The Potential of Augmented Reality (AR) for Defects and Safety Hazards Prevention in Architecture, Engineering and Construction (AEC) Industries

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In recent years, information technology has been developing at a rapid pace and offering many new applications in various industries such as Architecture, Engineering and Construction (AEC) (Wang, Huang, Liao, & Piao, 2018). As a new application, Augmented Reality (AR) is becoming increasingly prevalent in these industries (Rankohi & Waugh, 2013). AR technology has the capability to project and overlay 3D digital models onto physical space, while providing the user with visual simulations of the digital information (Feng & Chen, 2019). These researchers further indicate that AR visual simulations can improve learning during construction education, training (Wang et al., 2018), and enhance workers' quality and productivity (Chalhoub & Ayer, 2018). In view of this growing trend of AR technology, this article explores the potential of AR in the AEC industries, particularly in the areas of defect prevention and safety.

In the AEC industries, defects and safety hazards are prevalent throughout all phases of a project, most notably during the construction stage (Josephson & Hammarlund, 1999). They cause delays in the completion of a project, and incur additional manpower, time, and costs to amend. Traditional means of prevention requires multiple resources to be invested into monitoring and identifying construction defects (Gordon, Akinci, & Garrett, 2007). According to Feng & Chang (2019) and Park & Kim (2013), AR visualisations offer better opportunities than traditional drawing mediums which have difficulties communicating complex construction information clearly. Information communicated through AR mediums helps workers in identifying safety hazards, defects and allowing better analysis of severities and implications (Li, Yi, Chi, Wang, & Chan, 2017).

The causes of defects and hazards can be attributed to a multitude of factors occurring on the individual, organisational, and project levels. While the fundamental cause defects and its prevention can be difficult to identify, the direct causes can primarily be attributed to the individual, as an experienced personnel can possibly be trained in defect-prevention initiatives (Lopez, Edwards, & Davis, 2010). Subsequently, an organisation or management is considered to be a co-ordinated group of personnel, exemplifying the responsibility of the individual's role in preventing defects (Josephson & Hammarlund, 1999). Lastly, the progress of the project depends on smooth communication between many

complex processes across the project occurring simultaneously, a challenge for individuals working independently to fully comprehend at any moment (Lopez et al., 2010).

The individual's condition can be further split into three inter-related variables: motivation, knowledge and information (Josephson & Hammarlund, 1999). Motivation assumes that the individual has the desire to perform to the best of his abilities; knowledge refers to having the appropriate skills and experience; whilst information refers to the concise instructions that allow the individual to have a clear understanding and comprehension (Josephson & Hammarlund, 1999).

Notably, AR simulations contributes mostly to the information variable, because better information can improve the individual's motivation and knowledge (Josephson & Hammarlund, 1999). Students using AR simulations have displayed better levels of engagement and concentration during learning (Wang et al., 2018) and improvements in their abilities to visualise and identify defects and hazards (Le, Pedro, Pham, & Park, 2016). Identified defects and hazards can be easily communicated through an AR-BIM integrated system between the worker on site and the officer off-site so appropriate measures can be conceived (Park & Kim, 2013).

Research studies show that AR visual simulations are effective for improving workers' performance and preventing defects and safety hazards during construction (Chalhoub & Ayer, 2018); enhancing the clients' visual communication with the designer and contractor; and assisting architects to identify errors during the design phase (Lopez et al., 2010). In addition to visual simulations, AR can be incorporated with 'environment scanning technology' to become Mixed Reality (MR), an adapted form of AR with computational tools capable of enhancing its capacity to identify and monitor defects (Feng & Chen, 2019).

In conclusion, AR visual simulations can enhance the individual's understanding of project information, improve motivation, knowledge, and performance. AR can improve the productivity and quality of building projects in the AEC industries.

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