Title:
Innovative Integration: Enhancing STEM Education with the Infento Kit, 3D Printing, and Augmented Reality

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Abstract:
This paper explores the transformative potential of integrating the Infento Kit, 3D printing technology, and Augmented Reality (AR) into STEM education for primary and secondary school students. STEM (Science, Technology, Engineering, and Mathematics) education is crucial for preparing students for the challenges of the future, equipping them with critical thinking, problem-solving, and collaboration skills. The Infento Kit offers a hands-on, interdisciplinary approach to learning, allowing students to construct various structures and mechanisms. Augmented Reality enhances this experience by providing immersive digital overlays, enriching the learning environment and promoting deeper engagement. Additionally, the integration of 3D printing technology further expands the possibilities for hands-on learning and innovation. Through a comprehensive examination of pedagogical strategies, practical implementation methods, and case studies, this paper highlights the potential of this integrated approach to revolutionize STEM education and empower students to become lifelong learners and innovators.

Introduction

STEM education is increasingly recognized as essential for preparing students to thrive in a rapidly evolving technological landscape. Traditional approaches to teaching STEM subjects often lack engagement and fail to foster genuine curiosity and passion for learning. However, emerging technologies such as the Infento Kit, 3D printing, and Augmented Reality offer exciting opportunities to revolutionize STEM education, providing immersive, hands-on experiences that ignite students' imagination and creativity. This paper explores the synergistic relationship between these innovative tools and their potential to transform STEM learning in primary and secondary schools.

The Infento Kit:

The Infento Kit is a versatile educational tool that allows students to build a wide range of riding vehicles, from simple vehicles to complex mechanisms, from a walker to a scooter passing through tricycle, bicycle, go-kart, sledge and more. With its modular design and comprehensive instructional materials, the Infento Kit enables students to explore fundamental principles of physics, engineering, and design in a hands-on manner. By constructing and experimenting with their creations, students develop problem-solving

Fig. 1: Mini-bender.

skills, spatial reasoning, and a deeper understanding of STEM concepts. The guide to assembly provided through Augmented Reality further enriches the learning experience, offering step-by-step instructions and interactive demonstrations. The Infento Kit promotes collaboration and teamwork, as students work together to brainstorm ideas, troubleshoot challenges, and iterate on their designs. With its emphasis on creativity and exploration, the Infento Kit fosters a growth mindset and encourages students to take ownership of their learning.

Furthermore it is possible to see that the name Infento derives from two latin therms: infinitus (infinite) and planto (to make).

The main features of this kit are the squared structural profiles but in this project, in order to decrease the weight of the whole vehicle, are used aluminum hollow pipes. Since there are a lot of combinations in Infento kit, only one has been taken into account: Infento Mini-bender.

3D Printing technology:

In addition to the Infento Kit, 3D printing technology provides students with the opportunity to design and create their own custom parts and components. By leveraging 3D printing technology, students can prototype their ideas quickly and efficiently, bringing their concepts to life in a tangible form. 3D printing promotes creativity and innovation, allowing students to iterate on their designs and explore new possibilities. Whether creating custom parts for their Infento creations or designing entirely new projects, 3D printing technology expands the scope of hands-on learning and empowers students to unleash their creativity.

To manufacture the connection elements, two different 3D printers are used, both made by Sharebot company: Sharebot One and Sharebot Next Generation.

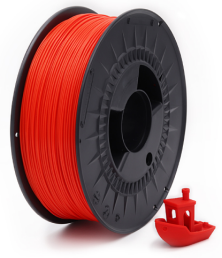
Sharebot One The first one is the Sharebot One, this printer is characterised by a good resolution up to 0.08 millimeters and offers a printing area of 150x150x150 mm.

The Sharebot One is capable to print only one type of material named PLA (Polylactic acid). This material is obtained from renewable resources with zero environmental impact and it is characterized by an excellent mechanical strength (compared to other conventional plastic) and low deformability at room temperature.

Once the component has been designed in Autodesk Inventor, a .stl file is generated and uploaded on 'Sharebot Continuum', the software that converts the .stl file into a .gcode.

The thickness adopted for each layer is 0.3 mm since after several attempts this value was able to print accurate pieces and obtain a good resolution in a shorter time.

[Sharebot One]



[PLA filament]

Fig. 2: Sharebot one kit

Sharebot Next Generation The second printer used is the Sharebot Next Generation. This machine is characterised by an excellent resolution of 0.05 millimeters and a printing space of 250x200x200 mm. It is able to print two different types of material, PLA and TPU.

Augmented Reality (AR):

Augmented Reality technology enhances the learning experience by overlaying digital content onto the physical world. By leveraging AR applications, educators can create immersive simulations and interactive experiences that bring abstract concepts to life. Augmented Reality enables students to visualize complex phenomena, conduct virtual experiments, and explore scientific principles in a dynamic and engaging manner.

Fig. 3: Students while using the AR app.

We have developed an augmented reality app which runs in the HoloLens, providing students with a guide to assembly for the Infento Kit vehicles. By providing real-time feedback and personalized learning experiences, AR technology promotes active engagement and deeper understanding across STEM disciplines.

Integration of Technologies:

By combining the hands-on construction capabilities of the Infento Kit with the design flexibility of 3D printing and the immersive overlays of Augmented Reality, educators can create powerful learning experiences that bridge the gap between theory and practice. For example, students could design custom parts using 3D printing software, fabricate them with a 3D printer, and then integrate them into their Infento creations. Augmented Reality could then provide additional guidance and instructions for assem-

bly, enhancing the learning process and promoting deeper understanding. By integrating these innovative technologies, educators can cater to diverse learning styles and provide students with opportunities to explore STEM concepts in a multi-dimensional manner.

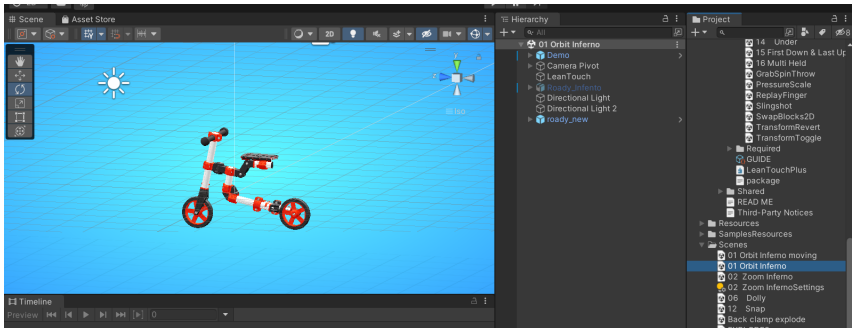


Fig. 4: Unity software overview

The augmented reality app has been developed in Unity 3D. This cutting-edge platform enables seamless integration of digital elements into the real world, providing an immersive experience for users. Specifically tailored to our needs, the app guides users through all the steps required to assemble the vehicle, offering clear and intuitive instructions at every stage. With Unity 3D's advanced capabilities, we've created a dynamic and interactive environment where users can visualize each component and understand its placement with precision. From basic concepts to intricate details, the app ensures a comprehensive learning experience, making the assembly process accessible and engaging for users of all skill levels.

User Interface Validation:

It was decided to use the System Usability Scale (SUS), invented by John Brooke in 1986. Before delving deeper into the characteristics of SUS, it is crucial to understand what usability entails. Defining the usability of a system or tool necessitates consideration of the context in which it is utilized and the users involved. Generally speaking, different classes of usability measures can be defined: effectiveness, which pertains to the ability to complete tasks using the defined system and achieve desired output quality; efficiency, which concerns the amount of resources utilized in task activities; and satisfaction, which reflects users' subjective reactions to using the system. The utilization of the HoloLens app not only facilitates the step-by-step assembly of the Infento vehicle but also enhances students' comprehension of the underlying principles. By seamlessly integrating digital instructions with physical components, the app offers an immersive learning experience. This approach not only equips students with practical skills in vehicle assembly but also fosters a deeper understanding of STEM concepts

Conclusion:

The integration of the Infento Kit, 3D printing, and Augmented Reality represents a transformative approach to STEM education, offering students immersive, hands-on learning experiences that inspire curiosity, creativity, and critical thinking. By harnessing the power of these innovative technologies, educators can create dynamic learning environments that engage students and empower them to become lifelong learners and innovators. As we look to the future of education, the synergy between the Infento Kit, 3D printing, and Augmented Reality holds immense promise for revolutionizing STEM learning and preparing students to tackle the challenges of tomorrow's world.

Table 1: SUS questionnaire results for HoloLens based application. Mean values ranges from 0 to 4 and negatively worded items have been normalized. The system obtain 85.2 / 10

	Statement	Likert Scale (1:5)	Normal Mean (0:4)	Std. Dev.
1	I think that I would like to use this app frequently	4.45	3.45	0.93
2	I found the app unnecessarily complex	2.00	3.00	1.73
3	I thought the app was easy to use	4.73	3.73	0.65
4	I think that I would need the support of a technical person to be able to use this app	2.00	3.00	1.34
5	found the various functions in this app were well integrated	4.64	3.64	0.50
6	I thought there was too much inconsistency in this app	1.45	3.55	0.69
7	I would imagine that most people would learn to use this app very quickly	4.64	3.64	0.50
8	I found the system very cumbersome to use	1.91	3.09	1.45
9	I felt very confident using the app	4.73	3.73	0.47
10	I needed to learn a lot of things before I could get going with this app	1.73	3.27	1.10
	Total (Sum*2.5)		**85.20**	**17.8**

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