Table 4. Metaverse intervention and its outcomes (N = 15).

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| --- | --- | --- | --- | --- | --- |
| **Authors (Year)** | **Type of metaverse** | **Settings** | **Interventions** | | **Kirkpatrick outcome evaluation** |
| **Courses** | **Examples of strategies (based on the TPACK\* model)** |
| Alhonkoski et al. (2021) | VR | Clinical skills/Clinical Practicum/ Laboratory | Not reported | TPK: 3D environment, 3D image, 3D hologram, & 3D printing  PCK: Use of gaming, images, simulation, or video strategies to teach how to perform clinical skills, increase interactions, and/or care for a variety of illnesses  TCK: Anatomy, disaster environment, EKG, NG tube placement, IV catheter insertion, medication administration, neonatal resuscitation, pharmacology, and spinal cord patient movement | * Level 1: Emotions, perceptions * Level 2: Knowledge, skills |
| Chen et al. (2020) | VR | Not reported | Fundamentals of nursing | TPK: Digital Clinical Experience or VSim® and hardware such as wearable haptics  PCK: Gaming, multimedia, simulation, or standardized patients used to promote confidence, improve knowledge in clinical scenarios, impact performance time and/or skills satisfaction  TCK: Advanced health assessment, decontamination, deterioration, IV insertion/injection, pulmonary disorders, and urinary catheterization | * Level 1: Satisfaction * Level 2: Knowledge, confidence, skills * Level 3: Performance time |
| Choi et al. (2021) | VR | Laboratories | Not reported | TPK: iVR using wearable haptics such as Oculus Rift and platforms such as Unity 3D and Google cardboard  PCK: Use of gaming, simulation, or video to enhance cognitive performance in clinical situations and/or psychomotor skills  TCK: Basic life support, IV insertion, needlestick prevention, and urinary catheterization | * Level 1: Anxiety, fear symptoms, learning attitude, motivation, satisfaction, user reaction, usability, familiarity * Level 2: Confidence, cognitive learning, critical thinking, performance, knowledge, psychomotor skills |
| Coyne et al. (2021) | VW | Classroom | Critical care and maternity | TPK: VS using platforms such as First2ACT WEB™, iSimulate and CliniSpace  PCK: Implementation of simulation via gaming and/or simulation to create a safe environment for learning and enhance clinical competence across several disciplines in areas of confidence, knowledge, and/or skill performance  TCK: General assessment, communication, COPD assessment, deterioration, hypoglycemia management, maternal assessment, management and evaluation of care, pre-eclampsia assessment, and triage | * Level 1: Attitude towards poverty, perceived ease of use, satisfaction, self-reflection, student evaluation, user-ability * Level 2: Knowledge, situation awareness, self-confidence, performance change, ISBAR (Introduction, Situation, Background, Assessment and Recommendation) rating, performance evaluation * Level 3: Performance (community home visit) |
| De Gagne et al. (2013) | VW | Classroom/  Clinical | Community nursing theory and clinical courses: pediatrics & public health | TPK: Mainly Second Life®  PCK: Implementation of simulation and/or live chats to educate on health care concepts, scenarios, and/or specific skills  TCK: Child health, community nursing, insulin therapy, interviewing skills, patient transfers, pre-eclampsia, trauma training | * Level 1: Self-reflection on understanding self-reflection on skill development, ease of use, realism, satisfaction, benefits, and barriers * Level 2: Confidence, knowledge, skills * Level 3: Performance (emergency medicine crisis resource management) |
| Fealy et al. (2019) | VR | Not reported | Not reported | TPK: Immersive VR (ie, use of Head Mounted Devices (HMD) products or CAVE systems  PCK: Assessment of skill accuracy, speed and /or skill retention via gaming and/or simulation  TCK: CPR and urinary catheterization | * Level 1: Satisfaction (comfort and learning with technology, system’s usability, reaction) * Level 2: Skill retention |
| Foronda et al. (2020) | AR  VR | Classroom/  Clinical/  Laboratory | Acute care nurse practitioner, adult health, fundamentals of nursing, ill-health, mental health, pediatrics, pediatric nurse practitioner, pharmacology, and public health | TPK: VCS and VS used with platforms such as Second Life®, Digital Clinical Experience™, and I-Human®, and free webtools (Mooshak)  PCK: Use of gaming, debriefing, multimedia, and/or simulation to promote engagement, knowledge (affective, application, cognitive, content, retention), and/or skills (accuracy, retention)  TCK- Communication, conflict management, deterioration, interviewing, IV venipuncture, life support training, leadership styles, maternal-newborn, pediatric respiratory content, perioperative care, and poverty | * Level 1: Anxiety, attitude, debriefing experience, fear, overall experience, perceived preparedness, quality evaluation, satisfaction, self-reflection, socialization and valuing, self-efficacy * Level 2: Clinical judgment, clinical teaching effectiveness, clinical decision making, collaborative competency, decontamination ability, emergency preparedness, self-confidence, transcultural self-efficacy, ability to perform on Objective Structured Clinical Examination |
| Irwin & Coutts (2015) | VW | Didactic/  Clinical simulation facility | Not reported | TPK: Second Life®  PCK: Simulation used for concept application in clinical scenarios to improve understanding and/or engagement in a safe environment  TCK: Assessment skills, birth, communication, decision-making skills, interviewing, leadership, lateral violence, mental health, patient safety, and rapid sequence intubation | * Level 1: Reaction, effectiveness, engagement * Level 2: Capacity to rescue, emergency crisis resource management, knowledge, performance in leadership and communication, transferability, skills (using a Capacity to Rescue Instrument in a clinical simulation facility) |
| Jallad & Işık (2021) | VR | Clinical/  Didactic | Adult health- advanced health appraisal, maternal health, and pediatrics | TPK: PILL-VRS, vSim®, and wearable haptics  PCK: Use of debriefing, gaming, and /or simulation to help to learn knowledge (acquisition, application, retention) and/or procedural skills during clinical scenarios and in certain health care environments  TCK: Adult health, decontamination, disaster training, IV insertion, IV pump skills, medication administration, maternal health, operating room/surgical fire safety, pediatrics (postoperative appendectomy care), phlebotomy, tracheostomy suctioning, and urinary catheterization | * Level 1: Anxiety, debriefing experience, fear, perceptions, preparedness, presence, satisfaction, usability * Level 2: knowledge on hazardous materials, fire safety, intravenous catheterization, pediatric care, decontamination, IV performance, self-confidence, self-efficacy, perioperative skills |
| Kim et al. (2021) | MR | Not reported | Not reported | TPK: Unity Engine (platform), HoloLens (visual device)  PCK: Use of simulation in a laboratory setting during various clinical scenarios or during the performance of procedures to improve critical thinking, knowledge, satisfaction, skills, and /or self-confidence  TCK: ICU monitoring, emergency situation, fire situation, lab scenario, patient assessment, and myocardial infarction | * Level 1: Satisfaction * Level 2: Assessment of patient needs, clinical performance, critical thinking, motivation, safety, self-confidence |
| Plotzky et al. (2021) | VR | Not reported | Not reported | TPK: A variety of haptic devices used such as HTC Vive and Oculus Rift  PCK: Use of simulation methods to support emergency response training, psychomotor skills, soft skills, and/or systematic procedures training  TCK: Auscultation, communication, decontamination, emergency response, empathy (dementia care), needle stick prevention, perioperative concepts, endotracheal suctioning, urinary catheterization, and wound care | * Level 1: Satisfaction * Level 2: Critical thinking, self-confidence, soft skills, emergency response, standard operating procedures |
| Rourke (2020) | VR  AR | Not reported | Not reported | TPK: VR headset or monitor, haptic device  PCK: Utilization of simulation to improve elements of psychomotor skill (ie, underpinning knowledge and/or skill performance)  TCK: Urinary catheterization and venipuncture | * Level 1: Not reported * Level 2 Knowledge, skill performance, time to complete skill |
| Shin et al. (2019) | VR  VW | Didactic/  Practicum | Pharmacology | TPK: Second Life®, Unity 3D, vSim®  PCK: Implementation of simulation and/or debriefing to share information and/or teach care of patients and/or clinical skills/procedures to improve cognitive, psychomotor, and/or affective outcomes  TCK: Adult health, asthma patient care, clinical reasoning, communication, decision making, decontamination, disaster management, interprofessional competencies, patient safety, pediatrics, pharmacology, pre-eclampsia, and wayfinding | * Level 1: Satisfaction * Level 2: Clinical performance skills, cognitive, competency, psychomotor skills, self-confidence, self-efficacy skills in communication, leadership, professionalism, and teamwork |
| Shorey & Ng (2021) | VW | Didactic/  Clinical | Not reported | TPK: iVRS and dVRS using Pill-VR, Second Life®, Shadow Health, vSim® with haptic devices  PCK: Use of gaming, simulation and/or standardized patients to teach clinical and/or nonclinical skills as well as management of disease processes to increase knowledge and/or psychomotor performance  TCK: Advanced health assessment, aseptic technique, blood transfusion, clinical management of COPD, decontamination, management of infant respiratory distress, IV insertion, maternal newborn (pre-eclampsia, group b strep), medication administration, patient deterioration management, phlebotomy, and urinary catheterization | * Level 1: Attitudes on poverty, fear, presence, perceptions, satisfaction, trait anxiety * Level 2: Cognition, confidence, instructional effectiveness and wayfinding confidence level, pediatric care knowledge, student learning on clinical deterioration, performance-blood transfusion, IV, psychomotor skills, preparedness, self-efficacy, proficiency, self-confidence, wayfinding ability |
| Woon et al. (2021) | VR | Not reported | Not reported | TPK: Low to high immersion VR training using computers with haptic devices and mobile applications  PCK: Mainly use of self-guided experiences of immersion to increase knowledge of clinical skills/procedures and/or management of disease processes  TCK: Aseptic technique, blood transfusion, care of cardiac, respiratory, and urinary patients, COPD, hypertension, decontamination, gastric lavage, heart valve anatomy, IV insertion, maternal newborn, medication administration, pediatric respiratory management, triage procedures, tracheostomy care, urinary catheterization, and vital signs | * Level 2: Knowledge |

Note: 3D = three-dimensional, AR = augmented reality, dVRS = desktop virtual reality simulation, iVR = immersive virtual reality, iVRS = immersive reality simulation, MR = mixed reality, VR = virtual reality, VW = virtual worlds, VS = virtual simulation, VCS = virtual clinical simulation, VRS = virtual reality simulation.

\*TPACK = technological pedagogical and content knowledge, PCK = pedagogical content knowledge, TCK = technological content knowledge, TPK = technological pedagogical knowledge (Koehler & Mishra, 2009).

\* Level 1 reaction is the degree to which participants find the training favorable, engaging, and relevant to their job. Level 2 learning is the degree to which participants acquire the intended knowledge, skills, attitude, confidence, and commitment based on their participation in the learning event. Level 3 behavior is the degree to which participants apply what they learned during training when they are back on the job. Level 4 results are the degree to which targeted outcomes occur as a result of the training and the support and accountability package (Kirkpatrick & Kirkpatrick, 2016).