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Augmented reality instructional tool in enhancing geography learners academic performance and retention in Osun state Nigeria

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Abstract

The emergence of new technological innovations in classroom has brought about greater changes in pedagogy especially in concepts related to abstraction such as Geography. Geography teaching and learning particularly elements of physical Geography, is mostly approached in a conventional pedagogical manner even as the concept consist abstractions. Physical Geography comprise abstractions leading to students' conceptual difficulties, leading to poor academic performance and low retention. On this basis, this study engaged a visualisation technology; Augmented Reality Instructional Tool (ARIT) to examine Geography learners' performance and retention when they are exposed to its' use in learning Physical Geography concepts. Four research questions were answered, while, one hypothesis was tested at 0.05 level of significance. A mixed method research approach of an experimental and survey designs was adopted. A multistage sampled intact class served as the participants. Three test instruments: an open-sourced AR mobile application (ARSJA); an adopted performance and retention test on physical geography (PRTPG); and a validated 7-Item questionnaire with a reliability value of 0.82 were employed as the research instrument. A retention rubric adopted based on Brown-Peterson Task of Memory was used as the qualitative content analysis tool. The major finding of the study was that ARIT enhances learners' performance and retention, and equally embrace gender equality. The study concluded, that the teaching and learning of Geography can be enhanced with the use of ARIT.

Keywords Augmented Reality · Instructional Tool · Geography · Academic · Retention · Performance · Reaction · Brown Peterson Scale

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1 Introduction

Nigeria as a federal entity recognises the important roles that education play in her socio-economic reform. This has necessitated Nigeria to prioritise and provide necessary supports to the education sector in order to form the core part of the human capital that will help develop her economy. This believe is resonated in the goals of education as stated in the Nigeria National Policy on Education (Federal Republic of Nigeria. FRN 2013) for post-basic education and career development (PBECD). The role of PBECD is to lay the foundation for further education; and provide trained manpower in the applied sciences, technology, and commerce at sub-professional grades towards economic development. These roles evidently show that Nigeria recognises the role of innovative technologies in her educational system (Ahmad 2014).

As laudable as the Policy is, the instructional process in Nigeria is still largely approached in a conventional manner, that is, one-to-all direct communication between students and teachers, which is usually confined to the cubicle of the classroom. This approach has been strongly criticised by contemporary educators such as (Ibáñez et al. 2011), that the eighteenth century way of educating is broken and in this digital age, more appropriate instructional strategies and technologies such as mobile computing technologies can significantly transform and create a breakthrough that will help the teachers do their jobs better and students learn concepts better especially abstract concepts.

As regards abstract concepts, some empirical studies such as the study of (Osman et al. 2007) were conducted with the sole purpose of learners self-assessing and suggesting how learning goals can be achieved within their context and how learners can be engaged in a more interesting manner, most especially in subjects that involve abstract concepts, particularly, Geography. (Osman et al. 2007) posit that students are less interested in studying Geography, because they perceive Geography to be a boring subject involving too many abstract concepts.

In fact, (Nor et al. 2015) claim that understanding the concepts in Geography requires a depth of understanding and visualisation skills. It is thus, safe to conclude that the difficulties experience in understanding the abstract concepts in Geography is the reason for the high failure rate in the subject especially in Nigerian context (Tsai and Yen 2014). The high failure rate could be attributed to conceptual misconception, owing to the fact that misconception among students has to be considered, because, it can interfere with the students' learning of scientific principles and concepts. Therefore, selecting the best and appropriate technology in the teaching of abstract concepts plays an important factor in avoiding and minimising the students' misconception of abstract concepts. Thereby improving students' performance in Geography. Hence, the aim of this study.

1.1 Literature review

Technology has become the knowledge transfer highway, therefore, the contemporary works of life, particularly education, now revolves around technology. (Ahmad 2014) asserts that the integration of technology in this century of digital age has evolved through several innovations, and virtually every human activity has been reshaped. Supporting this view, (Fleck and Simon 2013) posit that classrooms across the globe are equally not left out in ushering technologies for instructional purposes.

In line with this, (Matsutomo et al. 2012) opines that a groundswell of interest has been generated on how technology can best be harness to improve the efficiency and effectiveness of classroom instruction. The author argued that the popular notion that humans are so underdeveloped and devoid of basic infrastructure that humans cannot even afford to think about computers is not very valid anymore. The author concluded that with the decreasing cost and increasing usability of desktop computers, which in fact face the threat of extinction at the hands of emerging ubiquitous and sophisticated devices such as laptops and mobile phones have transformed the situation from bleak to bright.

(Ahmad 2014) states that education is characterised with a well-established history of adopting devices that are not originally intended for educational purposes. In a similar vein, (Marques 2017) posit that the integration of technology into instructional activity was never an accident. Therefore, the integration of technology into education was a calculated attempt in creating avenues for learners to learn more in less time, and learn at anywhere and anytime without reducing quality (Tijani 2009).

Empirically, the effectiveness of technology for instructional purposes have been examined across various modes, ranging from social media, flipped classroom, web quest, among others. Cumulatively, obtained results have indicated that classroom technology is an authentic and veritable tool when appropriately employed in bringing about effective and improved learning performance across levels of education and in various subject areas (Abanikannda 2017; Adedokun-Shittu et al. 2017a; Lin et al. 2011). In addition, classroom technology utilisation is believed to complement the traditional forms of teaching and learning (Yasak et al. 2010).

(Adedokun-Shittu et al. 2017b) posit that the overwhelming benefits of technology in teaching and learning have necessitated teachers and students alike to use technology without understanding the fundamentals of utilising classroom technology for instructional purposes. Hence, a successful utilisation of classroom technology does not only heavily depend on the perspective and willingness of teachers and students involved, but the adequate possession of appropriate technological skills and tools to improve teaching and learning.

The exciting potentials that visualisation technologies possess are enormous to facilitate the understanding of science concepts and preventing misconceptions in the scientific domain (Hay et al. 2000; Nor et al. 2015). In a study conducted by (Hay et al. 2000), the researchers indicated that improving students' visualisation skills is possible, and this can be achieved through the presentation of a variety of abstract visual media and subsequently allow students to explore and manipulate the media independently without teachers' influence. Several of these visualisation technologies do exist and had been previously examined. Among them are animation and simulation. (Pérez-López and Contero 2013) confirmed that improving students' mastery of abstract concepts can be achieved with the utilisation of virtual environments that have been designed for learning.

Visualisation technologies such as animation and simulation could be utilised in addressing the problem of misconception as well as helping students understand concepts better. In a study conducted by (Wu et al. 2001), which was targeted towards helping students understand the abstract concepts in Chemistry, the researchers developed a visualised animated environment in order to allow students to visualise the interactions among molecules and to better understand the related chemical concepts. The study concluded that the developed visualised animated environment helped students to learn better and understand chemistry concepts. Generally, visualisation

technologies provide a means for making visible phenomena that are too small, large, fast or slow to see with the unaided eye (Chen and Su 2011).

The use of visualisation technologies such as these in education are becoming more advanced and more sophisticated. Nowadays, one of the technologies that show great potential in education especially in visualising abstract concepts is Augmented Reality (AR). In technical term, AR is an amalgamation of computer-generated multimedia, which enhance user's perception of the real world through the addition of virtual information (Annetta et al. 2012). Augmented Reality Systems, according to (Annetta et al. 2012) is the technology that allows real and virtual objects to co-exist and interact with simultaneously. (Bacca et al. 2014) claimed that the process of combining virtual data with real world data can provide users with access to rich and meaningful multimedia content that is contextually relevant and can be easily and immediately acted upon. Unlike Virtual Reality (VR), which immerses the user's senses in a complete synthetic environment, AR licenses and permits the user to perceive the real environment through a virtual overlay.

Computer-generated objects such as virtual objects that are used in the AR systems may include 2 and 3-dimensional images, text, video only, audio only, audio-visuals, models, and animations among others. Ideally, users will perceive the virtual objects to be synchronising and co-existing within the real world. (Johnson et al. 2010) state that the potential that AR possesses in providing both powerful contextual, on-site learning experiences and exploration, and discovery of the connected nature of information in the real world is stronger than traditional means of visualising abstraction.

The application of AR is eclectic and it has been put to use in a number of fields, including education, in which AR technology provides students or technicians with necessary data about specific objects they are working with; and in museums, where artefacts can be tagged with information such as the artefact's historical context or where it was discovered (Marques 2017; Tsai and Yen 2014). Experts in the field of AR concluded that AR has the potential to engage and motivate learners to explore material from a variety of differing perspectives, and has been shown to be particularly useful for teaching subject matter that students could not possibly experience first-hand in the real world. It also affords the demonstration of spatial relationships and the interactions of elements within a 3D space whilst providing the potential for seamless interaction between the real and virtual worlds. It could prove a key element as educational technology developers move towards a vision of learning environments richly populated with a blend of hardware and software applications (Kerawalla et al. 2017; Shelton and Hedley 2002).

Within the academy, the use of AR in formal education is in its infancy. (Shelton and Hedley 2002) began to explore its use as a tool for undergraduate teaching in 2000. They found that it was especially useful for teaching about subject matter that students could not possibly experience first-hand in the real world. Educators are beginning to provide students with deeper, more meaningful experiences by linking educational content with specific places and objects. In many disciplines, field trips are part of the course; by supplementing these explorations with mobile technologies and data-collection devices (including digital cameras), the lessons can be extended beyond the field trip. In some cases, augmented reality technologies have been integrated into educational games. In MIT's Environmental Detectives, for example, students learn about environmental sciences and ecosystems by finding clues and solving a mystery on the MIT campus using PDAs fitted with GPS devices (EDUCAUSE 2005).

Previous studies have also explored AR for a number of architecture and construction applications. For example, (Roberts et al. 2002) used AR to overlay locations of subsurface utility lines onto real world views in order to demonstrate the potential of AR in helping maintenance workers avoid buried infrastructure and structural elements. (Kamat and El-Tawil 2005) used AR to study the extent of horizontal displacements sustained by structural elements due to extreme loading conditions and the result was advantageous. (Wang 2012) also studied the potential of AR as an assistant viewer for computer-aided drawing. They recorded a greater production results which were ultimately credited to AR.

A range of technologies can be used for augmented reality. Many augmented reality projects use headgear or a similar device that projects data into the user's field of vision, corresponding with a real object or space the user is observing. In the case of a technical course on PC maintenance, for example, augmented reality might overlay a schematic diagram onto the inside of a computer, allowing students to identify the various components and access technical specifications about them. PDAs or other portable devices can use GPS data to provide users with context including visual, audio, or text-based data about real objects or places. Augmented reality is not merely a companion text or multimedia file but a technology designed to see a real object or place and provide the user with appropriate information at the right time. Augmented reality is designed to blur the line between the reality the user is experiencing and the content provided by technology (EDUCAUSE 2005).

Integrating Mixed, Augmented, and Virtual Reality (MAVR) technologies into education has evoked growing interest among researchers and practitioners. (Cheng and Tsai 2013) discussed the potential of integrating augmented reality into science education, allowing students to get a first-hand experience of objects or phenomena that cannot be seen with the naked eye. The application of AR in education is not limited to teaching science, but has reached humanities and arts as well (Bacca et al. 2014). Augmented reality techniques can in general lead to enhanced understanding of content, improved memory retention, better task performance, and increased student collaboration and motivation (Radu 2014). Enhanced student motivation and collaboration can be attributed to the novelty of the experience as well as the possibility of adopting a more active type of learning in which students can move around the classroom.

Augmented reality applications can be designed for different subjects and student levels. As an example, the Malaysian government recently created educational materials for a Road safety initiative, which included modules that combined mixed learning environments, interactive multimedia, AR and VR (Bakar et al. 2011). Other example is the work of (Lin et al. 2011). In their project, the authors used AR and a touch-screen to enhance the educational resources about fish conservation in Taiwan. Their results focused on system usability which was positive in an educational context. There are also a number of studies that explore the applications of AR technology to language learning. An interesting study was conducted by (Ibáñez et al. 2011) where a multiuser AR platform for learning Spanish as a foreign language was developed. Results showed that AR has a positive effect on student motivation and improves the language learning process.

Other AR tools such as Construct3D developed by (Kaufmann and Papp 2017), have been specifically designed for Mathematics and Geometry education at high school and university levels, encouraging students to experiment with geometric constructions. Construct3D was validated as a simple learning tool which contributed

significantly to the improvement of spatial abilities and to maximize learning transfer. VR and AR have also been used to provide an experience-based learning environment for understanding physics laws (Irawati et al. 2008). In this system, simulation conditions were guaranteed via a 3D environment. Another AR application for Physics education was developed by (Matsutomo et al. 2012) where magnetic fields were visualized as realistic live magnetic distributions.

Virtual systems are useful when a laboratory is not available or when the experiences are dangerous, expensive, or time-consuming. (Chen and Su 2011) conducted a study where elementary school children could learn to paint. The system used a sketch environment with computer vision and AR. Children could draw directly on the interface which provided additional functions such as contour extraction, image processing, and AR rendering. Results showed that the sketch system encouraged young children to participate and brought the natural painting experience to a virtual environment. The study opened up alternative opportunities for AR applications and tracking technologies.

(Lee 2013) maintains that AR has been experimentally applied to both school and business environments. The author states further that now that the technologies that make AR possible are ubiquitous, powerful, and compact than earlier, it is possible to deliver AR experiences to not only the corporate settings but also classrooms through tablet computers like mobile devices. Thus, various instructional approaches can now utilise AR technology in the classroom. Sadly, AR is yet to be adopted in teaching and learning Geography in Nigeria.

Currently in Nigeria, there is a growing concern about Geography learners' poor academic performance as reported by WAEC Chief Examiner's Report (West African Examinations Council, WAEC 2016). This has necessitated conscious efforts geared toward improving the Geography instruction at all levels. The efficient and accurate teaching of Geography depends largely upon the appropriateness of instructional strategies and technologies employed which would be reflective on students' performance. Hence, the need for employing visualisation technology such as AR in this study.

1.2 Research methodology

A mixed method approach was employed in this study. Indicatively, both the quantitative and qualitative research approaches were adopted. The quantitative approach involved a descriptive research of the survey type which was used to determine students' reaction to learning geography with ARIT. Intact/static quasi-experimental design was employed to ascertain if the treatment had any resultant effect on the experimental group. The qualitative approach involved a content analysis of a retention rubric checklist adopted in accordance with Brown-Peterson Task of Memory to examine the retention level of students taught geography with the use of ARIT.

The population for the study included all Geography learners in Osun State Nigeria, while an intact class that have access to the use of mobile devices in a secondary school in Osun state, Nigeria was selected purposively to serve as the participants in this study. The research instruments employed in this study

included: an adopted AR mobile application (Augmented Reality Space Journey Application (ARSJA)) serving as an instructional tool (ARIT); a validated performance and retention test in Geography (PTG and RTG); a validated 7-Items researcher-designed questionnaire with a reliability value of 0.82 using Cronbach-Alpha at 0.05 level of significance; and a retention content analysis rubric adopted based on Brown-Peterson Task of Memory stipulating four levels of memory retention (Recall, Recognition, Relearning, and Reconstruction).

Data collected were analysed with range, statistical mean, *t*-test, and content analysis approach in order to answer the research questions raised and the hypothesis stated in this study at 0.05 significance level (Tables 1, 2 and 3).

1.3 Research questions

The following research questions were raised and answered in this study:

1. What is the academic performance of students taught Geography using augmented-reality instructional tool?
2. What is the retention performance of students taught Geography using augmented-reality instructional tool?
3. How do students react to augmented-reality instructional tool in learning Geography?
4. What is the retention level of students taught Geography using augmented-reality instructional tool?

1.4 Research hypothesis

The following hypothesis was stated and tested at 0.05 level of significance:

H₀₁: There is no significant difference between the retention performance of male and female students taught Geography using augmented-reality instructional tool.

Table 1 Performance in Using ARSJA to Learn Geography

Performance Test				Retention Test			
Test Scores	Frequency	Percentage	Performance Level	Test Scores	Frequency	Percentage	Performance Level
0–39	0	0.0	–	0–39	0	0.0	–
40–49	0	0.0	–	40–49	0	0.0	–
50–59	0	0.0	–	50–59	0	0.0	–
60–69	18	72.0	Very Good	60–69	2	8.0	Very Good
70–100	7	28.0	Excellent	70–100	23	92.0	Excellent
Total	1729	25	69.2	Very Good	1753	25	Excellent

Table 2 Mean of geography learners' reaction to augmented reality in learning geography

S/ N	Items	Mean
1.	I tend to develop more interest in the classroom because of the combination of visual impression in the instructional process.	3.33
2.	I find the content of these lessons interesting and every expectation I have for these lessons have been exceeded.	3.20
3.	It was not a waste of time to show me actual astronomical and celestial objects with AR.	3.20
4.	Using AR presentation for the lesson helped me to have a better learning experience.	3.13
5.	Seeing the astronomical and celestial objects in my environment offer a reality of experience which stimulates self-activity on my part as a student.	3.13
Grand Mean		3.21

Source: Field Survey, 2017 *Mean ≥ 2.5 = Agreed, Mean < 2.5 = Disagreed

Table 3 *t*-test Analysis of the Retention Performance of Male and Female Students' taught Geography using ARSJA

Gender	N	X	SD	df	<i>t</i>	Sig. (2 -tailed)	Remark
Female	11	84.67	9.94	23	-.748	.468	Accepted
Male	14	80.78	9.75				
Total	25						

1.5 Data analysis

1.5.1 Quantitative results

The benchmark of ranges 0–39, 40–44, 45–49, 50–59, 60–69, and 70–100 to represent fail, poor, fair, good, very good, and excellent respectively was employed. In the performance test conducted, 18 Geography learners performed in the very good category, while, only 7 performed excellently. A discrepancy in performance could be observed in the students' retention scores, revealing that many of the students performed excellently (Johnson et al. 2010) and only 2 performed in the very good category, compare to the performance test that was conducted. Summarily, the result of the study revealed that students perform excellently when taught Geography using AR. Equally, the study indicated that students were able to remember previously learnt concepts excellently.

In determining the Geography learners' reaction to learning geography with the use of ARIT, mean was employed to analyse the collected data and a benchmark of 2.5 of a 4-point Likert scale was adopted. The grand mean of 3.21 indicated that Geography learners have a positive reaction to learning Geography with the use of AR.

1.6 Hypothesis Testing

H₀₁: There is no significant difference between the retention performance of male and female students taught geography using ARIT.

The analysis revealed that there was no significant difference between the retention performance of male and female students taught geography using ARIT. This is reflected in the findings of the hypothesis tested; df (Cook 2006) $t = -.748$, $p > 0.05$. Thus, the hypothesis which states that “there is no significant difference between the retention performance of male and female students taught geography using augmented-reality instructional tool” was accepted.

2 Qualitative result

The retention performance test sheets were analysed using direct content analysis on problem-based activities in section B of the RTG. The analysis was guided by retention content analysis rubric adopted based on Brown-Peterson Task of Memory (BPTM), stipulating four (Ahmad 2014) levels of memory retention (Recall, Recognition, Relearning, and Reconstruction).

2.1 Problem-based activities in section B

Table 4 shows the distribution of questions in section B of the RTPG. Questions 1,2,3 and 4 were structured to measure the recall stage; question 5 and 7 were structured to measure the recognition stage; questions 3 and 6 were structured to measure relearning; and question 8 was structured to measure the reconstruction stage of memory retention of the respondents. The content was analysed by coding yes as $\checkmark$ and no as X in order to explain the students’ contents based on the themes extracted from the BPTM. The result is presented in Table 5:

Table 5 indicates that all the respondents were able to recall, repeat, and reproduce previously learnt concepts taught in Geography with the use of ARIT. The table also revealed that majority of the respondents were able to recognise and identify elements and objects that were previously learnt from a combination of learned and unlearned materials, just few (Ajani 2018) of the respondents were not able to recognise the concepts. Also, majority (Kamat and El-Tawil 2005) of the respondents were able to relearn the concepts that were already lost from the memory after the inability to recall at the initial level. The table however, showed that majority (Dzever 2015) of the respondents were not able to reconstruct and rearrange different parts of a broken link to its original form, only 11 of them were able to reconstruct and rearrange the broken link.

Table 4 Distribution of questions according to memory retention level

Retention Level	Recall	Recognition	Relearning	Reconstruction
Question(s)	1, 2, 3, and 4	5 and 7	3 and 6	8

Table 5 Content analysis results of respondents based on brown-peterson task of memory retention

Retention Level	Recall	Recognition	Relearning	Reconstruction
No. of Students	25	20	24	11

Based on the content analysis, students were able to retain more than half of the contents previously learnt in Geography with the use of ARIT, even though reconstruction was sparsely observed, this might be due to the limited structured duration that is available for students to interact and explore ARIT in the classroom. The analysis also indicated that ARIT is a cogent instructional tool in improving and enhancing the retention level of geography students, most especially in the elements of physical geography aspect. This implied that learning actually took place and ARIT improves students' retention level in Geography.

3 Discussion, conclusion and implication

This study examined Geography learners' performance and retention when taught using ARIT. The findings revealed that the use of ARIT in learning selected concepts like physical geography improves students' performance. This is in alignment with the study of (Fleck and Simon 2013; Shelton and Hedley 2002) on the use of AR in teaching students earth-sun relationships. The researchers asserted that AR interfaces do not merely change the delivery mechanism of instructional content but also fundamentally change the way that content is understood, through a unique combination of visual and sensory information that results in a powerful and superior level of cognitive access to complex visualization, better learning experience, and greater performance.

Equally, the findings of this study revealed that the use of ARIT to learn Geography improves students' retention. It was revealed from the findings that the nature of ARIT which involved integration of virtual 3D visual elements enhances students' ability to recall, recognise, relearn, and reconstruct concepts in Geography. This finding is in alignment with the study of (Pérez-López and Contero 2013). (Pérez-López and Contero 2013) investigated the use of AR in teaching digestive and circulatory systems and its role on knowledge retention. The results of the study by (Pérez-López and Contero 2013) suggested that AR use in the classroom helped learners retain more concepts than they did in traditional teaching methodology. (Pérez-López and Contero 2013) concluded that AR technology was a useful means to improve learners' motivation and interest, increased learners' performance in a learning environment, and enhance retention of concepts.

This study revealed that students' reaction to ARIT in learning geography is positive. This study found that ARIT allows learners to develop more interest in the classroom because of the combination of visual impression in the instructional process; learners find the content of lessons taught with ARIT interesting; showing the actual astronomical and celestial objects is not a time wasting activity; the use of augmented-reality presentation for learning physical geography helped learners to have a better learning experience. Overall, students reacted positively to using ARIT. These findings agreed with the study of (Annetta et al. 2012), the researchers posited that researchers,

teachers, and students alike were very pleased to find more collaboration while using the AR technology.

Similarly, gender difference does not exist between the retention performance of male and female students taught geography using ARIT in Osun state, Nigeria. This study established that both male and female students taught physical geography with the use of ARIT retained what had been previously learnt very well with no gender disparity. This finding is in accordance with the assertion of (Ahmad 2014). The researcher asserted that all performances regardless of their individual levels and irrespective of gender have similar knowledge retention rates.

The study concludes that newer visualisation technologies such as AR has grown in captivating users' interest and equally improve abstract concepts understanding. Unlike the inability of visualisation technologies explored in the past years, which couldn't bridge the gap to visualising abstraction especially in Geography and concurrently aiding concepts understanding, ARIT has been able to bridge this gap. With the ubiquitous capability of AR being able to incorporate digital-generated media into real environment of Geography learners and the ability to overlay digital media on the real world through students' device screen such as a smart phone, easy understating of abstract Geography concepts is enhanced, and subsequently improving their academic performance and aiding concepts retention.

The implication of these findings is that, the opportunities that AR offers to Geography learners by presenting abstract concepts to their real environment in an interactive manner enables Geography learners to have a better understanding and conception of the abstract concepts that are inherent in Geography. By implication, improving their academic performance and retention. This study therefore, recommends that, Geography instructors should embrace the utilisation of AR in the classroom in order to better learners' performance and retention, and engage learners in an interactive and entertaining manner.

This study was limited to the teaching and learning of selected concepts in Geography like elements of Geography. The findings of this study averred that both the academic performance and retention of previously learnt contents in Geography can be enhanced and improved with the utilisation of ARIT in visualising some concepts that are abstract in Geography. These abstract concepts include; the earth and the solar system; earth's rotation and revolution; and the earth's structure. Similarly, ARIT is learner and gender friendly. Thus, ARIT in Geography classroom may bridge the retention and performance gaps that might exist between male and female students offering the subject.

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