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Application of a Non-Immersive VR, IoT Based Approach to Help Moroccan Students Carry Out Practical Activities in a Personal Learning Style

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Abstract: In the last few years, the evolution of new Information and Communication Technologies (ICT) and networks has enabled the appearance and development of several platforms and tools that serve to operate and distribute the learning content. In some particular domains, especially the scientific one, learners need to work on practical activities, using specific products and equipment to complete, consolidate, or verify their conceptual acquisitions. However, facing the increasing number of learners in Moroccan institutions, it becomes hard and expensive for developing countries, like Morocco, to ensure the appropriate conditions for each learner to perform such activities. The majority of the suggested platforms and tools cannot solve this issue, because of their inefficiency regarding offering students good interactive practical activities. Virtual Reality (VR) and the Internet of Things (IoT), as the two most incredible technologies of the last few decades, can be used as an alternative to create a virtual environment where the learner can carry out practical activities like in the real world. In such an environment, learners interact with both virtual and physical objects. In this research paper, we propose a new approach based on VR and IoT to enhance learning by providing learners with an educational space where they can perform some practical activities. The hybrid proposed approach has been used to create a virtual environment where learners (the final year of high school) can measure ultrasonic velocity in the air. The evaluation results show that the manipulation and coupling of real objects with virtual 3D objects increases in a striking way the learning outcomes of learners, as this allows them to feel linked to the real context.

Keywords: Internet of Things; virtual reality; learning

1. Introduction

Virtual learning has increasingly been dominating our educational systems in their various stages: from primary school to university. These new modes have already been adopted worldwide in an extensive and unprecedented fashion. For instance, in Morocco, while this trend in learning is still novel, some local institutions launched the creation of MOOC (Massive Open Online Course), with the primary aim of promoting the mobility of people, knowledge, and information. This substantial move has allowed learners who lack the opportunity to attend regular classes to pursue education and career training under convenient conditions. Furthermore, many educational offerings by universities, such as Moodle, allow virtual practical training. This innovative technological platform enables educational institutions to design compelling online courses and e-learning spaces. In addition to acquiring theoretical knowledge, learners are required to carry out some level of practical work experience to supplement and strengthen their learning, by conducting technical or scientific experiments.

Unfortunately, most e-learning environments in place among local educational institutions in Morocco suffer a tremendous lack of practical, hands-on experience for beneficiaries.

While Internet technology has led to the advancing and altering of the course of classic education globally, by providing limitless possibilities for learning, innovation, and interaction between learners and teachers, it has paved the way toward an even greater development: the Internet of Things (IoT) [1,2]. Beyond merely connecting different devices, it has come to connect a set of things (from our living environment), such as home appliances and transportation. IoT can be described as a kind of rapid, growing network generation, where smart devices, things (objects), and people can be connected. Things in the IoT network are embedded into microcontrollers, sensors, and software that ensure data collection and exchange. The collected data can be processed to enable decision making. According to Cisco's experts, over 50 billion devices (Figure 1) will connect to the Internet in 2020 (https://newsroom.cisco.com/feature-content?type=webcontent&articleId=1208342). Consequently, various applications of IoT, including in education, are promising. IoT allows the proposition of new hybrid systems, by the confluence of physical objects with the digital world. One solution it offers is the powerful combination between Virtual Reality (VR) [3] and IoT. VR and IoT share the same philosophy: merging the digital and physical worlds, although in opposite directions. IoT is, on the one hand, characterized by bringing and making physical objects part of the virtual, digital environment; whereas, VR deals with making digital environments seem realistic. We believe that merging IoT and VR will widen the possibility for innovations in the education sector; such a solution can also improve the effectiveness of both the learning/training process and educational institution's infrastructure.

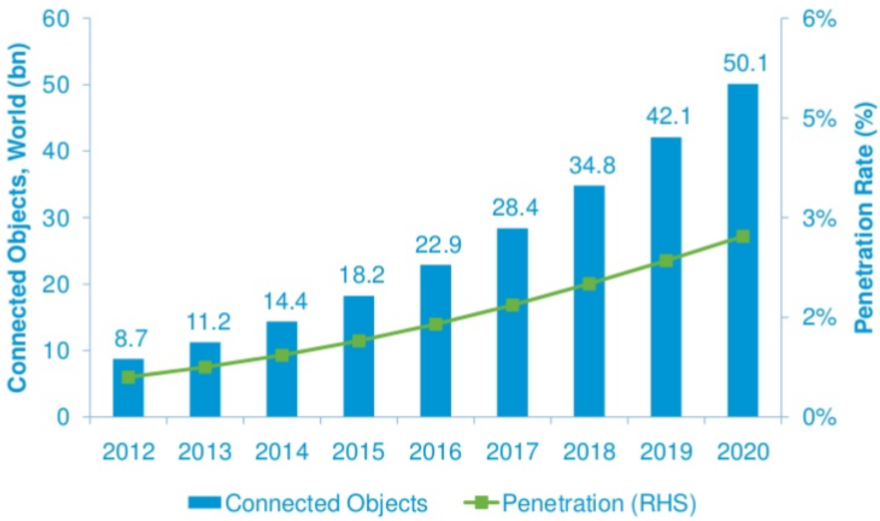

Figure 1. Number of connected objects expected to reach 50 bn by 2020.

The key novelty of this paper is the proposal of a non-immersive VR, IoT-based approach to allow Moroccan learners to consolidate their conceptual learning by carrying out some practical activities in a novel manner. With local schools and universities in Morocco being overcrowded, it becomes challenging to meet their needs for adequate education and training due to the lack of sufficient equipment. Having this solution will undoubtedly alleviate the barrier that stands in learners' way to better practical training.

Our choice for IoT is justified by the fact that learners live in a world where digital devices constitute a vital part of their daily lives. We believe that we can take advantage of their proficiency in using these modern tools in order to stimulate their thirst for learning and enable them to become the leaders of tomorrow. Other benefits include allowing each learner to learn at her/his own pace. For example, by using a smart handheld device, we can create tools that immerse the learner in a series of mathematical problems. Learners will keep track of their progress in a timely manner. Instructors will be able to monitor each learner's progress as well.

Additionally, the coupling of VR with IoT will give rise to a promising technology that can be used to create a virtual environment where the learner is an actor that can "learn by doing", through the interaction with the 3D virtual objects. Ultimately, an educational environment based on VR and IoT can solve the problem of the equipment/product insufficiency. Such an environment can provide learners with rich, interactive learning contents where they can:

- Perform tasks safely;
- Participate in learning situations that require repetition easily;
- Participate in learning situations that are too expensive to implement in reality.

The rest of the paper proceeds as follows: Section 2 describes some existing projects and work as a background. In Sections 3 and 4, we give a brief definition of IoT and VR and some of their domain applications, respectively. Section 5 reviews the related work in the literature. The fundamental components of our approach are presented in Section 6. In Section 7, we discuss the obtained results after a case study. Finally, Section 8 concludes the paper.

2. Background

As deeply studied over the last few years, technology can play a vital role in enhancing the quality of learning and competencies' acquisition [4–6]. Many educators and researchers have highlighted the necessity of putting learners in an authentic environment where they can be self-motivated and self-directed [7]. Those kinds of authentic environments are produced by merging both virtual and real environments [5,8]. In recent years, several projects have been conducted to increase the quality of learners' skills and therefore prepare them to participate effectively in the 21th Century economy. Singapore, for example, has implemented a national project where technology plays a vital role in enhancing education [9]. Another ambitious project was launched in April 2012 in the United Arab Emirates (UAE); the project, named the Mohammed Bin Rashid Smart Learning Program (MBRSLP), is an initiative that aims at making schools across the country adopt digital strategies in their classrooms. The present work comes in this context; it aims to propose a new approach based on IoT and VR to offer learners an authentic environment where they can learn more flexibly and smoothly and therefore be prepared to integrate this with a productive life.

3. Internet of Things

IoT has gained significant attention in the past few years among industrialist, policy makers, personal users, and technologists. The key concept of the Internet of Things (IoT) paradigm is reducing the existing gap between digital and physical worlds. The IoT extends the actual form of the Internet to a network of connected people and objects (things). Within the IoT, objects obtain intelligent behavior as they can collect, exchange data, and make decisions. The data gathering and exchange are guaranteed thanks to microcontrollers, sensors, and software embedded in objects.

The core of the IoT paradigm lies in the fact that personal devices (e.g., smart phones, tablets) play the role of a gateway that links people, the physical and the digital world (see Figure 2). Thus, IoT allows the existence of the people-to-people, people-to-objects, objects-to-people, and objects-to-objects information exchange paradigms.

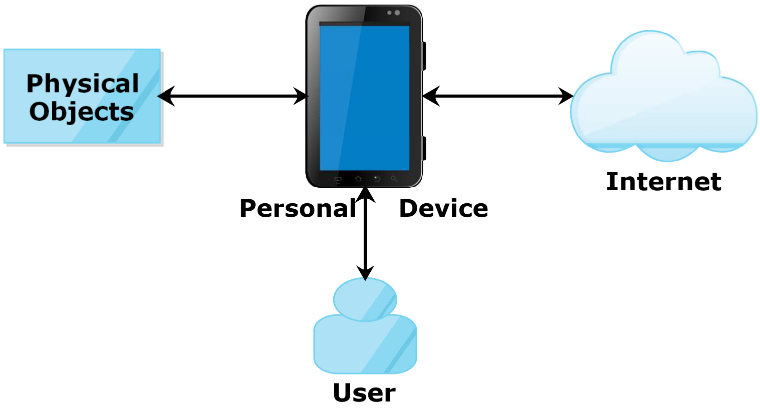

Figure 2. Personal device acting as a getaway between the Internet, people, and physical objects.

IoT has been extensively applied in a wide-ranging scope; in fact, IoT applications can embrace all human-object activities, such as:

- Smart home: With the increasing demand for human comfort and safety, many appliances and equipment have come into our households to ensure our wellbeing and comfort. There is a possibility to make our lives more comfortable, more convenient, and much easier: this is achieved through the management of all those appliances. Yet, managing them is a challenge. To surpass this problem, many proposals and solutions based on IoT have been given [10–12].
- Transportation: Several contributions have been suggested based on IoT that aim basically at transforming the transportation systems. The Internet of Things (IoT) is basically transforming the transportation systems: transportation-based IoT systems will optimize the traffic and allow tracking, delivering of merchandise, improving economics, public safety, and the environment [13].
- Environment: IoT can be used to track the variation of some environmental parameters such as temperature, humidity, and light level. The main goal of this task is to define the quality of the surrounding environment in which we are living [14].
- Healthcare: Healthcare represents a field in which IoT can be wildly applied. Medical devices can be considered as smart objects. Healthcare services based on IoT can play a major role in reducing costs, increasing the quality of life, and keeping patients safe and healthy [15].

4. Virtual Reality

The term Virtual Reality (VR) [3] refers to a computer technology that simulates the physical presence of a user in an artificially-generated environment. VR gives the possibility to perform in real time a certain number of actions defined by one or more computer programs and, therefore, to experience a certain number of visual, auditory, or touch sensations. VR applications can be divided into two types:

- Simulations of a real environment for training or educational purposes.
- Imagined environments for entertainment purposes: games or interactive stories.

VR applications can be found in almost every field. VR has been applied in the medical field; for instance, in [16], VR is used to create training simulators for knee, hip, and other orthopedic surgeries. VR is used also in anxiety disorder therapy [17]. VR is applied as well in the field of warfare [18,19]. Furthermore, VR has been applied widely in the engineering field, such as machine assembly [20,21].

5. Related Works

In this section, we present related work on the utilization of IoT and VR in the field of education. Those related works are divided into three categories: (i) VR and IoT in education, (ii) IoT in education, and (iii) VR in education.

5.1. IoT and VR in Education

Works coupling IoT and VR in education are very scarce. In [22], the authors proposed a new paradigm: the Virtual Environment of Things (VEoT). Their proposition aims at integrating real-world objects and virtual-world objects/avatars. To validate the VEoT paradigm, a VEoT-based NVE (Networked Virtual Environment), called X-Campus, has been implemented. The goal of X-Campus was to guide users to navigate in the building of the National Central University. In [23], the authors built a prototype of a smart campus based on IoT and VR. Furthermore, ref. [24] presented a virtual space based on VR and IoT. In [25], the authors gave some ideas about between VR and IoT in the remote control domain. The authors in [26] outlined different reasons for and benefits of using Augmented Reality (AR) with IoT.

5.2. IoT in Education

The Internet of Things has been extensively applied, including in education. Several contributions have been suggested in the literature using IoT in the educational field. For instance, in [27], the authors scrutinized the effectiveness and the necessity of using IoT in SCC (Smart College Campus); furthermore, they tackled the matter of using IoT for a smart campus application, where the classrooms have access to e-learning applications with the assistance of IoT tools. In [28], based on IoT, the authors suggested a system they used for the courses on computer hardware parts at the UCC (University of Cordoba Colombia). In their examinations, the internal components of the computer were marked with NFC (Near Field Communication) and QR code (Quick Response code), permitting the link with virtual objects. To certify their suggestion, the learners were split into two separate groups: an experimental and a control one. The final outcomes proved that those who did not use IoT missed their goals simply because they mostly relied on lectures; however, those who had access to IoT met them. Another work [29] presented an interactive model based on IoT that was aimed at English language teaching. The model relied on visual sensors and voice sensors that could correct English learner's mouth shape and pronunciation by comparing with the standard shape of the mouth and pronunciation, which included software. Moreover, the authors in [30] investigated the possibility of combining IoT with learning analytics techniques. The goal was to analyze learner's learning process, which would enable them to obtain the feedback they need to establish an effective lifelong learning environment. Another study talked about the impact of four different technologies on education; namely, cloud computing, IoT, data mining, and triple play were suggested in [31]. An additional study [32] discussed the application of IoT in education. The idea is about suggesting an educational IoT-based model with physical-machine object authentication. In this research [33], the authors split the application of IoT in education into four different categories: monitoring student's healthcare, energy management, classroom access control, improving teaching and learning, and real-time ecosystem monitoring. Afterwards, they analyzed the impact of those applications on the education business model. Furthermore, in [34], the authors proposed an architecture based on IoT, GPS (Global Positioning System), and Global System for Mobile (GSM) technologies for an e-learning system. In [35], the authors suggested an interesting work. They have proposed a learning system called F-learning (Free learning). F-learning is the result of applying IoT to an e-learning system. Their system utilized available learning resources all over the world and allowed students to learn anywhere and anytime. In [36], the authors proposed a work in progress at OUC (Open University of Catalonia). The goal of the paper was to expand the existing distance learning system of OUC by the integration of IoT technology, also increasing the motivation of learners enrolled in OUC. The research in [37] describes a distance learning platform for architecture teaching. Information is collected and exchanged rapidly thanks to the three interlinked networks based on IoT technology. The authors in [38] outlined some of the IoT impacts on e-learning systems. On the other hand, they also proposed a smart learning model based on IoT. The research paper [39] outlined an ongoing research project based on the IoT paradigm. It was about the design of an educational learning tool based on IoT for the disenfranchised primary school students in the north of Thailand. In [40], a practical implementation of IoT was done at the Information Engineering Department of Padova University (Italy). Their primary focus was to develop a web service model for Wireless Sensor Network (WSNs) and to come up with a framework to be validated through a case study.

5.3. Virtual Reality in Education

The work in [41] proposed a virtual lab based on VR where learners can perform the virtual assembly of instruments. VR is also used to create interactive 3D virtual laboratories to learn chemistry [42]. In [43], VR was used to create a 3D environment to teach students the special relativity concept. In [44], the authors presented a survey of different works related to the use of VR in dental education.

6. Proposal

6.1. Working System

The present work is a continuation of our previous work [45]. The main purpose of the proposed system is three-fold: (1) increase the learning outcomes of learners by the creation of an environment that is engaging, motivating, and efficient; (2) deal with the equipment insufficiency problem that almost all Moroccan educational institutions suffer from; (3) increase the rate of using new technologies in education inside the educational institutions. The architecture of the proposed system and the technologies involved are shown in Figure 3.

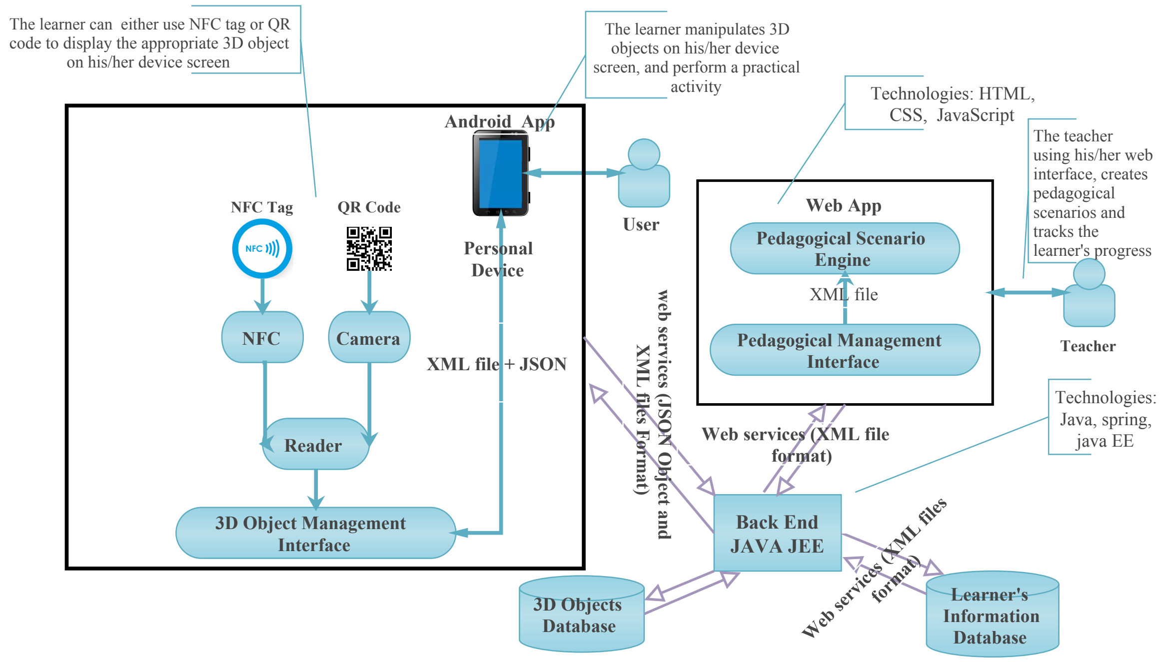

Figure 3. Overview of our approach.

In this architecture we adopt a back-end solution to separate our system into distinct sections. Our system consists of four parts:

- Android app: This is an Android application used by the learner. The main role of this application is QR code reading, 3D object display, and communication with other system components.
- Web app: This web application is reserved for the teacher. Through this application, the teacher can create a pedagogical scenario to lead the learner to achieve the learning objectives. The web app typically includes the HTML, CSS, and JavaScript that creates pages, menus, buttons, and everything else that forms the basis of what the teacher sees in his/her web browser.

- Databases: The proposed architecture uses two databases, one that contains 3D objects and the other that contains the learner's profiles. This second database is used by the teacher to generate tailored pedagogical scenarios.
- Back-end sever: The back-end server allows the communication between all the components above. Its main role is to verify information via the back-end databases, and the relevant information is then presented to the user (learner/teacher). It is built using Java EE, Java, and Spring codes.

The proposed architecture is the result of the confluence of IoT and VR technologies. This environment is based on the simplest VR form: A non-immersive VR application. It is a set of 3D objects that can be manipulated and explored interactively from a personal smart device. The content of the 3D object can be moved in different directions and zoomed in or out. Using the proposed system, learners can interact and manipulate both physical and virtual objects. Each one of the physical objects is associated with a 3D object.

Physical objects can be marked using two kinds of visual tags: NFC (Near Field Communication) or QR code (Quick Response code). We choose to tag the physical object with QR code, because it is free and very easy to use. QR codes used in the experiment were made using the free tool: https://fr.qr-code-generator.com/. Once the QR code is read, it delivers information instantly. This information may be of a very different nature: link to a web page, displaying text or an image, playing a sound, or a video. It is necessary to have a phone or tablet with a camera and an application that reads QR codes. The flowchart of the QR code reading process is shown in Figure 4.

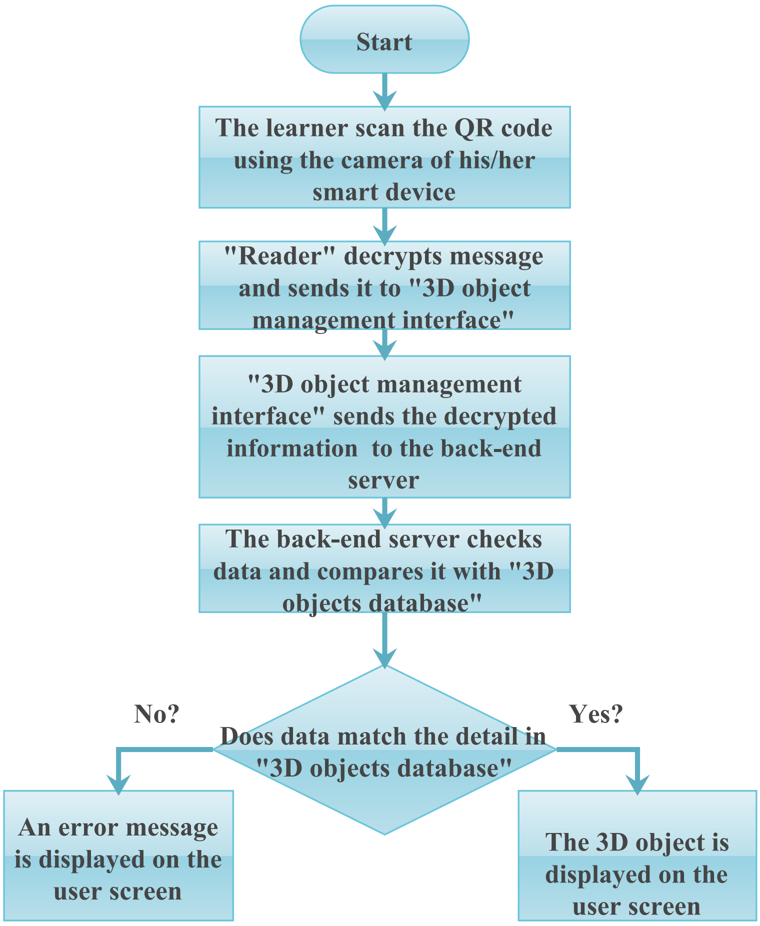

Figure 4. Flowchart of the process of reading a QR code.

When the learner brings his/her handheld device near the physical object and scans the QR code, the "reader" decrypts data included in the QR code and sends them to the "3D object management interface", which sends these in turn to the "back-end" server, which checks the received data. If the data match the details of a 3D object stored in the "3D objects database", then the "back-end" server loads the 3D object in JSON (JavaScript Object Notation) format. Afterwards, the 3D object (JSON file) is delivered by the "back-end" server to the "3D object management interface", which displays the 3D object on the learner's screen using a graphical user interface. At that moment, the learner can manipulate the 3D object and see all details, the usefulness, and the information related to the object. The 3D virtual objects were made using the famous game engine Unity (https://unity3d.com).

The proposed system is an educational space that allows learners (final year in a high school) to carry out a practical activity to measure ultrasonic velocity in air. The setup of this experiment is shown in Figure 5.

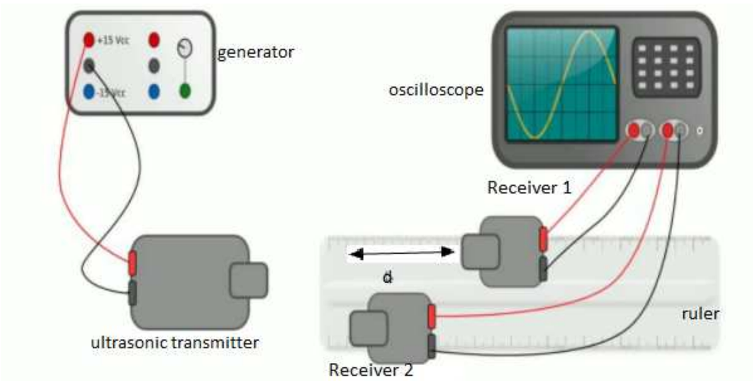

Figure 5. The setup for the measurement of ultrasonic wave's velocity.

The measuring devices consist of an ultrasonic transmitter, Receiver 1, Receiver 2, a ruler, and an oscilloscope. An ultrasound wave is a disturbance sound of 40 kHz in frequency. Ultrasounds are emitted by the ultrasonic transmitter and detected by Receiver 1 and Receiver 2. To measure ultrasonic velocity in air, the learner must follow the given steps:

1. Set the generator in the "salve mode" and the oscilloscope in scanning mode;
2. Set the oscilloscope to get one or two bursts on each input;
3. Determine the time difference τ between the beginnings of two bursts;
4. Measure the distance d;
5. For the measurement to be sufficiently accurate, it is necessary to repeat Step 3 with different values of the distance d.
6. Use the relationship: $v = \frac{d}{\tau}$ to measure the ultrasonic velocity in air.

Let us suppose now that there is only one copy of each device, which is insufficient to allow a large number of learners to perform the experiment. To solve this problem, our system can help: we tag each device with a QR code, then each learner opens the camera of his/her handheld device and scans the QR code. Figure 6 shows this process when a learner scans the QR code of the oscilloscope device.

When the leaner finish scanning all the physical objects, the whole 3D objects are shown constituting a 3D environment that allows learners to do the experiment of measuring the ultrasound velocity. We have highlighted the important role that can play IoT and VR technologies in promoting learning. However the focus should not be restricted on the technological side but it should take into consideration the pedagogical side. To exploit the interaction of a learner with the environment and therefore lead him/her to reach of the objective of learning (e.g., Measure ultrasound velocity), the teacher creates a *pedagogical scenario*.

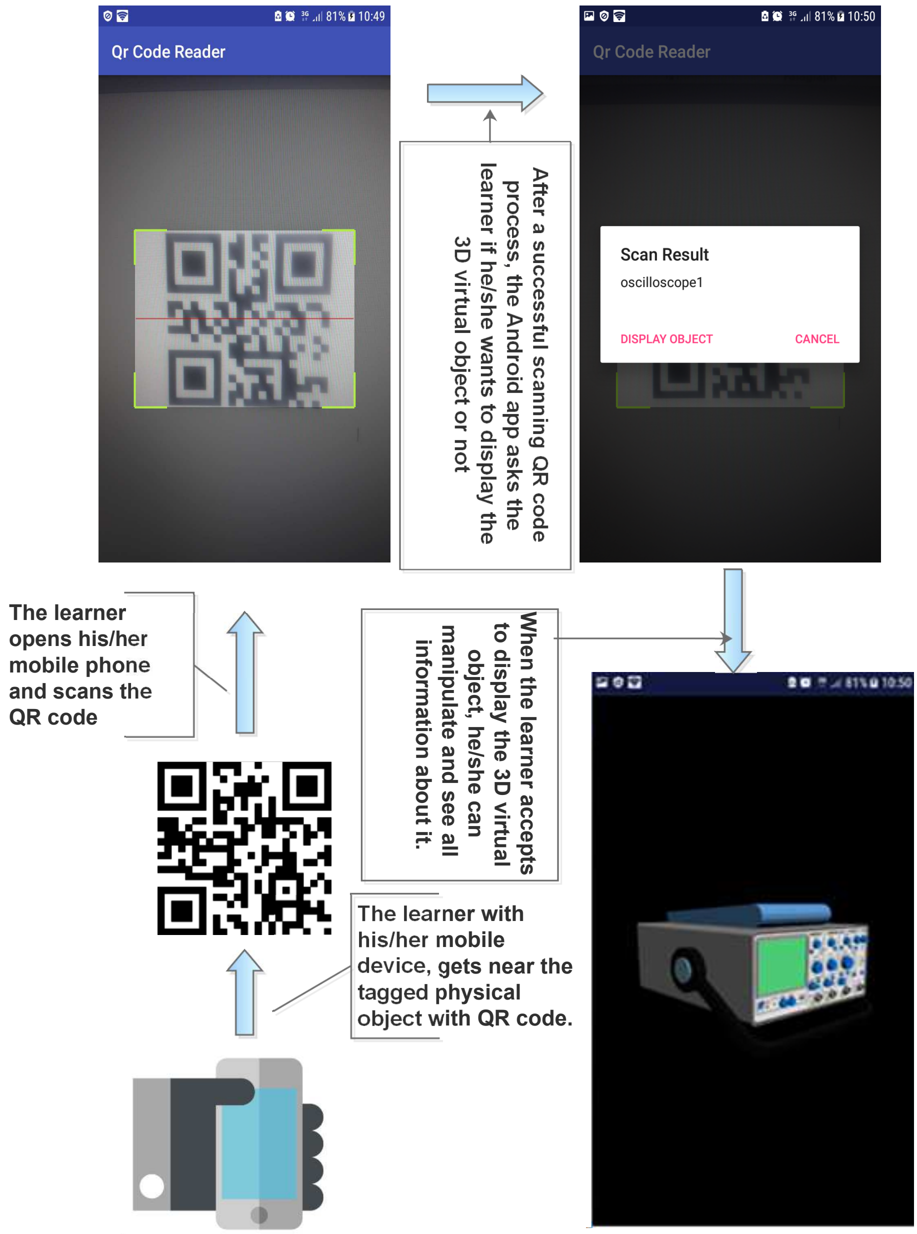

Figure 6. Reading the QR code and displaying the 3D object of the Oscilloscope.

In this paper, we have used the approach based on [46] to generate the appropriate pedagogical scenarios for each learner. The pedagogical scenario specifies generally five types of information [46]:

- Learning objectives: It is basically a text file that describes the predetermined skills and knowledge to be achieved by learners that accomplish the pedagogical scenario.
- Prerequisites: These are skills and knowledge necessary for a learner so he/she can start an educational activity correctly.
- Roles: they describe roles of everyone involved in an educational activity.
- Activities: They consist of describing educational activities (the basic component of the pedagogical scenario) performed in the environment by the learner.
- Resources: These are the resources necessary to accomplish a learning session perfectly (audio file, images, etc.). These kinds of resources can be used, as well as a tool to guide (assistant) a learner in case he/she cannot finish a task after several attempts.

- Environment: It describes the context of the execution of the learning activity, and it contains additional resources necessary for the execution of the activities. In our case, it is the virtual environment for training.

In Table 1, we give an extract of the pedagogical scenario in XML format:

Table 1. An extract of the pedagogical scenario in XML format.

```
<Pedagogical-scenario>
<Environments>
<Environment identifier = “85ds5sddfed56s4”>
<Title> Physics-PW </Title>
<class-model type = “XMI” url = “XML/PW-Environment1.world-model.xmi”/>
<virtual-environment type = “Mascaret” url = “PW-Environment1.world.xml”/>
...
</Environment>
</Environments>
<Activities>
<Educational-Activities identifier=4d5fd45s16a6 isvisible = “true”>
<Title> Ultrasonic wave’s velocity</Title>
<environment-ref ref = “85ds5sddfed56s4/”>
<Participants id = ”6q9sq54s9” name = “Learner1” Role = “ROLE”/>
...
</Educational-Activities>
</Activities>
</Pedagogical-scenario>
```

The XML file that describes the pedagogical scenario is delivered by the “back-end” server to the Android app to be executed.

6.2. Security and Privacy

The complimentary relationship that characterizes both IoT and cloud computing allows, for example, a user with a mobile device to access information in real time, anytime, anywhere [47]. Despite the numerous advantages this dual technology offers, the challenge remains with regards to security and private data protection for its users. To secure user data and applications, many solutions and frameworks have been suggested and implemented. For instance, the authors in [48] focused on the the human factor of system security by developing a security awareness training framework. The main role of the framework was to train operators of critical infrastructure on various social engineering security threats. The research work [49] suggested a formal probabilistic framework for process learning to compose Service-Specific Overlays (SSO) in cloud networks. An additional work [50] discussed the requirements model for the runtime execution and control of an intention-oriented cloud-based application. Furthermore, a secured objective-driven programming model created automatically at runtime by the PAA (Provisioning-Assurance-Auditing) cloud engine along with the XACML (eXtensible Access Control Markup Language) security annotation representation was presented in [51]. In [52], the authors summarized previous investigatory research that aimed at managing the numerous physical and virtual components in cloud computing.

In this paper, we used the Spring security framework, which provides both authentication and authorization support to secure Java application. It comes with the implementations of popular security algorithms. On the one hand, we can use either mechanisms provided by the framework or use additional systems for the authentication process. For example, Spring security allows us to authenticate via an LDAP (Lightweight Directory Access Protocol) directory, OpenID, JAAS (Java Authentication and Authorization Service), Kerberos, and many others. On the other hand, Spring security makes it easy to add authorizations to web requests, methods, or even objects.

7. Results

The participants of this experiment were students from three classes of the final year in a high school. After a preliminary test, we chose 30 (12 females and 18 males) learners who had the equivalent basic knowledge level required to participate in the experiment. Afterwards, the selected learners were separated randomly into two independent groups (15 learners in each group). For the experimental group, learners used the learning system based on IoT and VR, while the control group took only a theoretical course. Table 2 shows the results obtained after a post-test. The post-test consisted of 10 questions divided into two types of questions: true or false (four questions) and multiple choice questions (six questions). The results of the experimental group were significantly better than the results achieved by the learners who had only the theoretical course.

Table 2. Post-test results for both groups (control and experimental).

Number of Learners	Good Results (Score $\geq$ 10/20)	Bad Results (Score < 10/20)
15 learners (control group)	8 learners (53.33%)	7 learners (46.67%)
15 learners (experimental group)	14 learners (93.33%)	1 learner (6.66%)

The scores obtained by students varied in an interval between zero and 20. Good results were when the obtained score was greater than or equal to 10/20, and bad results were when the obtained score was strictly lower than 10/20.

Finally, to get some feedback from learners who participated in this experiment (experimental group), we asked them to fill in a questionnaire about several sides of the proposed system. The questionnaire contained eight questions. The results are shown in Table 3.

Table 3. Results of the questionnaire.

Questions	Strongly Agree	Agree	Neutral	Do Not Agree
1. It makes me feel more independent	86.66%	13.33%	0.0%	0.0%
2. It is fun to use	100%	0.0%	0.0%	0.0%
3. Does the environment seem so realistic?	80%	13.33%	6.66%	0.0%
4. I will participate in similar experiments?	100%	0.0%	0.0%	0.0%
5. It helped me understand the experiment	93.66%	0.0%	6.66%	0.0%
6. I feel comfortable during the experiment	86.66%	6.66%	6.66%	0.0%
7. I was very motivated during the experiment	93.66%	6.66%	0.0%	0.0%
8. I can re-use it every time without any help	86.66%	13.33%	0.0%	0.0%

Analyzing the learners' responses to the questionnaire, the results were very encouraging regarding different aspects of the learners' interaction with the system.

In fact, the survey showed that all learners (100% of responders) found the proposed educational space fun to use. In addition, 86.66% strongly agreed that performing the virtual practical activity made them feel more independent. Furthermore, 80% of learners strongly agreed that the design of the 3D components seemed realistic, allowing them to feel closely connected to reality. Only 6.66% of learners surveyed kept their responses neutral. When asked if they would be willing to participate in similar experiments in the future, 100% of learners expressed their approval. To the statement "It helped me understand the environment", 93.66% of learners surveyed reported that they strongly agreed, and only 6.66% abstained. In addition, 86.66% and 6.66% of learners strongly agreed and agreed, respectively, that they felt comfortable during the experiment, while only 6.66% of the learners were indifferent. As the questionnaire responses had unanimously shown, this virtual practical activity is a new, intriguing concept for learners; therefore, the vast majority of our sample exhibited a high degree of motivation for such exciting, educational experiments, affirming their desire to perform them autonomously if given the opportunity in the future.

8. Conclusions

We have outlined in this paper a new hybrid approach to enhance learning by making education more engaging, motivating, and relevant for learners. The idea was merging two of the most powerful and wonderful technologies of the last few years (VR and IoT). The proposed approach was used to create an educational space allowing learners to measure the ultrasonic wave's velocity in air. In this respect, we thought, as a step forward, that our approach should be used in other domains, like computer science or networking. To evaluate the proposed approach. A survey was given to the learners. The results of this survey showed that the majority of the learners were satisfied with the services our system offered. However, some learners abstained from giving their feedback; therefore, we can consider this as a negative sign. Thus, for future work, we will try firstly to improve the quality of the 3D components' design, so that it looks as realistic as possible. Furthermore, more information allowing good guidance for learners during the experiment should be inserted into the pedagogical scenario. In addition to this, another drawback of our approach can be identified: it encompasses only the personal learning style. In fact, we look forward in our future research to adding the social style, which can allow learners, in addition to their interaction with the learning environment, to interact with other learners.

Author Contributions: All authors contributed to the work presented in this paper. M.F. had the original idea and performed the overall coordination in the writing of the paper. M.F. and A.J. developed the code of the overall virtual environment. All authors contributed to the writing of the article.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Jayavardhana, G.; Rajkumar, B.; Slaven, M.; Marimuthu, P. Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Gen. Comput. Syst.* **2013**, *29*, 1645–1660. [CrossRef]
2. Gushima, K.; Nakajima, T. A Design Space for Virtuality-Introduced Internet of Things. *Future Internet* **2017**, *9*, 60. [CrossRef]
3. Fuchs, P.; Moreau, G. Le traité de la réalité virtuelle. In *Science Mathématiques et Informatique*; Presses de l'Ecole des Mines, Ed.; Publishing House: Paris, France, 2003; ISBN 978-2911762475.
4. Chee-Kit, L.; Peter, S.; BaoHui, Z.; Hyo-Jeong, S.; Wenli, C.; Lung-Hsiang, W. Leveraging mobile technology for sustainable seamless learning: A research agenda. *Br. J. Educ. Technol.* **2010**, *41*, 154–169. [CrossRef]
5. Zhu, Z.-T.; Yu, M.-H.; Riezebos, P. A research framework of smart education. *Smart Learn. Environ.* **2016**, *3*, 1–17. [CrossRef]
6. John, D. Making sense of MOOCs: Musings in a maze of myth, paradox and possibility. *J. Interact. Media Educ.* **2012**, *3*, 1–20. [CrossRef]
7. Idros, S.N.S.; Mohamed, A.R.; Esa, N.; Samsudin, M.A.; Daud, K.A.M. Enhancing self-directed learning skills through e-SOLMS for Malaysian learners. *Procedia-Soc. Behav. Sci.* **2010**, *2*, 698–706. [CrossRef]
8. Minami, M.; Morikawa, H.; Aoyama, T. The design of naming-based service composition system for ubiquitous computing applications. In Proceedings of the Symposium on Applications and the Internet-Workshops, Tokyo, Japan, 26–30 January 2004; pp. 304–312. [CrossRef]
9. Margaret, T.A.H. Promises and threats: iN2015 Masterplan to pervasive compting in Singapore. *Technol. Soc.* **2012**, *17*, 37–56. [CrossRef]
10. Rui, L.; Yongqi, G. Smart Home System Design Based on Internet of Things. In Proceedings of the 12th International Conference on Computer Science & Education, Houston, TX, USA, 22–25 August 2017; pp. 444–448. [CrossRef]
11. Himanshu, V.; Madhu, J.; Khushhali, G.; Adityan, V.; Gaurav, V. Smart home system based on Internet of Things. In Proceedings of the 3rd International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, India, 16–18 March 2016.
12. Mussab, A.; Zaidan, A.A.; Zaidan, B.B.; Mohammed, T.; Kiah, M.L.M. A Review of Smart Home Applications based on Internet of Things. *J. Netw. Comput. Appl.* **2017**, *97*, 48–65. [CrossRef]

13. Thiyagarajan, M.B.; Umamaheswaran, R.K.; Viswanathan, M.B. An Internet of Things based Intelligent Transportation System. In Proceedings of the International Conference on Vehicular Electronics and Safety (ICVES), Hyderabad, India, 16–17 December 2014; pp. 174–179. [CrossRef]
14. Bhoomika, K.N.; Deepa, C.; Rashmi, R.K.; Srinivasa, R. Internet of Things for Environmental Monitoring. In Proceedingsof the 1st International Conference on Innovations in Computing & Networking (ICICN16), Bengaluru, India, 12–13 May 2016; pp. 497–501.
15. Jorge, G.; Byron, O.; Emilio, Z. Patient Monitoring System Based on Internet of Things. In Proceedings of the 7th International Conference on Ambient Systems, Networks and Tech-nologies, Madrid, Spain, 25–26 May 2016; pp. 90–97. [CrossRef]
16. Vaughan, N.; Dubey, V.N.; Wainwright, T.W.; Middleton, R.G. A review of virtual reality based training simulators for orthopaedicsurgery. *Med. Eng. Phys.* **2015**, *38*, 1–13. [CrossRef]
17. Krijn, M.; Emmelkamp, P.M.G.; Olafsson, R.P.; Biemond, R. Virtual reality exposure therapy of anxiety disorders: A review. *Clin. Psychol. Rev.* **2004**, *24*, 259–281. [CrossRef] [PubMed]
18. Rizzo, A.; Parsons, T.D.; Lange, B.; Kenny, P.; Buckwalter, J.G.; Rothbaum, B.; Difede, J.; Frazier, J.; Newman, B.; Williams, J.; et al. Virtual Reality Goes to War: A Brief Review of the Future of Military Behavioral Healthcare. *J. Clin. Psychol. Med. Settings* **2011**, *18*, 176–187. [CrossRef] [PubMed]
19. Federica, P.; Nicola, T.; Luca, A.; Luciana, A.; Fabrizia, M. Developing effective virtual reality training for military forces and emergency operators: From technology to human factors. In Proceedings of the 14th International Conference on Modeling and Applied Simulation, Seattle, WA, USA, 14–16 April 2015; pp. 176–187.
20. Nee, A.Y.C.; Ong, S.K. Virtual and Augmented Reality Applications in Manufacturing. *IFAC Proc. Vol.* **2013**, *46*, 15–26. [CrossRef]
21. Seth, A.; Vance, J.M.; Oliver, J.H. Virtual reality for assembly methods prototyping: A review. *Virtual Real.* **2011**, *15*, 5–20. [CrossRef]
22. Wu, J.-W.; Chou, D.-W.; Jiang, J.-R. The Virtual Environment of Things (VEoT): A Framework for Integrating Smart Things into Networked Virtual Environments. In Proceedings of the IEEE International Conference on Internet of Things (iThings), and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom), Taipei, Taiwan, 1–3 September 2014; pp. 456–459. [CrossRef]
23. Huang, Y.; Ali, S.; Bi, X.; Zhai, X.; Liu, R.; Guo, F.; Yu, P. Research on Smart Campus Based on the Internet of Things and Virtual Reality. *Int. J. Smart Home* **2016**, *10*, 213–220. [CrossRef]
24. Kodym, O. Creation of Virtual Reality Space Based on Internet of Things. In Proceedings of the 13th International Carpathian Control Conference (ICCC), High Tatras, Slovakia, 28–31 May 2012; pp. 296–299. [CrossRef]
25. Cheng, T. Application and research of using the virtual reality technology to realize the remote control. *Adv. Sci. Technol. Lett.* **2013**, *28*, 1–4. [CrossRef]
26. Ilic, A.; Fleisch, E. *Augmented Reality and the Internet of Things*; Auto-ID Labs White Paper, No. BIZAPP-068; Auto-ID Labs ETH/HSG: Zurich, Switzerland, 2016; doi:10.13140/RG.2.2.22003.12321.
27. Veeramanickam, M.R.M.; Mohanapriya, M. IoT enabled Futurus Smart Campus with effective E-Learning: I-Campus. *GSTF J. Eng. Technol.* **2016**, *3*, 81–87._3.4.164. [CrossRef]
28. Jorge, G.; Juan, F.H.; Oscar, H.; Luis, P.; Daniela, G. Interaction System Based on Internet of Things as Support for Education. In Proceedings of the 4th International Conference on Emerging Ubiquitous Systems and Pervasive Networks, Niagara Falls, ON, Canada, 21–24 October 2013; pp. 132–139. [CrossRef]
29. Wang, Y. English Interactive Teaching Model which based upon Internet of Things. In Proceedings of the International Conference on Computer Application and System Modeling, Taiyuan, China, 22–24 October 2010; pp. 587–590. [CrossRef]
30. Jeannette, C.; Vic, C. Educational living labs: A novel internet-of-things based approach to teaching and research. In Proceedings of the 9th International Conference on Intelligent Environments, Athens, Greece, 16–17 July 2013; pp. 92–99. [CrossRef]
31. Angelo, P. C.; Nicola, B.; Paolo, C.; Michele, R.; Zach, S.; Michele, Z. Architecture and Protocols for the Internet of Things: A Case Study. In Proceedings of the 8th IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops), Mannheim, Germany, 29 March–2 April 2010; pp. 678–683. [CrossRef]

32. Majid, B.; Alberto, S.; Jeffrie, S.; Brayan, M. Internet of Things Simulation Tools: Proposing Educational Components. In Proceedings of the Ninth International Conference on Advances in System Simulation, Athens, Greece, 8–12 October 2017; pp. 57–63.
33. Maryam, B.; Siavosh, H.M. The Effect of the Internet of Things (IoT) on Education Business Model. In Proceedings of the 12th International Conference on Signal-Image Technology & Internet-Based Systems, Naples, Italy, 28 November–1 December 2016; pp. 435–441. [CrossRef]
34. Madhavi, V.; Sanjeev, W. An Architectural Approach of Internet of Things in E-Learning. In Proceedings of the International Conference on Communications and Signal Processing (ICCSP), Melmaruvathur, India, 2–4 April 2015; pp. 1773–1776. [CrossRef]
35. Omar, S.; Yasser, A. Internet of Things-Based Free Learning System: Performance Evaluation and Communication Perspective. *IETE J. Res.* **2016**, *63*, 31–44. [CrossRef]
36. Muriel, G.D.; Juan, A.M.F. Expanding the learning environment: Combining physicality and virtuality, The Internet of Things for e-Learning. In Proceedings of the 10th IEEE International Conference on Advanced Learning Technologies, Sousse, Tunisia, 5–7 July 2010; pp. 730–731. [CrossRef]
37. Yuqiao, Y.; Kanhua, Y. Construction of Distance Education Classroom in Architec-ture Specialty Based on Internet of Things Technology. *Int. J. Emerg. Technol. Learn. (iJET)* **2016**, *11*, 56–61. [CrossRef]
38. Zaid, A.; Tanupriya, C.; Subhash, C.G.; Gaurav, R. Internet of Things and its applications in E-learning. In Proceedings of the 3rd IEEE International Conference on Computational Intelligence and Communication Technology, Ghaziabad, India, 9–10 February 2017; pp. 1–5. [CrossRef]
39. Putjorn, P.; Chee, S.A.; Deravi, F.; Narong, C. Exploring the Internet of "Educational Things" (IoET) in rural underprivileged areas. In Proceedings of the 12th International Conference on Electrical Engineering, Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), Hua Hin, Thailand, 24–27 June 2015; pp. 1–5. [CrossRef]
40. Zanella, A.; Bui, N.; Castellani, A.; Vangelista, L.; Zorzi, M. Internet of Things for Smart Cities. *IEEE Internet Things J.* **2012**, *1*, 22–32. [CrossRef]
41. Liu, D.; Valdiviezo-Díaz, P.; Riofrio, G.; Sun, Y.-M.; Barba, R. Integration of Virtual Labs into Science E-learning. In Proceedings of the International Conference on Virtual and Augmented Reality in Education, Monterrey, Mexico, 19–21 November 2015; pp. 95–102. [CrossRef]
42. Numan, A.; Sehat, U.; Aftab, A.; Jamal, R. Interactive Virtual Chemistry Laboratory for Simulation of High School Experiments. In Proceedings of the International Conference on Computer Graphics, Animation and Gaming Technologies, Ankara, Turkey, 14 October 2014.
43. Dominic, M.; Margaret, W.; Timothy, J.M.; Craig, S.; Michael, W. Student experiences of virtual reality: A case study in learningspecial relativity. *Am. J. Phys.* **2016**, *78*, 862–868. [CrossRef]
44. Elby, R.; Mahmoud, M.B.; Roy, G. The need for virtual reality simulators in dental education: A review. *Saudi Dent. J.* **2014**, *29*, 41–47. [CrossRef]
45. Fahim, M.; Jakimi, A.; El bermi, L. Towards New Approach to Enhance Learning Based on Internet of Things and Virtual Reality. In Proceedings of the International Conference on Learning and Optimization Algorithms: Theory and Applications, Rabat, Morocco, 2–5 May 2018; doi:10.1145/3230905.3230955.
46. Fahim, M.; Jakimi, A. El bermi, L. Pedagogical Scenarization for Virtual Environ-ments for Training: Towards Genericity, Coherence and Adaptivity. *Int. J. Adv. Eng. Res. Sci. (IJAERS)* **2016**, *12*, 96–103. [CrossRef]
47. Al-Jumeily, D.; Williams, D.; Hussain, A.J.; Griffiths, P. Can We Truly Learn from A Cloud Or Is It Just A Lot of Thunder? *Dev. E-Syst. Eng.* **2010**, 131–139, doi:10.1109/DeSE.2010.30. [CrossRef]
48. Ibrahim, G.; Jibran, S.; Mohammad, H.; Hanan, F.; Vaclav, P.; Sardar, J.; Sohail, J.; Baker, T. Security threats to critical infrastructure: The human factor. *J. Supercomput.* **2018**, *74*, 4986–5002. [CrossRef]
49. Ismaeel, A.R.; Yehia, K.; Moayad, A.; Burak, K.A probabilistic process learning approach for service composition in cloud networks. In Proceedings of the IEEE 30th Canadian Conference on Electrical and Computer Engineering (CCECE), Windsor, ON, Canada, 30 April–3 May 2017; pp. 1–6. [CrossRef]
50. Thar, B.; Michael, M.; Martin, R.; Azzelarabe, T.B. Intention-oriented programming support for runtime adaptive autonomic cloud-based applications. *Comput. Electr. Eng.* **2013**, *39*, 2400–2412. [CrossRef]

51. Yasir, K.; Thar, B.; Azzelerabe, T.B. Security Support for Intention Driven Elastic Cloud Computing. In Proceedings of the Sixth UKSim/AMSS European Symposium on Computer Modeling and Simulation, Valetta, Malta, 14–16 November 2012; pp. 67–73, doi:10.1109/EMS.2012.17. [CrossRef]
52. Hughes, G.; Al-Jumeily, D.; Hussain, A. Supporting Cloud Computing Management through an Object Mapping Declarative Language. *Dev. E-Syst. Eng.* **2010**, 175–181, doi:10.1109/DeSE.2010.36. [CrossRef]