Automata: AR Integration in Action for Bridging Theory and Application in Mechanical Systems with AI Generating Case Studies

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Abstract

In the scope of the new technological era we live in, creative learning, prototyping and innovative problem solving are increasing in value day by day; revealing a significant lack of knowledge between theoretical knowledge and practical application in mechanical systems. Due to this, newcomers in K12 laboratories find it quite challenging to take on new projects by themselves. Aiming to find a constructive way to fill this gap, we prototyped hands-on kits called "automata". The kits we designed in total have 6 models, completely open-sourced, which we produce in our fablab consisting of a farm of 20+ 3D printers. The kits illustrate core concepts of cams, cranks and gears, each model has its own original design which illustrates systems we constantly face in our daily lives but fail to realize. To encourage innovative and creative thinking, we enhanced the kits with augmented reality (AR) by creating our own website, "AutomatAR". As users interact with these models, movements are mirrored by corresponding AR animations on their mobile devices. Users overcome our AR scenarios, case studies, then generate their own case studies with, again, our own AI website. We had the opportunity to test this kit on K12 students, each workshop resulting with high accuracy of learning in our feedback forms. We believe this workshop is a great contribution to constructionist and innovative learning since by connecting physical building with digital visualization, the kit offers an interactive approach to learning mechanics, helping K12 students to bridge the gap between theory of mechanics and the practical technological application.

Tools, Skills and Materials: Tools->3D Printer, Tools->Fusion360, Skills->Creativity, Skills->Building Mechanical Systems, Materials->PLA.

Keywords and Phrases: Mechanical Systems, Interactive Learning, Hands-On Kit, Augmented Reality (AR)

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1. Workshop Description

1.1 Scope, Motivation, and Background

During our time in mentoring our FIRST Tech Challenge (FTC) team and struggles we observed of newcomers to our FIRST Robotics Competition (FRC) team, we realized a significant gap in apprehension and application of mechanical systems. In order to bridge this gap and allow them to apply the necessary skill sets that are embedded within STEM areas we created the Automata Kits, covering areas from 3D design and mechanics to augmented reality. Automata, originated from Greek means "self-acting", which are mechanical devices designed to automatically carry out a sequence of operations or mimic the movements of living beings. During the design process of the kits, our primary goal was to create a design such that all K12 students would be able to grasp the mechanical system dedicated to the kit with ease, thus making them hands-on kits. We designed the kits ourselves from Fusion360 and are fabricating them from our fablab, consisting of a farm of 20+ 3D printers. Our kits focus on cam systems, different gear systems- like geneva stop, and crank systems. We created a bridge between mechanics and technology by integrating our kits with augmented reality (AR). Our kits consist of six models, each reflecting a fundamental mechanical principle such as gears, cams and crank systems. Each kit consists of the same base, decreasing the complexity of the kits and supporting sustainability. These models, which are designed and 3D printed by us, and the research towards it develops a better understanding in mechanical systems and creates interest when

integrating augmented reality (AR) elements. All AR animations are based upon the theme "Life Below Water", which is the 14th SDG. This dual integration of AR aims to create more interactivity and enhance comprehension, particularly in complex mechanical systems.

1.2 Detailed Schedule

At the beginning of the workshop, we will be explaining the purpose of our project and display our previous observations. Later, we will start building the first kit with the 3D printed models that we will provide for the participants. We will continue building the kits one by one until finishing the sixth. We'll explain our aim in making the AR integrations, the interface of our own app and guide the attendees to do the AR integration of each kit respectively. We'll allow the attendees to experiment with the kits by trying to build new systems for the remaining time and let them come up with new AR interactions, enhancing their creativity.

1.3 Outcomes

By the end of our workshop, we aim to have 6 different automata kits built by the attendees themselves which all are integrated with the designed AR. We hope that all the participants have grasped the basics of any mechanical system and know how to build, use or arrange them.

1.4 Participants

We invite everyone who is interested in learning about our approach to introductory courses for STEM. The kit is normally targeted to K12 students with little or no background information about mechanical systems. We also invite any educators who are looking for ways to reduce the complexity of mechanical systems, who might provide us with much insightful feedback.

2. Relevance

We wanted to provide a tangible, interactive learning experience. We believed the best way to do so was hands-on kits. Our workshop will help inspire participants to dive more deeply into STEM subjects such as technology, computer science and engineering. We believe that extending designing teachings to our daily educational lives can help students dive into mechanics with ease. We are currently working on distributing the kit to 81 provinces of Turkey, with support of a foundation, aiming to inspire youth and guide them on their journey towards discovering their predispositions in robotics, and observe the step-by-step application of the engineering. We are hoping to gather data regarding students' experiences and feedback while they assemble their kits, helping us to improve our kits as desired. Furthermore, we believe our kit, which brings a new approach to AR and innovative education with constructionism, would be a valuable contribution to the Constructionism and Fablearn community. Our project provides new constructionist technologies and hands-on experiences within the theme of "Making and Innovation in Constructionist Learning".

3. Requirements

3.1 Number of Participants

The maximum number of participants we would prefer to have is 25.

3.2 Technology and Materials

We will be bringing all the required materials (3d printed kits, manuals of the kits, etc.) with us and will not be in need of any other material assistance. We require the participants to have technological devices with them to be able to do the AR integrations.

3.3 Space and Logistics

We require tables that are suitable to build kits on in the workshop. We would also like to have a projector or a display for showing our presentation.

4. Bios

Sedat Yalcin is the Head of the Computer Science Department at Hisar School, a K-12 institution in Istanbul, Turkey. He is an Apple Distinguished Educator, the one and only Fab Academy Node in Turkey and the director of Hisar Idealab Fablab where he develops and publishes interdisciplinary Human-Computer Interaction, Artificial Intelligence, and Constructionism projects with students. Two years ago he published the first AI curriculum book for high school students in Turkey. For the last 11 years, he has been the Chapter Ambassador for Turkey of Technovation Girls.

Irmak Ureten is a junior at Hisar High School. She takes an active role in Technovation Turkey, aiming to encourage girls from all around Turkey to pursue their interests in STEM and entrepreneurship. For the last three years, she has been developing research and maker projects within the ideaLab regarding human-computer interactions. She has presented her work in MUM ’24, Innovation ’23 ’24 (ACS Athens) and FabEdu ’24, ’25.

Ahmet Burhan Bas is a senior at Hisar High School. For the last four years, he has been developing research and maker projects within Hisar Idealab Fablab. For the last 3 years, he is the head of the organizing committee of Hisar Coding Summit where programming, CAD, design thinking, cybersecurity, etc. workshops are given by students to students increasing peer-to-peer collaboration with participants from all around the world. He presented his work in MUM ’24, Innovation ’23 ’24 (ACS Athens) and FabEdu ’24.

Kaan Tabag is a freshman at Hisar High School. For more than 5 years now he has been intertwined with robotics competitions, such as FRC and FTC, a project kid per se. He has worked in the ideaLab since early middle school. He is also in charge of ideaLab’s 3d printer farm.

Arda Efe Ozcan is a sophomore at Hisar High School. He has worked on many research & development projects within the Hisar Idealab Fablab, regarding computer sciences and humanities. He is head of electronics of our FRC team, in control of our manufacturing machines such as PCB cutting machines, laser cutters or CNCs.

Maya Bilgisel is a freshman at Hisar High School. Throughout this year he has developed research projects at Hisar Idealab Fablab ranging from Augmented Reality to Artificial Intelligence in Education. She presented her work at the Coding Summit ’25 and Innovation ’25.