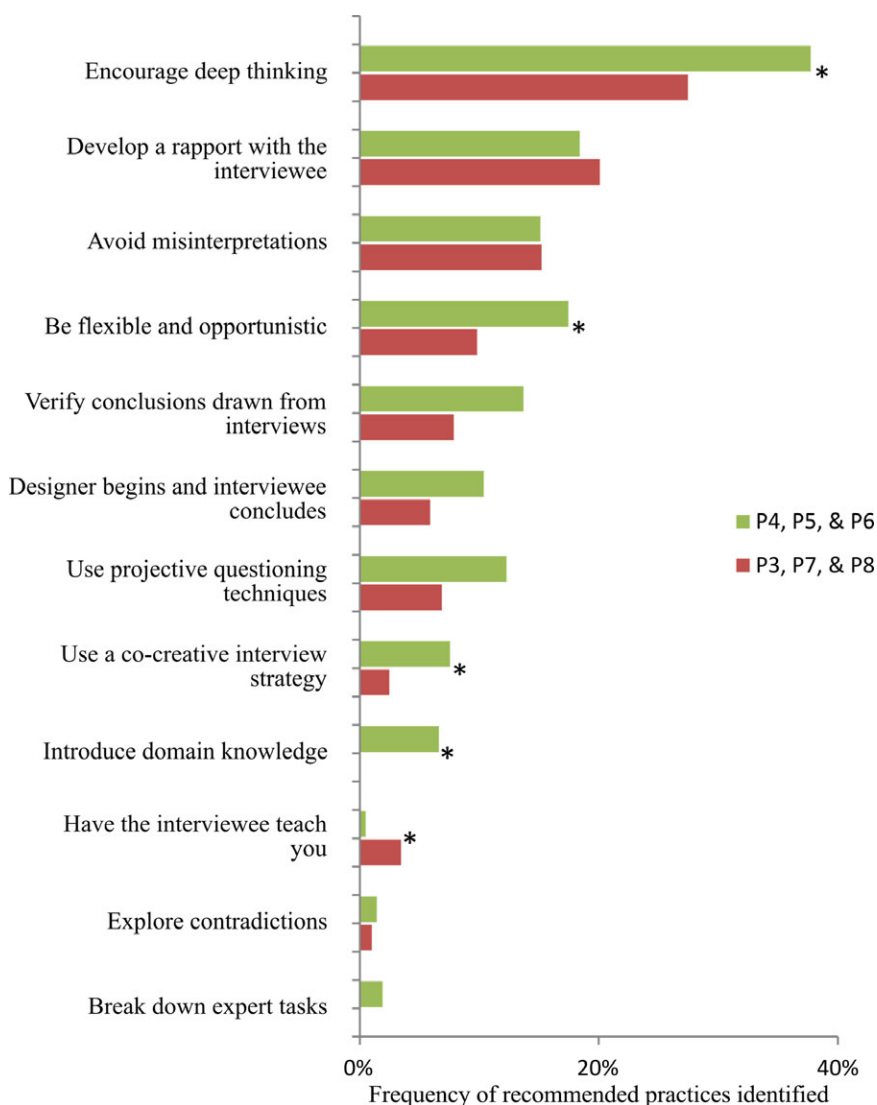


Figure 4. Results of recommended practices coding for Participants 4, 5 and 6 (participants whose interviews contained the most instances of recommended interviewing practices overall) versus Participants 3, 7 and 8 (participants whose interviews contained the fewest instances of recommended interviewing practices overall). The asterisk (*) indicates a statistically significant difference ($p < 0.05$).

instances of each recommended practice. In Figure 4, we show how frequently participants displayed individual recommended practices when asking questions during stakeholder interviews (the average frequency of Participants 4, 5 and 6 is plotted against that of Participants 3, 7 and 8). As demonstrated by Figure 4, the three participants whose interviews contained the most instances of recommended interviewing practices overall exhibited 10 of the 12 recommended practices more frequently than the three participants whose interviews contained the fewest instances of recommended practices, of which four were statistically significant

($p < 0.05$): encouraging deep thinking, being flexible and opportunistic, using a co-creative interview strategy, and introducing domain knowledge. Minimal differences were observed in developing rapport with interviewee, avoiding misinterpretations, exploring contradictions, and breaking down expert tasks.

5. Discussion

5.1. Interpretations and contributions

This study assessed novice engineering designers as they performed a simulated design task. The coding scheme developed in this study enabled design interview performance to be evaluated during a requirements elicitation task. Grounding the coding methodology in the literature supports its validity, and the high inter-rater reliability (mean kappa of 0.82) demonstrated that multiple coders could apply it consistently (Jonsson & Svingby 2007). Additionally, our results included an empirical link between interview performance as assessed using the recommended practice scheme, and information gathered within interviews that were subsequently used to support the development of requirements. Application of the coding scheme to the design task data revealed statistically significant differences in performance within a group of novice designers; specific behaviours accounted for these differences.

The synthesis of the literature resulting in the development of a reliable coding methodology to evaluate interview performance is applicable to design research, practice, and education. While design texts have encouraged extensive stakeholder interaction, this study augments the existing literature by (a) compiling recommended design interviewing practices, (b) establishing a reliable and systematic method for evaluating aspects of design interview performance and (c) providing an empirical foundation for pedagogical and practical tools to support aspects of design interviewing. Importantly, our evaluation method emphasises interviewing approaches that novice designers can implement effectively, and thus serves as a useful counterpoint to other evaluation methods, such as Bano *et al.* (2019), that focus on novice designers' interviewing mistakes.

The positive relationship found in this study between interview performance and the elicitation of information used in the development of product requirements emphasises the tangible effect that using recommended practices can have on a design process; participants whose interviews contained more instances of recommended interviewing practices applied more information gathered from stakeholder interviews to the development of product requirements. This finding adds experimental data to support the value of design interviewing during front-end design, which has been discussed extensively within the literature, but in broader, nonspecific terms (van Rijn *et al.* 2011; Dym, Little & Orwin 2013; Dieter & Schmidt 2021). While it is unclear exactly why participants whose interviews contained more instances of recommended interviewing practices ultimately applied more information, one possible explanation is that this finding reflects the quality of information elicited. Prior work indicates that requirements elicitation can be challenging because stakeholders may provide ambiguous responses (Ferrari *et al.* 2016) and designers may struggle to gather comprehensive information about stakeholder experiences (Sutcliffe & Sawyer 2013; Rosa *et al.* 2021). Hypothetically, recommended interviewing practices should support designers in overcoming these challenges by enabling the elicitation of specific and diverse

stakeholder data. We did not evaluate the quality of information elicited by participants. However, it logically follows that participants who successfully gathered relevant stakeholder data would be more likely to subsequently use those data to inform their requirements, while participants whose interviews were less 'successful' might rely less on stakeholder data.

Another possible explanation reverses the implied causality of our findings: some participants may have been planning to integrate stakeholder information into their requirements elicitation processes regardless, and thus employed interviewing practices (that aligned with recommended practices) that would enable them to elicit needed information. For instance, Zoltowski, Oakes & Cardella (2012) described how some engineering students highly value the perspectives of stakeholders for informing their design projects. Loweth *et al.* (2021), in their study of capstone design teams, found that novice designers who highly valued stakeholder perspectives also employed recommended interviewing practices more consistently than peers with comparable levels of interviewing experience. Participants 4, 5 and 6 in our study may similarly have valued stakeholders to inform their requirements development processes, which may have led them to employ more recommended practices. More work is needed to determine relationships between novice designers' perspectives on stakeholder engagement, their use of recommended interviewing practices, and their use of stakeholder data to inform their design decisions.

Specific recommended practices were leveraged most frequently by participants whose interviews contained the most instances of recommended interviewing practices overall. Both groups (participants whose interviews contained the most instances of recommended practices and participants whose interviews contained the fewest instances of recommended practices) developed rapport with interviewees and avoided misinterpretations during interviews at the same rate, suggesting that these two recommended practices were executed similarly across these groups of participants, or that the differences in executing these skills require a more nuanced analysis to expose. The participants whose interviews contained the most instances of recommended interviewing practices displayed significantly greater usage of specific recommended practices such as encouraging deep thinking, being flexible and opportunistic, using a co-creative strategy, and introducing domain knowledge. While this finding does not necessarily reveal which recommended practices are more critical to interacting with stakeholders, it could suggest that there are certain recommended practices that are more natural or easier to learn while others require a more intentional application or advanced knowledge. This hypothesis aligns with findings from Loweth *et al.* (2021), who observed that novice designers in a capstone design course employed interview practices such as encouraging deep thinking mainly in situations where there seemed to be clear and specific information that they hoped to gather.

Beyond participants' abilities to enact recommended practices, the generalised linear model revealed other factors that affected interview performance. A statistically significant positive effect with respect to the interview number (i.e., first, second and third interview) indicated that participants improved their interview performance as their experience increased during the design task, which has pedagogical implications. Additionally, interviews with one particular interviewee were statistically negatively correlated with participants' interview performance, emphasising the impact that an individual stakeholder can have on the interview.

5.2. Implications

In educational and training contexts, the coding scheme can be used by instructors to evaluate students' audio-recorded or transcribed interviews by providing a structured method of analysis for a generally unstructured process, which inherently makes interviews difficult to evaluate. Instructors can use the coding scheme to identify which recommended practices students are and are not using. Additionally, instructors can also choose to focus on a subset of the recommended practices in the coding scheme, customising their assessment of students' work to fit the needs of their particular students. This approach would provide instructors with a method for assessing and providing feedback on design interview performance within a classroom context. Because the coding scheme can be applied retroactively to interview transcripts, instructors could provide feedback on the interviews students conduct for their design projects (in project-based courses) as opposed to classroom-based simulated interviews (e.g., providing feedback during/after a mock interview). Additionally, because the coding scheme is applied at the question level, instructors can also provide feedback to student designers as they develop their interview protocols, allowing them to improve their questions prior to conducting their first stakeholder interview.

An additional implication is to encourage focus on design interviewing intentionally within design courses. The positive relationship found between interview performance and the elicitation of information used supports the importance of instruction of design interviewing within engineering curricula. Further, specific recommended practices may be more challenging to learn than others and, given the constraints of adding content to engineering design curricula, these findings could guide instructors in determining where to focus instruction.

The developed coding scheme can also be used by designers to evaluate their own interview protocols prior to conducting interviews. Within both industry practice and education, this scheme can be used as an efficient and low-cost method for designers to develop their interviewing skill set by supporting peer-to-peer learning within training programs or through self-reflection exercises that can be implemented during real-world implementation of stakeholder interviews. Designers can use the recommended practices coding scheme retroactively to assess which recommended practices were or were not used effectively (e.g., Were there moments where the designer could have been more opportunistic in pursuing a line of questioning? Were there times when the designer failed to verify a conclusion or interpretation drawn from a stakeholder's response?). The coding scheme can be applied as a tool to help designers develop higher quality interview protocols by comparing the questions they develop to the recommended practices identified and adjusting them accordingly. Whereas design interview protocols are typically improved through pilot testing, use of the recommended practices coding scheme will allow designers to improve the quality of their interviewing protocols during initial development leading to more effective initial interviews. This collection of strategies supports reflective practice, which is key in the development of design expertise (Valkenburg & Dorst 1998; Adams, Turns & Atman 2003; Davis *et al.* 2013). This coding scheme could be expanded to a guiding tool that includes the additional recommended practices that were not assessed in this study as well as non-question-based recommended practices (e.g., tone and body language).

These findings can also serve as a foundation for propelling additional design research initiatives aimed at investigating more nuanced interview and information gathering practices within the engineering design community. Many of the existing resources within the engineering design community provide high-level guidance on who to engage during front-end engineering design activities and how to execute the engagements. The list of practices within this scheme can serve as a starting point for additional design research aimed at explicating practitioner behaviour in greater detail to facilitate transfer of knowledge that otherwise is most commonly obtained through years of experience and trial and error. Furthermore, while this study focused on novice engineering designers, subsequent studies can be performed to evaluate the utility of the findings for engineering design practitioners and explore specific details regarding interviewing and information gathering practices.

Ultimately, the findings from this research have the long-term potential to support the success of designed products. For example, if end users' and stakeholders' needs are more comprehensively and accurately captured through requirements elicitation interviews by designer practitioners with expert-level interview skills, there is an increased likelihood that their ensuing design stages will yield concept solutions that more appropriately address the targeted problems.

5.3. Limitations

Interviewing is a complex skill and our study was limited in that only a subset of interviewing behaviours was assessed in this study. We acknowledge that other behaviours, such as interview 'mistakes' (e.g., Bano *et al.* 2019), contribute to a holistic assessment of interview performance.

Additionally, in order to conduct a controlled, laboratory-based study of design interview performance, we made study design decisions that may not be representative of real-world design work. For example, participants were given access to seven different stakeholders to interview during the design task. While these stakeholders were purposefully selected to represent a broad range of perspectives (which would be desired when designing a real product), the limited number of stakeholders (and therefore limited perspectives) available to the participants is a study design constraint that would not normally exist during real-world design. Further, because of the experimental design context, we were also unable to control for potential impacts of stakeholders being interviewed multiple times, that is, earlier interviews with participants might have influenced how stakeholders answered questions in later interviews with other participants.

Another limitation was that we were not able to control or assess every stage in a process of moving from data collection during interviews to a set of developed requirements. While we were able to establish a fairly strong relationship between interview performance and the use of the information gathered during the interview to support the development of requirements, we did not control for the multiple phases between these two activities. Beyond effective interviewing skills, the process of developing representative requirements involves eliciting meaningful information from stakeholders, synthesising information across multiple end-users and stakeholders, and navigating potentially

conflicting information. In other words, asking an effective question does not automatically translate to successfully leveraging the resulting information in the development of requirements. The linear model did not take into consideration participants' uses of other information sources that were available to them that may have informed their interviews and requirements. Additionally, this analysis only considered interview information that appeared as a source for the product requirements; however, relevant information from interviewees may not have been captured within requirements. For example, stakeholder interviews can be performed to refine the target market for a product or to better understand features that should not be included in a product. Another limitation is that we assigned equal weights to each recommended practice in defining overall interview performance because the existing literature did not provide information to more accurately interpret the relative contributions of recommended practices to overall interview performance. In practice, some recommended practices could be more important than others, however, without a rigorous method of evaluating the end-product associated with interviews (while being able to control for variability between interview contexts), establishing this weighting was not possible.

6. Conclusions

Design processes that emphasise engagement early and often with stakeholders continue to gain traction within the engineering design community because of their ability to promote deep understanding and integration of stakeholder needs. However, in order to fully leverage the benefits of deep stakeholder understanding, designers need to be able to effectively execute engagements with stakeholders, particularly interviews, which are an important method for eliciting and developing product requirements. While stakeholder engagement has been shown to positively affect design outcomes, studies to date have described novice designers' challenges with implementing stakeholder engagement including interviewing. Therefore, this research aimed to characterise how novice designers elicited information to inform the development of product requirements during stakeholder interviews. The primary contributions of this work included: the identification and compilation of recommended design interviewing practices garnered through secondary research, which formed the basis of a multifunctional coding scheme. The findings demonstrated that the coding scheme could be used to assess interview performance differences among novice designers and elucidate specific shortcomings among novice design interviewers with respect to recommended practices including encouraging deep thinking and being flexible and opportunistic. The developed and successfully applied recommended interviewing practices coding scheme has the potential to enable design educators to more effectively evaluate their students' interview performance and enable them to deliver more specific feedback aligned with recommended practices. Likewise, the coding scheme can also be used to inform protocol development, evaluate interview protocols prior to conducting interviews, aid in the performance of self-evaluation and reflective practice on interviews conducted, and provide a mechanism for facilitating peer-to-peer feedback on this complex skill set.

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A. Appendix

Table A1. Cross tabulation of the number of recommended practices that were coded simultaneously within the transcripts analysed.

		BP1	BP2	BP3	BP4	BP5	BP6	BP7	BP8	BP9	BP10	BP11	BP12
Encourage deep thinking	BP1	179											
Develop a rapport with the interviewee	BP2	0	95										
Avoid misinterpretations	BP3	0	3	119									
Be flexible and opportunistic	BP4	35	1	3	80								
Verify conclusions drawn from interviews	BP5	21	1	0	7	69							
Designer begins and interviewee concludes	BP6	6	10	1	1	4	47						
Use projective questioning techniques	BP7	30	1	0	7	6	2	51					
Use a co-creative interview strategy	BP8	12	0	0	2	6	7	7	23				
Introduce domain knowledge	BP9	13	0	1	5	5	3	1	2	27			
Have the interviewee teach you	BP10	0	2	2	1	0	1	0	0	0	9		
Explore contradictions	BP11	3	0	0	0	4	0	1	0	0	0	5	
Break down expert tasks	BP12	2	0	0	0	0	0	1	0	0	0	0	4

Table A2. Correlation coefficients (Pearson) between the recommended practices coded during our analysis.

		BP1	BP2	BP3	BP4	BP5	BP6	BP7	BP8	BP9	BP10	BP11	BP12
Encourage deep thinking	BP1	1											
Develop a rapport with the interviewee	BP2	−0.28	1										
Avoid misinterpretations	BP3	−0.33	−0.18	1									
Be flexible and opportunistic	BP4	0.12	−0.16	−0.16	1								
Verify conclusions drawn from interviews	BP5	0.00	−0.14	−0.18	−0.03	1							
Designer begins and interviewee concludes	BP6	−0.11	0.04	−0.13	−0.10	−0.03	1						
Use projective questioning techniques	BP7	0.19	−0.12	−0.15	0.00	0.00	−0.04	1					
Use a co-creative interview strategy	BP8	0.10	−0.09	−0.10	−0.03	0.09	0.17	0.16	1				
Introduce domain knowledge	BP9	0.09	−0.09	−0.09	0.03	0.05	0.03	−0.04	0.04	1			
Have the interviewee teach you	BP10	−0.08	0.02	0.01	−0.01	−0.04	0.01	−0.04	−0.02	−0.03	1		
Explore contradictions	BP11	0.06	−0.04	−0.05	−0.04	0.20	−0.03	0.04	−0.02	−0.02	−0.01	1	
Break down expert tasks	BP12	0.04	−0.04	−0.04	−0.03	−0.03	−0.02	0.05	−0.02	−0.02	−0.01	−0.01	1

Table A3. Recommended practice codes that could not be applied to interview transcripts

Unused recommended practice codes

Recommended practice	Description	Design application	Coding	References
Generate empathy	A typical goal for interviews is to be able to (by the end) empathise with the interviewee. This dramatically improves the interviewer's ability to extrapolate findings from the interview to new situations	A key goal of stakeholder interaction is to generate empathy so that the designer can make more informed decisions during later portions of the design process. It is also a critical aspect of developing a useful persona during the design process	– Designer words questions in a personal way in order to generate empathy	Leonard & Rayport 1997
Focus the interview	Interviews should be tailored to the specific expertise, prior experiences, or knowledge base of the interviewee. Covering too many topics will likely lead to a superficial understanding of many topics, as opposed to developing a deep understanding of critical topics	Designers should tailor interviews to the stakeholder's specific expertise or prior experience. This leads to richer data that could more likely lead to requirements definition. Interviews with experts, for example, should focus on understanding the underlying principles on a specific topic. Experts have the ability to understand the 'big picture' and understand the interaction between specific ideas	– Question asked about a specific aspect of the stakeholder's expertise (e.g., a deeper dive than merely asking safety expert about safety) – Question asking about stakeholder's prior experiences	Wooten & Rowley 1995; Luck 2007; Dray & Siegel 2009; Burnay <i>et al.</i> 2014
Avoid overloading interviewee's memory limits	Asking too many questions at once (or a complicated question) can overload the interviewee's memory and lead to questions not being		– [Neg] Designer asks complicated questions that require stakeholder to keep many items in mind at once	Wiseman & Tulving 1976; Tulving 1983; Byrd <i>et al.</i> 1992

Table A3. Continued.

Unused recommended practice codes

Recommended practice	Description	Design application	Coding	References
	completely answered or to superficial answers. Multipart or complicated questions should be broken down to be more manageable for the interviewee			
Account for cross-cultural communication	Communication differences between cultures means that techniques or styles of questioning appropriate in the interviewer's culture may not be appropriate for a given interviewee, leading to erroneous information being collected	Globalisation has led to the frequent situation where a designer is developing a product for a culture significantly different from their own. In these contexts, explicit effort must be made by the designer to formulate the interview/interview questions so that they are appropriate for the stakeholder	– [Neg] Designer words questions in a manner that the stakeholder does not understand due to the disciplinary boundary	Lee & Lee 2009
Recognise and reduce biases	Questions can easily be worded in a manner that encourages certain answers or the interview as a whole can bias the results (by focusing only on specific topics). Interviewers must be cognizant of this and strive to recognise and remove biasing from interviews	The designer will bring to each design problem a set of personal views and prior assumptions. During interviews, these might appear in the form of biasing questions. Questions that will be asked should be assessed prior to the interview to determine if they might significantly bias the stakeholder's response	– [Neg] Designer asks leading questions – [Neg] Designer biases set of questions towards a particular solution (e.g., only asking about boy or girl toys and not considering a gender neutral toy) – [Neg] Designer uses interview only to confirm previously defined product requirements	Gammack & Anderson 1990; Wooten & Rowley 1995

Table A3. Continued.

Unused recommended practice codes

Recommended practice	Description	Design application	Coding	References
Develop an interview plan	The interview should be premeditated, either by defining specific goals for the interview, developing relevant question, creating a semi-structured interview guide, and so forth. A well-structured interview will flow from one topic to another more naturally and slowly build up to the most important topics	Each interview should have a specific plan and be gauged to the stakeholder's area of expertise. The interview should slowly build towards specific, product related questions. Beginning with more general questions reduces chances of biasing the interview and gives the stakeholder time to become comfortable with the line of questioning before reaching more critical questions	<ul style="list-style-type: none"> – Designer develops a semi-structured interview guide – First, Rapport development; second, interview definition; third, general questions/ product context/ stakeholder background and fourth, deep dive questions – [Neg] Designer runs out of questions during interview 	Wooten & Rowley 1995; Strickland 2001; Hands, Peiris & Gregor 2004; Luck 2007; Evnin & Pries 2008; Huang & Deng 2008
Seek relevant information	It is critical for the interviewer to be focused on the precise information (or type of information) they are attempting to elicit. Straying too far from the relevant information can dramatically reduce the utility of an interview	Designers have clear goals during front-end design interviews: fully define the problem, understand the context of use, elicit requirements/constraints, and to develop engineering specifications. It is the designer's job during the interview to ensure that information elicitation is always pushing the stakeholder to provide information applicable to these goals	<ul style="list-style-type: none"> – Designer asks questions directly related to the requirements that they have developed – Designer asks stakeholders to prioritise requirements – [Neg] Stakeholder provides information that could directly translate to requirement, but student does not develop this requirement 	Tsai <i>et al.</i> 1997; Browne & Rogich 2001; Rinkus <i>et al.</i> 2005; Randall, Harper & Rouncefield 2007; Martin <i>et al.</i> 2012

Table A3. Continued.

Unused recommended practice codes

Recommended practice	Description	Design application	Coding	References
Explore interactions		Exploring the interactions that a stakeholder has with products or their environment can lead to critical design information. The rich information obtained from interviews maybe one of the few opportunities to better understand how a stakeholder currently interacts with products or their environment	<ul style="list-style-type: none"> – Designer asks questions about how the stakeholder interacts with current products and future product – Example: Are the toys hard to clean? Are there any issues when you have to organise the toys? Does your kid have trouble pressing the buttons? 	Islam & Omasreiter 2005

Table A4. Examples of each recommended practice found in the data.

Code/Recommended practice	Examples from data
Encourage deep thinking	<p>Example: So do you prefer more abstract-looking ... toys or more... toys that look like something in particular?</p> <p>Example: Do you find that there are certain toys that are overstimulating? Is it the lights? The sounds? The moving parts?</p>
Develop a rapport with the interviewee	<p>Example: I just have several questions I need to ask you, I'm sure you have been through this a lot already. Um, so, can I have your specific kids' ages? Is that OK?</p>
Avoid misinterpretations	<p>Example: What do you mean by enriched?</p> <p>Example: So overall, you would say keep it simple</p>
Be flexible and opportunistic	<p>Example: So ah, when you are talking about specific purposes for the toys, uh, do you mean like learning objectives?</p> <p>Example: So, you were talking a little bit about sometimes you lead children to certain toys, um, like intentionally, have them play with toys. What sort of decisions go into like which toy you might ask a certain child to play with?</p>
Verify the conclusions drawn from interviews	<p>Example: So, as a rule of thumb, from what I understood from what you are saying is, the more possibility a toy brings, the longer they can keep, ah, the attention</p> <p>Example: Okay, umm, I talked to other parents, they liked it when toys could be brought out at different levels, had different levels to their complexity. Is that something you would like? So, you could present it in a simple sense then kind of keep adding features, so that the child stays engaged?</p>
Designer begins and interviewee concludes	<p>Example: Uh, so, uh, what we are doing is that we are designing a toy for, ah, young kids, of 1, 5 years of age, that can help them, uh ... understand cause and effect. And, uh, so I've done a little bit of research.</p> <p>Example: Do you have any other comments on these requirements?</p>
Use projective questioning techniques	<p>Example: so, if you were to ... I'm sorry. Um, start to formulate like your ideal um, assessment... How would you run that test and what standards would you make sure to have and what things would you look for and um, also it's like a lot of part question. But also like what um, uh, like specifications would you use to be like, 'Okay, like, I have confidence that this did help them develop that, that skill in their life'.</p> <p>Example: if you were looking at like an array of toys, I guess, were you drawn to ones that like, specifically said, you know helps with this, whatever kind of ability, or is it more just like, what are the other factors that go into choosing, you know, a toy for your kids?</p>
Use a co-creative interview strategy	<p>Example: Okay. Um. So, if you, if you were to make a toy, what would you do? How would, like, how you make it? Would you put all the bells and whistles on it, or, um. Would you try to make it educational, or to some extent?</p> <p>Example: Are there any, uh, things that you can think of, of, 'Oh I wish this toy had this', or 'I wish there was a toy that did this'. Do you have any ideas as to kind of uh, new and improved feature in a toy?</p>

Table A4. Continued.

Code/Recommended practice	Examples from data
Introduce domain knowledge	<p>Example: I've also seen a few other, uh, names in my research that popped up. And another one is, um, uh, Vygotsky's theory of social, uh, cultural development and, uh, can you tell me a little bit about that one as well?</p> <p>Example: So, the first thing, I, ah, I found in my research is that somebody on the internet was saying, 'Music is helpful for teaching kids'. What other things do you think might be helpful?</p>
Have the interviewee teach you	<p>Example: Because I'm not very knowledgeable in cognitive sciences. I have some basics...how would you explain [this concept] to someone who does not have any background?</p> <p>Example: OK. How does it play, since I'm not familiar, how does it umm, how does it play, like when does it play a song?</p>
Explore contradictions	<p>Example: Okay, umm, I talked to other parents, they liked it when toys could be brought out at different levels, had different levels to their complexity. Is that something you would like?</p>
Break down expert tasks	<p>Example: What's a typical day in your childcare, or, you know, or when, in your kindergarten, um, for this specific age group? So, I guess that when we are talking, if we could talk, specifically, about 1 to 3 year olds, and then, 3 to 5 year olds?</p>