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Flexibility in augmented reality storytelling apps

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ABSTRACT

This research inquiries about the flexibility of two augmented reality storytelling apps, as well as eight specific variables of this cognitive characteristic of creativity from the Creapp 6–12 questionnaire. The study concludes that they meet all the specific variables of flexibility, used in convergent and divergent mode activities: they stimulate critical and divergent thinking, accessibility and adaptation to different levels of difficulty, including variety of codes, allow the interrelation of disparate elements, build different stories, manipulate and exchange elements, change and reformulate the story.

Keywords: creativity, flexibility, teaching methodologies, augmented reality, educational technology

1. Introduction

Digital narrative formats[1] procure new interaction possibilities for users[2–5]. These new formats are making their way in front of the analog format of story or album book in the educational field gaining increasing importance[6]. Digital applications (apps) consisting of augmented reality (AR) stories can be a new incentive, if used appropriately, for the promotion of the reading and learning habit, as it is shown for example by Ivanov Ivanov[7], or Campillo-Alhama and Martinez-Sala[8]. This is a current deficiency. In the empirical study by Felipe Morales et al.[9], the lack of reading habits of students preparing for the Degree of Early Childhood and Primary Education in Spain has been demonstrated.

In this situation it is an advantage, however, the access through tablet or mobile of these apps allows to be within reach of any user[10]. This point in favor is confirmed by the comparative study of Trucco and Palma[11] that foresees a greater increase in decreasing order in the Caribbean, South and Central America and Mexico. This study reports a high consumption of cell phones:

> The evolution of cell phone subscriptions per 100 inhabitants, unlike indicators of Internet or computer access, has increased faster and is converging with access to this equipment with countries at the forefront of technological development such as the United States and South Korea[11].

AR is part of expanded reality (XR). AR enriches the real reality in which the individual is, as pointed out by Manas Valle and Pena Timón[12], or

Martinez-Cano et al.[13] It allows the latter to visualize in this complementary information, either 3D elements, sounds, images and videos, positioned by means of certain physical marks, either space scanning or GPS data within what Carrera Álvarez et al[14], call digital ecosystem.

The previous publications reviewed, pioneers in Spanish with echo in Latin America, carried out by Reinoso[15], Cabero Almenara and Barroso Osuna[16], Roig-Vila et al.[17], López Meneses[18], Colussi and Assunção Reis[19] and Paíno-Ambrosio and Rodríguez-Fidalgo[20] on the application of AR for teachers or undergraduates of the Degree of Education began being of generic type raised in subjects of Educational Technology. On another occasion, the use of certain apps and narrative formats[21] digital in combination with certain teaching methodologies for both Early Childhood Education and Primary Education[22–24] on the basis of the uses of their analog counterparts[25,26]. A general thesis on AR in Education[27] directed by Victoria Marín and Julio Barroso has also been raised. Another thesis directed by Ignacio Aguaded, on multimedia formats for early childhood education also addresses AR[28]. Also Noelia Ibarra has directed another thesis that includes AR within the multimedia phenomenon[29].

However, on this occasion, in the research area described above, we propose to carry out a more specific study based on a basic area that gives great importance to these apps for the Primary Education curriculum: language. The novel inquiry is based on an educational intervention in the classroom in which students in the second year of "Didactics of Oral and Written Language" and in the third year of a related subject, "Verbal Competence", were asked to participate. These undergraduates belonging to the Primary Education Degree in the 2019–2020 academic year were able to experience AR stories by choosing two types of stories due to the format in which they were presented by the publishers, namely Arbi bookso Kokinos. The volumes experimented in team in Spanish through tablet and mobile. After experimenting with these stories, the students had to crea-

tively design in teams an innovative activity for primary school students through an active strategy, proposing the use in AR or in analog or mixed mode. If possible, they had to justify why they had planned the activity in such a way and with such an innovative teaching methodology[30]. This experimentation allowed them to learn first-hand about these two new apps linked to this new digital narrative format, as well as the educational possibilities, both convergent and divergent, according to Guilford's[31] classification, that they allow in combination with appropriate teaching strategies. After designing the activity, we asked them to give their opinion on the eight aspects related to the flexibility that these two apps allow, taking into account both the convergent and divergent thinking possibilities that they could consider both from the story of the Arbi books publishing house and the Kokinos publishing house.

In this sense it is worth remembering that convergent thinking also called logical or conventional is that which is directed to a correct and conventional solution to the problem by finding a single solution to it, on the other hand, divergent thinking is a flexible exercise of broad search for solutions in which, critically, as well as irrational and intuitive the input problem is questioned to give a novel approach to solutions[32].

1.1. ICTs for the promotion of creativity in education

The creative dimension is key in the personal, social, etc. Development of individuals and should be encouraged from the educational environment[33,34], especially by Primary Education teachers as this stage is a particularly sensitive period to boost it[35,36]. Teacher training at this educational level should be oriented towards the development of the necessary skills to express ideas and feelings through the mastery of language in its different forms, prioritizing innovation and creativity[33,37]. In this regard, in the current context, apps are considered optimal tools because they boost creativity and multiple skills implicitly[34,39] while favoring students' immersion in the digital environment[40,41]. In general terms,

teachers should implement an educational use of Information and Communication Technologies (ICT)[42] enhancing in their integration, not only the technological aspects, but, above all, the pedagogical ones[43–45].

ICTs have been an important factor of change in different areas and sectors of society, including education[46,47]. In this field, they have acquired a leading role due to the possibilities they offer with respect to the learning process[48–51]. In general terms, it can be stated that emerging technologies are transforming training and learning scenarios[52]. Among these, AR stands out for its educational possibilities and potential to improve learning and teaching[53–55]. This technology helps and favors the teaching of complex concepts and elements due to its abstract nature by allowing to materialize them virtually[56]. In addition, it is a very attractive tool for teachers and students because of its usable and friendly environment, its ability to motivate and because it favors collaborative work[52]. It also stands out for its easy implementation among students due to the familiarity with which they, from a very early age, download and use apps[57–61].

AR and apps are closely related, their increasing development is largely due to the use and massive implementation of cell phones[52,62,63]. In this sense, another advantage of AR in the educational setting is that it only requires incorporating students' own devices which facilitates its implementation[64,65].

In the formal educational environment regarding the development of the creative dimension through AR apps, story apps gain special importance due to their potential to boost it by taking advantage of their playful nature[34,38]. Its integration in the educational field is still incipient and requires the necessary research to ensure an efficient use[34,65–67]. This research should be developed at the level of apps, of the student body, but, also of teachers due to the responsibility they hold regarding the empowerment and acquisition of digital competences by stu-

dents[42,68,69] and to make up for possible shortcomings derived from insufficient training[64,70] and from lack of usage experiences[65,71–73].

Despite the advantages mentioned above, there is a scarcity of research on this type of apps in the teaching field, especially with regard to their evaluation as an essential preliminary phase for their correct integration into the teaching activity[65,74], hence the interest of this study on AR story apps as tools that enhance creativity.

Among the key factors that determine the effectiveness of methodologies and tools in order to enhance creativity, the present study focuses on flexibility because of its relevance[75]. As Guilford[76] points out, flexibility is one of the six dimensions that define creativity and is associated with personal traits related to fluency and flexibility of thought, originality, capacity for redefining situations, for elaboration, etc. In the same sense, Marín refers to flexibility as the capacity to propose alternatives to everyday situations, linking it also to creativity. Moreover, in the field of study of this research, the apps of stories and tales, the relationship between flexibility and creativity has been found, as well as the ability of these apps to foster it[34,38]. Specifically, it is concluded that they favor critical and constructive reflection through the options related to the assessment and selection of different alternatives of content and form in relation to the construction of the story[38].

Regarding the apps under study, it should be noted that Arbi book proposes a story design with left page text, right page analog and flat drawing and also characters and elements in three dimensions (AR) with planned movement accompanied by music for each page. If necessary, every so often it poses a reading comprehension question that must be answered successfully to continue progressing in reading. At the end of the book there is a poster with a left and right page, as well as two games to provide space for gamification. Arbi book presents four stories in total composed by Iker Bruguera. In these stories Arbi, a gentleman boy, together with his gang of

friends, solves serious problems that affect the community, such as lack of emotions, lack of ecological care, etc. Kokinos offers another possibility. For example, in the story "Valentina", authored by Lena Mazilu. This story deals with the emotional difficulties of an individual and how she overcomes them. A little bear manages to get out of her comfort zone and overcomes her fears. We find that both pages are presented in analog and augmented mode on a single plane. In addition, the voice-over narration can be activated from the beginning. Every other page can be interacted with by touching the screen where other characters appear in augmented mode or set elements move. It is also sometimes accompanied by sounds and music. In both editorials, the ethical content about values is raised in the story.

2. Hypothesis and research objectives

The hypothesis of this research is to affirm that in a positive way these two apps allow cognitive flexibility in a convergent and divergent way. The minor hypotheses coincide with the specific objectives listed.

We recall that flexibility is a factor of creativity already highlighted by Torrance[77] in the creative thinking test. We understand that this flexibility is developed in eight aspects that coincide with the eight specific research objectives listed below.

Thus, the general objective of this research is to find out if these two AR story apps (one app of Valentina and the other of Arbi and her friends' stories) allow convergent and divergent flexibility applied in activities in the Primary Education classroom in the area of Language.

The specific objectives aim to discover eight facets of this flexibility in these apps. These variables come described in the validated test[38], namely:

1. Is the environment accessible (to be observed, manipulated, etc.).

2. Adapts to different levels of difficulty of the children.

3. Includes variety of codes (verbal, iconic, sound, etc.) to the perception of the senses.

4. Allows the manipulation and exchange of elements.

5. Allows for the interrelation of disparate elements.

6. Gives freedom to construct different types of stories.

7. Offers the possibility of changing and reformulating the story.

8. Stimulates critical or divergent thinking.

The academic and professional interest of this research lies in the evaluation of AR apps for story development. Their integration, as well as that of any other ICT, as complementary tools for learning processes is not free of prejudice if it is not done correctly, i.e., accompanied by "evidence-based practices that take advantage of their benefits and instruct students to successfully navigate in the digital world"[78]. In this sense, their evaluation becomes essential for teachers who must know the potential of the tools they use as complements in the learning-teaching processes prior to their implementation[47,65,66] from a technological and pedagogical point of view[43].

3. Methods

The methodology of this inquiry firstly consisted of an extensive bibliographic review of the literature in Spanish about AR applied to Education. Secondly, it is approached from a quantitative, empirical methodology through the collection and analysis of statistical data using an anonymous questionnaire developed with Google forms.

3.1. Participants

Individuals were able to answer in a weighted, anonymous and voluntary way through a link located

on the virtual campus, within a period of one week immediately after the intervention. The university students enrolled in the Primary Education Degrees at the Faculty of Education of the University of Huelva in the academic year 2017–2018 were a total of 309 students (transparencia.uhu.es). This study was carried out in the academic year 2019–2020, so it shows that participated in our research (N = 128) is an enough sample. In addition, this sample is raised homogeneous by age and by the number of individuals is valid to question on these eight aspects and that individuals provide significant results.

These are students of the Primary Education Degree, starting between 19 to 21 years old, namely, second year (n = 97), third year (n = 31) and Erasmus (n = 1). When analyzing the sample, we were surprised to discover that only 46.8% of the students were of the expected age for these two academic years, 81% were between 19 and 23 years of age and almost a quarter of the sample was 19.4% over the age of 23 up to 42 years of age. 23 years represents the minimum age to finish the degree. Therefore, this is a sample with more than half of a higher than expected maturity. The sample is mostly female (69.5%) and mostly composed of second year students (75%).

3.2. Instruments

The sample was also questioned about age, grade, sex, and the subject they had taken. In addition, they were asked what story they had experienced. Likewise, they answered eight questions about flexibility corresponding to the Creapp 6–12 test[38]. We asked about the flexibility dimension with respect to two apps with application in the area of language that had not been studied previously. These were two AR stories in Spanish, "Valentina" from the Kokinos publishing house and another story from the Arbi books publishing house, "Arbi y sus amigos" with which the individuals in the sample had previously experimented.

This dimension of flexibility with respect to the creative potential of an app is part of the Creapp 6–12 questionnaire composed by Del Moral Pérez et al.[38] The complete questionnaire addresses five dimensions to address the creative potential of app: flexibility, originality, fluency, problem solving, and product development with a total of 40 items. Each question is answered on a four-possibility estimate scale: strongly, somewhat, slightly or not at all agree. Each of these possibilities is measured quantitatively by means of the corresponding numerical rating with 4 equaling "very much" and 1 equaling "do not agree at all". This questionnaire is validated by experts[38] and by further research analyzing a sample of ten apps[34].

4. Results

Regarding age, the sample was significantly composed by 81.6% by students aged 19 to 23 years and the remaining 19.4% was composed by students aged 24 years up to 42 years. In decreasing order, 25.8% were students aged 19, followed by 21.9% aged 20, 16.5% aged 21, and so on.

In reference to gender identification, the sample is composed mostly of women 69.5% and 28.9% of men. In addition, 0.8% preferred not to specify the sex and 0.8% expressed "other sex".

Regarding the grade to which they belonged and the subject they were studying, most of the individuals surveyed were in the second grade, 75% of them studying "Didactics". Only 24.2% were third year students studying "Verbal Competence" and 0.8% were Erasmus students studying "Didactics".

Most of the students chose the book of Arbi and his friends, 54.7%, as opposed to the story of Valentina, 45.3%.

4.1. Analysis of flexibility

Regarding the analysis of the eight flexibility factors, we report the following results.

As can be seen in **Figure 1**, regarding the first factor of analysis, as to whether the app environment was accessible, the students answered in the affirmative with 63.3% stating "quite agree", with 27.3%

"very much agreeing". Both percentages, if added together, result in a positive significant data, representing 90.6% of the analyzed sample. Consequently, the first specific hypothesis has been proven. In the sample, the negative data are as follows: 5.5% reflect "little" and 3.9% "not at all".
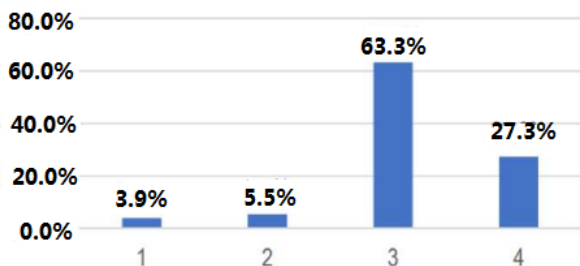

Figure 1. Evaluation of accessibility.
Source: own elaboration.

The results of the second factor, in reference to whether the app adapts to the different levels of difficulty, are shown in **Figure 2**. 57% answered "quite a lot" and 33.6% answered "a lot". Their sum reaches 90.6%, which is also a significant favorable figure. Therefore, also, the second specific hypothesis has been proved. The negative data reflected is 9.4% reflecting "little" and no student has selected the option "none" or score 1.
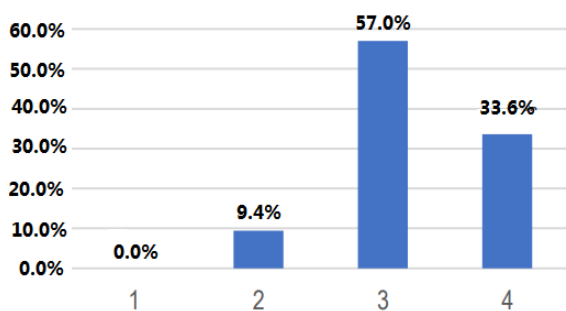

Figure 2. Evaluation of levels of difficulty.
Source: own elaboration.

The results relating to the variety of codes (verbal, iconic, sound, etc.). Those relating to the third factor, show that 48.4% of the individuals surveyed said "a great deal" and 45.3% "quite a lot". The two ratings therefore add up to 93.8%. The negative data reflected are limited to the option "little", which was selected by 6.3% of those surveyed. In this case, as

in the previous one, the option "none" was not selected (**Figure 3**). Based on the data shown in **Figure 3**, the third specific hypothesis has been proved.
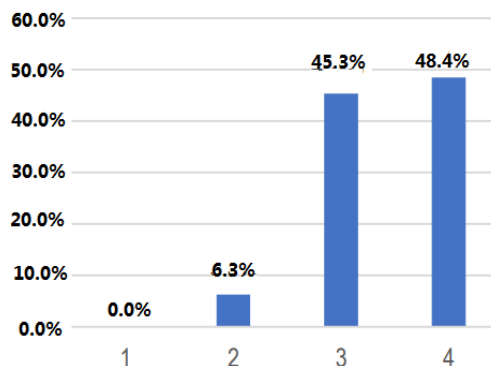

Figure 3. Evaluation of the variety of codes.
Source: own elaboration.

Figure 4 shows the evaluation of the fourth factor, concerning the manipulation and exchange of elements. The responses are, again, concentrated in the highest scores: 52.3% "quite a lot" and 33.6% "a lot." These percentages, when added together, bring a significant figure of 85.9%. Therefore, the fourth specific hypothesis is also verified. The negative data reflected is 14.1% reflecting "a little," this being the factor with the highest score for this option. And as in the previous cases (factors 2 and 3) option 1 or "not at all" has not been considered.
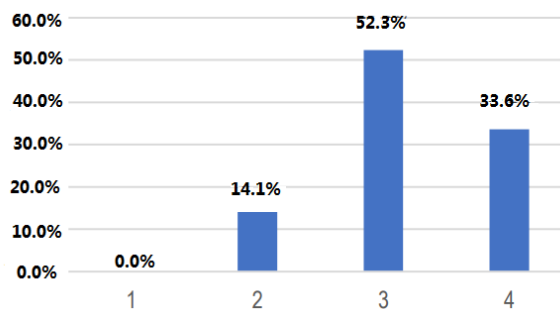

Figure 4. Evaluation of the manipulation and exchange of elements.
Source: own elaboration.

Regarding the fifth factor, that apps enable the interrelation of disparate elements, 61.7% responded "quite a lot" and 26.6% "very much" (**Figure 5**). When added together, these two figures result in 88.3%, which is also a significant figure. The fifth specific hypothesis has therefore been proven. The negative data reflected is 10.2% reflecting "little"
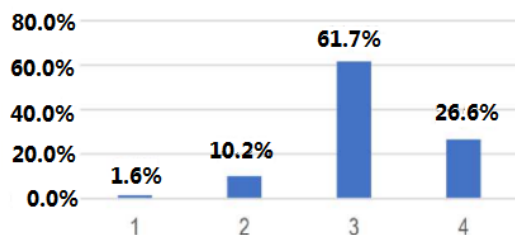
and 1.6% reflecting "none" (**Figure 5**).

Figure 5. Evaluation of the interrelation of disparate elements.
Source: own elaboration.

Regarding the freedom granted by the app to construct different types of stories, 47.7% of the students answered "a lot" and 40.6% "quite a lot" (**Figure 6**). The sum of both amounts, and therefore of the two positive scores, the significant figure of 88.3%. The sixth specific hypothesis is also verified. The negative data reflected only 8.6% of the students who answered "little" and 3.1% who answered "not at all" (**Figure 6**).
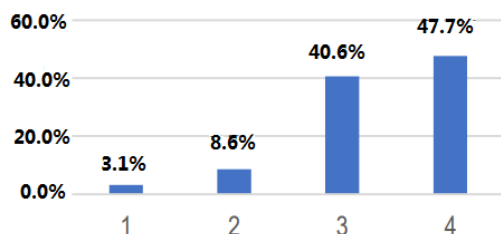

Figure 6. Freedom for the construction of narratives.
Source: own elaboration.

Figure 7 shows the results of the evaluation of the seventh factor, related to the possibility of changing and reformulating the story offered by the app. In this regard, 48.4% of the students answered "quite a lot" and 28.1% "a lot". Adding the two figures together, the result is 76.5% of the sample. Consequently, the seventh specific hypothesis has been proven, as have the previous six hypotheses. The negative data reflected (12.5% for "a little" and 10.9% for "not at all") are among the highest overall, and the highest for the "not at all" option.
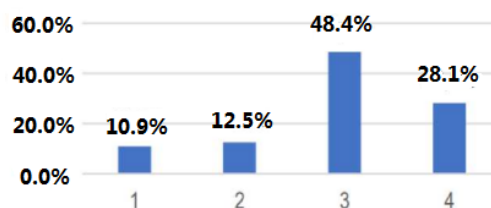

Figure 7. Evaluation of the possibility of changes and reformulation of the story.
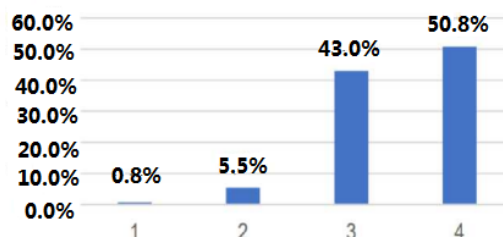Source: Prepared by the authors.

Figure 8. Evaluation of the potential to promote critical and divergent thinking.
Source: own elaboration.

The last factor evaluated, regarding the stimulation of critical or divergent thinking, is shown in **Figure 8**. Some 50.8% of respondents chose "very much" and 43% "quite a lot". The sum of the favorable ratings is again in the majority (93.8%). This data is significant and confirms hypothesis eight. The negative data reflected is 5.5% reflecting "little" and 0.8% "not at all".

Finally, we present a summary of the mean scores obtained in each of the factors according to the evaluation scale (1–4) as well as the overall flexibility for the two apps and for each one, respectively (**Figure 9**).
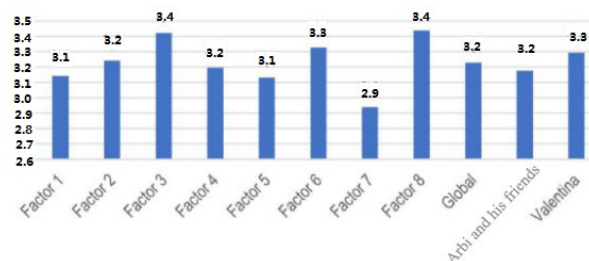

Figure 9. Average evaluation of flexibility.
Source: own elaboration.

As can be seen in **Figure 9**, all the dimensions associated with the evaluation of flexibility have been positively evaluated, with most scores between the maximum scores (3–4), with factors 3 (variety of

codes (verbal, iconic, sound, etc.) and 8 (stimulate critical or divergent thinking) having the highest scores and factor 7 (possibility of changing and reformulating the story) having the lowest score.

It should also be noted that factors 2 (levels of difficulty), 3 (variety of codes) and 4 (manipulation and interchange of elements) did not receive any score associated with "nothing", i.e. Score 1. And that factors 7 (possibility of changing and reformulating the story) and 4 (manipulation and interchange of elements) are the ones that were most often selected for scores 1 or "nothing" and 2 or "little", respectively.

Overall, flexibility achieves a high average score (3.2) that is maintained for the individual apps, with the Valentina app scoring slightly better.

5. Conclusions

AR stories are presented as a digital narrative format that can stimulate new generations of readers in Latin America thanks to the accessibility allowed using smartphones.

Publications on AR, both those that report good practices and scientific research, are relatively recent in this decade in Spanish. It is a topic that is arousing growing interest. As applied to Education, R. Reinoso, belonging to the Espiral Association, published in 2012 in relation to good practices. From that moment on, scientific research has been carried out at university level in a generic way led by specialists such as J. Cabero Almenara, J. Barroso Osuna, R. Roig-Vila and E. López Meneses. The subject matter is fully addressed in the thesis directed by the specialists V. Marín and J. Barroso Osuna, and indirectly in some doctoral theses directed by other ICT specialists such as I. Aguaded and N. Ibarra. C. Magadán and B. Pena Acuna oversee presenting the praxis of Primary and Early Childhood Education. The latter also investigates the concrete applications that can be used in the area of Language with respect to innovative teaching strategies and in relation to

the foreseen content blocks, namely, oral competence, reading and writing competence, knowledge of the language and literary education.

In line with these authors, as well as with the research and studies reviewed, we conclude that AR can and should be considered as a basic element of education due to its numerous advantages, but being aware that its implementation is not free of requirements. As is generally the case with ICTs, their integration in the service of education offers a wide range of very attractive possibilities, but also very demanding and, in some cases, overwhelming due to the speed with which they evolve.

Specifically, about AR, the studies consulted coincide in pointing out that its integration requires a didactic application, taking care of the dimensions of creativity, collaboration and reflection. Regarding flexibility, as a determinant factor of creativity, in the two-story apps under investigation, Valentina's, which posed an emotional problem, slightly predominated over that of Arbi and her friends, which presented a community problem.

The analysis of the eight specific variables of flexibility allows us to partially verify (sub-hypothesis) and, in general, the general hypothesis of this research, since the results positively affirm that the two apps allow convergent and divergent flexibility, having been verified in all eight specific facets.

In decreasing order of exposure, the sample highlighted with high percentages that the apps stimulate critical thinking and divergent thinking. Secondly, accessibility and adaptation to different levels of difficulty. Thirdly, they emphasized that they include a variety of codes. Fourth, that it allows the interrelation of disparate elements. Fifth, that it allows freedom to construct different narratives. Sixth, they emphasized the manipulation and exchange of elements. Finally, the possibility of changing and reformulating the story has been underlined with sufficient individuals.

It is considered that AR stories can be at the direct service of convergent and divergent activities for

the blocks of contents indicated for Primary Education referring to reading and writing, reading habits, literary education, and knowledge of language. Likewise, it is deduced that AR as a digital narrative format contains useful applications in the educational and creative sphere combined with appropriate strategies that can be at the service of the development of the area of Language and other disciplines at the Primary Education level, as well as we bet on its visual-sound appeal and "wow", its effectiveness at other levels.

Finally, it is important to allude to the challenges that AR still faces in order to guarantee an adequate pedagogical integration. Fundamentally, there is a need to promote the training of teachers in this type of methodologies, as well as to improve the connectivity infrastructure in university facilities.

Conflict of interest

The authors declare no conflict of interest.

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