Sponge.

Virtual reality for workplace learning:

An exploration of learner reaction, knowledge acquisition, retention, and post-learning confidence

Abstract

VR has been rated by the L&D Global Sentiment Survey as the fourth-hottest workplace trend for 2017. But the inevitable question now arising is: 'Is virtual reality for learning just hype?'. VR offers big opportunities for learning, but currently there are few evaluative studies on the usefulness of VR as a learning tool[1]. This exploratory pilot study aims to uncover the relative effectiveness of VR for workplace learning by comparing it against two other popular digital learning media types: an online PDF, and a gamified elearning interaction.

The study compared learner reaction, knowledge acquisition, knowledge retention and confidence, to determine if one online learning method was more effective than another. Our results revealed that participants found VR significantly more enjoyable, significantly easier to concentrate on, and it provided greater learning satisfaction than the other learning interventions. Our results revealed that mobile VR was at least as effective as the online PDF and gamified interaction for knowledge acquisition (out of 10, 9.45 versus 8.70 and 9.36, respectively; $p > .05$) and retention (out of 10, 9.00 versus 7.71 and 7.80, respectively; $p > .05$). In terms of confidence to apply the newly acquired knowledge, VR yielded high confidence ratings that were comparable with the other learning interventions. While further research is needed to verify these findings, this pilot study indicated that VR is at least as effective as the other digital learning interventions, and provides significant benefits in terms of user experience.

Introduction

Goldman Sachs have forecast the education Virtual Reality (VR) market at $700 million by 2025[2], and with VR being rated the fourth-hottest workplace trend for 2017[3], it's no wonder that VR is of significant interest to the learning industry right now. As well as VR being able to transport users to virtual environments they could have only imagined before[4], in a more practical sense, VR can give employees the chance to practise behaviours in a realistic environment and visibly discover the consequences, before actually starting the job.

But the inevitable question that educators and corporate learning departments are asking is - 'Is virtual reality just hype?'. With a recent study reporting that 35% of staff find uninspiring content a barrier to learning online[5], it has never been so important to explore the effectiveness of emerging technologies for workplace learning interventions. The truth is that VR appears to offer big opportunities for learning, but currently there are few evaluative studies on the usefulness of VR as a learning tool[4]. This explorative pilot study sets out to begin our journey into understanding the effectiveness of VR for workplace learning by comparing it to other, more popular methods.

> **"Learning is the process whereby knowledge is created through the transformation of experience"**
>
> Kolb, D. A.[6]

Underpinning learning theories

Before we answer the question 'is VR effective for learning?', we must first understand the learning theories that underpin VR learning. Kolb's Experiential Learning Theory[6] states that learning involves the acquisition of abstract concepts that can be applied to a range of scenarios. The development of a new concept is formed from new experiences. Kolb says, "Learning is the process whereby knowledge is created through the transformation of experience"[6]. Therefore, in order to learn, we need to have a concrete experience, reflect on that experience, make abstract conclusions and then actively experiment with the new information by applying what was learned and observing the result[7]. The concept of learning from experience is also echoed in Knowles' Principles of Andragogy[8], which states that encountering experiences, including mistakes, provides the basis for learning. Thus, it would seem logical to create learning interventions that replicate real-life learning experiences as closely as possible, without the risks that comes with mistakes. VR gives us this ability[9].

The validity of VR as a pedagogically effective method of learning is also supported by Constructivist Learning theories[10], which state that knowledge is constructed by learners through experience and activity[11]. Learning should be experiential and applicable to real-life scenarios[12]. There is a growing body of evidence that supports the connection between VR and Constructivist principles[13 - 17]. VR can unlock learning affordances that were not previously possible, including the ability to teach people through life-like experiences[18].

With VR, learners are able to interact with a simulated environment in real time[19] and treat that environment in the same way they would the real world[20]. These technical capabilities support Constructivist Learning principles by giving the learners an active role in their learning and thereby building up their knowledge based on experience[21].

While the use of VR for learning appears to be underpinned by experience-based learning theories, it is also important to understand the nuances delivered by VR that enhance the learning experience. A key factor seems to be presence.

Presence

Presence is a 'fundamental property of consciousness'[22], and in terms of virtual reality, 'presence' refers to the sensation of being present in a virtual environment, even though you know your body is physically located elsewhere[23]. Despite the fact that people know they do not really exist in the virtual environment, they still consciously react to the virtual events as if they are real[24]. But presence does not just stop at the sense of existing in the virtual environment, it also refers to a user's ability to interact with that environment[24]. By creating life-like experiences in VR that are authentic enough to evoke a sense of presence, it is now possible to blur the conscious barrier between the real and virtual worlds[24]. This means mental representations and experiences can be formed and later recalled, informing real-world knowledge and enhancing performance[25 - 27].

Use in formal education

Research shows there is a growing trend to utilise VR in formal education[28 - 30]. Educators have used 3D modelling and virtual realities to teach abstract concepts[31]. Positive outcomes have been reported in educational studies that used VR to teach subjects such as anatomy[32, 33], geosciences[34], physics concepts[35] and improved writing skills[36].
An explanation for the positive effect of VR for learning has been attributed to a reduced extraneous cognitive load, which allowed learners to focus on actively processing the informative material[37]. However, other studies have discovered greater learning outcomes with 2D simulations compared with 3D virtual worlds, due to distractors in the virtual world[38]. This suggests that creating overcomplicated experiences can inhibit learning. This implies that any virtual world needs to be thoughtfully designed to enhance the learning, rather than distract from it. The research also suggests that VR is particularly suited to learning that is enhanced by multiple perspectives of the same scenario[39]. It is also useful for subjects that require problem solving ability and creativity[40].

Although these educational studies can give some interesting insights into practical applications for the use of VR training, many of the studies in this area are based only on desktop VR experiences. Desktop VR is a 3D image that can be explored via a keyboard, mouse, joystick or haptics on a desktop computer[41, 42], and although realistic graphics have been shown to enhance engagement in learning, they do not provide the fully immersive experience that can be achieved in a state-of-the-art VR headset[43]. Education is likely to be restricted by less immersive technology due to financial feasibility[44]. However, there are indications of higher adoption in fully immersive VR training in the medical industry.

> **VR needs to be thoughtfully designed to enhance the learning, rather than distract from it.**

Medical use cases

As one of the biggest adopters of VR[45], there is a large body of research about the use of VR in the healthcare sector. VR has been utilised in medicine for a range of different purposes, such as surgery simulation, phobia treatment, robotic surgery and skills training. VR training has particular appeal in healthcare, as errors impact on human life. VR training for surgical skills was first proposed in 1993 by Satava[46]. Since then research has shown that medical practitioners who underwent training using VR simulations demonstrated improved dexterity and performance when undertaking real surgery, compared with control groups[47 - 49]. VR has helped medical students learn about anatomy by giving them the chance to explore delicate organs that would usually involve expensive cadaver dissection[50]. VR has also been claimed to be as effective as traditional methods that involve dissection and reading text books[51].

VR for workplace learning

As demonstrated, evidence around the effectiveness of VR for academic learning is positive according to early adopters. However, there appears to be a distinct lack of research around the effectiveness of VR training in the organisational workplace. Any worthwhile innovation for learning should begin with solid pedagogy and be robustly examined against other methods before it can be widely accepted[52]. VR in the workplace is gaining increasing popularity, research attention and application[40]. Therefore, it is becoming increasingly important to undertake theory-based research to explore the principles and guidelines that can aid the learning industry in producing effective VR-based learning[53].

In terms of workplace learning, VR training has seen success in topics such as crisis and emergency management, as it offers a cost-effective alternative to live simulations. When training for high-pressure situations, there is a need for training to simulate the cognitive overload and pressure that is likely to be encountered in practice[54].
To demonstrate competence in crisis management, VR creators need to evoke an emotional state that is similar to that experienced in real life, as emotions have a strong impact on decision-making and problem solving. But creating live situations is only possible for a few possible scenarios and can be complicated and expensive[55].

A 2014 study carried out on police officers compared a virtual training environment to a real-life simulated training environment and a control group[55]. They found that the virtual training environment yielded the same learning transfer as the standard training, and was significantly more effective than the control group. This study suggests that virtual training environments, such as VR, could make a cost-effective substitute for real-world simulated practice.

Successful results with VR training are not limited to crisis and emergency training. VR has outperformed conventional learning methods when training workers in manual skills for assembly tasks[56], high-risk procedures for powerline maintenance[57], safety procedures for construction workers[58] and safe behaviours in the mining industry[59]. The Health and Safety Executive reported an annual spend of £4.8 billion on workplace injury in Britain in 2015[60]. So, it stands to reason that it is worth investigating more effective safety training for other high-risk industries, such as agriculture, forestry, construction, manufacturing, retail, and transportation. However, despite this emerging evidence, there is still very little research into the validity of VR training compared to other methods.

The Sponge study

As demonstrated, studies are beginning to indicate the effectiveness of VR training for specific workplace scenarios that pose significant risk and require practice[56 - 58]. However there is currently not enough evidence that focuses on modern head-mounted VR interventions to clarify whether VR training can live up to the perceived hype for broader workplace learning.

We aim to compare a mobile VR training experience for street fundraisers to other, popular digital learning interventions.

Research question

We argue that mobile VR can be used to teach observational skills and decision-making. The aim of our study is to compare three types of digital learning methods:- an online PDF, a gamified elearning interaction, and a mobile VR experience - to determine which online learning method is most effective for workplace learning.

As there are currently no standardised methods for evaluating VR training, we constructed outcome measures based on Kirkpatrick's model for training evaluation[61], which recommends evaluating reaction, learning, behaviour and results, to determine learning effectiveness.

Our outcome measures are listed here:

- **Reaction:** We measured learner reaction and engagement by assessing levels of enjoyment, ability to concentrate and learning satisfaction.
- **Learning:** We measured learning using post-learning assessments. We captured knowledge acquisition immediately after the training and learning retention a month later.
- **Behaviour and Results (Confidence for application):** As this was a pilot study on participants who would not have the opportunity to execute the training in the workplace, we could not explicitly measure behaviour and results. Therefore, in our study we asked participants to rate their perceived confidence for application.

Methodology

Participants

Participants were recruited through advertising on Sponge social media and via an email from Plymouth University Careers' Service. The participants were paid £5 for their initial participation. Participants who completed the knowledge retention follow-up survey were entered into a draw for the chance to win a £50 Amazon voucher, which was awarded at random.

Participants were randomised 1:1:1 to the PDF learning condition, the gamified condition or the mobile VR condition.

Digital learning methods

The content used in this study was workplace training on the rules and regulations of street fundraising. In particular, we focused on the learning outcome: "By the end of the experience, learners should understand the rules about who they are allowed to approach whilst street fundraising". This learning content and outcome was chosen due to its ability to be communicated across all three learning methods and its clear, measurable learning objective.

We produced three different learning experiences that were all based on the same content:

- **PDF document:**
  a four-page online document that specified the rules of who street fundraisers are allowed to approach.
- **Gamified interaction:**
  an illustrated gamified interaction consisting of a brief introduction that explained the rules of the game, a binary yes/no interaction where learners had to decide whether they were allowed to approach that person (illustrated character), followed by a 'hotspot' feedback where learners could see which questions they had got right/wrong and learn the correct response.
- **Mobile VR experience:**
  an interactive 360 degree video displayed on a smartphone in a mobile VR headset. It consisted of an introduction from a virtual presenter, followed by an interaction where users had to spot people to approach and make a binary choice whether they were or were not allowed to approach the person, then instant video feedback on their decision.

Procedure

The study design is summarised in Fig. 1. The study was conducted in two stages:

Stage 1
Pre- and post-learning survey

A written brief was given to each participant on arrival and written consent was obtained. Each participant was assigned to a computer to fill out the pre-learning survey on their own. Once the participant had completed the pre-learning survey, a researcher read them scripted instructions and presented them with their randomly allocated learning intervention. In each condition, participants were told they could take as much time as they needed on the learning experience, and that they would be asked questions about the experience afterwards. Once the participant had finished the learning experience, they were asked to fill out the post-learning survey. After the post-learning survey was completed participants were supplied with a paper copy of a mini debrief, paid and thanked for their time.

Stage 2
Follow-up retention survey

One month after the learning experience, participants were emailed the online learning retention follow-up survey, which contained the same 10 questions used for knowledge acquisition. This survey was completed by participants at home in their own time. Participants were given three days in total to complete the follow-up survey. Once the deadline for responses had passed, one participant was awarded the £50 voucher and all participants received a full written debrief.

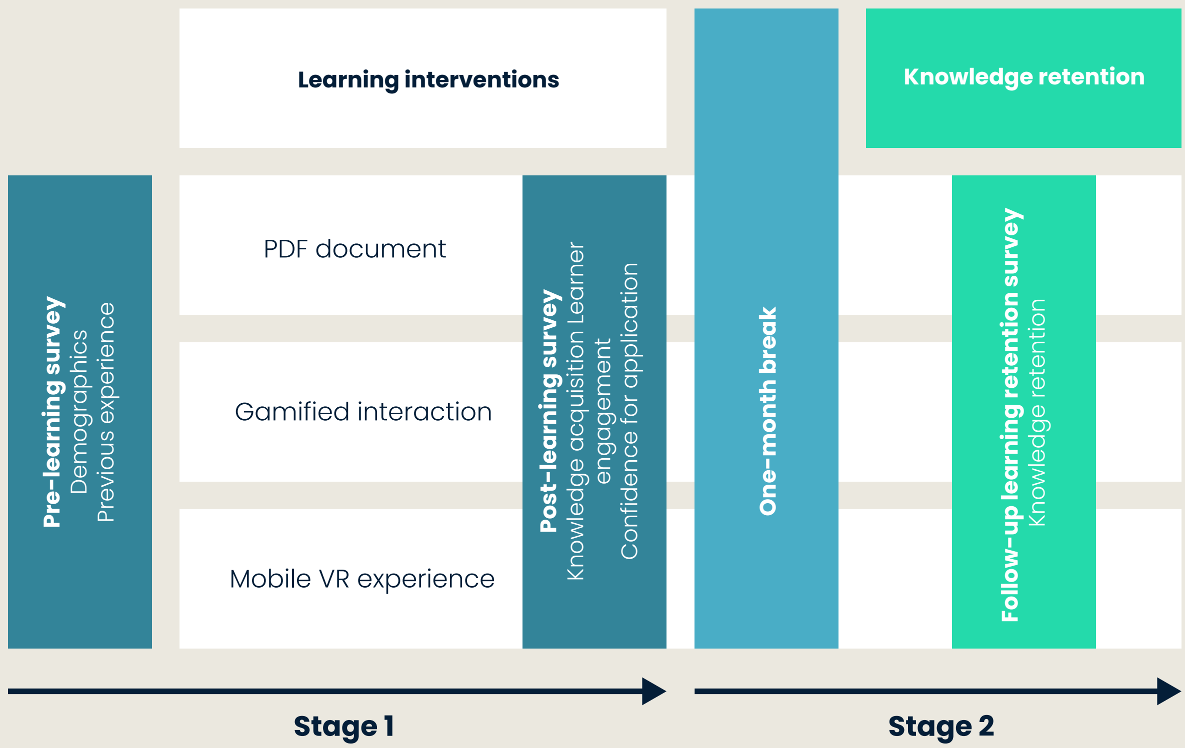


Fig.1. A model summarising the study design

Outcomes

As mentioned above, outcomes were assessed via three online surveys in total. The first was conducted before the learning experience, the second was given immediately after, and the follow-up learning retention survey was emailed to participants one month after the learning experience. The surveys contained the following sections:

1. Pre-learning survey
   1.1. Participant demographics
   1.2. Fundraising experience
   1.3. Virtual reality experience
2. Post-learning survey
   2.1 Learner reaction/engagement – 7-point Likert-scale, self-report questions on enjoyment, learning satisfaction and concentration.
   2.2. Learning acquisition and confidence – 10 questions about the learning objectives that should have been attained from the learning experience; each question was followed by a confidence rating
   2.3. Perceived confidence to apply – three Likert-style questions about learners' confidence in their current knowledge, confidence for application and confidence in one month's time
   2.4. Memorability of experience questions
   2.5. Perceived value of the learning - opinion-based questions
3. Learning retention follow-up survey
   3.1. Learning retention and confidence – the same 10 questions from the learning acquisition section about the learning objectives were asked again one month later; each question was followed by a confidence rating

Statistical Analyses

A p value of <.05 was adopted as the significance threshold throughout all statistical analyses. Data normality was tested for all experiments using the Shapiro-Wilk Test for normality. Skewness and kurtosis were examined, as were boxplots and histograms. The distribution of data between groups was measured by a Levene's test to check homogeneity of variance for data that was normally distributed. A one-way ANOVA was used to test the homogeneity of variance for non-parametric data. Where the data was not normally distributed, non-parametric alternatives were used.

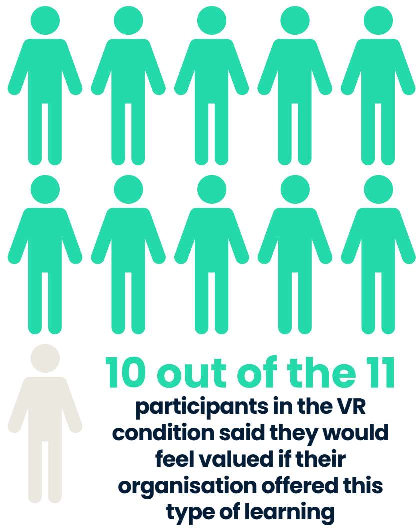
Results

Participants

Thirty-two adult volunteers participated in the initial part of the study: 10 participants encountered the PDF learning condition, 11 participants were in the gamified condition and 11 participants were in the mobile VR condition.

Of the original 32 participants, 19 (59%) took part in the follow-up knowledge retention survey. There were 7 participants in the PDF condition, 5 participants in the gamified condition and 7 participants in the mobile VR condition.

The average age of the participants was 24.19 years. Ninety percent of the participants were full-time students. The participants' previous experience of street fundraising was measured. Of the 32 participants 53.1% had worked for a charity before and 21.9% had taken part in street fundraising before. However, after interrogating the participants' charity experience no participants were excluded from the study as their experience was not directly related to the street fundraising outcomes that were being tested against in this study.



Learner Reactions

Our enjoyment subscale consisted of 10 items, our concentration subscale consisted of 7 items, and our learning satisfaction subscale consisted of 10 items. As the scales used were created with a mixture of questions from existing scales we tested the reliability of our scales with Cronbach's Alpha. All subscales were found to be highly reliable with Cronbach's alphas of .97, .87, and .90 respectively. The results from the survey are displayed in Table 1 below.

Table 1

Learner mean reactions (on a 7-point Likert scale)

Reactions	**PDF** M (SD)	**Game** M (SD)	**VR** M (SD)
Enjoyment	3.82 (1.46)	5.46 (.95)	6.46 (.69)
Concentration	4.99 (1.19)	6.10 (.53)	6.66 (.40)
Satisfaction	4.60 (.86)	5.59 (.71)	6.55 (.39)

Enjoyment

As shown in Table 1, on average the VR group scored highest for enjoyment, followed by the game, followed by the PDF. The PDF had the widest range of responses. A Kruskal-Wallis H test showed that there was a statistically significant difference in enjoyment between the different learning groups, $\chi^2(2) = 16.36$, $p < .001$, with a mean rank enjoyment score of 8.15 for the PDF, 15.91 for the game and 24.68 for the VR experience. Post-hoc tests revealed that the VR group scored significantly higher for enjoyment than the game group, and the game group scored significantly higher than the PDF group to a level of $p < .05$.

Concentration

Again, on average the VR group scored highest for concentration, followed by the game, followed by the PDF (see Table 1). A Kruskal-Wallis H test showed that there was a statistically significant difference in concentration between the different learning groups, $\chi^2(2) = 14.49$, $p = .001$, with a mean rank concentration score of 8.8 for the PDF, 15.73 for the game and 24.27 for the VR experience. Post-hoc tests revealed that the VR group scored significantly higher in concentration than the game group, and the game group scored significantly higher than the PDF group to a level of $p < .05$.

Learner satisfaction

In terms of learning satisfaction, VR again scored highest, followed by the game, followed by the PDF, as displayed in Table 1. A one-way ANOVA was conducted to evaluate differences in learner satisfaction between the groups. There was a statistically significant difference between groups as determined by one-way ANOVA $F(2, 29) = 21.69$, $p < .001$. Post-hoc tests revealed the VR group scored statistically higher for satisfaction rating than the game group, and the game group scored statistically higher for satisfaction ratings than the PDF group, both to a level of $p < .05$.

Learning

We measured knowledge acquisition directly after the learning experience and knowledge retention one month later.

Knowledge acquisition

Results are shown in Figure 2.

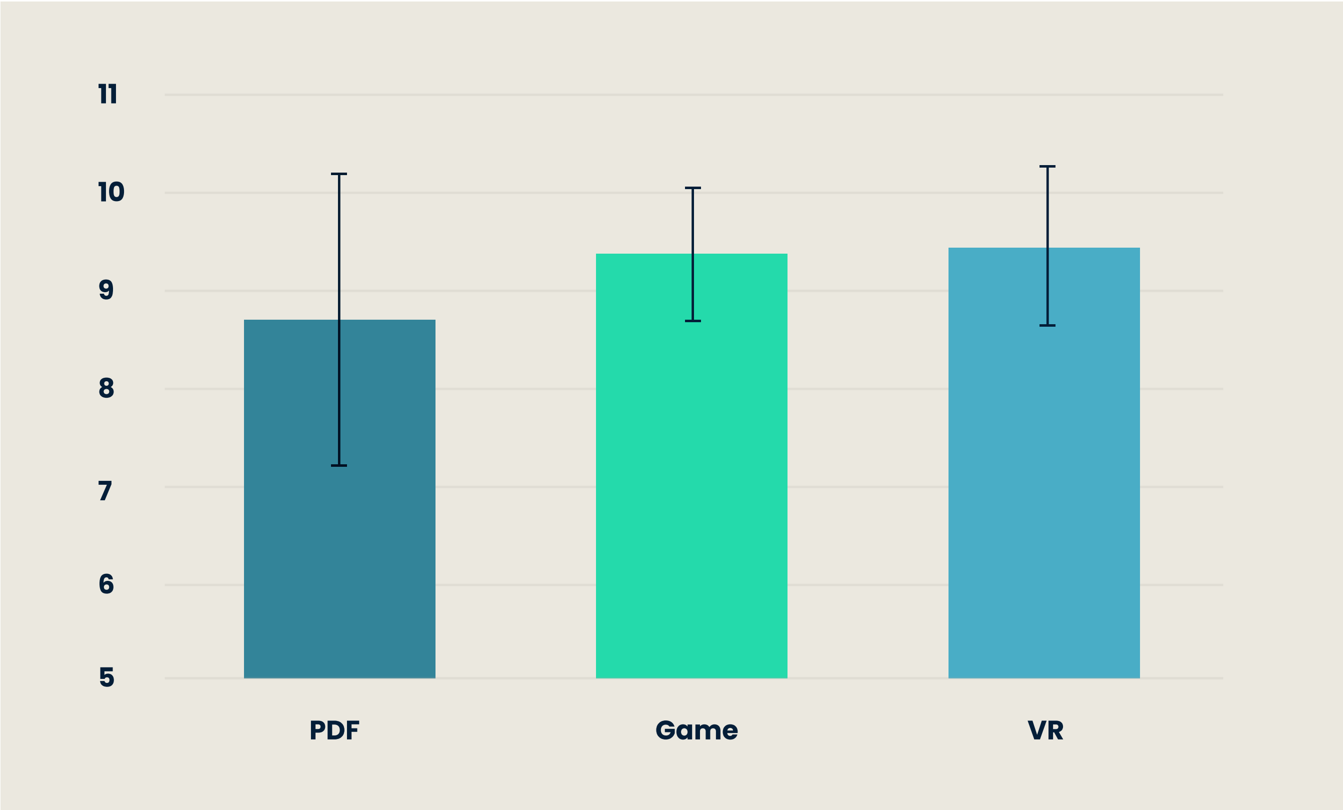


Fig. 2. Mean (SD) score out of 10 for knowledge acquisition immediately post learning

A Kruskal-Wallis H test was used to measure the difference in knowledge acquisition between the groups. The test showed no significant difference in knowledge acquisition between the different learning groups ($p > .05$).

Although the difference was not statistically significant, numerically, the VR condition ($M = 9.45$) produced the highest knowledge acquisition score followed by the game ($M = 8.70$), followed by the PDF ($M = 9.36$). This provided some evidence for our hypothesis that VR is better placed to teach observational skills and decision-making than traditional techniques.

Knowledge retention

Results are shown in Figure 3.

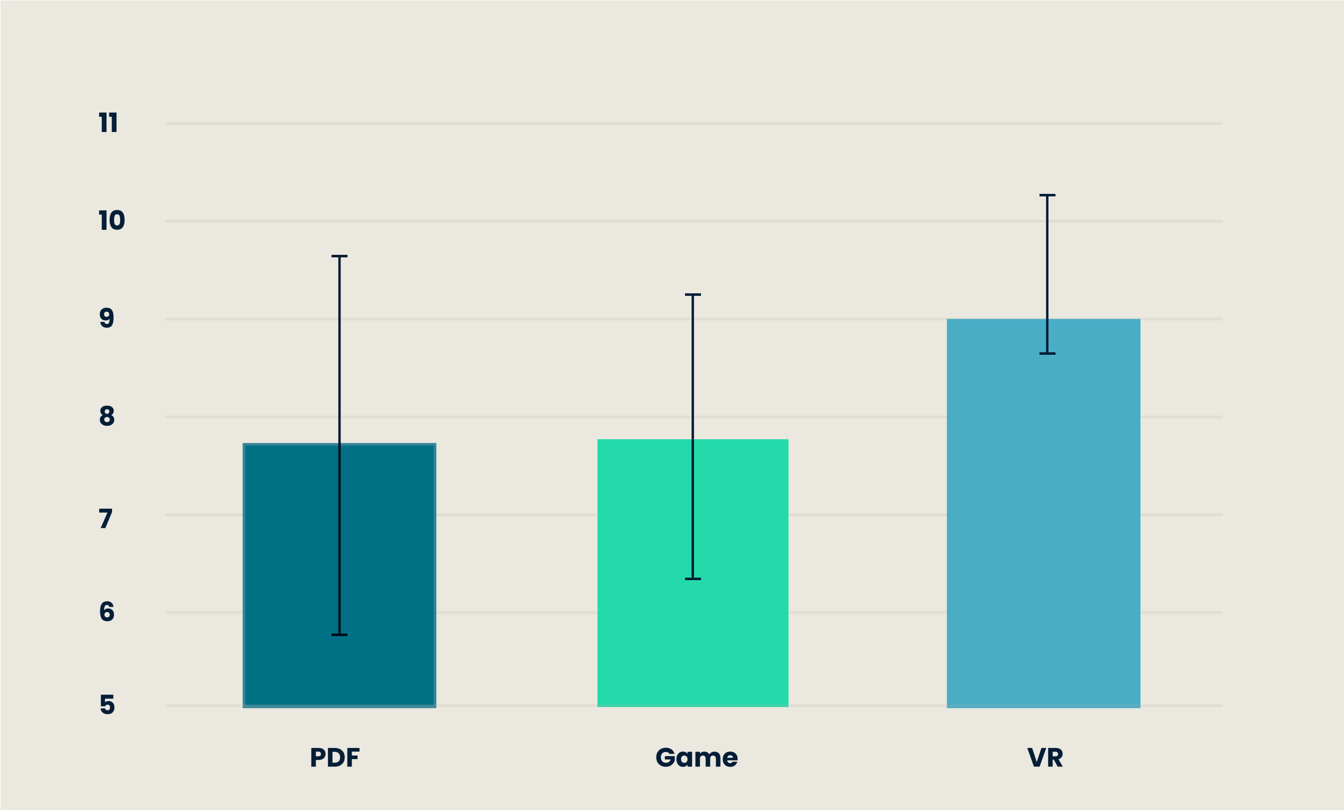


Fig. 3. Mean (SD) score out of 10 for knowledge retention at one month

A one-way ANOVA was used to measure the difference in knowledge retention between the groups. The test showed no significant difference in knowledge retention between the different learning groups ($p > .05$).

Again, although the difference was not statistically significant, the VR learning condition led to better knowledge retention ($M = 9.00$) than the game ($M = 7.80$) or the PDF ($M = 7.71$). Although non-significant, VR scored, numerically, markedly higher, which provided some evidence for our hypothesis that VR learning increases knowledge retention.

Confidence

Perceived confidence for application

As shown in Table 2, perceived confidence was similar across all three conditions for the first two questions. However, on the third question "How confident would you feel if you were tested on your knowledge of who to approach in a month's time?" the game group displayed the highest level of perceived confidence, followed by the VR, and the perceived confidence in the PDF condition was lowest.

The difference in confidence between the groups in question three was statistically significant, $\chi^2(2) = 8.27$, $p = .016$, with a mean rank score of 10.55 for the PDF, 21.05 for the game and 17.36 for the VR experience.

Post-hoc tests revealed that the game group scored significantly higher in perceived confidence than the PDF group. However, there was no significant difference between the VR and PDF group, or the VR and game group ($p > .05$).

Table 2

Confidence for application questions (on a 5-point Likert-scale)

Reactions	PDF M (SD)	Game M (SD)	VR M (SD)
Confidence in knowledge	3.82 (1.46)	5.46 (.95)	6.46 (.69)
Confidence in application	4.99 (1.19)	6.10 (.53)	6.66 (.40)
Confidence in one month time	4.60 (.86)	5.59 (.71)	6.55 (.39)

Confidence in responses

No significant difference was found between the groups in terms of confidence in their responses for the knowledge acquisition or knowledge retention questions ($p > .05$).

Discussion

To help strengthen the case for the use of VR in workplace learning, we conducted an exploratory pilot study which compared a VR learning intervention against more traditional digital learning techniques for the workplace (a PDF and a gamified interaction). We explored participants' reaction to the learning in terms of enjoyment, ability to concentrate and learning satisfaction. We also looked at how the different learning interventions affected participants' ability to acquire and retain the information, and their perceived confidence for application.

Our results demonstrated participants had a significantly more positive reaction towards the VR learning intervention than the other techniques. We also found that mobile VR is at least as effective for learning, in terms of knowledge acquisition and retention, as the popular methods of PDF reading and a gamified interaction. With an average score of 9.45 out of 10 for knowledge acquisition and 9 out of 10 for knowledge retention, this suggests that our VR intervention was a success for teaching the observational skills and decision-making associated with street fundraising. In terms of confidence to apply what was learned, VR yielded high confidence ratings that were comparable to the other learning interventions.

While not statistically significant, VR scored numerically higher than the PDF and game for both outcomes, suggesting that VR is at least as effective, and potentially more effective, than the other methods. We believe the lack of significant difference between the groups could have been due to the small sample size. We also noticed that knowledge acquisition and retention scores were high across all groups, which may suggest that a larger, more difficult, robust measure of learning was needed. In the future, we would like to replicate the study with a larger sample size, more difficult and diverse questions, and even a broader learning experience. We would also include a control group that does not receive any training to evidence that learning has occurred after the learning interventions.

Although our data only numerically indicated that a VR learning intervention was more effective in terms of learning, our study did demonstrate a significant impact on learner reaction and opinion. Our results revealed that participants found VR significantly more enjoyable, significantly easier to concentrate on and found it provided greater learning satisfaction. Learning measures alone will not always prove that knowledge gained in training will be applied. Holton[62] explains that the transfer between learning and performance is dependent upon the person's motivation to learn, as well as the transfer design and climate. Studies have shown that when learners have a positive attitude towards the training, they are more likely to encounter knowledge transfer[63]. Further studies have found that organisational learning culture is associated with job satisfaction and motivation to transfer learning64, which highlights the importance of giving employees interesting and positive training experiences which motivate and inspire them to apply the learning. Interestingly, 10 out of the 11 participants who took part in the VR condition said they would feel valued if their organisation offered this type of learning experience.

Therefore, the greater positive reaction seen from the VR condition could have a positive impact on learning outcomes as well as learning engagement.

In terms of confidence, our participants demonstrated an equal level of perceived confidence across all the learning conditions. According to Bloom's Taxonomy65 there are six levels to the cognitive domain. The learning outcomes from the street fundraiser example used in this study only required the first two stages, remembering and comprehending, making the learning relatively simplistic. All three learning condition groups rated high confidence on average, which suggests that all three learning interventions provided sufficient levels of information to give participants confidence in their knowledge. However, if this same study was carried out with more complicated learning outcomes that involved mastery, we may have seen more variation in the participants' perceived confidence to apply.

Taken together, our results suggest that VR training at a minimum can be as effective for learning as standard digital learning interventions. It provides the same level confidence, and the results suggest it may even provide higher levels of knowledge acquisition and retention. Furthermore, VR training evokes a more positive reaction towards the learning and increased learner engagement, which may be expected to improve future application of the acquired knowledge.

So, to answer the question 'does VR live up to its hype?' Our pilot study indicates that for observational learning and decision-making it does provide learners with a more positive learning experience than other techniques, and yields good levels of knowledge acquisition, retention and confidence. However, our exploratory study has only really scratched the surface of VR's potential for learning.

Our study was based on mobile VR as this is an affordable and accessible method to deliver VR training across large organisations. However, there are a wide variety of VR technologies that can be utilised, such as desktop VR, fully immersive room-scale VR and the addition of haptics to increase the immersive experience. To fully understand VR's capability for learning we need to begin exploring these associated emerging technologies; not just to emulate current practices, but to create new, pedagogically sound practices[66].

Organisations are beginning to realise that workplace learning can be used to achieve long-term strategic goals, instead of just short-term objectives[67]. But to understand the impact of learning, we need to gather empirical evidence around the effectiveness of these newer learning interventions. Currently there is a lack of evidence in learning and development, and although this pilot study is a very small step towards gathering more empirical data around learning techniques, we are keen to embrace the power of research. If evidence around the effectiveness of different learning interventions can be gathered as they emerge, we can foster a culture of evidence-based practice based on solid pedagogy.

As a next step, we are keen to explore the effectiveness of mobile VR further, with a larger participant group. We would also like to explore learning outcomes beyond that of knowledge acquisition and retention. Ideally, we would be looking to see how VR training truly affects workplace performance in real employees. As emerging technologies continue to emerge, we have a duty as learning professionals to explore how technologies can be utilised and transformed into meaningful learning experiences.

This study has demonstrated that VR is beginning to show great potential for workplace learning in terms of decision-making and observation. But it is important not to believe that VR is a one-size-fits-all solution. More research should be conducted into what type of learning subjects benefit most from VR methods. To innovate, we need to embrace a spirit of discovery, be ready to explore new technologies and techniques, and begin creating more exciting learning experiences that make a difference to employees. This study only required the first two stages; remembering and comprehending, making the learning relatively simplistic. All three learning condition groups rated high confidence on average, which suggests that all three learning interventions provided sufficient levels of information to give participants confidence in their knowledge. However, if this same study was carried out with more complicated learning outcomes that involved mastery, we may have seen more variation in the participants' perceived confidence to apply.

Conclusion

In conclusion, the rationale for using VR techniques for learning is underpinned by learning theories such as Kolb's Experiential Learning Theory[6], Knowles' Principles of Andragogy[8] and Constructivist Learning theories10. VR for learning has already seen success for early adopters in formal education[34, 35] and in healthcare[47 - 49]. Studies are beginning to demonstrate the effectiveness of VR for very specific workplace learning needs that involve great risk[54 - 58], but there is still not enough research the focuses on more general workplace learning needs. Our pilot study aimed to compare a VR training experience for street fundraisers to two other popular digital learning methods: a PDF reading task and a gamified interaction.

Our pilot data suggested that VR is a valid and effective method for workplace learning when teaching observational skills and decision-making. Our research demonstrated that learners are significantly more engaged by a VR learning intervention. The results indicated that VR may be more effective for learning, in terms of knowledge acquisition and retention, than a PDF or a gamified interaction. We also found that VR delivered comparable levels of learner confidence. We concluded that VR delivered a greater learning experience compared to the other techniques as the content is significantly easier to concentrate on and the overall experience delivers higher enjoyment and learning satisfaction.

> **Our research demonstrated that learners are significantly more engaged by a VR learning intervention.**

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hello@spongelearning.com

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