

# Exploring Engineering Students' Perception on using Augmented Reality to Improve Learning Performance in the Context of COVID-19 Pandemic

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**Abstract** – The study evaluates the energy engineering students' perception and insights concerning the use and usefulness of AR technology in online engineering education during COVID-19 pandemic. The assessment is based on the following criteria: usefulness, suitability, advantages for different activities, types of overlays. Results show an increased interest for AR applications in all types of teaching activities, and its usefulness for a better understanding of studied topics. Among the most important advantages of using AR are considered closer connection to practice, speeding and deepening learning. Overall, these results indicate an improved user perception of AR from acceptance to high interest.

**Keywords** – augmented reality, COVID-19, energy engineering, online teaching, student perception.

## 1. Introduction

March 11, 2022, marked two years since Covid-19 was declared a pandemic by the World Health Organization.

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The COVID-19 pandemic and the requirement of compulsory social distancing boosted digital technologies that became a vital tool to allow society to continue its daily activities [1].

Year 2019 represented a real challenge and a turning-point for the teaching systems within engineering universities [2]. These had to adapt the traditional way of delivering education and training, and to switch from face-to-face to online teaching [3],[4]. Furthermore, this switch to online teaching and to using new digital technology challenged educators to rethink the structure and content of the courses [5], [6]. Approaches to the use of remote education laboratories are emphasized in the scientific literature [7], [8], [9].

In this context, Augmented Reality (AR) technology is one of the powerful instruments [10], [11] that facilitates an immersive virtual experience into the real environment [12], [13], [14]. An extensive study on AR in higher education was conducted during 2005-2019, high-lighting AR advantages in motivating student interaction and interest [15]. In 2020, a review of publications on the use of AR in education was published [16].

The ways in which AR technology is used in education before and during the COVID-19 pandemic was discussed in several papers. [17] gives examples of using AR within real laboratory experiments. [18] presents an example of an alternative learning approach during the COVID-19 pandemic and a way to connect physical and virtual learning spaces by virtual visits. [19] investigates the students' attitude towards using augmented reality apps in e-learning activities. AR allows students better under-standing, higher commitment, and an increased learning incentive [20], [21]. The usefulness of AR in education is emphasized by [22], [23]. The paper show both its benefits and limitations. The need of specialized IT software teams to create, integrate and maintain AR applications is emphasized. In this context, teacher professional development programs are very



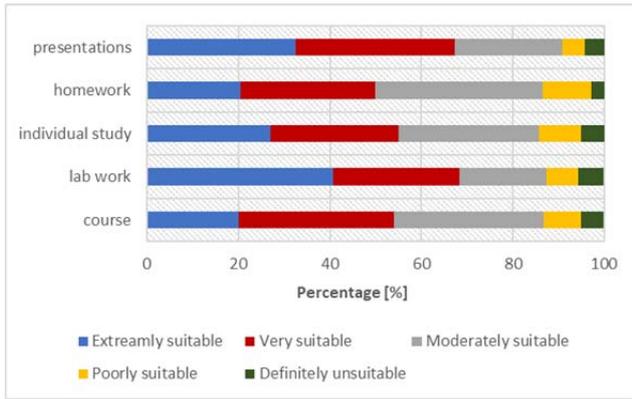


Figure 2. Assessment of usefulness of AR for educational activities

The advantages of using AR in educational activities are depicted in Figure 3. Closer connection to practice appears to be the most important advantage of AR, is being ranked as extremely useful by 43.6% and very useful by 25.7% of the participants. Faster and deeper learning are the next almost equal choices (67.8% and 67.6% respectively), but faster learning represents a greater advantage than deeper learning (35.7% and 28.9% respectively). An almost insignificant percentage of respondents (1.4%) did not consider faster learning to be an advantage.

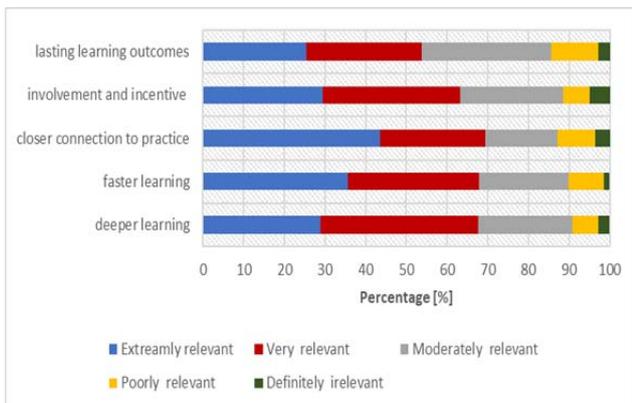


Figure 3. Assessment of advantages of using AR in educational activities

As well, the percentage of respondents who do not think AR has benefits is low, ranging between 2.8% and 5%.

The usefulness of AR based on different types of uses are presented in Figure 4.

The inner view of devices is ranked as the most suitable use of AR, as chosen by about 75% of respondents (extremely suitable 51.7% and very suitable 23.1%).

Other higher per-centages of AR usefulness were obtained for monitoring, command & control devices (73.1%), in situ views (71.9%), and video explanations (72.9%).

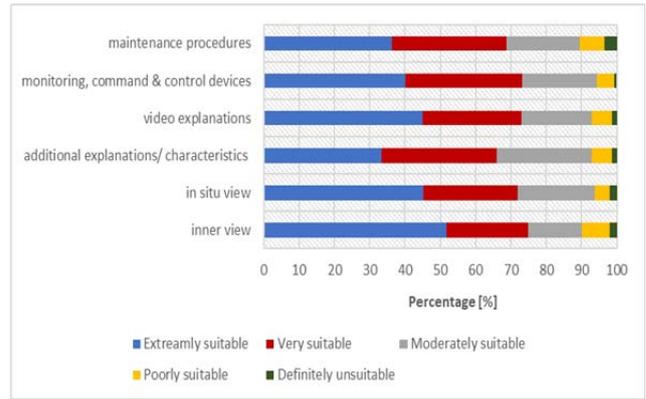


Figure 4. Assessment of AR add-ins

The perception of respondents concerning the irrelevance of AR uses ranges from 0.7% to 3.5%, being therefore very low.

The effectiveness of AR overlays for enhancing physical reality is displayed in Figure 5. About 80% of the survey participants considered video as a primary significant AR overlay for enhancing physical reality (extremely significant 47.2% and very significant 31.7%).

Also, around 73% of the respondents considered schemes as a primary significant AR overlay for enhancing physical reality (extremely significant 37.9% and very significant 35%).

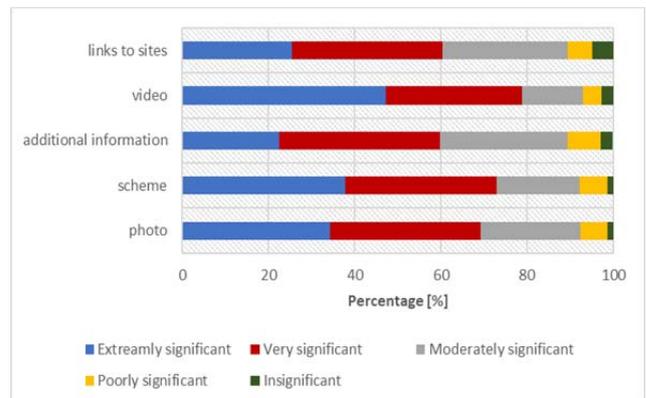


Figure 5. Assessment of effectiveness of AR overlays for enhancing physical reality

69.3% of the survey participants considered photos as a primary significant AR overlay for enhancing physical reality (extremely significant 34.3% and very significant 35%). As well, the percentage of answers considering schemes and photos as being insignificant is very low (1.4%).

#### 4. Discussion

Figures 6-9 present a comparison of energy engineering students' perception during face-to face activities in 2019, before COVID-19 [26], and during online activities due to pandemic conditions in 2021.

Results show an increased interest in 2021 for AR applications in all types of teaching activities, and its

usefulness for a better understanding of studied topics.

With reference to the usefulness of AR for educational activities (Figure 6), one can see that individual study as well as homework became better candidates for AR use.

Furthermore, the difference between the degree of suitability of AR for all the educational activities diminished. However, lab work remains the first choice.

The students did not find any significant differences between the types of relevant advantages of using AR in educational activities (Figure 7). Closer connection to practice gained importance during pandemic conditions.

The overall relevance of AR add-ins (Figure 8) increased and flattened. The inner and in situ view of devices became more important in 2021, probably due to the impossibility of seeing the real equipment.

One can see the types of AR overlays (Figure 9) follow the same pattern of flattening and growth with respect to 2019, as the one displayed by the overall relevance of AR add-ins (Figure 8). However, video remains the top choice of the respondents, whereas additional information gains preference.

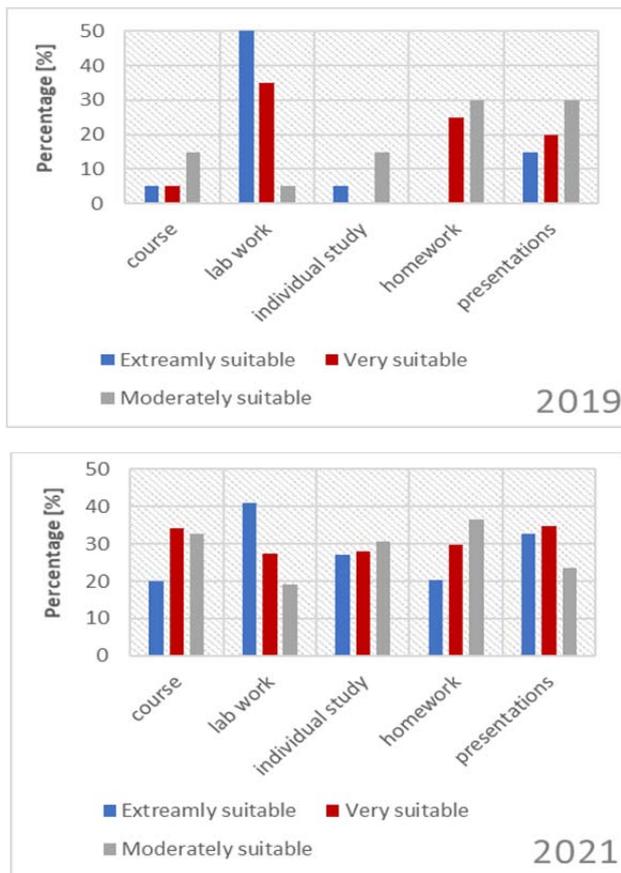


Figure 6. Most useful educational activities suited for AR applications: during face-to face activities (before COVID-19) and during pandemic conditions (2021)

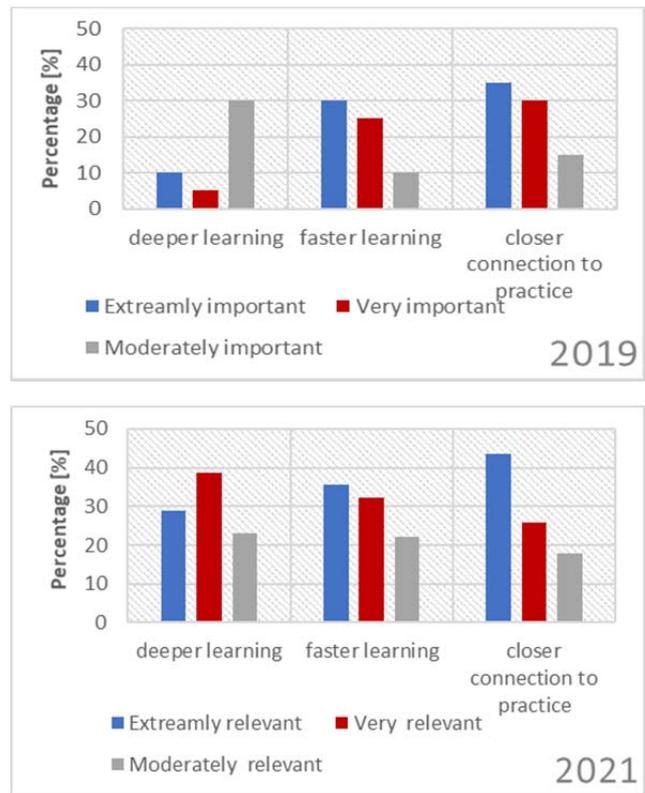


Figure 7. The most relevant advantages of using AR in educational activities: during face-to face activities (before COVID-19) and during pandemic conditions (2021)

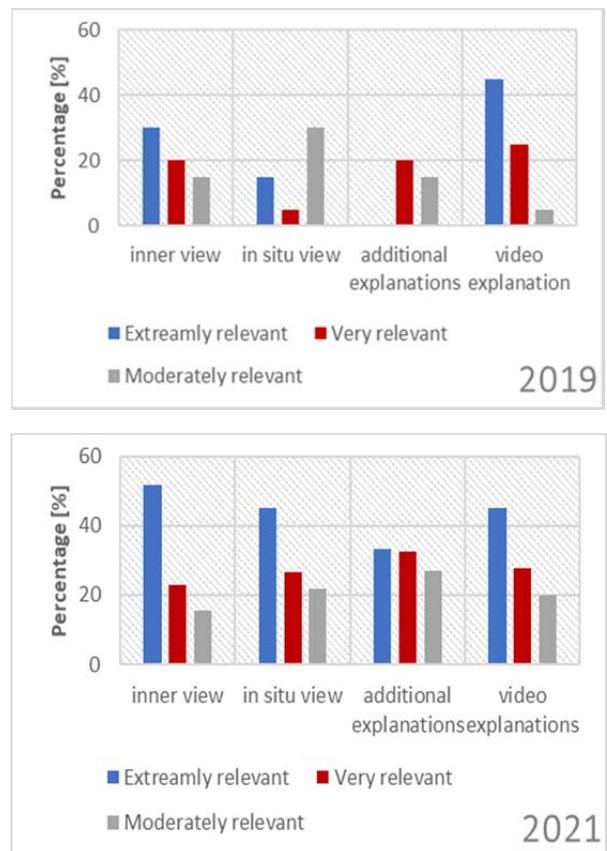


Figure 8. Most relevant AR add-ins: during face-to face activities (before COVID-19) and during pandemic conditions (2021)

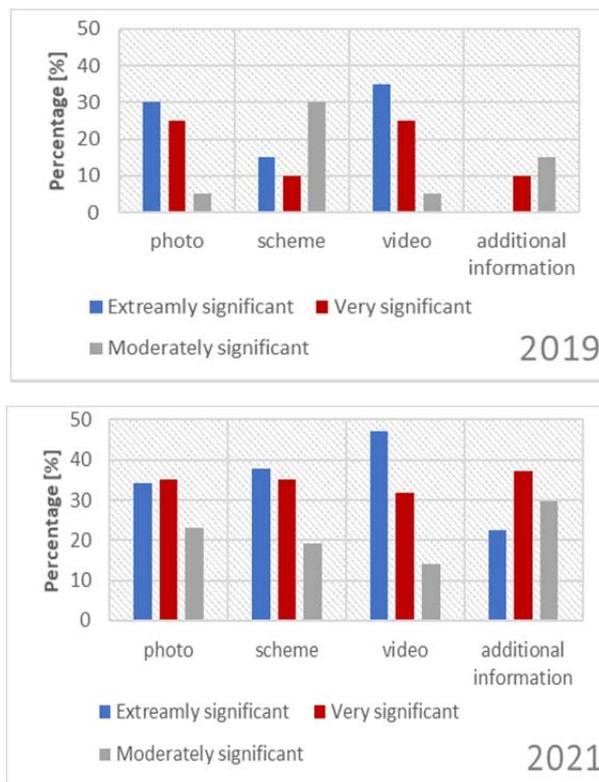


Figure 9. The most relevant advantages of using AR in educational activities: during face-to face activities (before COVID-19) and during pandemic conditions (2021)

Knowledge and skills acquired during university years lay the foundation for the thorough understanding of theoretical concepts and their use into practice in real technical environments. Considering the proliferation of information and communication technologies in the context of past and possible future pandemic restrictions, it is a challenge to keep the right direction through the multiple possibilities of exploring ex-tened and virtual worlds in education, besides the reality around us. Therefore, a more practical, flexible and sustainable approach is needed in the engineering education field to overcome the barriers raised by COVID-19. AR proves to be a good choice for online education and addressing different learning styles.

According to the students view, using AR in university education facilitates a faster and more thorough understanding of technical topics.

## 5. Conclusions

The aim of the paper was to design and apply a flexible and sustainable teaching system able to increase e-learning acceptance and participation and improve students' knowledge, results, and competences.

A comparison of energy engineering students' perception from 2019 (when AR technology was

used in traditional face-to-face education) and 2021 (when AR technology was used online) was made.

Results show an increased interest in 2021 for AR applications in all types of teaching activities, and its usefulness for a better understanding of studied topics. Among the most important advantages of using AR are considered closer connection to practice (69% of participants), speeding and deepening learning (68% of participants).

Unfortunately, society is facing important concerns triggered by the biggest COVID - 19 outbreak in China since the beginning of the pandemic [29].

The risk of the rapid spreading of highly infectious COVID - 19 variants determined a combination of measures consisting in border controls, mass testing, vaccines, quarantine procedures and lockdowns. An important issue is to continually provide education and move forward with this virus, develop, and keep pace with science and technology to support resilient academic systems.

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