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Blending printed texts with digital resources through augmented reality interaction

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Abstract
Traditional printed textbooks represented a static medium of knowledge transfer for many years. The advent of technology introduced several digital material encouraged the educational institution to plan for the transfer to e-book and other related digital media. Both printed and digital materials have their own advantages and disadvantages as explained in the literature review. This work introduces a way to blend both through the augmentation of printed textbook with interactive entries to the digital media. The well planned entries guide the learners into the digital world that is recommended by the expert educators. The learners, however, still have the freedom to select and repeat the material they like to study according to their own learning style. An application was developed and used by a group of students to evaluate the print/digital blending concept. The quantitative measurements proved an increase in the interest, confidence and perceived performance of the learners using proved easy to use useful application. Making the application available to the learners of different disciplines through simple user interface was also recommended as one of the possible future works.

Keywords Audio-visual resources · Augmented reality · Computer-assisted learning · Interactive pedagogy · Resource based learning · Blended learning

1 Introduction

Educators' main task in traditional education is to facilitate the knowledge transfer to learners through face-to-face class sessions. Traditional approaches vary from passive (one way) to dynamic or active students' engagement. However, material taught in traditional classrooms where learning does not involve hands-on experiments or

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demonstrations were found to be difficult to understand (Wang and Chi 2012). There is consensus among researchers that dynamic content adds considerable benefits to the learning process (Way 2016; Edgcomb and Vahid 2014).

Although active learning, such as teacher-students interaction through demonstration, in-class activities, or/and discussion proved to be more effective (Michel et al. 2009), students in such dynamic environments are still having only one opportunity to acquire the knowledge. Looking carefully at any classroom show us two types of students; those who are involved in questions-answers/discussion activities (if offered), and others with wondering eyes trying to capture words and sentences to put them in writing or just add them to their information repository. This issue is amplified for those who are studying in English as their second language (Sawir 2005; Zhang and Mi 2010; Yates and Wahid 2013; Santos et al. 2014). Both dynamic and "information dump" lectures allow a little opportunity for the students to retain the information (Hackathorn et al. 2011) that may lead to what can be called as "one opportunity learners".

To invest in proactive teaching styles that aid in learning improvement, several resources were invented and used, such as maps, drawings, field visits, bringing materials and small animals to the classroom, as well as the school laboratories (Rodríguez-Vizzuett et al. 2015). Such resources are available in school and hardly demonstrated again as per individual student's need, which can also be referred to as "one opportunity learning".

The advent in communication technology created new paradigms of learning supported by technological tools to enhance the classroom teaching for a better knowledge acquisition (Rodríguez-Vizzuett et al. 2015). Several in-class supporting resources were simulated through the computer and became available to students outside the classroom for self or remote study. However, some laboratory experiments or hybrid (technology supported experiments such as the one mentioned in (Furió et al. 2017) are still class-based exercises. Nevertheless, such cases can be demonstrated through videos. The use of audio-video, touchscreen and tablets in the learning environments are now more preferable by learner over traditional environments (Sawyer 2012; Chen et al. 2017).

The adoption of technology through computerized applications made the learning and understanding easier and more interesting than before (Al-Imamy et al. 2006; Rodríguez-Vizzuett et al. 2015). In addition, students' performance was also improved through blended learning that adds technology to the traditional learning (Nour et al. 2007).

To provide interactive benefits, several schools and universities have substituted commercial textbooks with digital media that is accessible through mobile and/or paperless e-Books (Green and Kissinger 2010; Way 2016). Does this mean a replacement of technology to all the printed material? Several educational institutions were replaced or planning to replace the conventional textbooks with e-books for several reasons, including its flexibility and accessibility (Peru 2017), as well as other visual features and interactivity (Woody et al. 2010). In spite of the extra visual and interactive features of e-books, students seem to still prefer printed textbooks and even use their annotations and augmentation more than the material found in e-books (Shepperd et al. 2008). Despite its popularity, eBooks cannot be considered as an alternative to the printed books for several reasons including the discomfort due to eye strain caused by computer screens (Kropman et al. 2004; Gregory and Cox 2017).

Therefore, to get the maximum of textbook support, technology must be available when desired and needs to be adapted to suit individuals based on their learning styles. Since printed textbooks are in demand but lack the visual interactivity of the e-books, adding technological access to the printed textbooks will combine the benefits of both formats. This blend will allow the student to study in the traditional format but with the added opportunity to augment the material needed based on the users learning style, forming what we may call “style driven learning” because learners can access their favorite material according to their style of study. Some students, for instance, play video explaining the material in details, whilst others access program code, flowchart or extra pictures.

With the diffusion of Augmented Reality technology, a wide range of different supporting material can be overlaid on the textbook images to animate or make them active based on the learners requirements.

1.1 Related work

As discussed previously, one of the main educators’ concerns is to emphasize the concepts taught to learners using different approaches. The advent of technology during the last few decades pushed the support to a higher level using simulations (Harder 2010), computer aided tools (Alizadeh et al. 2008) and blended learning (Nour et al. 2007). Augmented Reality is recognized as one of the potential teaching tools since its appearance early last decade (Zhu 2016).

Early researches of AR in classroom focused on the recognition of special markers. High students’ interest and expectation of better performance were reported (Lee et al. 2009). Billinghurst and Duenser (2012) identified AR as a valuable tool for teaching. They extended the traditional books with augmented contents by adding additional elements of interactivity to enhance learning (Billinghurst and Duenser 2012). One of the main obstacles they identified is the need for high development knowledge that is not available to the educators. MacIntyre et al. (2016) used a special setting to augment the students’ work through projection to convert the classroom into a learning studio environment using a few cameras.

Augmented reality is also used in the education of those who need special support. Wang and Tucker (2010) used the web browser for video communication with deaf people through sign language. Jemni et al. (2016) developed a web-browser tool to teach and help students with hearing impairment to learn the sign language through online courses. Video modeling storybooks were used through augmented reality to train the children with autism disorder (Chen et al. 2016). AR also used in the learning of EFL English composition (Liu and Tsai 2013).

With the recent popularity of smartphones and their sophisticated cameras, AR reached almost every aspect and used for training in fields like navigation, sightseeing, military and medicine (Sudarshan 2018).

One of the attempts towards the text/technology synergy is the integration of mobile multimedia into textbooks (Uluyol and Agca 2012). Here, bar-codes were added near the physical text to access the related multimedia material. This approach, while novel, may not encourage users to access the material behind the codes and will likely result in minimum use of the technology as identified with the e-books usage (Woody et al. 2010). However, this approach supports the use of textbook as the source of knowledge acquisition and adds links to the related digital material.

Montoya et al. (2017) focused on the type of contents as static or dynamic. The dynamic contents were found to have more impact on the students’ performance. We believe that both contents should be available for the students to select based on their learning style. In some universities, including the one where this work was performed, teaching programming is done through distinct logic and coding activities. This approach gives the students an opportunity to focus and understand the logic before making simple syntax errors (Al-Imamy 2017). Although the students enjoy the logic learning period, they are still struggling, at least to some extent, when they convert the logic into code. Since there are only few works found in the field of programming augmentation (Mesía et al., 2016), this study contributes to this neglected research area. The objective of this article is to test the acceptance of texts/images augmentation with interactive buttons that, when triggered by the learner, displays explanatory text or multimedia.

The guided augmentation also contributes to the challenge of minimizing the cognitive load while maximizing the learning (Nadolny 2017) through the blend of recommended media material with the printed text through overlaid buttons representing what is called (interactive print). Researches were limited to testing few factors gained from augmented reality, such as students' interest (Yilmaz et al. 2017) and motivation (Cheng and Tsai 2016), but "quantitative evidence for its effectiveness is still scarce" (Sommerauer and Müller 2014). This work investigates five factors quantitatively; interest, ease of use, usefulness, confidence and performance. All these factors will be analyzed and discussed throughout the rest of the article.

2 Research methodology

Augmented reality based application was developed to assist students learning the programming concepts. Several instructional augmentations as well as video clips become available to the user as soon as he/she shoot the mobile camera to the booklet pictures. The main objective of the application was to assist the students in understanding the programming syntax. It also tests the students' feeling about the use of augmented reality as an interactive addition to the "previously" passive textbook. The article measures the students' interest, confidence and performance as well as the application's ease of use and usefulness.

2.1 Background

Due to the complexity of programming languages several universities, including **P**rince **M**ohammad bin Fahd **U**niversity (PMU) in the Kingdom of Saudi Arabia, divided the students' learning process into two phases. Students in the first phase used the visual logic tool[1] to learn the logic using simple executable flowcharts. This stage is similar to teaching a new driver how to control automatic transmission vehicle in the sense that unlike a vehicle with manual transmission, the driver will focus mainly on the road instead of focusing on changing gears. Beginner programmers using visual logic can also ignore the coding syntax and focus on the program logic. The transition from logic to coding, however, is not trivial and needs support to integrate the two phases together as reported in (Al-Imamy 2017). Augmented reality is used in this to help the integration and transition process.

[1] http://www.visuallogic.org

2.2 Augmented reality applications

This study is based on practical augmented reality applications developed initially to help the transition from programming logic into coding. The AR applications were used by students of "MISY 2312: Introductory Programming for Information Systems" course for the last three years. The first application was developed using "Metaio" which is a German AR company with subsidiaries in US.[2] Applications developed using Metaio creator can easily be accessed using the Junaio browser (created by Metaio) through 3G and 4G mobiles. Students used the application until the deactivation of its channels on the 15th of December 2015 when its company acquired by Apple Inc.

To continue the experiment, new applications were developed using Vuforia AR API[3] under "unity for mobile"platform.[4] The applications were developed for both Android and IOS smart phones/tablets. They are uploaded in both playstore and appstore for the students to download and use.

2.3 The experiment

The experiment focused on the main Java structure, output, variables and input. A small booklet was prepared and distributed as handout to the students. The same document is also available online.[5] To download the application, students load and use either Android[6] or IOS.[7]

After the introductory instructions, the application switches the mobile camera on. Pointing the camera towards either the hard or the soft copy will make the application display four buttons related to the recognized picture as shown in Fig. 1a. Pressing on the "Pin" button at the top right of the screen will freeze the application on the picture under exposure and its related button, for more flexibility, as in Fig. 1b.

Clicking the "Class' button will show the location of the class in the flowchart picture, as in Fig. 2a. Clicking again will display the pure java code, as in Fig. 2b. Students can understand the need for the class structure, how and where this code should appear through the toggling click on this "class" button.

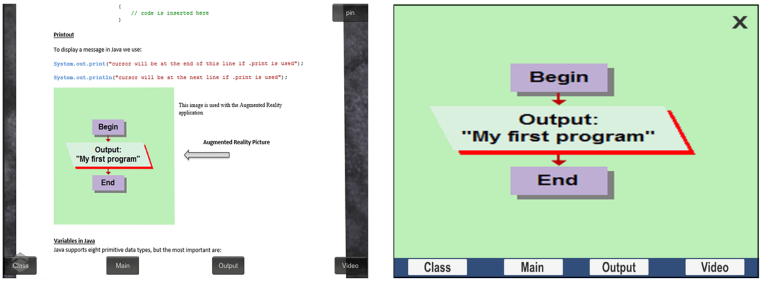
Clicking button "Main" will similarly show the code location and syntax on both flowchart and Java Integrated Development Environment (IDE).

After understanding the structure through buttons "Class" and "Main" students are able now to write Java command, such as the output construct seen in Fig. 3.

When the "Output" button is pressed the equivalent Java output command to the flowchart shown in Fig. 3a is displayed as in Fig. 3b.

The last button on the far right plays a video showing the process of writing the first Java program that output a simple message. To circumvent the internet connection problems during the lesson, the video has been embedded in the application. However, the same video is available in YouTube as a reference for the future. Snapshots from the video are shown in Fig. 4.

[2] http://en.wikipedia.org/wiki/Metaio
[3] http://www.vuforia.com
[4] http://unity3d.com
[5] http://slikke.net/ar
[6] http://apkpure.com/dr-samer-ar-java1/com.slikke.samer
[7] http://itunes.apple.com/us/app/augmented-java-1/id1230212623?ls=1&mt=8



(a) (b)

Fig. 1 Picture detection and recognition. **a** Augmentation buttons appear at the bottom of the picture. **b** A fixed picture replaces the detected image

Play, pause and progress bar were added to the video to give the learners an opportunity to navigate through the different pieces of the clip as needed.

As seen from the figures, different buttons appeared at the bottom of the screen as per the augmented picture giving the user the flexibility for retrieving any piece of information, picture, code or video as needed. Selecting the information needed by the individual learner learners is representing the concept of event or style driven learning.

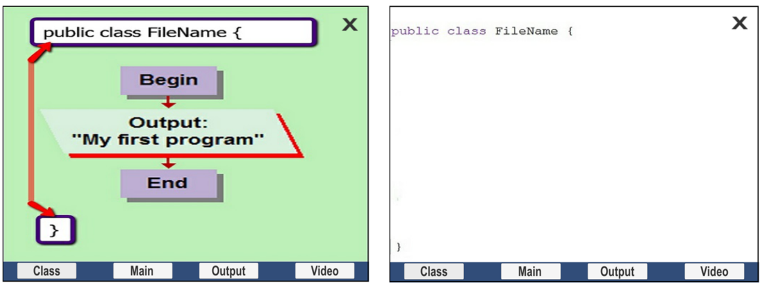
The 'X' at the top right of the image is pressed when the user like to dismiss this picture and its related button to shoot into another one.

The augmentation buttons are changed according to the scanned picture. To emphasize the concept few pictures from the images of Figs. 5 and 6 are shown below.

2.4 Research hypothesis

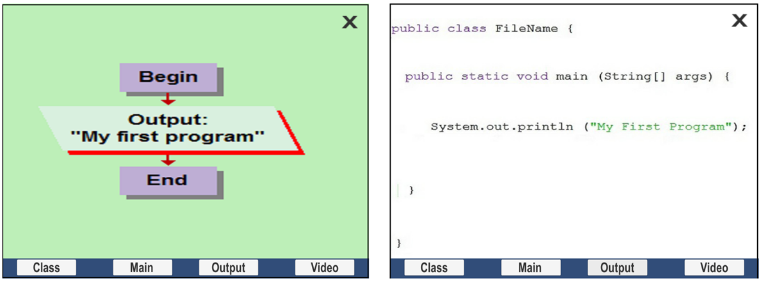
After allowing the students to investigate the application for about 30 min they were asked to fill out a questionnaire to express their opinion about the use of Augmented Reality to support the textbook for a better teaching.

The appearance of new overlaid objects into the real world scene is a sort of fun (Mesia et al. 2016) that leads to interest by itself. Increasing the interest in any subject is one of the primary factors that instructors often try to create for more students' involvement in the subject. The use of smartphone applications in classroom is proved



(a) (b)

Fig. 2 Java class structure. **a** Shows the location and syntax of code on the flowchart. **b** Shows the pure code in any of the famous Java IDE



(a) (b)

Fig. 3 A complete conversion of flowchart printing output message into Java code. **a** Shows the output flowchart using visual logic. **b** Shows the complete java code needed for the output

to be influential (Hegarty and Thompson 2019). Therefore, augmenting the textbook through such devices with useful buttons or widgets used for different learning tracks will hypothetically increase the students' interest and engagement. Due to the relationship between interest and performance (Abrantes et al. 2007) high interest may lead to a better performance. Therefore, to test the impact of the environment of augmentation on the students' interest, the following hypothesis is proposed:

H10:Interest – *The use of Augmented Reality in teaching has had no effect on the learners' interest.*

The application used to augment the pictures (flowcharts) found in the textbook should be easy to use because no enhancement in performance is possible if it is not perceived as being easy to use (Saadé and Bahli 2005). The simple augmentation will keep the benefit and enjoyment of the use of conventional textbook, but adds easy access to extra information or multi-media. Hence, the second hypothesis deals with the ease of use:

H20: Ease of use – *The application used in the augmentation of textbook's pictures (flowcharts) is difficult to use.*

The main reason for using augmented reality in this work is to support the text with extra variant materials. If the added material is trivial, has no sense, or adds no extra knowledge then the augmentation process is not useful. Usefulness by definition refers to the measurement of person's believe that the application enhances his/her performance (Saadé and Bahli 2005). Therefore, it is worth investigating the learners' opinion

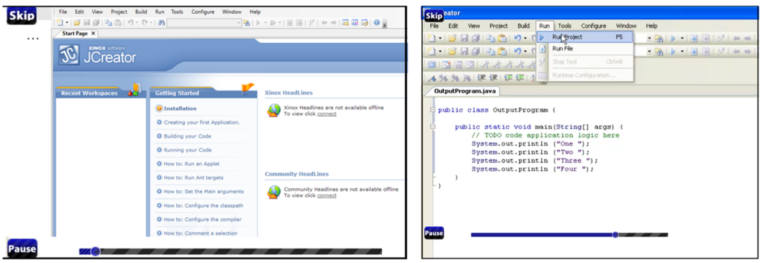


Fig. 4 Snapshots from the video which is also available through the following link: http://www.youtube.com/watch?v=EI8Q8ZQttgc&index=1&list=PLne5VIdYZDPnZVJWMD3YNK6

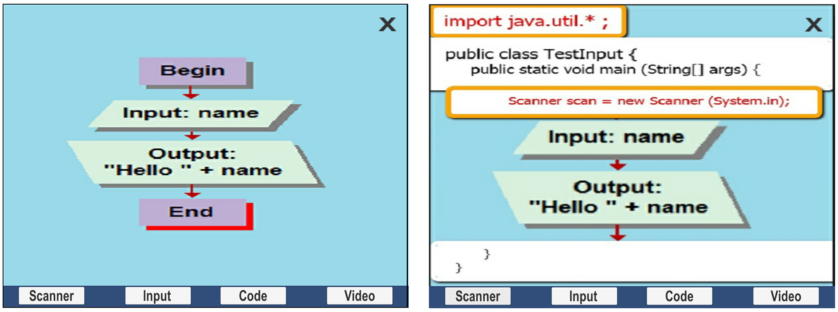


Fig. 5 Augmented "Input" construct showing the "Scanner" class import and use

about the usefulness of Augmented Reality in the learning process. Hence, the third hypothesis uses the related group of survey questions to test the following hypothesis:

H30: Usefulness *– The augmented material is not useful enough for the learning process.*

Learners' confidence has an impact of the learning process. Students with high self-confidence will adapt the tools to gain more experience that may increase their performance (Saadé and Bahli 2005). On the contrary, students perform poorly when they lack self-confidence. To test the impact of Augmented Reality environment on the confidence, the following hypothesis is proposed:

H40: Confidence *– The use of Augmented Reality environment has had no effect on the learners' confidence in the subject.*

The developed application used in this research is an Event Driven Environment (EDE) that helps the learners to navigate freely. With the EDE learners can easily direct their learning track through the sequence of reading, watching and listening that they like to investigate without forcing them through compulsory long learning and topic sequence tracks. Then the learner will follow the concepts that need to focus on and repeat for more understanding.

Therefore, it could be claimed that Augmented Reality's visualization and interactivity could improve students' performance. Hence, the null hypothesis is:

H50: Performance *– Augmented Reality has no positive impact on the students' performance.*

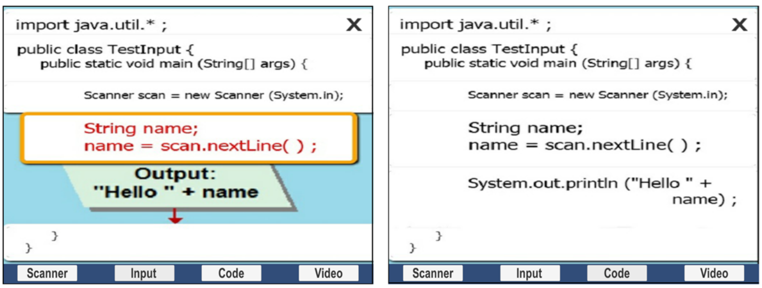


Fig. 6 Augmented "Input" construct showing the Java code

The above hypotheses were tested through 21 questionnaire items collected from 129 samples studying “Introduction to Programming” course over more than two years. Drawing on the Technology Acceptance Model (TAM) and the rate of diffusion model the questions items were borrowed from various resources (Davis 1985; Valente and Rogers 1995; Tveden-Nyborg et al. 2013). The samples include mixed students of different genders and levels for the four majors in the **C**ollege **O**f **B**usiness **A**dministration COBA (Accounting, Finance, Business Administration and MIS) in PMU.

As well as answering the questions several students wrote comments about their experience with the AR approach. Summary of these comments will be grouped and presented in the following research results section.

3 Results

The research quantitative data were collected through a questionnaire with a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). The 21 items were factored into five groups representing the perception of learning through augmented textbook. The above mentioned groups were mapped into the hypotheses shown in Table 1.

3.1 Exploratory statistics

Table 2 shows the demographic data for the sample. Based on majors’ program requirement and the students’ number, the majority of the surveyed students were majoring in Business Administration (35.66%) and Finance (34.11%) where programming must be taken as an elective. Despite the low number of MIS students in comparison with BA and FIN the percentage is (27.13%) as programming is a required course for this major. Students in the Accounting major can select between either Finance or MIS courses as electives, this explains the 3.10% of students taking programming as an elective. About 70% of the surveyed students were male and 30% female. Except the freshmen level, the number of students is almost equally distributed over the rest of levels.

The collected data for the different course sections are reliable as seen in the descriptive statistics shown below in Table 3.

Table 1 Hypotheses list

No.	Title	Hypothesis
H10	Interest	The use of Augmented Reality in teaching has had no effect on the learners’ interest
H20	Ease of use	The application used in the augmentation of textbook’s pictures (flowcharts) is difficult to use
H30	Usefulness	The augmented material is not useful enough for the learning process
H40	Confidence	The use of Augmented Reality environment has had no effect on the learners’ confidence in the subject
H50	Performance	Augmented Reality has no positive impact on the students’ performance

Table 2 Demographic statistics

Major				Gender		Level			
ACT	FIN	BA	MIS	Male	Female	Fresh.	Soph.	Junior	Senior
3%	34%	36%	27%	71%	29%	3%	29%	30%	38%

Table 4 below shows the statistical summary for the five variables. All of them have averages above 4 (Agree) which indicate favorable ratings for all the variables. Standard deviation is fairly consistent across the variables. The reliability scales were all above 0.9 on Cronbach's Alpha measurement which means the data have excellent reliability.

3.2 Hypotheses tests

Table 5 below shows the hypotheses' t-tests. The first one tests whether the textbook augmentation is an interesting tool to use or not (INTEREST). The second hypothesis tests whether the augmentation application is easy to use (EASEOFUSE). The third one tests the (USEFULNESS) of the application. The forth hypothesis investigates the effect of the tool on learners' (CONFIDENCE). The last one represents the students' experience with the textbook augmentation on regards to its influence on their (PERFORMANCE). The table also shows all null hypotheses were rejected at the p-value <.05 when the data compared with the central value of in Likert scale "neutral". This means that responses are significantly "agree' or "strongly agree" with the questions that are all referred positively to the augmented reality. Though, questions are distributed over the mentioned five hypotheses.

3.3 Interrelationship model

Since Interest, Ease of Use, Usefulness and Confidence are expected to enhance the performance for on-line learning (Saadé and Bahli 2005) and use of

Table 3 Groups Descriptive Statistics

Section Number	N	Minimum	Maximum	Average	Std. Deviation	Reliabili (*C. alpha*)
1	21	1	5	4.20	1.27	0.99
2	17	2	5	4.80	0.56	0.95
3	12	1	5	3.78	1.19	0.97
4	15	1	5	4.15	0.83	0.97
5	18	1	5	4.02	1.47	0.99
6	9	1	5	4.23	1.32	0.99
7	11	1	5	3.65	1.41	0.99
8	11	1	5	4.46	0.96	0.99
9	15	1	5	4.56	0.58	0.89
All groups	**129**	**1**	**5**	**4.00**	**1.16**	**0.99**

Table 4 Hypotheses Descriptive statistics

Variable	N	Min	Max	Mean	Std. Dev.	Reliability (C. Alpha)
Interest	129	1.00	5.00	4.25	1.03	.957
EaseOfUse	129	1.00	5.00	4.22	1.10	.902
Usefulness	129	1.00	5.00	4.27	1.15	.939
Confidence	129	1.00	5.00	4.26	1.07	.951
Performance	129	1.00	5.00	4.27	1.06	.959

multimedia in learning (Saadé et al. 2019), it was found worth to test the following interrelationship model:

Figure 7 showing the interrelationship model to test the impact of interest, ease of use, usefulness and confidence on students' performance.

The statistical analysis of the model is shown in Tables 6. It reveals that student performance was reflected by interest ($\beta = .46$, $p < .05$), usefulness ($\beta = .27$, $p < .05$) and confidence ($\beta = .19$, $p < .05$). The three indicator model accounts for 95% ($R^2 = .95$) of the variance in performance. Results are explained further in the discussion subsection.

3.4 Free comments

The survey contains an open question to record the free comments. Following are few of these comments about augmented reality in general and the application in particular:

- Innovative and entertaining program that cop up well with the high tech era and introduces new methods of better quality learning.
- I Think That's will help the students to learn and be more confident.
- THANK YOU. IT WAS A GOOD IDEA TO NEW METHOD OF TEACHING.
- I really loved this application, and teaching method. It is very unique, and very well-designed to teach students. I extremely loved this application, and I support the instructor into bringing this application alive to the world. Good luck
- AMAZING APP.
- It's great!

Table 5 Hypotheses test results

Hypo. No.	Variables	D.F.	T-Stat.	Mean Diff.
1	Interest	128	13.788*	1.25
2	EaseOfUse	128	13.619*	1.22
3	Usefulness	128	12.533*	1.27
4	Confidence	128	13.346*	1.26
5	Performance	128	13.619*	1.27

*Significant

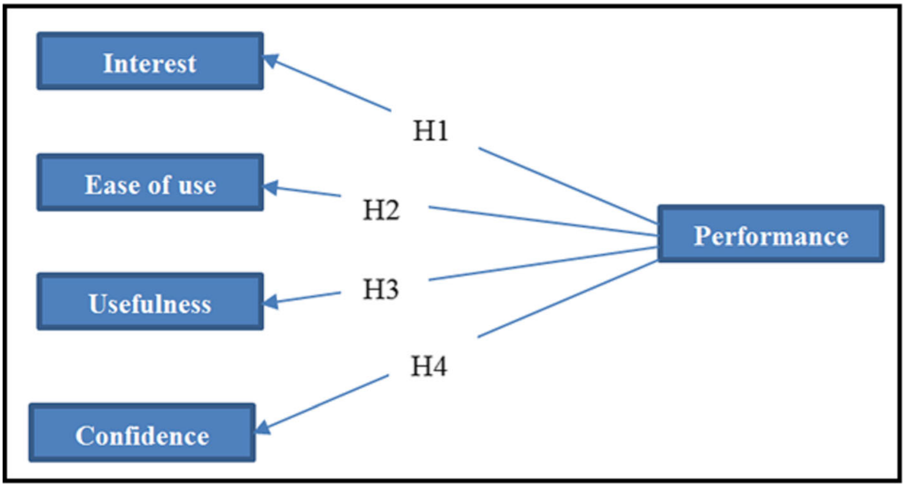


Fig. 7 Interrelationship model showing the impact of the independent variables on students' performance

- One of the best applications.
- It's a Step into the Future.
- It is a useful and interesting application.
- Has more impact than traditional learning for this generation.
- I am impressed by the program hope it becomes official soon.
- So awesome, creatively and easy to use.
- I like the simplicity of the application and how it is user-friendly.
- It was so good, I like it because when I took notes I can't catch all the things that he explained in class, but now I have them in the app.
- The application is smart and easy to use, appreciate the designer for it.
- Thanks for your efforts to help us at class and at home. Appreciated.

The comments apparently support the hypotheses tests of the previous section.

Table 6 Coefficients Variables Extended from the Regression Analysis of the Interrelationship Model

Model	Unstandardized Coefficients		Standardized Coefficients			R^2 Adj.	R^2
Predictor variables	B	Std. Error	Beta	t	Sig.		
(Constant)	.067	.094		.717	.475		
Interest	.476	.073	.462	6.545	.000		
EaseOfUse	.081	.059	.083	1.336	.174		
Usefulness	.248	.057	.268	4.315	.000		
Confidence	.185	.065	.187	2.842	.005		
Model						**.949**	**.947**

Note. Dependent variable: students' Performance

4 Discussion

Students are usually facing difficulty in studying computer programming due to its need for creativity and innovation skills. Such skills are not easy to build in the crowd of learning logic and syntax to develop a wide variety of programs according to the problems under study. Learning logic and syntax at the same time is similar to start learning to drive using a car with manual transmission. To let the students focus on logic learning before going through the complications of syntax, introducing a flowchart based programming tool was found perfect for learning the logic. After well controlling the logic, students experienced a problem when they try to convert the flowchart into Java code (like automatic cars drivers trying to drive manual cars). It was noticed how frustrated the students at this stage when they fail to transfer the simple flowchart into a running code. Therefore, a new technology is needed to make the transition process easy and interesting. Augmented reality application developed for this purpose found to be interesting, easy to use and useful for the students to understand the code writing with confidence. Using the mobile in the learning added more interest to the learning process. Above that, the augmented material is limited to the students' need as set by the instructor and driven by the augmented picture. So, instead of leaving the learner sink in the overwhelming digital material available through the internet, guided links are used to guide the learners to the text complementary material. This overlaid blended material could be instructional text, code or video casting. The international buttons varies depending on each augmented picture as set by the instructor that could be called as "guided augmentation". Although the buttons are event driven; means selected as per learners need, they are limited to what the instructor feels important for the learning. The other important feature of the application is the ability to embed the augmented material within the application such as all augmentation materials are available anywhere regardless of the availability of internet. The other important issue that added to the success of the application is the use of smart phones that students love to use in learning, at least in Saudi Arabia where the study was conducted.

The interrelationship model (Figure 7) shows a significant prediction of high performance. The result of a simple linear regression (Table 6) revealed that student performance was reflected by interest, usefulness and confidence. The three indicator model accounts for 95% (R^2=.95) of the variance in performance. Table 6 also shows no significant contribution from the ease of use variable. This is due to the feeling of students that the application is significantly easy to use (see Table 5) because they are already literate in technology especially for those studying programming and using Visual Logic application during the first half of the semester. Therefore, ease of use is not a plausible factor that could significantly contribute to the performance.The significant contribution of the independent variables to better performance meets the students' expectation of high performance indicated by the significance rejection of the null performance hypothesis as seen in Table 5.

As well as prove of learners' interest, confidence and performance and the application ease of use and usefulness through the analysis of survey, an open question supports the mentioned factors.

Although the experiment applied on computer programming subject it could easily be transferred into other subjects, but must be developed under the supervision of the instructors of the subject.

5 Conclusions

This work is a contribution to the limited empirical studies measuring the role of augmented reality on performance within the learning process. The effect of using augmented reality in teaching found to be of interest to the learners and increase their confidence and performance expectations. The application used was proved to be easy to use and useful for effective learning. The results showed that blending the printed with the digital materials creates an effective learning environment that is superior to either mentioned resources when used individually. That's because the navigation through the huge overwhelming digital resources make learners unfocused due to several reasons including their lack of expertise in the field on regards to the scope and dimensions of the available and required digital material. On the other hand, printed static material is not enough without extra support. Therefore, printed text augmented with well selected digital resources planned and set by the instructor as a guide to the students into the digital world will create the magic.

Meanwhile, learners are still enjoying the freedom of selecting the material they like to study and/or repeat based on their learning style through the interactive buttons.To make the application works in different fields a technical training and/or support should be offered to the instructors. However, shielding the technical complication from the instructors guide design can be simplified and reduced to filling out a form and loading some pictures and resources by the instructor on the internet. However, this option needs time and budget to create such a sophisticated application.

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Open data Survey questions and data may be requested from the author.

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