Investigation of scenarios format delivery in user studies for future technology

Xia Liu & Setia Hermawati

Human Factors Research Group, Mechanical, Materials and Manufacturing Engineering Department, Faculty of Engineering, the University of Nottingham, UK

ABSTRACT

Manufacturing is a domain that is heavily influenced by and relies on future technology which have direct effects on its employees. It is known that user studies are required to ensure that products or systems meet requirement from and are accepted by potential users. However, it is difficult to explore users' responses for future technology that users have no direct experience and knowledge. ContraVison is one of user study methods and is commonly used to study perceptions and acceptance of new future technology. Participants are typically exposed to positive and negative scenarios. This study investigates how different format of scenarios delivery (video, audio and text) in a modified ContraVision affects the richness of information that could be obtained from potential users. Thirty participants were recruited and divided evenly into three groups of user studies. Data was collected through semi-structured interviews and thematic analysis was used. There was no significant effect of the scenarios format delivery on the richness of information that could be obtained from participants in these three groups, although there was a trend that video offers richer information than audio and text. However, further study was required to ascertain this finding as limited characteristics and number of participants in this study might have an impact on the results of current study.

KEYWORDS

ContraVision, smart manufacturing, user study, scenarios

Introduction

Since the industrial revolution which began in the mid-18th century, the manufacturing industry has been revolutionizing due to the commercialization of electricity and the development of information and communication technologies and automation systems in the late 20th century(Kang et al., 2016). In recent years, the Internet of Things, cloud computing, and big data make it possible to acquire, collect, and analyse large amounts of data to realise smart manufacturing. Data-driven manufacturing can be regarded as a necessary condition for smart manufacturing (Tao et al., 2018). For example, many sensors are deployed in the manufacturing process to collect manufacturing data (Mourtzis et al., 2016). It is even envisioned that wearable sensors will not only collect manufacturing process data but also physiological and other data from manufacturing workers. These data can then be used for various purposes (Hermawati and Lawson, 2019) such as monitoring the workers' well-being, ensuring their safety while collaborating with robots etc. However, capturing and using such data is not without controversy (Trentesaux and Caillaud, 2019; Mancini et al., 2009). Thus, user studies to explore the perception of potential users on such technology is warranted to ensure that users concerns are identified and addressed (Helander, 2006).

ContraVison (Mancini et al., 2010) is a suitable method to explore users' perceptions and acceptance of future technology by presenting both positive and negative aspects of the technology. They reported that this approach elicited a wider spectrum of issues and revealed more facets of the perception that people might have of the technology. It has been used to explore future technology in different context (Mancini et al., 2010; Price et al., 2010; Bennaceur et al., 2016, Marinescu, et al., 2021). Most, if not all, reported ContraVision studies have used videos to present positive and negative aspects of future technology. Using the same scene, the protagonists in the scene will either have positive (utopian) or negative (dystopian) attitudes towards the technology. The advantage of presenting the scenarios in the video format is that there are pictures, music, and speaking, which can trigger the user's vision and hearing at the same time. These give participants a richer three-dimensional experience and result in a more immersive experience. However, producing a video can be expensive, complicated, and time-consuming. On the other hand, producing audio-based or text-based scenarios is simpler, less time-consuming, and less expensive than video production even though they are less immersive than video-based scenarios. In other words, each scenario delivery format has their advantages and disadvantages. Unfortunately, to date, no studies have investigated the implication of using alternative formats, for instance using audio or text, whilst conducting ContraVision user study. Choosing an appropriate format can save time, money, and energy while achieving the goal.

This study aims to fill this gap by studying the effect of scenarios format delivery in a modified Contravision user study and investigates if different scenarios delivery formats (video, audio, text) affect the richness of elicited information from participants. The richness referred to how well each scenario delivery format helps identification of emerging themes related to a future technology in a manufacturing context. It is expected that the results of the study can better inform those who are interested to conduct ContraVision user study which scenarios delivery format they should choose and the implication of their choice.

Methods

The study was designed as between group comparison i.e. video, audio and text group. Thirty participants were recruited and divided evenly into the three groups. Group 1, 2 and 3 were exposed to video-based, audio-based, and text-based scenarios, respectively. Identical scenarios (both negative and positive) were presented in each group and the order of scenarios presentation in each group was also counter balanced i.e. five participants in each group watched positive followed by negative scenario, while the other five were shown the scenarios in the reverse order. The scenarios depicted the experience of a worker in a manufacturing company that used a range of future technology such as wearable sensors, collaborative robot and virtual reality. The videos that illustrates positive and negative scenarios are accessible at https://www.youtube.com/watch?v=G0meV8MjtDs and https://www.youtube.com/watch?v=4XgQAmiT3RY. The audio-based scenarios was created by extracting the audio from these videos whilst the text-based scenarios was created by transcribing from the video format.

There were two pre-requisites of ContraVision study as described by Mancini et al. (2010). The first one was to provide two short videos of the same topic that were: 1) comparable (i.e. presenting the same topic, utilising the same cinematic style and the same number of scenes representing the same situation, location and characters), and contrastable (characters show different attitudes or behaviour with respect to the technology and its adoption). This pre-requisite was met and adhered

to in this study. The second pre-requisite was to only expose a participant to one scenario to avoid carry-over effects between viewings that could contaminate findings from second viewing. This pre-requisite was not adhered to in this study as each participant were exposed to both scenarios. This modification was adopted in order to maximise information elicitation from each participant. Concerns on carry-over effects between viewing were addressed by adopting counterbalancing in the study.

Each participant was presented with each scenario and was given opportunities to view the scenario more than once if requested. Shortly after presenting the scenario, each participant was interviewed and asked the following questions:

- If you are a worker in a digital manufacturing companies (in the video/ audio/ text), do you want to use these technologies in your daily job? And why?
  If the answer is YES: in which way do you think this technology will help you? Or what are its advantages? What potential problems do you think these technologies may have?
  If the answer if NO: in which way do you think these technologies will harm you? Or what are the risks? What potential benefits do you think these technologies may have?
- If you are a manager in a digital manufacturing companies (in the video/ audio/ text), do you want to use these technologies to manage workers? And why?
  If the answer is YES: in which way do you think these technologies will help you? Or what are its advantages? What potential problems do you think this technology may have?
  If the answer if NO: in which way do you think these technologies will harm you? Or what are the risks? What potential benefits do you think these technologies may have?

Due to the limitation of Covid-19, the study was conducted online by Microsoft Teams, Zoom, or other online meeting tools. The interview was recorded and transcribed.

Thematic analysis was used to analyse the data. It is commonly used to analyse qualitative data such as interview results (Evans and Lewis, 2018). Transcription from all participants were read multiple times and preliminary codes were assigned. This was then followed by identifying pattern or themes that emerged from the preliminary codes. The themes were then used to re-analyse the responses from each participant and the number of themes identified by each participant was recorded.

Results

A total of 30 participants, ranged between 20-30 years old of mainly undergraduate and postgraduate students were recruited. 29 of participants were international students (Chinese) and one British. Ten themes were identified from the responses of theses participants. Detailed of the themes are shown below:

1. Benefit (efficiency or capacity): This theme mainly referred to the benefit of using the presented such as improved work efficiency and design efficiency, better products, improved productivity, and convenience as the benefit of the presented future technology. All 30 participants identified this theme.
2. Collaboration and competition: This theme focused on cooperation and competition such as teamwork becoming more efficient, opportunities to communicate with people worldwide, team members having competitive relationships, reducing communication barriers caused by culture. Only 15 participants identified this theme

3. Cost: This theme referred to financial costs incurred to the company when implementing the presented future technology. 25 participants identified this theme.
4. Data security and privacy: This theme was closely related to collection of potentially sensitive personal information. Concerns raised by participants included collection of potentially personal and behavioural data, infringement on privacy, security of collected data, intellectual property rights of collected data, and technology disclosure. 28 participants identified this theme which clearly indicated the importance of this theme.
5. Emergency: This theme referred to circumstances in which the future technology failed or did not work as expected when it encountered an unusual situation. Only 8 participants identified this theme.
6. Human and social factors: This theme referred to the implication of the future technology on future workers and social aspects. A wide range of issues under this theme was identified by participants. Some of the issues were increasing unemployment, lack of employees' engagement with their job, potential for poor employees' work experience, increasing sense of crisis, lack of humane care and dehumanization, uncomfortable working conditions, reduced job satisfaction, insecurity, decreasing enthusiasm, psychological pressure, increased sense of being exploited by companies, increased work-related anxiety, lack of freedom and privacy, etc. 29 participants identified this theme.
7. Machine or data: This theme referred to issues and benefits that were related to machines and data of the future technology. Some identified issued were how well ethics principles were embedded in machines, how often upgrading required for machines, machines' accuracy, sensors' accuracy, how reliable and secure the process related to data backup and the level of machine intelligence. Positive aspects were also identified such as future technology's machine could replace dangerous work, it offered stable performance as they were not affected by emotions. 28 participants identified this theme.
8. Physical and personal safety: This theme focused on the safety of the work environment and personal safety. Participants mainly mentioned the need to ensure employees health and safety, reduce potential risks and hazard on employees, provide hazard warning etc. 24 participants identified this theme.
9. Responsibility: This theme referred to the responsibilities of employees or managers in the company such as employee injury responsibility, system accountability, and clear division of responsibility. Only 6 participants identified this theme.
10. Telecommuting: This theme referred to a specific technology, virtual reality, which was presented in the future technology. 12 participants identified this theme and mentioned the positive aspect of being able to work from home.

Table 1 shows how many themes were identified by each participant in each group. A single factor or one-way between subjects ANOVA was then conducted to compare the effect of scenarios format delivery on number of themes identified. Unfortunately, there was no significant effect of the scenarios format delivery on the number of themes identified by participants in these three groups [$F(2.27) = 0.45$, $p = 0.64$]. Although not significantly different, Table 1 suggests a trend that video offers richer information than audio and text. The table also showed that using audio-based scenarios did not result in elicitation of richer information than text.

Table 1: Number of identified themes by each participant in each group

Participants	Group 1 (video)	Group 2 (audio)	Group 3 (text)
1	9	5	4
2	7	4	7

3	8	8	6
4	6	8	8
5	7	7	8
6	8	7	9
7	7	7	5
8	6	7	7
9	7	8	7
10	6	5	5
Total	71	66	66

The study also found that responses from participants were heavily influenced by participants' background and experience. For example, one participant who put a lot of emphasis on data security and privacy theme mentioned "I study and work in the United States, Americans pay more attention to personal privacy and freedom…". Another participant who highlighted responsibility theme mentioned that "Because I'm not a computer student, I study law, and I tend to find information about the law…. I think that for science and technology development to serve humanity, there must be matching standards and laws to maintain….".

Discussions

As manufacturing becomes smarter, the technology in this sector constantly evolves. It is important to study users' attitudes towards future technology. ContraVision is one of user study methods that is suitable for studying users' views and attitudes towards future. Given that researchers need to consider the cost of time, human and material in conducting ContraVision, it is important that researchers choose the most optimum delivery format or at least understand the implication of their choice. This study showed a trend of video-based scenarios conveying the most information from scenarios and assisting participants to identify more themes, resulting in richer elicitation of information. Scenarios can be conveyed in various forms, such as video, audio, text, graphic storyboards (Nilsson et al., 2020). However, video scenarios make it possible to illustrate a design vision of prospective systems more effectively than written documents or static sketches(Young and Greenlee, 1992). According to previous research, video is more effective at transmitting information than static forms such as text. Albeit not statistically significant, this study's findings supported this.

It was also found that audio and text-based scenarios offered the same level of richness of information. This means that text-based scenarios could be chosen if developing video-based scenarios could not be achieved due to limited resources. Choosing text-based scenarios means that less effort and resources are needed without any impact on the richness of elicited information. This finding was unexpected because, even though the difference between the two was not statistically significant, audio was reported to increase comprehension in comparison to text (Gondy and Kauchak, 2019). It is possible that this was caused by the fact that nine of participants in group 2 (audio) were non-native speakers. It was reported that Chinese students' listening ability was frequently poor in comparison to their reading ability (Juan and Abidin, 2013). Thus, it was possible that participants' poor listening abilities resulted in similar outcome from group 2 (audio) and group 3(text). However, this effect was not seen in group 1 (video) although video also contained audio information. This was likely because participants could use visual clues and made connection between spoken words and images video. Studies have reported that videos have a

significant effect on promoting comprehension even in non-native speakers (Kim, 2015; Mohammadian et al., 2018).

The themes identified in this study suggested that future technology in manufacturing was not necessarily perceived in positive light by participants. As a matter of fact, most identified themes were presented in negative light by most participants. It is highly important that concerns raised by participants are addressed since failure in doing so may result in low trust and acceptance of the presented future technology. It was reported that unaddressed concerns related to privacy and security may lead to users resistance (Mani and Chouk, 2019; Rangarajan et al., 2019). In this study, participants clearly perceived that there was risks involved in the presented technology. It was reported that users' perceived risk have a significant effect on their trust intention which leads to their decision on whether to adopt future technology (Ho et al., 2017).

This study was conducted during the height of Covid-19 pandemic and was mainly done through online meetings. Consequently, the recruitment of participants was challenging, and convenience sampling had to be employed which resulted in the limited characteristics and number of participants. For instance, 29 of the 30 participants were Chinese students. Although these students studied in native English-speaking countries and thus had the ability to understand English, their understanding of English may be poorer in comparison to native speakers. Furthermore, none of the participants had previous work experiences in manufacturing sector. Ideally, user study should recruit participants from a targeted and relevant population to ensure that they were familiar with the context of scenarios that were presented. While there was no general consensus of number participants required in ContraVision study, studies using ContraVision method have reported between involvement of 11 to 134 participants (Mancini et al., 2010; Price et al., 2010; Bennaceur et al., 2016, Marinescu, et al., 2021). Thus, as his study only involved 10 participants in each group, the number of participants in this study could be considered as rather low. Consequently, it could be said that the generalisability of the result of this study was limited and any interpretation of the study results in other context should be taken with care.

In future studies of ContraVision, the researcher believe that the following research directions are worth exploring:

- To conduct a similar study with a higher number of participants.
- To conduct a similar study that matches the language used in the scenarios with participants' mother tongue to reduce potential bias and ensure that participants fully understand the content of the scenarios.
- To ensure that participants background and experience is taken into the account while conducting ContraVision. In this study, it was found that participants' expertise or field of study affected how they perceived the presented scenarios.

Summary

There was no significant effect of the scenarios format delivery on the richness of information that could be obtained from participants in these three groups, although there was a trend that video offers richer information than audio and text. The themes identified by participants' were likely influenced by their background and experience.

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