Project on the first phases of User-Centered Interactive Systems Design methodology and prototype design.

**“Teaching and interactive assistive elements with augmented reality.”**

1. **The idea:**

When comes to teacher needs, in order to analyze and demonstrate a mechanical, electrical or any other structure, the most preferable way is to show all the main parts that system consists of and analyze their properties braking apart the structure or virtually present each part over a screen. The problem that arises, is that students are not familiar with the whole system or structure and it’s hard for them to understand and realize how all parts coexist and counteract.

Geometric visualization, spatial perception of problems and geometric reasoning have always been regarded as essential skills for engineering students, but students always encounter problems of lack of visualization skills in the learning process. AR and MR technologies provide a promising approach to solve such problems and have been used to help students with object visualization problems[1]. For example, the building information model (BIM) has been used in construction engineering and architectural education for long, where drawbacks in the teaching of BIM are well-known, such as students being unfamiliar with the field operation and decision-making process. MR presents an object in a three-dimensional (3D) representation of its two-dimensional (2D) sketch. Compared with traditional direct observation, students’ visualization skills have improved a lot[2].

Likewise, a possible solution could be an assistive presentation of that system’s assembly with the help of AR or MR, so the teacher shall show both units and parts of a system together with the system assembly in a real time manner. Thus, students shall be able to realize the system straightforwardly and avoid misconceptions. Furthermore, students with different background and skills level, can exercise and realize the system presented with a quiz page that provides information with a depth relevant to their academic level.

So far, a lot of work has been done by the so called ‘3d industry’[3]–[5] *(AR, VR, Gaming and Marketing development by technical artists and Lead 3D Programmer’s collaboration)* presenting extensive educational solutions with 3d models and animations usually integrated into proprietary software (See: Appendix A). As such, 3d graphical entities, 3d animations, 3d simulations and 3d elements on presentations have become mainstream[6]–[9]. However, there is a very high cost that significantly limits utilization by common users. Open-source software communities like [Open 3D Engine (o3de.org)](https://www.o3de.org/), [Blender](https://www.blender.org/?msclkid=ace9ea22a7c111ec8e51d2dc564e7298), [Godot](https://godotengine.org/?msclkid=c945f652a7c111ecb47c993864126466), Unreal engine plugins, [Unity Open Projects](https://unity.com/open-projects#:~:text=Unity%20Open%20Projects%20is%20a,a%20development%20project%20is%20like.), [Panda3D](https://www.panda3d.org/), [VPython](https://vpython.org/?msclkid=6dc85380a7c211ec9da46b44f850f5e9), etc., are evolving to reach a broader audience though. Inevitably, cost-effective solutions are to an increasing extent for portable AR and VR technologies provided by smartphone-based mobile applications providing tremendous potential for education[10], [11]. AR and VR can both be used effectively to teach science-based information. However, AR and VR have their own set of strengths and weaknesses that should be considered while integrating these technologies into learning environments[12]–[15].

Thus, to mitigate the side effects of these complex architectures and their special requirements, an easier and smarter way is to create customized web applications appending layers of 2d, 3d or pseudo-3d images over a basic background layer. [ …todo]

1. **Ideas from users in relation to the proposed system**

We define the typical users of the system to two main categories: i) Educators and ii) Scholars. Teachers/Educators shall use the proposed system as an assistive tool to improve the efficacy of their job. Scholars, however, shall use the system as a training tool that can provide valuable feedback to former category at the same time, too.

We also ran a survey questionnaire to evaluate these typical user profiles: see Appendix A [todo].

* 1. **Questionnaire results**

As expected, the results of our survey, ….[todo].

Pie graph? /presentation…[todo]

1. **The basics of design** [todo**]**
   * Hardware:
     + Public: Hosting services (e.g., Hostinger, Amazon AWS)
     + Testing – Private: Localhost
     + No external 3d visualization device needed, but would be nice as a future option
   * Software:
     + Angular.js
     + Three.js (library for 3D rendering) \*\*Too complicated for now\*\*
     + JavaScript
     + bootstrap
     + HTML, CSS
   * Input/Output devices:
     + Desktop: mouse (left-click, hover, scroll)
     + Mobile: touch
   * Technical Restrictions:
     + Mobile: no hover
     + WIMP (Windows, Icons, Menus, Pointers) easy to use interface
2. **User Requirements Specification.** [todo]
   1. **Personas:**

**Persona 1:** Kikkos Kikkou (Technical School Educator):

Gender: Male, Age: 52, Married with 4 children, 11 years at education public sector, 12 years at heavy-duty tractor services, Basic computer knowledge, basic English language knowledge, BSc Mech. Engineering, Teaches a series of automotive technology lessons, likes sports.

As an automotive expert, he can easily handle machinery and mechanical systems. Usually, spends his most time at the school laboratories preparing his everyday lectures and practical workshops on basic automotive systems.

**Persona 2:** Pambos Anastasiou (Cyprus technical school student):

Gender: Male, Age 16, Studies Vehicle engineering, He usually plays with and services his 50cc. motorbike, likes tic-toc and girls, poor English knowledge, mediocre results, feels boring in class, after schools helps at his father’s job.

* 1. **Scenarios:** [todo]

(Learning task through navigation \*)

* 1. **User’s Requirements specification:**

**R1.** Scholars shall be able to learn through an interactive process and Educators shall be able to react/get feedback.

* + - Fast responses when navigating between components.
    - Ability to navigate back and forth (start page/ previous page).

**R2.** Different language needs to be used for explaining the systems’ components based on the student’s level and the required terminology.

* + - English/Greek Language.

**R3.** Personal data shall not be provided by the user.

* + - No login or signup process.
    - A number ID shall be assigned for every student entry for tracking and feedback purposes.

**R4.** Student’s results shall be kept to a database and feedback shall be provided:

* + - to the Educator for the student’s score,
    - to the student for his score/rank and/or his mistakes.

**R5.** [todo]

1. **Prototype Design & Evaluation.** [todo]

Based on fidelity, we started a low fidelity prototype showing and deciding the basic web application behavior.

**FILE**

**EDIT**

**VIEW**

**HELP**



**Open**

**Save**

**Close**

**EXIT**

**Undo**

**Redo**

**Edit text**

**Copy**

**Preferences…**

**Path**

**Devices**

**…**

**Nav tools…**

**Test mode**

**Tools…**

**Help…**

**About**

**rotate**

**Zoom**

**Pan**

**reset**

**Car systems…**

**Student’s Level…**

**QUIZ**

**break system**

**clutch**

**engine**

**gearbox**

**other…**

**Easy mode**

**Extensive mode**

**| | S I d e b a r | |**



Based on supported functionalities, we considered a vertical path having functionality for selected tasks/feature and gradually enrich them.

Based on how prototype is Based on how it is embedded in the final system, we use a throw away prototyping model to proper validate and derive the system requirements.

**The basic structure of the website should be as follows:**

**1)Main window**

**Learning Area:** When selecting a system from the drop-down menu, the learning area updates with the current system. The user can interact with the system (zoom in, zoom out, rotate, etc.) and can click in certain points of interests which are indicated with a special icon. When clicking to those points the user can read more about that component from a small pop-up dialog.

**Testing Area:** Displays the test for the selected car system. The system contains blank boxes where you drag and drop the name of the specific component.

**[File]**

Basic functions for Open, Close, Save and Exit

**[Edit]**

The undo/redo function is used to reverse a mistake

The Edit text and copy functions are giving extra functionality to append or create text elements

**{Preferences…}**

**(path)** indicates the root path that graphical elements reside

**(devices)** \*experimental – for future 3d (AR) interface

**[View]**

The View tab enables you to rotate elements and tags, zoom in and out, pan through screen and reset the view to its initial.

**{Nav Tools}** Navigation toolbar with common functions of

**(rotate, Zoom, Pan, Reset)**

**{Test mode}** Displays the test for the selected car system. The system contains blank boxes where you drag and drop the name of the specific component.

**{Tools}** Displays the available

**(car systems)** Drop-down menu with the different car systems (break system, engine, transmission system, etc.).

**{Student’s level}** Select student’s level by exposing information in accordance with the level selected for secondary and high school, or for academic level. Based on the selected level the info texts for the components change accordingly.

**(Easy mode, Extensive mode)**

**[Quiz]** When this tab is selected, a quiz under the active car system is displayed on the Main window.

**[Help]** A link with application instructions.

**[About]** A link to credits**.**

**Sidebar:** The sidebar provides in a list form the different components of the current system that is displayed in the learning area. When the user clicks in a component, the corresponding pop-up dialog appears in the learning area.

**Language options button:** (Greek, English)

**minimize, maximize and close buttons:** window behavior buttons

1. **Experiences.** [todo]

Appendix A: Web resources tools and applications on immersive, augmented, and virtual reality deployments.

Web AR

<https://en.wikipedia.org/wiki/Augmented_web>

<https://ar-link.net/ar-demos/rims/>

<https://www.whatiswebar.com/>

<https://createwebxr.com/webAR.html>

<https://www.banuba.com/blog/best-web-ar-platforms-and-tools>

<https://gravityjack.com/news/webar-handbook/>

<https://www.8thwall.com/discover/automotive>

<https://rockpaperreality.com/web-ar/how-does-web-based-augmented-reality-work/>

AR links & trends

<https://mobidev.biz/blog/augmented-reality-trends-future-ar-technologies>

<https://library.harvard.edu/services-tools/teaching-and-learning-3d-content>

<https://www.educause.edu/ecar/research-publications/learning-in-three-dimensions-report-on-the-educause-hp-campus-of-the-future-project/pedagogical-uses-of-3d-tech>

<https://www.iste.org/explore/Computer-Science/Harness-the-power-of-3D-models-in-the-classroom>

<https://medium.com/@ImaginusVR/why-3d-models-are-great-for-education-692b2f9c03ab>

<https://www.emerald.com/insight/content/doi/10.1108/JARHE-06-2020-0172/full/html>

<https://blogs.oregonstate.edu/inspire/2018/08/15/5-ways-3d-models-can-help-in-education/>

<https://www.researchgate.net/publication/295264063_Using_3D_Modeling_Techniques_to_Enhance_Teaching_of_Difficult_Anatomical_Concepts>

[HTML Image Maps (w3schools.com)](https://www.w3schools.com/html/html_images_imagemap.asp)

AR/VR (XR) solutions

<https://semcon.com/>

<https://semcon.com/offerings/training-solutions/authoring-tools/>

<https://www.arvizio.io/>

<https://program-ace.com/blog/augmented-reality-sdk/>

<https://www.inglobetechnologies.com/ar-media>

<https://www.youtube.com/watch?v=1t1gBVykneA> magic window 2d

<https://aframe.io/>

<https://developers.google.com/web/updates/2018/06/ar-for-the-web>

Appendix B: Questionnaire from users in relation to the proposed system

i. Teacher/educator as a user (*likert scale*):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Question** | **Strongly disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly agree** |
| **Q1: When I must teach a mechanical system,**  **I don’t have the time to disassemble it first.** | **□** | **□** | **□** | **□** | **□** |
| **Q2: It is easier to explain the system part by part and then as a whole unit.** | **□** | **□** | **□** | **□** | **□** |
| **Q3: It is not possible for all the students to discern equally the assembly.** | **□** | **□** | **□** | **□** | **□** |
| **Q4: I believe that my students realize properly how the mechanical system is functioning.** | **□** | **□** | **□** | **□** | **□** |
| **Q5: I present to students every part of the assembly at the board/projector screen.** | **□** | **□** | **□** | **□** | **□** |
| **Q6: The time to explain how the whole system works is the same with the time to explain every single part of that system.** | **□** | **□** | **□** | **□** | **□** |
| **Q7: I present different details to different class audiences.** | **□** | **□** | **□** | **□** | **□** |
| **Q8: My feedback of evaluation is poor.** | **□** | **□** | **□** | **□** | **□** |

ii. Scholar as a user (*likert scale*):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Question** | **Strongly disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly agree** |
| **Q1:** | **□** | **□** | **□** | **□** | **□** |
| **Q2:** | **□** | **□** | **□** | **□** | **□** |
| **Q3:** | **□** | **□** | **□** | **□** | **□** |
| **Q4:** | **□** | **□** | **□** | **□** | **□** |
| **Q5:** | **□** | **□** | **□** | **□** | **□** |
| **Q6:** | **□** | **□** | **□** | **□** | **□** |
| **Q7:** | **□** | **□** | **□** | **□** | **□** |
| **Q8:** | **□** | **□** | **□** | **□** | **□** |

Appendix C: Resources

[1] S. Tumkor, “Personalization of engineering education with the mixed reality mobile applications,” *Comput Appl Eng Educ*, vol. 26, no. 5, pp. 1734–1741, Sep. 2018, doi: 10.1002/cae.21942.

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[9] J. S. Ortiz, B. S. Guevara, E. G. Espinosa, J. Santana, L. R. Tamayo, and V. H. Andaluz, “3D Virtual Content for Education Applications,” in *2020 15th Iberian Conference on Information Systems and Technologies (CISTI)*, Sevilla, Spain, Jun. 2020, pp. 1–5. doi: 10.23919/CISTI49556.2020.9140822.

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