# Application of VR & AR Tools for Technical Drawing Education

Dr. Ertu Unver

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*University of*
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# Project Description

There are concerns from Higher Education (HE) institutions and industry about the decline in standards of Technical Drawings (TD) due to the lack of understanding of basic principles and conventions that underpin the best practices. The project aimed to create Virtual and Augmented reality applications to improve the teaching and learning performance of Technical Drawing and related standards.

**Project Duration:**
Sep 2017-Dec 2019

**Funder:**
EU Erasmus + Vocational Education Strategic Partnership Projects
Total Funding: 155k Euro. Ref.# 20171 TR01 KA202 45941.

**Research Partners, consultants, collaborators:**
University of Huddersfield, UK
(Role: design and development of training material).
Bursa Uludağ University, Bursa, Turkey
(Role: COORDINATOR, engineering input & pilot study).
Technical University of Sofia, Bulgaria
(Role: engineering input & pilot study).
Bizpark Business Solution Co, Turkey
(Role: software development).

**The Role of Dr Ertu Unver:**
The collaboration brought together expertise in design, engineering and software development. Dr Unver coordinated the University of Huddersfield research team and managed the software development team (Commercial partner: Bizpark). In addition, Dr Unver led the 'Material Development' work package, which involved the design and development of all of the AR/VR, animation and visualisation training content. Content was developed using a double diamond research methodology. Information, including user requirements and course data, compiled by the engineering partners (Universities: Bursa and Sofia) was fed into the development process, led by Dr Unver to develop ideation, storyboarding, CAD models and animation rendering for AR and VR development.



# Research Aims & Objectives

**Research Aims & Objectives:**
The project aimed to create Virtual and Augmented Reality applications to improve the teaching and learning performance of Technical Drawing and related standards. This involved:

- Design and development of AR and VR animation tools to improve teaching of technical drawing.
- Evaluation of the developed tools and methods with international user groups, to assess the effectiveness in comparison traditional teaching and learning methods.

**Key Outcomes:**
*AR and VR Apps* for Technical Drawing Education
(Available, for free of charge, together supporting materials & animations, from http://vrindesign.org)

*Augmented Reality App:*
Title: Augmented Reality application for Android 7+ Mobile Devices for T&L of Design for Manufacture.
(http://vrindesign.org/en/Courses)

*Virtual Reality App:*
Title: Virtual Reality Application for HTC Vive Device for T&L of Design for Manufacture (http://vrindesign.org/en/Courses)

*Book:*
VR/AR in Design, A Guide to Interactive Technical Drawing for Engineer and Designers. ISBN: 978-1-86218-165-6

*Journal Paper:*
An Approach to Improve Technical Drawing using VR and AR Tools, Journal of Computer-Aided Design and Applications, 17(4), 836-849.

# Research Context

There are concerns from Higher Education (HE) institutions and industry about the decline in standards of Technical Drawings (TD) due to the lack of understanding of basic principles and conventions that underpin the best practices. There is growing evidence that simulations/animations along with augmented and virtual reality (AR/VR) technologies can improve learners' engagement, competence, and skills; especially when compared to traditional didactic methods. The purpose of this work was to develop and examine the overall effect as well as the impact of virtual and augmented reality-based methods and tools on the teaching/learning experience of technical drawing principles in the context of higher education settings.

TD must fully define the properties required to produce a designed item. These drawings ultimately represent a contractual instrument in the transformation of a design into a physical reality, protecting both the designer and manufacturer from legal liability. The decline in standards, due to the lack of understanding of basic principles and the conventions of drafting skills that underpin these practices, represent a challenge for HE institutions and traditional teaching strategies. Despite the knowledge that engineering and product design students generally prefer visual, sensing, inductive, and active learning styles: most engineering education and in particular the teaching of technical drawing skills has relied on auditory, abstract, deductive, passive, and sequential teaching styles.

The introduction and broadening of 3D tools as a key teaching component in the design process has significantly changed the teaching of TD related subjects as a result. However, HE institutions are still left with the challenge of developing new T&L tools and methods to make sure students acquire the knowledge and skills on TD required to meet the demands of both academia and industry.[1]



AR/VR technologies have already found potential applications in areas of education where students are facing some learning challenges. These applications have incorporated for example desktop-based virtual reality technologies to stimulate learning, to teach abstract concepts, to teach scientific inquiry and engineering subjects. AR/VR offers to HE institutions an efficient way to present complex and difficult theories/concepts to design and engineering students. Students can comprehend complex theories and concepts with the contextually enriched interaction offered by AR technology. For example, animations have shown to provide more enthusiasm for the learning activity, better performance in understanding the appearances and features of objects and improve the spatial visualization capabilities.

1. Unver, E.: Strategies for the transition to CAD based 3D design education, Computer-Aided Design and Applications, 3(1-4), 2006, 323-330. https://doi.org/10.1080/16864360.2006.10738470

# Research Methods & Process

This project addressed the use of low-cost mobile based AR/VR tools developed with the support of animation and simulation tools, alongside text-based/traditional teaching methods.

While current AR/VR developments/research is primarily technology-driven, this project combined pedagogy and technology to provide a multi-disciplinary user-centred research approach, for the design, development and testing of the AR and VR applications. Users were at the core of the development process, which followed a Design Centric Hybrid (DeCH) method for immersive education technology developments (Fig. 1). Initially, the primary areas of TDs that require support from AR/VR technologies were identified. An extensive international survey, involving 320 stakeholders from a comprehensive range of TD-user backgrounds participated. Six key areas of TD were identified.

A Race Car was selected as the centrepiece of the project (Fig. 2), which had been designed (CAD) and physically manufactured, providing a variety of components (Fig. 3) for use in AR/VR/ animations. Context/environment was assigned in AR/VR/animations to enhance understanding of each component and its context.

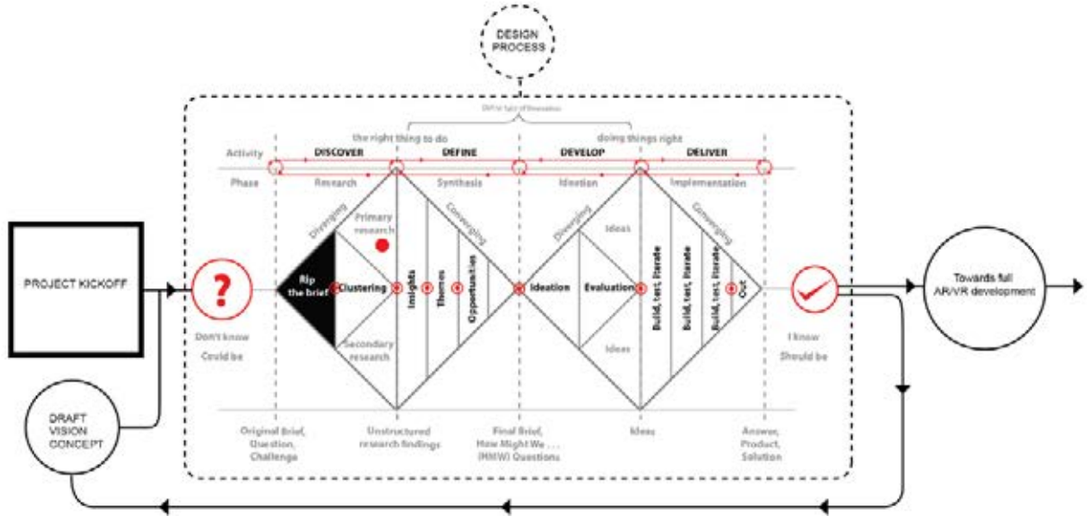



Figure 1: Design Centric Hybrid (DeCH) method



Figure 2: Modelling of race car used in this project

The content and applications were developed following AR/VR design and development process (Fig. 4). Multiple software packages were utilised, including Adobe suite for storyboards and graphics. For 3D content generation, SolidWorks for modelling with content imported to 3D Studio Max for animation process. The model was converted to polygonal data. Appropriate textures were then applied to the model, and various animation methods were utilized to create the content, including camera and object movement. Unity was used to create interactive AR/VR applications with ARCore for building the AR experience.

A multi-disciplinary approach was essential to create the visually rich and interactive content.

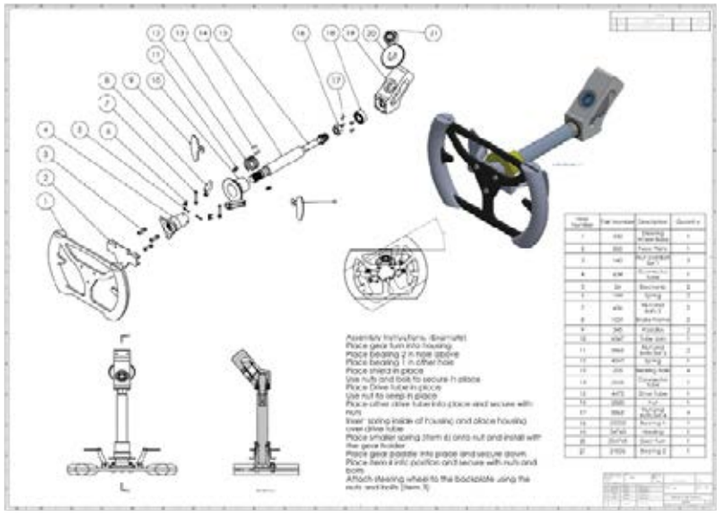


Figure 3: TD for steering wheel assembly

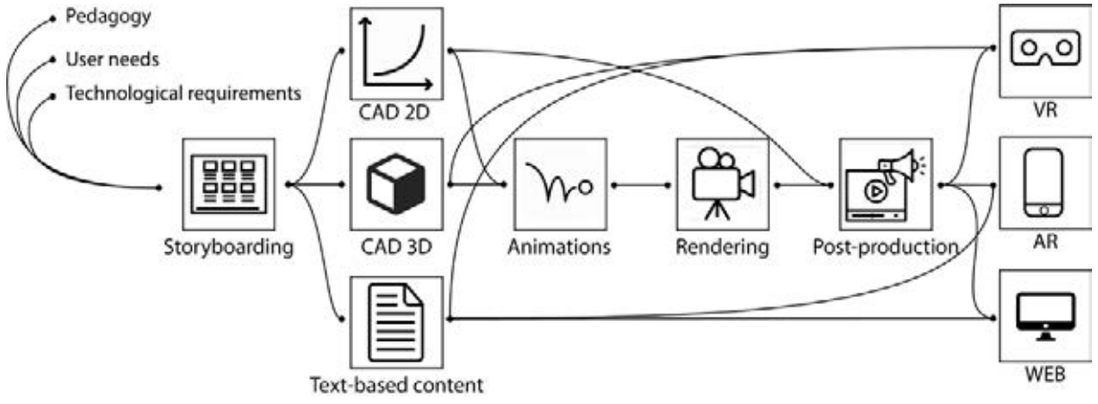
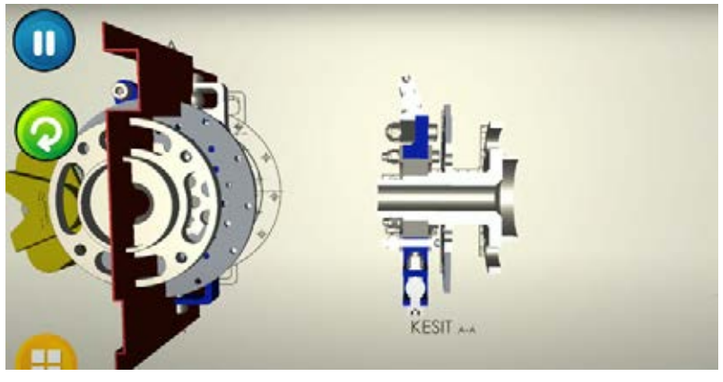



Figure 4: AR/VR design and development process

**AR/VR Technical Drawing Case Study:**
Several AR applications were developed for improving understanding in the six areas of TD education. Figure 5 shows examples of the AR applications in use, as demonstrated in the course videos (http://vrindesign.org/en/Gallery#; http://vrindesign.org/en/Courses), this includes (a) tolerancing with fit table; (b) sectioning; (c) symmetry tolerances (d) assembly drawing (balloon tolerancing) which is commonly used in creation of TDs. VR development included the creation of 3D content and the programming of interaction.

Stakeholder feedback facilitated continual improvement/ development of tools. To determine the contribution of the applications to learning outcomes, a pilot study was designed based on an experimental research design with control group, spanning 3 countries. The data were collected by a conceptual comprehension test and an achievement test.


(a)



(b)

(c)

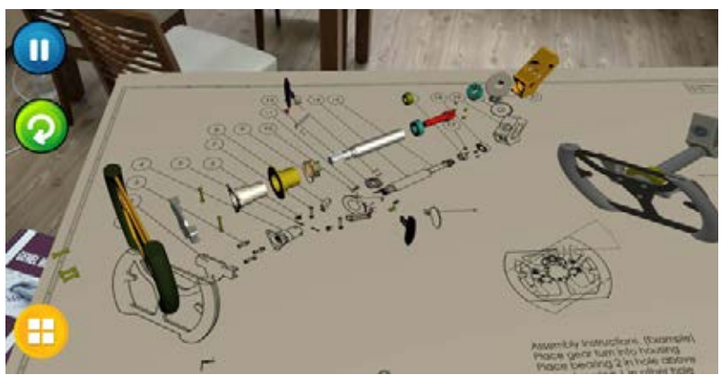

(d)

Figure 5: Examples of AR applications in use, demonstrating:
(a) tolerancing
(b) sectioning
(c) symmetry tolerances
(d) assembly drawing

# Research Outcomes & Dissemination

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|---|---|
| **Book:** | VR/AR in Design, A Guide to Interactive Technical Drawing for Engineer and Designers. ISBN: 978-1-86218-165-6. File Name: AR VR Book_Printed.pdf |
| **Website:** | Virtual and Augmented Reality in Design for Manufacture in English, Turkish, and Bulgarian Languages. http://vrindesign.org/en |
| **Apps:** | Augmented Reality application for Android 7+ Mobile Devices for T&L of Design for Manufacture. File Name: ARinDesign.V2.1.apk http://vrindesign.org/en/Courses#<br><br>Virtual Reality Application for HTC Vive Device for T&L of Design for Manufacture. File Name: VrInDesignAPK. Online at: http://vrindesign.org/en/Courses# |
| **3D Animated Training Videos:** | 14 videos covering, Dimensioning, Projections, Tolerances, Geometric Dimensioning, Surface Roughness and Assembly drawings (online available on chapters at: http://vrindesign.org/en/Courses# |
| **Project Report:** | Strategic Partnership Project Report, (Intellectual Outputs 1-2-3-4), Virtual and Augmented Reality (V&AR) in Design for Manufacture (Project No: 2017-1-TR01-KA202-45941), available at: http://vrindesign.org/Content/Upload/Doc/vr-in-design---project-report-a4-144pages-6be62c98bfd7.pdf |



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| **Journal Paper:** | Huerta, O., Unver, E., Arslan, R., Kus, A., & Allen, J. (2020). An approach to improve technical drawing using VR and AR tools. Computer-Aided Design & Applications Journal, 17, 836-849. http://cad-journal.net/files/vol_17/CAD_17(4)_2020_836-849.pdf |
| **Conference Paper:** | Huerta, O., Kus, A., Unver, E., Aslan, R., Dawood, M., Kofoglu, M., & Ivanov, V. (2019, February). A Design-based Approach to Enhancing Technical Drawing Skills in Design and Engineering Education using VR and AR Tools. In 14th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications (pp. 306-313). Science and Technology Publications, Lda. https://www.scitepress.org/Link.aspx?doi=10.5220/0007566003060313 |

# Conclusion

This research demonstrated the use of AR/VR applications and animations for teaching and learning TD has a positive impact. Across the focus group, participants reported a positive experience with the use of the materials developed in which they felt immersed and engaged with the activities. Preliminary results showed that students who were trained with V/AR applications have 20% higher performance or learning outcomes than control group.

The project has resulted in a set of dedicated AR/VR based resources for Technical Drawing education, with extensive supporting material and animations. All resources and apps are available free-of-charge from vrindesign.org, in multiple languages. These novel resources are being implemented into teaching programmes internationally, and to-date have been accessed from 39 different countries.

While application of AR/VR technology is well researched and continually developing, study of user experience and pedagogy, in this area, is particularly limited. The process of creating the AR/VR content is time-consuming if not developed using effective design and visualisation methods. We have given careful consideration of end-user requirements and expectations to engage students for interactivity needed when creating AR/VR content.

Further work includes the development of an AR/VR application to other operating systems to reach a wider market.

**Output Type:**
Textbook, textual, visual, or aural content encountered as part of the user experience on websites, application programmes, factual information, analysis or data, or fictional, imaginative and/or creative work, using pictorial, video, audio, etc

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