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A pedagogical Approach for Integrating Smartphones into Learning Activities: Evidence Based Practice at Secondary School

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Abstract: *Research in emerging technologies has argued that the pedagogical integration of smart-phones in learning activities is important to engage students in meaningful learning experiences. Recent studies have shown that SOAR pedagogy is effective when implemented in social science environments. Some of empirical studies of SOAR based mobile learning have demonstrated examples of different learning scenarios with positive results toward students' performance. However, there is a little research exploring the augmentation of SOAR based mobile devices in field of science learning environments. This research is based on an experimental study where participants were divided to the experimental group (EG), (n = 33) who employed SOAR with mobile devices and control group (CG), (n =33) who followed mobile without SOAR approach. The purpose was to examine and compare the effectiveness of two mobile learning approaches on improving students' learning achievement. In particular, EG group engagement and perspectives are investigated as to explore whether the mobile SOAR approach had positive effect on learning activities. The study was carried out in a secondary school located in Khartoum state in Sudan, both quantitative and qualitative techniques were employed to collect and analyze the data in order to understand the variations between two pedagogical approaches. Our results indicated that significant differences existed between students learning achievement, the EG students' achievement was significantly higher compared to CG students. Moreover, the EG students reported that the mobile SOAR approach has influenced their engagement and create positive perspectives toward learning activities. We conclude by arguing that, diverse learning technology environments, and large sample size are critical to explore the potential of mobile SOAR approach in improving students learning performance.*

Keywords: mobile based SOAR. pedagogical approach. learning activities. secondary school. integrating smartphones

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INTRODUCTION

For several years, educational technology research has confirmed that technology can be a useful resource for enhancing quality of teaching and learning. With the rapid development of digital learning technologies such as mobile devices, students not only have opportunities to access digital learning content but also have chances to communicate, collaborate, interact with peers and create knowledge (Elsafi, 2018). Recent studies demonstrated that, mobile devices have great potentials to support learners for participating and integrating authentic learning environments, and developing meaningful learning (Herrington et al. 2014; Land et al. 2014). The effective integration of mobile devices in the learning process could improve students' academic achievements and promote group collaboration (Suárez et al., 2018; Strobl et al., 2019).

To reach the value of mobile technologies in knowledge acquisition and transferring, deep and meaningful learning, the designer or instructor should not only focus on the medium of instruction/ technology but also the learning content should be pedagogically sound. Schramm (1977) suggested that learning is influenced more by the content and instructional method than by the type of technology used to deliver instruction. However, to improve learners' quality of learning, teachers have to develop competencies and skills on how mobile learning technologies can be used to benefit students' learning. Teachers need to implement effective mobile learning strategies to contribute into appropriate pedagogical practices of mobile devices in the learning process (Gros, 2016). Thus, incorporating effective pedagogical strategies into mobile learning are critical to meet the students' interest, diversity and modern learning styles (Ally et al, 2014).

On the other hand, studies reported an important point, students lack to organize what they have learned with mobile devices became a critical issue for successful integration of mobile devices in learning process (Palalas, 2018). If the use of mobile devices are found to be pedagogically inappropriate, then students are expected to choose and engage in non-useful activities (Ahmed, 2015; Ramadan & Chen, 2018). This study adopt a pedagogical approach called "SOAR", which an acronym stands for four theoretically driven and empirically supported components comprised; Select (S), Organize (O), Associate (A), and Regulate (R). Each component of SOAR is based on the cognitive process of meaningful learning and development (Jairam & Kiewra, 2009). The study aims to answer the following questions:

1. Do students who implement the mobile based SOAR learning approach outperformed those who implement mobile without SOAR learning approach in learning achievement (factual, conceptual and relationships knowledge)?

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2. To what extent has a mobile SOAR approach achieved to enhance students' engagement and create personal perspectives about learning activities?

ICT Initiatives and deployment

The debate supports the idea of Information and Communication Technologies (ICT) could foster teaching and learning process has been widely accepted among educational stakeholders in Sudan. Sudan has attached great importance to ICT implementation in education. As mentioned by Tairab and Ronghuai (2017), Sudan had a long history as a country introduced ICT into education system. The government understands that developing individual's technology skills and competencies is critical for better life, as therefore, many initiatives are focused to implement ICT for secondary schools. For instance in 1999, educational goals through the national strategic plan are clearly stated: having strong technology infrastructure, developing human resources, encouraging and supporting national software industries, introducing ICT based Arabic learning content (Nour, 2016).

The ICT strategic plan starts practically in 2002, it was specifically focused on a series of practical steps including: curriculum reform and development, improving teachers' ICT skills, enhancing the ability of life-long learning. For achieving these goals the Ministry of Education (MoE) equipped the schools with technology infrastructure (e.g. computers, white boards, scanners, etc.) and trained teachers for professional development to fulfill the intended goals of ICT implementation in education context. But unfortunately, the expectation about ICT potentials to drive the change in teaching and learning practice at the level of schools remained largely not achieved.

The possible reasons for these poorly outcomes are various, ranging from county's political problems (decades of war and conflicts, social and political instability, deterioration of economic, etc.) to reasons concerned to traditional of schools practice and teachers alike resistance to accept the change, incomplete training programs support technology integration, a lack of measuring and monitoring whether the programs are having impact on classroom practice, these are created a large gap of successful ICT integration into classrooms practice.

Regarding the use of smartphones at the level of Sudanese secondary schools, the authors acknowledge that during conducting the experiment, students have shown strong interest to use these devices for teaching and learning purposes. Many schools, particularly private ones have not banned students to bring smartphones into classrooms, schools' teachers and administrates encourage students to use mobile devices for educational purposes. Despite of these considerable efforts, the absentation of government initiatives and deployment to utilize the potentials of mobile devices, as well as a lack of effective instructional methods are major challenges into seamless integration of mobile devices in learning process.

Impact of smartphones on promoting learning engagement

Research on mobile and ubiquitous learning technologies have provided insights into how students' motivation could occur during learning activities, and provided credible evidence about the role of smartphones on promoting students' engagement in learning process. For instance, Jeno et al. (2017) have examined how a mobile technology tool could impact specific identifications including (a) compared to activities based on a traditional textbook, (b) its effect on students' intrinsic motivation and engagement (c) perceived competences. The result of study concluded that the mobile learning application has developed students' level of perceived competence and promoted their intrinsic motivation and engagement. Researchers asserted that, for designing the effective mobile learning environments, instructors need to addresses students' personal attitudes towards technology use and gaining understandings about their perspectives and social culture on the use of mobile devices for learning purposes (Chang & Samsudin, 2014; Farjon et al., 2019).

Likewise, an investigation of a mobile learning application employed by the United States (US) students for learning grammar which focuses on Spanish courses was undertaken (Cho & Castañeda, 2019). The study emphasized to examine the changes that could happen in students' motivation and engagement after they participated in mobile game applications for improving Spanish language grammar rules. Two types of measurements were administrated for 82 US university students in Spanish classes. The first was Motivated Strategies for Learning Questionnaire (MSLQ) and the second was an effective engagement scale. The results of the study yielded that a significant improvement has made in self-efficacy, intrinsic motivation and engagement. When designing mobile learning strategies, instructors should take into consideration aspects of promoting students' engagement during mobile learning activities, as to avoid distraction and interference in learning (Elsafi, 2020).

Duane and Satre (2014) have stated three critical points in which an effective mobile learning strategy could support students' learning engagement: (a) the learning strategy should help students to engage in studying learning content, (b) in the learning strategy sophisticated understandings should be reached, and (c) encourage students to demonstrate understanding and interpret the learning content in a way that cannot be achieved in conventional strategies.

LITERATURE REVIEW

The implementation of SOAR in technology learning environments such as computers and smartphones have demonstrated positive effects on students' knowledge construction. Jairam and Kiewra (2010) examined the impact of SOAR for computer-based learning materials and used students' self-report and observation to indicate the method that they used to study computer-based learning materials. The study conducted two experiments, in the experiment one, 114 students were surveyed to specify and describe strategies used to study computer-based materials and reported their behavior when they study materials.

In the second experiment, 108 students read an online text about a specific subject and created materials that reflected their preferred study methods, then they observed how learning methods were used for computer-based materials and compare observations with participants' reports from the experiment 1. Following the observations session, the participants in experiment 2 were divided into a control group and 4 experimental groups (S group, SO group, SOA group, and SOAR group). Each group was followed a specified method to create their study materials based on SOAR components or preferred methods. In the end, all participants assigned to an online test. The results showed, those who are used the SOAR method outscored students who used preferred methods. In addition, observations of students' preferred study methods confirmed that students were used ineffective study strategies during learning.

Daher (2014) investigated the impact of SOAR based computer learning materials by examining how stages of SOAR (select, organize, associate, and regulate) could successfully be integrated into the learning process to improve university students' cognitive skills of wild life content. In the learning process, the instructor first provided students with background knowledge about the learning targets (a unit about; Gibbons, Orangutans, and Gorillas. To verify the effectiveness of the SOAR based-computer learning approach, the instructor conducted the experiment in which the experimental group used the SOAR based-computer approach, whereas the control group used non-SOAR/ preferred study learning strategies. The post achievement test results revealed that, the experimental group did better and outperformed those of the control group.

Similarly, an investigation of SOAR study strategies for learning from multiple online resources was undertaken by (Daher & Kiewra, 2016). One question guided the study: How does SOAR training affect students to study from multiple online resources and impact achievement? 134 college students assigned to the expermental group (SOAR strategy) and the control group (preferred strategies/autonomy learning strategy). Both control and experiment groups were directed to online training materials available on multiple websites. The findings conclude that the SOAR strategy group achieved more than preferred strategy group in learning outcomes.

Another recent case study about SOAR based computer was conducted by Luo and Kiewra (2019). The study aimed to investigate the synthesis writing benefits of SOAR that helped students to select, organize, associate, and regulate information from more than one source to construct a new text. The study conducted two experiments, in the experiment 1, teacher provided students four texts about "the creativity" and asked students to write one essay that compares the four types of creativity either following computer-based SOAR (the experimental group) or none- SOAR (the control group). The result from the scoring rubric (based on selection of information, essay organization) has shown that, the experimental group constructed a better meaningful essay than the control group.

From previous SOAR case studies, the positive impacts of SOAR strategies on students learning achievements in different learning contexts were confirmed. The SOAR learning strategy yielded strong and conclusive evidence to the positive effect on students learning outcomes. However, the SOAR learning strategy guided students into successful learning achievements. Empirically SOAR was robust for developing students' skills and create meaningful learning in various learning disciplinary for instance (psychology and life science). SOAR elements have been proven to support the cognitive process of learning. Therefore, in this research, it is reasonable to propose that SOAR-based mobile learning may also be effective to develop secondary schools' students' cognitive skills of physic topic.

METHODOLOGY

The study followed the explanatory sequential design approach to explain in details and provide evidence to experiment results. The first phase of the study was the experimental design which undertaken the quasi-experiment procedures to cause the effect relationship between the implementation of the mobile SOAR strategy and students' academic achievements. In the case of a researcher needs to provide enough description and elaboration for the experimental results, the qualitative approach should follow to support understandings (Creswell & Gutterman, 2019). For this reason, purposeful sampling was employed and only 6 students from EG were interviewed.

In respect to the ethical consideration of the study, the participants were informed with the nature and aim of the study and were given a full explanation of their rights and responsibilities before the beginning of the experiment. The agreement of students to participant in the study was obtained after their parents assigned to consent forms.

Participants

The participants of the study were a private secondary school students attending to a Physic course as a part of formal curriculum. The average age of participants was 16. The school encourages students to use mobile devices for searching and accessing online educational resources). The sample was chosen by means of purposive sampling since only the students of a particular level of skill and upwards could take the activities and complete the given assignment based on mobile devices. For this reason (second year-male secondary school students) were selected to participant in the study. The participants had the same cultural background, and they were given some command for using mobile devices to complete the assignment.

Experiment procedures

Students were randomly assigned to: an experimental group ($n = 33$) and control group ($n = 33$). The experimental group (EG) followed a mobile with SOAR approach, while the control group (CG) followed

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a mobile without SOAR learning approach. All groups were performed a pretest to be assessed about previous knowledge on the topic presented afterword (facts, concepts and relationships of direct current circuits). The participants of EG who followed mobile with SOAR were oriented to access a platform that contained the intended materials they were supposed to study. Before the starting of the experimental phase, EG students had given a session so as to be familiar with the platform, perform the process of the mobile SOAR approach and access learning materials. The first stage was to access the platform and *Select* information relevant to the topic, the second stage was to *Organize* information to facilitate understanding, the third stage was to *Associate* selected and organized information about (Direct Current Circuits) to support understanding, and finally they were *Regulated* information by performed three types of tests about facts, concepts and relationship of the topic.

The all three tests were aimed to assess students: cognitive ability of factual knowledge, ability of conceptual understanding and establishing a relationship between the components of the topic being taught. Before all necessary information about the topic was presented, the participants in CG / the mobile without SOAR approach were instructed to navigate leaning materials (Current, voltage, resistance in direct current circuits) via a platform using mobile devices and perform learning activities, then assigned to the three on online tests (facts, concepts and relationships). At the end of the experiment all the participants were presented to a post achievement test to determine which group could significantly obtain better learning achievement. After the end of post-test, 6 participants from EG were answered an interview questions on their sense of engagement and interaction during the learning activities. Figure 1 and figure 2 presented examples of participants' performance during learning activities.

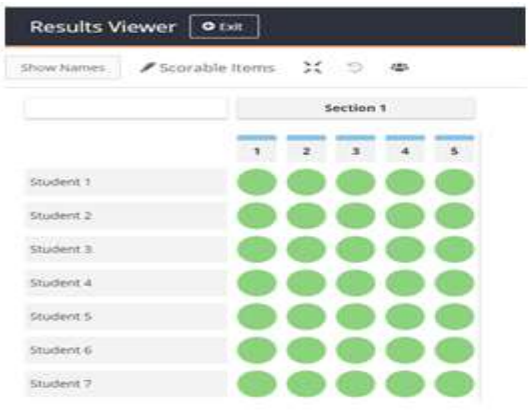

Figure 1. Example of EG performance

Figure 2. Example of CG performance

RESULTS

Quantitative analysis

Pretest

Before the beginning of experiment, the participants took a pretest to evaluate prior knowledge about the subject being tough before conducting learning activities. Following one-way ANOVA analysis, the mean of CG was compared with the mean of EG to determine whether significant differences could exist between two groups related to the prior knowledge of students. The result is presented in Table 1, which includes the number of students (N), Mean (M), Standard Deviation (SD), degree of freedom and P-value. From the results of assessing the homogeneity of variances, it can be seen that the two groups had an equivalent pre-require knowledge of the topic which means no significant differences found between two groups $F(2.9) = 2.9$, $p > 0.05$).

Table 1. Shows the results of pretest.

Variable	Groups	N	M	SD	F	P-value
Pre-test	Experimental group	33	75.5	7.9	2.9	0.92
	Control group	33	72.3	7.7		

Factual, conceptual and relationship knowledge test results

After evaluating the tests of (factual, conceptual and relationship) of both groups, it is seemed that, EG has a better learning outcome in terms of factual knowledge, conceptual knowledge and relationship knowledge compared to the participants of CG. In details, from the result of factual knowledge test presented in Table 2, students of mobile SOAR approach demonstrated better achivement than their peers (CG) who employed the mobile without SOAR secinario. The ANOVA analysis shows that, significant differences existed between EG and CG, $P < (0.05)$, the mean of the EG ($M = 14.9$) was higher than the mean of the CG ($M = 13.7$). Hence we can conclude that, the learning outcome is enhanced in terms of factual knowledge by implementation of the mobile SOAR approach.

With regard to the conceptual knowledge test, the difference in learning achievements is statistically significant, as presented in Table 2. The result genarated by ANOVA analysis sugessted that, significant differences existed between two groups, $P < 0.05$), the mean of the EG ($M = 32..8$) Was higher than the mean of the CG ($M = 29.2$). In respect to the relationship knowledge test, ANOVA was performed to show the differences in the mean between two groups of participants. The result presented in Table 2 shows that, significant differences found between EG and CG, $P < (0.05)$, the mean of EG ($M = 34.5$) is higher than the mean of CG ($M = 31.9$). Overall, the learning outcomes in three tests (factual, conceptual,

and relationship) were higher for EG, which means the mobile SOAR approach enhanced EG to perform better in learning achievement.

Table2. Presented the result of fact, concept and relationship test

Variable	Groups	N	M	SD	F	P-value
Factual knowledge	EG	33	14.9	1.5	6.0	
	CG	33	13.7	1.6		0.02
Conceptual knowledge	EG	33	32.8	4.5	8.3	0.01
	CG	33	29.2	5.8		
Relationship knowledge	EG	33	34.5	1.9	11.	0.00
	CG	33	31.9	3.9	2	

Posttest result

The results of posttest presented in Table 3 revealed that there were significant differences in achievement scores between EG and CG participants (p = 0.02). However, this result suggested the participants who followed the mobile with SOAR approach outperformed those who followed the mobile without SOAR approach which means the mobile with SOAR approach was more effective in developing students' understandings of the physic topic.

Table 3. Shows the results of post-test

Variable	Groups	N	M	SD	F	P-value
Post-test	Experimental group	33	77.3	7.8	9.9	.002
	Control group	33	71.2	8.1		

Qualitative analysis

Flow up interviews with 6 students from EG were conducted after the execution of the experiment. The interviews aimed to provide more explanation and elaboration to the results obtained from the experiment, by focusing to investigate recruited participants to what extent the different stages of incorporating mobile with SOAR learning approach could affect students to study learning materials. Also, the interviews aimed to offer insights into students' perspectives toward applied the mobile SOAR learning strategy during learning activities and to report the challenges encountering due to the learning process.

Six students from the experimental group were participated in the interview. The interviewees were selected based on the results of quantitative data analysis of post-test achievement. They were selected according to "higher quartile, middle quartile and lower quartile" of results distribution. The data obtained from each interviewee were recorded, transcribed and then coded based on questions of the interview. For

example, the main codes comprised the participants' perspectives as results of their experiences about a SOAR mobile learning strategy and how these processes could support understandings in terms of facts, concepts and relationships knowledge of the Physic topic.

Engagement

The first theme was concerned to the participants' sense of engagement during learning activities, they confirmed that they followed stages of mobile SOAR. All the interviewees explained that they were engaged during the study processes, for example, one student mentioned.

> *"I watched the video and read articles, then I pointed out some words on the note tool that I thought were very important for me to understand the elements of electrical circuit components. I moved to the other document, I figured out some explanation to some elements such as the voltage, current, and resistance, I organized the words with their sub-meanings and made them more clear and put them in the table. ……. finally I completed the achievement test".*

It seems that the mobile SOAR learning strategy allows students to study the topic elements effectively and therefore able to put their efforts on focusing to move from one to the next stage until the completion the learning material and assignment. Clearly, such engagement in learning process following the mobile SOAR learning strategy to learn the physic subject could lead to higher learning performance.

Perspectives

The second theme focused on participants' perspectives about the use of mobile SOAR learning strategy, to what extent does Mobile SOAR supported students' developing understanding of Physic knowledge?. No doubt mobile SOAR has its impact on students' learning performance, therefore it expected that each participant has a specific self-perspective generated as the result of experience of mobile SOAR approach. The participants acknowledged that the use of the mobile device was very interesting and motivate them to study essential concepts of the topic and effectively complete learning activities. Particularly, the components of the topic presented in the video were useful and elicit motivation, it helps to represent the ways of how circuit works and how one element of the circuit could affect or be affected by another element at different conditions of the circuit. One of the student perspectives:

> *"The video animation was interactive; it presents how components of the circuit can replace and using circuit's measurement tools to read currents and voltages of the circuit".*

Perhaps watching the interaction between circuit elements was helped students to understand the concepts and relationships between the circuit components.

Challenges

A few students were encountered some challenges could attribute to a lack mobile technologies to performing learning activities employed mobile with SOAR approach. They mentioned that, insufficient time was challenge to effectively perform learning activities.

> *"I spent a lot of time to revise the content, find characteristics of the topic and relate them to develop understanding; I only had enough time to relate three or four objects with their sub-characteristics. I think it would be more interested if I had extra time to add more sub-consequence ideas of concepts for better understanding.*

Thus, they did not successfully perform in developing understanding regarding the topic. This may attribute to students' lack of mobile technology skills (e.g., low performance, pace, etc.) and they had some challenges in the process of mobile SOAR strategy. So it was not surprised they did worse in performing learning activities compared to those who familiar with using mobile devices.

DISCUSSION

Aligned with relevant previous studies, (Igo et al., 2008; Varga & Bauer, 2017, Elsafi, 2021), the findings of factual knowledge test provide evidence to the positive impact of the mobile SOAR learning design on supporting students recall factual knowledge of direct current circuits elements and raising concern about the importance of integrating mobile SOAR into the classroom activities. Specifically in the learning science fields to demonstrate students' ability to gain a higher academic achievement utilized the potentials of mobile devices.

Statistically, the results revealed, there were differences between two groups of students in factual knowledge scores. EG whose members did follow the mobile SOAR approach outperformed their peers in CG. From this result, the participants of EG have learned more facts about the topic compared to CG participants. This result could also demonstrate the capability and the potential of mobile learning in supporting such cognitive skills. The interview has also supported this result, the participants of the EG explained that, it's easier to read the online learning content by mobile devices and organize ideas by taking notes. The result agreed with one particular study of a science course which illustrated that students selected information using laptop computers is more quickly than they can write on papers (Kiewra et al., 2018).

The results also provided evidence into the positive impact of mobile SOAR approach, the EG have leveraged the advantages of mobile SOAR on developing students' conceptual understanding due to the

successful implementation of SOAR approach. To conclude, the mobile SOAR approach was better to develop students' conceptual knowledge about the topic. These findings have confirmed that cognitive competence depends on a deep foundation of the factual knowledge. Another justification for these findings might be the advantages of mobile devices such as quick access to information, easy to read and navigation. This result agreed with other findings reported by Wehenkel et al., (2017), they found that the mobile application was significantly improved students' cognitive skills regarding the acquisition of factual and skill-based knowledge.

In terms of relationship knowledge results, the findings generated from ANOVA analyses have shown significant differences between students' relationships knowledge scores. The EG whose members followed the mobile SOAR learning approach outperformed their peers in CG. This result explained, the implementation of mobile SOAR strategy was important to develop students' relationships knowledge of the topic. The result also has demonstrated the importance of mobile SOAR on how knowledge could organize and establish concept relationships within a person's mind, however, for having a block of meaningful learning and facilitate retrieval of information (Ifenthaler et al., 2009). The qualitative follow up interview results revealed, how mobile SOAR stages affect students' learning. Overall, from the results of three knowledge test items (factual, conceptual and relationships), EG have significantly obtained higher academic achievement scores than CG. This could attribute to the effective integration of the mobile SOAR approach. Designing an appropriate mobile learning style could help students at achieving higher academic results (Stanton & Ophoff, 2013). These findings agreed with other previous research that reported, students applied SOAR to learn materials from multiple online resources obtained higher scores than students who implemented other learning strategies. Such findings could offer insights into the importance of designing mobile learning activities based on the SOAR strategy as well as provide conclusive evidence why achievement test scores of EG were significantly better than scores of CG.

CONCLUSION AND RECOMMANDATION

This study adopted the mobile SOAR learning approach and demonstrated its impact on improving students' factual, conceptual and relationships knowledge of physic topic. The research design used the mixed-method explanatory approach that comprised both quantitative and qualitative methods. The quantitative phase has conducted a quasi-experiment design, to explore the difference in the effectiveness of mobile SOAR versus mobile without SOAR respectively. From the quantitative standpoints evince have been provided from a variety of measurements, to what extent that mobile SOAR has positively influenced students learning outcomes. The qualitative follow up interviews conducted with 6 students selected from EG participants to gain their perspectives about mobile SOAR learning strategy integration.

The interview results offered an interpretation to the students' behavior through the learning process and how it could vary in a way that affects academic achievements. The authors admit that this level of understanding to the nature of mobile SOAR learning among secondary school students for studying online learning materials in regards to the factual, conceptual and relationships knowledge of the physic

subject cannot be reached without conducting the mixed-method approach. This study proves the value of implementing the mobile SOAR learning strategy through the experimental explanatory sequential mixed method. Although using the mobile SOAR strategy to study online learning materials empirically is relatively unexplored. This research along with previous literature (Jairam & Kiewra, 2009; Daher & Kiewra, 2016; Kiewra et al., 2018) helps to empirically explain the contribution of the instructional approach (SOAR) on how it could influence students to study online learning materials. The future mobile SOAR researches have to look at diverse sampling that covers different schools settings and learning environments. It would be more interesting if the mobile SOAR approach could take place in authentic learning environments to comprise both in the field and in classroom activities. This research was done in the capital city of Sudan "Khartoum" while other Sudanese cities have different circumstances such as school environments and the level of technology awareness, therefore, conducting a comparison study perhaps may generate different results. The future studies can emphasize to investigate the mobile SOAR approach in other science topics using a large sample.

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