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The Application of Smartphones and Two-dimensional Barcodes in a Chemistry Laboratory Manual

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Abstract As the percentage of using smartphones in campuses increases, the use of two-dimensional barcodes becomes very useful, so do the applications associated with them. The electronic version of the chemistry laboratory manual symbolized by the two-dimensional barcode is strongly recommended in Computer-based Learning and Internet/Web-based Learning. It can decrease the partial attention in the laboratory by connecting students electronically using their smartphones to a video, a blog, a data sheet that visualize the experiments.

Keywords First-year undergraduate, Computer-based learning, Internet/Web-based learning, Two-dimensional barcode

1. Introduction

The evolution of smartphones continues in today's electronic societies with the application of electronic libraries and scientific applications[1, 2]. Statistics show that North America has the lowest percentage of youth using smartphones. Only 22.9% of teens between 14 and 18 havea smartphone while 30.8% of students between 19 and 24 havea smartphone. China has the highest percentage of youth using smartphones, with 99.4% and 119.7% of teens and students using smartphones, respectively. Some extreme cases of mobile penetration exceed 200% in the United Arab of Emirates and Qatar, denoting high levels of multiple account owners[3]. Due to the variable applications and the high penetration level among youth and students, it is important to realize that smartphones are not just mobile phones; they are portable computers and can be used with a combination of augmented reality applications in the classroom. Augmented reality applications combine digital information with images and can be classified into markerless and marker-based types. The markerless type adds digital information on top of animage on a smartphone camera based on the global positioning system (GPS) location, while the marker-based type uses a physical reference point such as a two-dimensional (2D)barcode to connect a smartphone to information[4]. One of the most sophisticated applications of smartphones that is widely spread commercially is scanning 2D barcodes. Chemists have used cell phones for teaching[5–9]. Moreover, in one study, chemistry educators created three types of media content and linked it to 2D barcodes: (1)videos and photo blogs demonstrating laboratory instruments or procedures, (2)videos of homework and exercises, and (3)outreach videos performed by the chemistry club[10, 11]. The results showed that 59% of students indicated that interacting with 2D barcodes made the material more accessible, and 77% indicated that having a video that could be accessed on a worksheet made it easier to visualize problems in class[5]. Videos have also been incorporated into online journals[4]. Different types of 2D barcodes are available. In addition, easy-to-use, free programs are available to convert a uniform resource locator (URL) into a barcode that can beread with a smartphone[12, 13]. Educators are responsible for making concepts easier and for solving the problems faced by students. Smartphones are not the solution, but they can help by introducing computer-based learning and internet/ web-based learning in education.

2. Objectives

The objectives of this application are to:

1. Introduce technology in education
2. Create a laboratory manual that uses a 2D barcode
3. Minimize the use of paper to save energy and natural resources
4. Create electronic interactive social groups via web sites

3. Methodology

The laboratory trainer created a web site that contained three different experiments for first-year undergraduate students. The three experiments (on density, acid–base

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titration, and redox titration) represented a small section of the laboratory manual that would be used to apply the 2D barcode. Each experiment contained a different application: The density experiment applied Excel for calculations, the acid–base experiment applied asimple Word document for printing the data sheet, and there dox titration experiment applied avideo for demonstrating the redox theory.

3.1. Creation of the 2D Barcode

The laboratory trainer created the 2D barcode using the following steps:

1. Open the App store.
2. Download a “QR code maker”application.
3. Create the QR code for a URL address.
4. Save it as a picture in the photo library, and provide the students with this 2D barcode electronically or give them a paper copy.

3.2. Scan and Read the QR Code

The students scanned the QR code and read it simply by following these simple steps:

1. Open the App store.
2. Download an application that can scan a 2D barcode (e.g., either “Google” or “Scan”).
3. Scan the 2D barcode using the smartphone camera, which directs you to the URL address.
4. Open the electronic e-manual using your smartphone.

3.3. ElectronicVersionof the E-manual

As the 2D barcode created, students can scan it and start working their laboratory work. After performing the experiments, the students can share their comments through Google group on the same 2D barcode. The instructor received and evaluate the data sheet, calculation via the e-mail.

4. Conclusions

Academic campuses are hosting more and more college students who have smartphones. They are often experienced in creating and editing videos, attaching documents and photos, etc., and the use of marker-based augmented reality has become a part oftheir lifestyle. Chemistry students were scanned for the availability of smartphones and showed 120% of smartphone penetration and 20% of multiple account owner. Chemists decided to engage this technique in the laboratory by using 2D barcodes, which connect the information directly to a physical object (e.g., a scientific instrument, a paper, or a book). These 2D barcodes are very useful in the chemistry laboratory. Theycan be placed on instruments to explain the instructions of use, on bottles of chemicals to show the physical and chemical information, or on laboratory instructions to connect to a video showing the procedure. The use of 2D barcodes decreases partial attention in the laboratory and helps students to manage their attention. A part of the class couldbe devoted to smartphone technology, where they can practice, read, and visualize experiments electronically. Currently, the main limitation of using smartphones for reading 2D barcodes is that certain formats are not supported and need to be installed previously. The other limitation is that there must be wireless internet support on campus.

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