

UNIVERSITI TEKNOLOGI MARA

**METaverse IN DENTISTRY:
DEVELOPMENT AND EVALUATION OF META-
OHE FOR ORAL HEALTH PROMOTION AND
EDUCATION**

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ABSTRACT

Introduction: Oral diseases remain among the most prevalent non-communicable diseases globally, disproportionately affecting adolescents due to behavioural vulnerabilities and socio-environmental risk factors. Despite the long-standing implementation of school-based oral health programmes by the Ministry of Health (MOH) in Malaysia, national data continue to report high caries and gingival disease prevalence among secondary school adolescents. Traditional oral health education (OHE) methods—typically delivered through didactic talks and printed materials—have limited effectiveness in engaging today’s digital-native youth. While mobile health (mHealth) interventions such as SMS or WhatsApp have offered incremental improvements, they often fail to provide immersive, experiential learning capable of sustaining behavioural change. This dissertation addresses critical gap by developing and evaluating Meta-OHE, the Metaverse-based oral health education platform tailored for adolescents. **Methods:** This study employed a Design and Development Research (DDR) framework with three phases: (1) Need Analysis, (2) Design and Development, and (3) Evaluation. Mixed-methods were applied throughout. In the Need Analysis phase, a systematic review following PRISMA guidelines examined the use of immersive technologies in oral health education in oral health promotion. Additionally, 12 in-depth interviews with international and local experts and 16 focus group discussions involving 81 adolescents were conducted. In the Design and Development phase, the Meta-OHE platform was built using Mitoworld and Spatial platforms through a proposed nine-phase model. Meta-OHE module content was developed using the ADDIE model and validated by experts and end-users. Usability testing was performed with 10 beta testers using a validated 10-item SUS-based instrument. A user acceptance survey ($n = 478$) analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). In the Evaluation phase and a three-arm quasi-experimental study ($n = 220$), comparing Meta-OHE against WhatsApp-based and conventional OHE on oral health knowledge and attitude. **Results:** The systematic review highlighted those immersive technologies consistently improved knowledge, attitudes, and engagement but lacked theoretical grounding, adolescent focus, and lack of interventional studies on Metaverse in improving oral health. Expert interviews identified six facilitators (e.g., technological readiness, experiential learning) and six barriers (e.g., infrastructure, data privacy), and five recommendations (e.g, sectoral collaboration, improve training and awareness). FGDs confirmed adolescents’ strong interest in Metaverse-based learning and yielded 12 youth-informed design elements integrated into Meta-OHE. Usability testing showed excellent system performance (mean SUS score = 83.3, SD = 4.03). The PLS-SEM model demonstrated high explanatory power ($R^2 = 0.616$ for Behavioural Intention) with significant paths for Attitude ($\beta = 0.328$, $p < 0.001$), Perceived Usefulness ($\beta = 0.225$, $p < 0.001$), and Perceived Price ($\beta = -0.108$, $p = 0.008$). Household income moderated certain relationships, but gender had no effect. In the quasi-experimental study, Wilcoxon tests showed significant improvements within all groups ($p < 0.001$). Quade’s ANCOVA and post hoc analysis confirmed that Meta-OHE achieved significantly greater gains in knowledge and attitude compared to other groups ($p < 0.001$). Meta-OHE participants achieved good post-intervention mean scores (Knowledge: $M = 19.55$; Attitude: $M = 17.58$). **Conclusion:** Meta-OHE demonstrated high usability, strong acceptance, and superior effectiveness compared to mHealth and traditional methods. Grounded in behavioural theory and co-designed with end-users, it advances the evidence-based for immersive oral health promotion and education.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Oral diseases particularly dental caries and periodontal conditions constitute a major global public health burden, especially among children and adolescents, and pose a significant and serious economic burden (Petersen et al., 2005b; Righolt et al., 2018). Untreated dental caries remains the most prevalent health condition worldwide, while severe periodontal disease affects nearly 10% of the global population and often results in tooth loss (Bernabe et al., 2020; Kassebaum et al., 2014). Globally, an estimated 60% to 90% of school-aged children suffer from dental caries (Petersen et al., 2005b), and approximately 1.2 billion adolescents representing 16% of the global population are particularly vulnerable to oral health issues (World Health Organization, 2024).

In South-East Asia, the situation is especially concerning, with the World Health Organization (WHO) reporting that between 70% to 95% of school-aged children are affected by dental caries (WHO, 2013). In Malaysia, the National Health and Morbidity Survey (NHMS) 2017 estimated that adolescents aged 10 to 19 years comprise approximately 5.5 million individuals, or 18% of the national population (Institute for Public Health, 2018). The same survey reported a dental caries prevalence of 33.3% among 12-year-old schoolchildren, while earlier national oral health surveys highlighted high levels of gingival bleeding, with over 98% of children requiring oral hygiene instructions (Oral Health Division, 2017). While Malaysia is progressing toward the national target of 70% caries-free prevalence among 12-year-olds as outlined in the National Oral Health Plan 2011–2020 more efforts are needed to sustain and improve oral health among adolescents (Oral Health Division, 2017). Although Malaysia is on track to achieve the national objective of having 70% of 12-year-olds caries-free as outlined in the National Oral Health Plan 2011-2020, with an average ‘Decayed Missing Filled Teeth’ (DMFT) score of less than one, a time-series analysis study predicted that the caries-free prevalence among 16-year-old schoolchildren in Malaysia would plateau, showing little change in the coming decade, which is concerning (Najihah et al., 2023). However, a lot still needs to be done to ensure that