ConicAR: development of an augmented reality application for exploration of conic sections

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Introduction

For the visualization of three-dimensional graphs and figures, such as conic sections (circle, ellipse, parabola and hyperbola), flat representations on the blackboard and photographs have traditionally been used, also three-dimensional physical models in plastic, wood or some other materials. The implementation of technologies such as Augmented Reality (AR) or Virtual Reality (VR) for learning mathematics, allow the student an immersive experience that can improve visualization and learning [2, 3].

Objectives

1. Develop an AR application for mobile devices for the visualization and exploration of conic sections.
2. Evaluate the performance of this application with respect to its usability, as well as the user flow experience.

Methods

As part of a school Project, four students of Computer System Engineering and a mathematics teacher from Montemorelos University integrated a team for development of the application. For this development the following technologies were used: Unity®, Vuforia®, Inkscape® y Blender®. This is the first version of the app, and it is available only for Android® operating system devices. ConicAR was develop in Spanish, and can be freely obtained from the Google Play Store[1]. Development for the IOS® operating system is expected for a next stage. To activate the RA on the device (see Figure 1) it is required to point the camera toward the marker (see Figure 2).

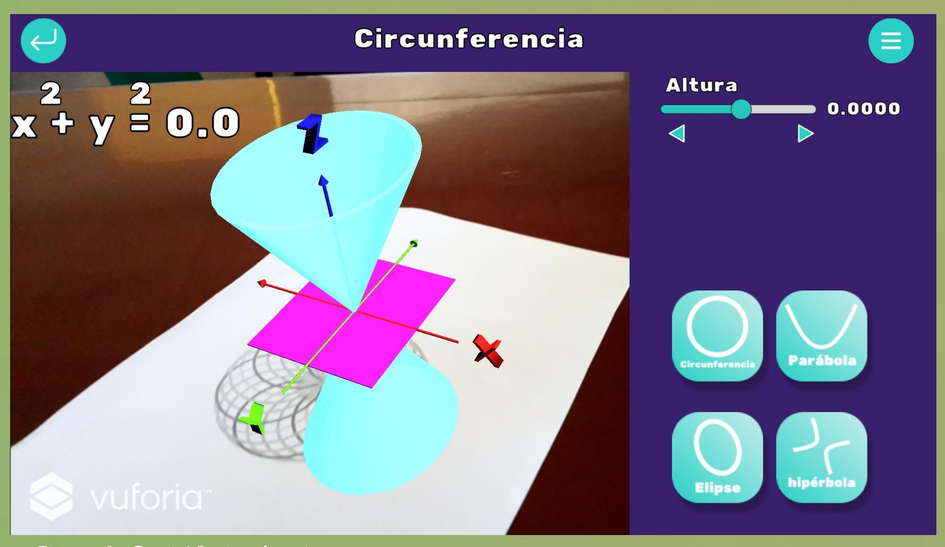

Figure 1. ConicAR visualization to explore the four conic sections

Figure 2. Marker to activate the RA on the app

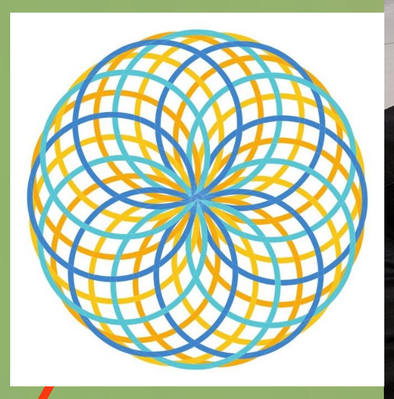

Figure 3. Student working with ConicAR during the learning activity

Figure 4. Engineering students using ConicAR during the learning activity

To evaluate the performance of the app a pedagogical intervention (learning activity) was implemented on a group of 24 engineering freshmen students (see Figures 3 & 4), during march 2022, with a duration of two hours. The app usability was evaluate through the Questionnaire for User Interface Satisfaction (QUIS)[5], which uses a Likert-type scale ranging from 0 (poor usability experience) to 9 (excellent experience). In addition, this scale also evaluate five specific aspects of the system usability, which are shown in the Table 1.

Flow experience, also known as optimal experience, was evaluated using the Dispositional Flow Scale 2 (DFS-2), that uses a 5 points Likert-type scale (1: very bad flow experience, 5: excellent experience).

Results

The average participants level of flow experience, after they uses the ConicAR app, measured as one-dimensional construct, was 3.58 (*SD*= 0.44), while the average degree of usability was 7.53 (*SD*= 0.91). Table 1 show the degree of usability for every specific aspect. Students reported that ConicAR is easy to use, not complicated, with a attractive minimalist design.

	General reaction	Terminology	Learning	Capabilities	Interface
Mean	7.53	6.80	7.32	7.69	6.77
SD	0.91	1.41	1.38	1.13	1.94

Table 1. Evaluation on the five aspects of the app usability using QUIS®

Conclusions

Results of this study suggest that ConicAR can be used by teachers to improve the visualization and understanding of conic sections on high school or university freshmen students. This app shown an acceptable degree of usability and user flow experience. However, since users reported some disconformities, the app needs to be refined in order to improve its performance.

References

1. Google Play Store (2022): ConicAr. Acceso anticipado https://play.google.com/store/apps/details?id=com.um.conicar&hl=es_MX
2. Jackson, S. A., Eklund R. C., & Martin, A. J. (23 june 2020). *Flow Scales*. Mind Garden. https://www.mindgarden.com/100-flow-scales
3. Kommetter, C., y Ebner, M. (2019). A Pedagogical Framework for Mixed Reality in Classrooms based on a Literature Review. In J. Theo Bastiaens (Ed.), *Proceedings of EdMedia+Innovate Learning* (pp. 919-929). Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/210261
4. Salinas, P., y Pulido, S. (2015). Visualization of Conics through Augmented Reality. *Procedia Computer Science, 75*, 147–150. https://doi.org/10.1016/j.procs.2015.12.231
5. UM Ventures. (29 march 2022). QUIS: The Questionnaire for User Interaction Satisfaction. https://www.umventures.org/technologies/quis%E2%84%A2-questionnaire-user-interaction-satisfaction-0