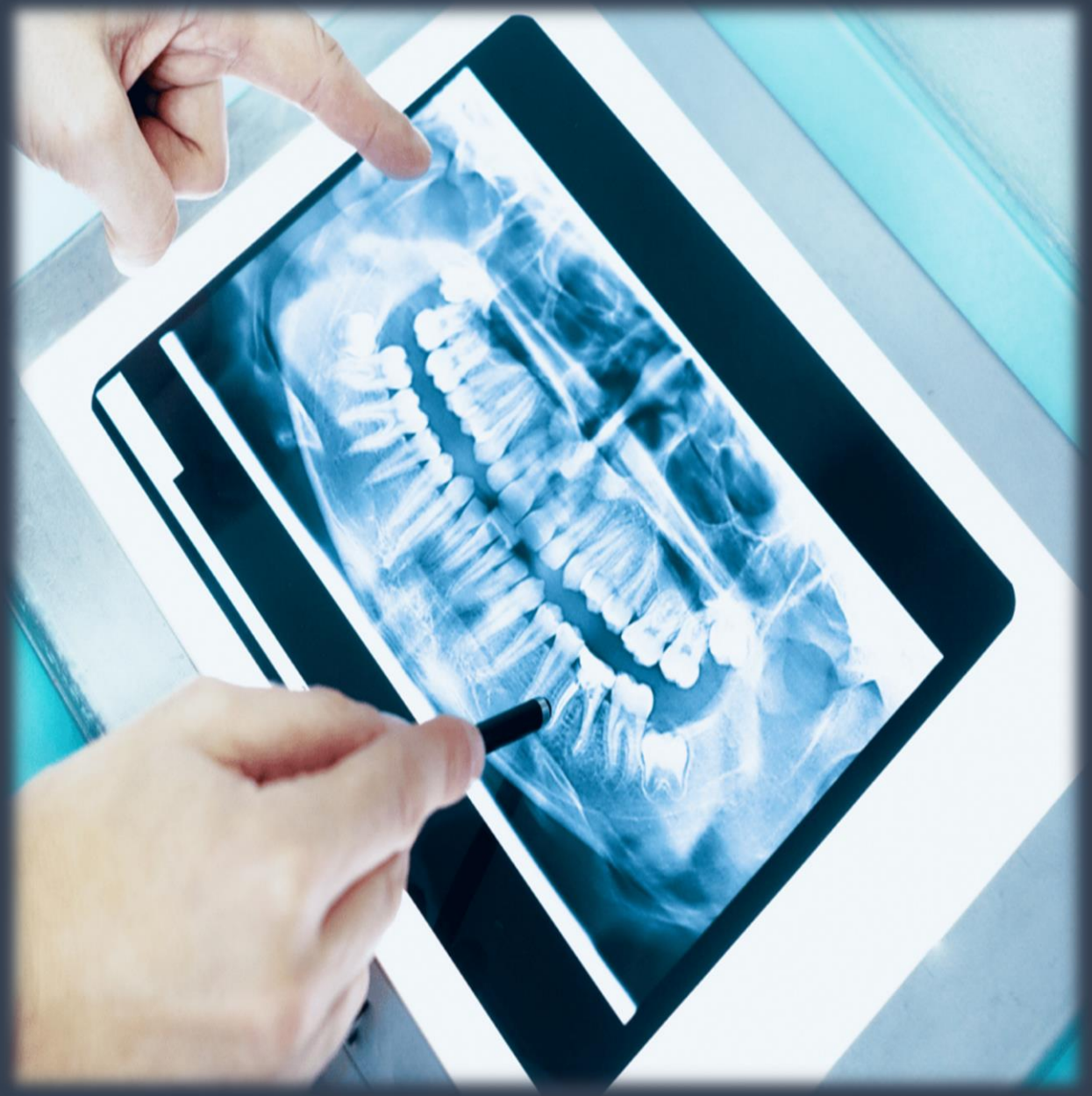

Virtual Patient Simulator for Skill Training in Dentistry

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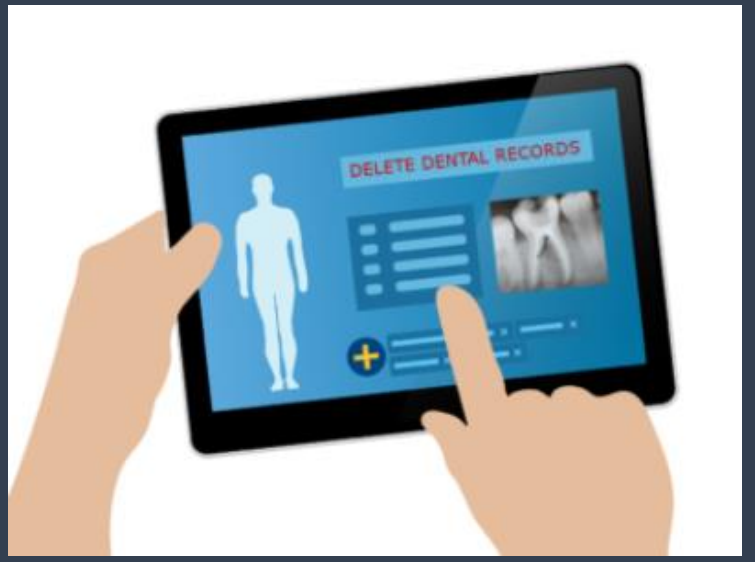
Background

Dental Students

- Appropriate patient assessment is a basic skill that would be required in any clinical discipline.
- This includes proper history taking, adequate examination of the patient and the decision on the required investigations.

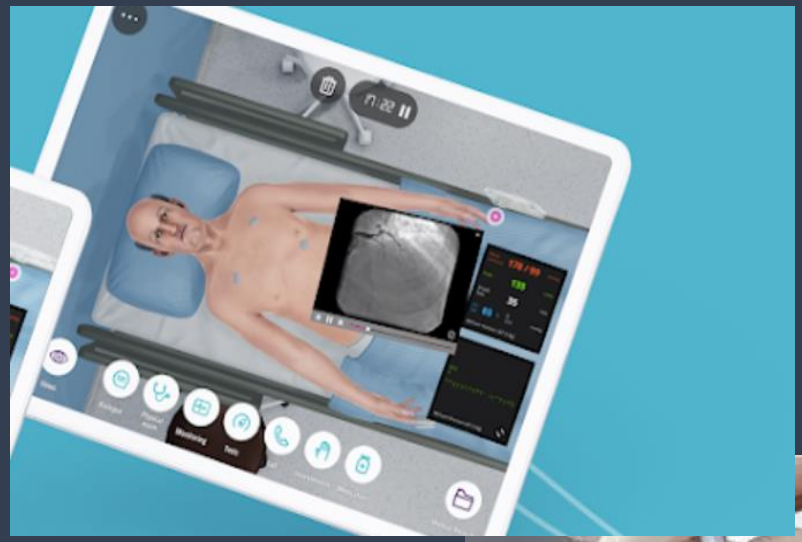
Manikin Patients

- Manikin patients are used for repetitive and deliberate practice
- Record keeping, reproducibility, assessment



Motivation

1. Need for training in adequate
    1. Patient assessment
    2. Clinical reasoning methods
    3. Problem based decision making
2. Less human resources
3. Less chances for a real time tutoring system to improve skill training



Methodology

- Virtual simulators were considered under different approaches
  - Haptic based devices and non-haptic based devices
  - Problem based learning(PBL) approach -> PBL+ Intelligence tutoring systems(ITS)
  - Medical related works -> Dentistry related works
  - Multimedia systems -> apply 3D graphics
  - Clinical training and clinical reasoning skills
  - Game engines -> use game engines in implementation of medical simulators
- Key words
  - Problem-based learning, Dentistry, Virtual patients, Game engines, Virtual simulation
- Resources from

  Google scholar, PubMed

Related Work

- **Web-SP[1]** - A system of Web-based Simulation of Patients
- **COMET[2]** – Combination of ITS and computer-supported collaborative learning
- **Virtual World(VW)[3]**- 3D environment for students to work collaboratively
- **Virtual Patient Collection(VPC)[4]**- Analyse VP scenarios integrated into the combined internal medicine and surgery curriculum
- **Virtual reality training simulator(VRTS)[5]** –Haptic based simulator for tooth preparation practise
- **Virtual Learning Environment (VLE)[6]** - Diagnosis and treatment planning in dentistry
- **ALICE[7]** - A Web-based immersive virtual patient, students can move around a virtual environment in the first person, much as in a video game
- **AI Chatbot[8]** – A virtual patient with a conversational chatbot with AI

1. Urresti-Gundlach, M., Tolks, D., Kiessling, C., Wagner-Menghin, M., Härtl, A., & Hege, I. (2017). **Do virtual patients prepare medical students for the real world? Development and application of a framework to compare a virtual patient collection with population data**

2. Suebnukarn, Siriwan & Haddawy, Peter. (2007). **COMET: A Collaborative Tutoring System for Medical Problem-Based Learning. Intelligent Systems**

3. Jivram T, Kavia S, Poulton E, Hernandez AS, Woodham LA and Poulton T (2021) **The Development of a Virtual World Problem-Based Learning Tutorial and Comparison With Interactive Text-Based Tutorials**

4. Urresti-Gundlach, M., Tolks, D., Kiessling, C., Wagner-Menghin, M., Härtl, A., & Hege, I. (2017). **Do virtual patients prepare medical students for the real world? Development and application of a framework to compare a virtual patient collection with population data. BMC medical education**

5. Jung, H., Kim, H., & Moon, S. (2018). **Virtual reality training simulator for tooth preparation techniques.**

6. Janda, M. S., Mattheos, N., Nattestad, A., Wagner, A., Nebel, D., Färbom, C., & Attström, R (2004). **Simulation of patient encounters using a virtual patient in periodontology instruction of dental students: design, usability, and learning effect in history-taking skills.**

7. Kleinert, R., Heiermann, N., Plum, P.S., Wahba, R., Chang, D.H., Maus, M., Chon, S.H., Hoelscher, A.H. and Stippel, D.L., 2015. **Web-based immersive virtual patient simulators: Positive effect on clinical reasoning in medical education**.

8. Suárez, A., Adanero, A., Díaz-Flores García, V., Freire, Y., & Algar, J. (2022). **Using a Virtual Patient via an Artificial Intelligence Chatbot to Develop Dental Students' Diagnostic Skills.**

Virtual Patient Classification

Class label	Predominant competency	Predominant technology	Related implementations
Case introductions	Knowledge	Multimedia systems	Web-SP
Interactive Patient Scenario	Clinical reasoning	Multimedia systems	VPC, VLE
Gaming environment	Clinical reasoning and Team training	Virtual worlds	Virtual World
High Fidelity Software Simulation	Procedural or basic clinical skills	Dynamic simulations or mixed reality	VTRS
High Fidelity Manikin	Procedural and basic clinical skills, /Team training	Manikins or Part Task Trainers	COMET, ALICE
Virtual Standardized Patient	Patient communication skills	Conversational characters	AI chatbot

Kononowicz, A. A., Zary, N., Edelbring, S., Corral, J., & Hege, I. (2015). **Virtual patients-what are we talking about? A framework to classify the meanings of the term in healthcare education.**

Analysis – Functional comparison

Features	Techniques	Web-SP	COMET	VW	VPC	VRTS	VLE	ALICE	AI Chatbot
Haptic-based						✓			
Introduction to the system	Instructions in text					✓			✓
	Instruction in video			✓				✓	
History taking	Textual	✓		✓	✓	✓	✓	✓	✓
Examination and investigation	Textual		✓	✓	✓		✓	✓	✓
	Selecting from drop-down list	✓							
	Providing resources with 3D images			✓		✓			
	Providing resources with 2D images	✓	✓				✓	✓	
	Proving resources with videos							✓	
PBL			✓	✓					

Analysis – Functional comparison

Features	Techniques	Web-SP	COMET	VW	VPC	VRTS	VLE	ALICE	AI Chatbot
Chat System (with the patient)	Textual			✓			✓		✓
Tool Selection	3D images			✓		✓			
Diagnosis	Only diagnosis		✓	✓					
	Diagnosis with treatment instructions	✓				✓	✓	✓	
Feedback System	Textual	✓	✓	✓		✓	✓		✓
	Access to the previous diagnosis	✓							
	Case feedback for the tutor						✓		
Individual Supervision	Tracking log	✓					✓		
	Evaluation					✓	✓	✓	✓

Analysis –Technical comparison

- Chat system

System	Technology/Programming Language	Remarks
VW	virtual world Second Life (SL) by Linden Labs	• Detection of keywords in the question. • Text-chat and voice communication • Use Standard Boolean operators • Add alternative wordings identified from prior PBL experiences
VLE	PHP	• Data calls are handled on server side over the Internet • Searches a database for answers • delivers response as text, sound, image or movie to the student
AI chatbot	Dialog flow application	• Detection of keywords in the question • Use natural language processing algorithms • Capable of understanding the nuances of human language by learning through action and feedback

- 3D Images

System	Technology/Programming Language	Remarks
VW	virtual world Second Life (SL) by Linden Labs	• Create avatars • “holodeck” tool – For large variety of rooms or scenarios in limited space
VRTS	Unity3D	• TC Vive Pro VR headset is used

- Evaluation

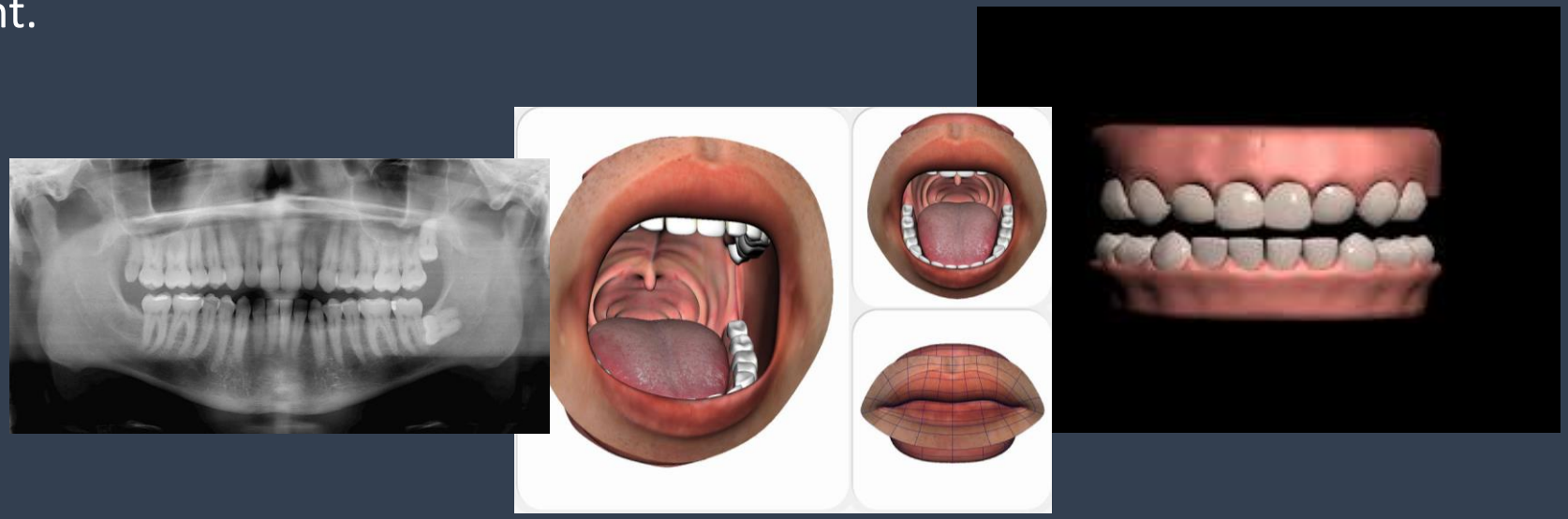
System	Technology/Programming Language	Remarks
ALICE	SPSS software package version 20	• Analyse performance in the pre- and postquestionnaire data
COMET	Bayesian network, Conditional probability tables	• BNs to model individual student knowledge and activity

Research Gap 01.

- When presenting the scenario with 2D images stored in a database, it limits the learning areas of the student.
- 3D images will give more sense in visual aids than 2D images in patient examination.
- Generating 3D images, system by itself will be an advantage for the admin.

Proposed system:

- Implementations of system generated 3D images, radiography, etc. for different cases to be referred by the student.
    - Use game engines



Game Engines

Unity 3D

- Cross-platform integration
- Assest store management
- Use C#

Id Tech4

- Normal Mapping and Specular Highlighting
- Virtual Texturing
- Use C++

Source Engine

- Large degree of mod-ability
- Industry-leading facial expression technology
- Use C++

Unreal Engine

- Ability to create hyper-realistic environments
- Immersive virtual worlds
- Use C++

Marks, S., Windsor, J., & Wünsche, B. (2007, December). **Evaluation of game engines for simulated surgical training**.

Generating 3D images

Unity 3D can be identified as the most efficient game engine

Create or generate the 3D model inside the Unity 3D	Create or generate the 3D model externally
Unity photogrammetry Authoring digital assets of original real-world objects	**3Ds Max** A software purely used for 3D modeling Commercial Tool
Unity ProBuilder A unique hybrid of 3D modeling and level design tools	**Maya** Strong in animation Commercial Tool
Unity Terrain 3D terrain visualization of GIS data	**Blender** Free game development engine

Research Gap 02.

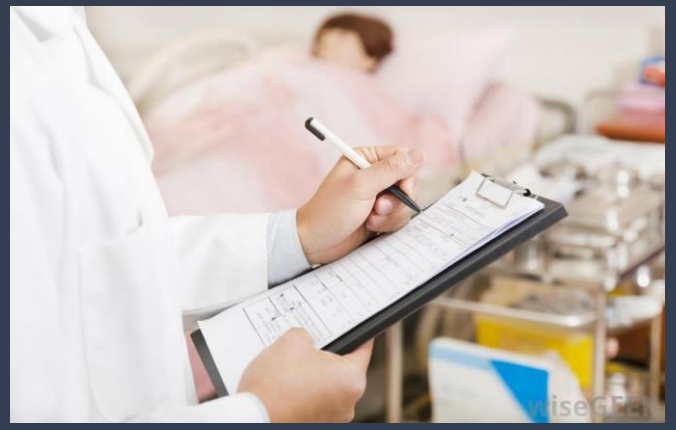
- Student assessment system needs a detailed feedback than just giving an evaluation

- **Proposed System**
  - Improved and efficient feedback systems with case by case feedback system for students.

Research Gap 03.

- For better analysis of the performance of students, keeping records is important.

- **Proposed System**
  - Records of history of students including tracking logs, activity logs, evaluations, etc. for the admin.(ex: University, Institute)



Recaps

- Virtual patient systems has been implemented using various approaches
  - Ex : haptic based, web-based, chat system, virtual patient
- Systems for student skill training can be implemented with evaluation and feedback systems
- Game engines can be utilized to design a manikin patient system including 3D graphics

Thank You