The Impact of Advance Organizers in Virtual Classrooms on the Development of Integrated Science Process Skills

Abstract

Unlike virtual classrooms that have received extensive research attention in both academic and practical contexts because of their ability to improve students' outcomes, the use of advance organizers are still in need for more research to prove their efficacy in fulfilling expected learning outcomes in these virtual classrooms. Hence, the present study aims to identify the impact of using such organizers in virtual classrooms on the development of students' integrated science process skills. It was applied to 64 students who were studying for their Master's degree in the vocational education techniques in the "Research Project" course. Participants were randomly divided into two equal experimental groups with 32 students in each. An assessment card of five main domains was used to evaluate students' skills in research procedural definition, identification and control of the research variables, questions and/or hypotheses, procedures and experimentation besides research interpretation of the results. Data analysis showed that the use of advance organizers in virtual classes was of great effect on the development of participants' integrated science process skills because skills of students in the first experimental group were better mastered than the skills of their peers in the second experimental group in accordance with the whole subskills in the five domains.

Keywords: Virtual Classrooms; Advance Organizers; Integrative Science; Integrative Science Processes Skills; Covid-19

Introduction

In many nations affected by the COVID-19 pandemic, the situation in higher education institutions has changed [1]. Therefore, students and teachers are recommended to switch to online learning instead of face-to-face classes as usually occurs at various educational institutions [2]. One type of this online learning is the virtual classroom that shares some characteristics with ordinary or traditional classrooms [2, 3] such as flexibility, practicality, and accessibility to learning environments that are not limited by time or place [4, 5]. Najran University in Saudi Arabia, as well as other educational institutions in other countries, could transfer to online learning and conduct virtual classrooms by providing its staff with an educational platform known as 'Blackboard', a system that enabled both students and faculty members to restore the whole content and requirements of any academic course. Synchronous and asynchronous discussions are provided through this system in addition to the ability to conduct the electronic tests and utilize many multimedia files [6]. Moreover, virtual classes are allowed on this Blackboard system as one tool of e-learning.

Virtual classrooms are electronic classrooms that can be expanded in time, space, and content [7, 8]. They offer various learning environments that enable video and audio broadcasts besides discussion boards [9]. They are virtual because they can overcome spatial constraints where learners can attend from different locations without time constraints. One of the main characteristics of virtual classrooms is the fact that virtual sessions can be recorded in advance and then delivered to students who can watch them everywhere at their own pace and time [10, 11]. Another characteristic of

Comment[Author1]: Good opening rationale.

Comment[Author2]: What are you referring to when you say 'it was' - the study or organisers?

Comment[Author3]: This abstract is much clearer than the previous version. I feel like I know what the research is about, how the study was accomplished, and what its outcomes were.

Comment[Author4]: I would say 'have been' because advice on online learning has since been rescinded in many locales.

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Comment[Author5]: I've made a few minor grammatical corrections here and throughout, but generally it's improved on the last reading.

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Comment[Author6]: The use of the term 'expanded' here is a little confusing with reference to time and space, as this makes it sound as though it they are physical rather than virtual.

virtual classrooms is the fact that they are used in the educational process to cancel any geographical barriers where students can enter the class and record the whole session. Moreover, they reduce students' anxiety, increase their motivation, and more importantly improve their communication and collaboration [12, 13].

On other hand, the term 'advance organizers' was first used by Ausubel in the 1960s [12]. They represent the introductory material to be presented to learners before the teaching content [14]. They are used to familiarize students with new concepts and connections between them before beginning integrating new knowledge to their prior information [15, 16]. In brief, advance organizers are used when asking students to recall and combine existing knowledge with new information offered in various learning situations [17]. An advanced organizer is mainly used to activate the learner's prior knowledge to better understand its similarity to new information under study [18]. Furthermore, it is used to stimulate students to practice the learning task by creating meaning for them because its use can clarify the learning objective and provide a context to motivate the learner to learn how to accomplish the task [19]. The use of advance organizers provides learners with commendable advantages that can positively influence students' acquisition of concepts [20] and involves a set of procedures starting with providing previous knowledge, establishing clear links between prior and new knowledge, teaching new vocabulary in the same context, and highlighting key vocabulary [21].

Science process skills, the present study aims to test its improvement through the use of advanced organizers in virtual classrooms, are certain potentials used to enable students to think as scientists and researchers while conducting their research [22-24]. They are of two basic models, i.e. basic skills and skills of integrative science processes Basic skills model includes prediction, measurement, classification, and observation while integrative science processes model involves procedural definition, variables' identification and control, research questions and hypotheses, procedures and experimentation, and lastly interpretation of results [25]. Students' empowerment in these integrated science process skills is very important because they help students easily look for new information, solve problems in different situations, and gain knowledge from practice [26]. Being skillful in such skills, a student can process and build any scientific information and meanwhile understand the nature of the kind of science he is studying [27, 28]. Apart from the various ways and means to access scientific information, advance organizers help students to think scientifically [29-31]. In addition, at Najran University, many academic courses primarily depend on integrated science process skills. One of these courses is the "Research Project" course that assumes that fulfilling students' needs could be through developing these integrated science process skills.

Review of Related Literature

Empirical studies in accordance with the effect of using advance organizers in classrooms, as an approach of providing educational materials to learners, have proved that they increase academic achievement, enhance ability to learn, and lead to better retention of the learnt materials [32-34]. For example, The Babaei, Izadpanah [35] concluded that advance organizers use was effective in improving students' listening comprehension. Van der Meij [14] argued that advance organizers integrated in educational videos were effective in developing students' programming skills. Besides, Nevisi, Hosseinpur [36] revealed an effect of using advance organizers in developing students' ability to write an English abstract. Susan and Oche [37],

Comment[Author7]: A good summary of virtual classrooms and their advantages.

Comment[Author8]: I wouldn't say 'on the other hand' as it sounds as though it contradicts what you've previously said, whereas it is additional to it.

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Comment[Author9]: Good summary of AOs. There is plenty of clear and succinct explanation of necessary background information.

Comment[Author10]: Good setup here as to why it is relevant to study this course at Najran.

Comment[Author11]: When referring to more than two authors, you typically want to say 'Babaei, et al.' unless otherwise specified in the in-house referencing rules. Some will use 'Smith, Jones, Abed, and Chang' in the first instance, and then 'Smith, et al.' after that, so just check the PeerJ's guidance on in-text citations.

Comment[Author12]: I've not altered this here, but it is convention to use present tense when referring to the claims of an academic paper. So it would be 'Smith concludes' or 'Jones argues'. Using past tense is not technically incorrect. I haven't corrected it here, however, as it's consistent throughout and it's really your decision.

revealed an impact of using such organizers in developing students' attitude towards learning biology.

With regard to the effectiveness of other methods and strategies in developing the skills of integrative science processes, many studies were conducted. Sharma [38] for instance, concluded that the seven-stage educational model (7E) was effective in developing the skills of integrative science processes for grade nine students. Harahap, Nasution [39] supported the effect of blended learning approach in fostering learners' science process abilities during plant tissue culture. Moreover, Prayitno, Corebima [40] emphasized the fact that inquiry-based learning was effective in improving 7th graders' science process skills.

In light of these findings, it can be argued that the use of advance organizers developed in the context of virtual classrooms may improve integrated science process skills of students enrolled in "Research Project" course. Therefore, the present study aims to identify the effect of using advance organizers in virtual classrooms on developing students' integrated science process skills, i.e. Procedural definition, research variables define and adjustment, research questions and assignments, procedures and experimentation, and results interpretation. That is, it aims to answer the following main question:

RQ: How effective is using advance organizers in virtual classrooms in developing students' integrated science process skills (i.e. procedural definition, research variables define and adjustment, research questions and assignments, procedures and experimentation, and results interpretation) and in developing these skills as a whole?

Methodology

Research Methods

In the present study, multi-dimensional research and data collection approaches are adopted to evaluate participant students' research plans. In order to allow comparison of evidence from multiple streams in a pragmatic approach to empirical research across groups of respondents, qualitative and quantitative approaches were integrated into this study [41, 42] and mainly to fully answer the main question of the present study. Quantitative approach of data analysis is better used with data that can be examined and quantified for correlations with other sets of data [43]. This approach is considered appropriate for the use of Likert's five-point scale for students' scores on each subskill of the Integrated Scientific Process skills Evaluation Card where scores are used to compare the level of skills of participants in both groups. Similarly, a qualitative approach is used because it can yield more personalized and detailed data regarding experience [43]. It is fit for the content analysis of participants' research plans in both groups.

Data Collection

An assessment card of five domains was designed and used to evaluate students' integrated science process skills, (Appendix A), after reviewing related educational literature and previous studies such as Sharma [38], Elfeky and Elbyaly [44], Hernawati, Amin [45], Juhji and Nuangchalerm [46], Elfeky and Elbyaly [47]. To confirm its reliability, it was offered to a jury of experts and specialists who were faculties at Najran University in the fields of educational technology, curriculum and instruction and psychology. Once they accepted the task, they were requested to express their views with regard to the card's sub-skills or phrases appropriateness to

Comment[Author13]: This is a good overview of the literature and examples of some of its claims. However, I would consider extending it and making clear where more research is needed in relation to your study.

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Comment[Author14]: How are these other methods and strategies related back to this research? Do you test AOs against them? Make it clear why this is relevant to the study's focus. If it isn't, I wouldn't include it in a paper of this length.

Comment[Author15]: Any reason to doubt that they might improve ISPS? If not, why conduct the study? You need to show that there is still work to be done to demonstrate their effectiveness. It might be, for instance, that too little research has been carried out in KSA to assume that AOs will improve ISPS within this context, or perhaps AO research has focused on another area other than ISPS. This will give you a stronger rationale and make the study's contribution more apparent.

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Comment[Author16]: RQ is a little wordy but it works.

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Comment[Author17]: I would just say 'to answer its research question'.

Comment[Author18]: 'A quantitative approach to data analysis...' would be better.

Comment[Author19]: I would add that using both quantitative and qualitative approach - a 'mixed-methods' approach - can be useful for triangulation of results also, strengthening the validity of research findings.

measure each domain that stands for one skill of the integrated science processes. Besides, they were requested to check the phrases' clarity and soundness of their linguistic formulation, and they were asked to add any items or delete inappropriate ones. Thus, the final version of the card consisted of five main domains i.e. procedural definition domain with five subskills or phrases, study variables identification and control domain with five subskills, research questions and hypotheses domain with six subskills, procedures and experimentation domain with six subskills, and interpretation of results domain with four subskills. Likert's five-point scale was used beginning from 1=Very little to 5= Very much for each domain's subskill or phrase. Moreover, Cronbach's Alpha was used to check the card's internal consistency. Stability of the scorecard was verified by applying it to a pilot sample of 30 students who were excluded of the study. Stability coefficient was (0.88) for the card as a whole, indicating that it was fit for the study aims and for evaluating the students' final research plans. Three specialists and impartial faculty members were requested to evaluate each final product of every participant. Once evaluation was done, the three scores of each student were accounted for to work out the average score of each participant.

Comment[Author20]: Use 'additionally' instead.

Comment[Author21]: Is there a table of these domains and subskills available?

Comment[Author22]: Really thorough overview of how your research instruments were developed.

Study Sample

Sixty-four students who were studying for their Master's degree in vocational education techniques participated in the present study. They were all enrolled in a "Research Project" academic course provided by Najran University in Saudi Arabia. They were all male students; their average age was 23 years old with a standard deviation about 2.48. Participant students were divided into two experimental groups, i.e. first and second experimental groups. The first experimental group learnt the course via the use of advance organizers in virtual classrooms while the second experimental group studied the course via virtual classrooms without using any advance organizers.

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Comment[Author23]: Nice to have this overview of the sample. One thing I'd add is how you came by this sample. How were the students identified and sampled (i.e., was it purposive, randomised, etc.)?

Data Analysis

ANOVA was used to evaluate students' homogeneity before the beginning of the experiment, i.e. pre-evaluation stage. At the end of the course, t-test for independent samples were used to compare the means of students' scores in both groups. In addition, thematic analysis was used to identify themes raised across a text and to generate results and findings [43].

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Comment[Author24]: I'm a little confused as to what thematic analysis is applied to here. You mention collecting quantitative data using a Likert scale to generate the study's quantitative data, but what is the nature of the qualitative data and how was it collected? Is it open-ended questionnaire responses, interview data, observational data? How is it used to support or complement the quantitative analysis? Moreover, you need to say slightly more about your process of thematic analysis. Was the coding deductive or inductive, for example? Did you follow a specific approach or model for thematic analysis (e.g., Braun & Clarke)? We need to see much more on this.

Ethical Considerations

The Najran University Deanship of Scientific Research review board approved conducting the present study in its decision No.:444-45-22144-DS. Then all participants were informed about the main objective of the present study during the orientation meeting at the beginning of the course. Furthermore, participants who agreed to take part in the study were requested to submit their written consent electronically via the blackboard system. Moreover, it is worth mentioning that methods used in this investigation followed the guidelines set forth in the Helsinki Declaration.

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Comment[Author25]: Try and keep capitalisation of 'blackboard' consistent throughout.

Pre-Assessment of Participants' Science Integrated Process Skills

At the beginning of the first week of the course (Sunday), each participant was informed via an advertisement on the university's blackboard system to submit a complete research plan for the topic chosen at the end of the weak (Saturday).

Keeping in mind that research plan should involve research procedural definition, variable identification and control, questions and hypotheses, procedures and experimentation, and finally an interpretation of the results. An independent evaluator who was a faculty member at the college of education evaluated the whole research plan, using the developed evaluation card. All scores were collected and processed using ANOVA. Results are presented in table 1.

Table 1.

Results in table (1) show that the differences between the mean scores of students in both experimental groups regarding their integrated science process skills in the pre-application card were not statistically significant ($\alpha \leq 0.05$). In other words, participant students' skills in accordance with the research plan's five main domains were homogeneous. All of them were having equal abilities of integrative science process skills before being exposed to the experiment.

Experimental Processing Teaching Material

Before delivering the course content to students, it was organized into ten lectures to discuss the main research plan domains, i.e. procedural definition, variables identification and control, questions and hypotheses, procedures and experimentation, and interpretation of results. To fully fulfill the main objectives of the present study, many Instructional Design models were reviewed to come up with a set of indicative steps to follow while designing and producing these lectures. In addition, learners' characteristics were accounted for, too. After that, synchronous virtual classes were used to deliver each lecture to students in both experimental groups using the Collaborate Ultra Experience LTI application developed during the emergence of Covid-19 pandemic and integrated within Blackboard e-learning management system by the Deanship of Information Technologies at Najran University. In fact, such an application can be seen as a unique addition to university instructors who use Blackboard system because it enabled them to hold virtual meetings, live lectures, and video conferencing. Besides this, it provided them with a chat room, live audio and video broadcasting, whiteboard, application sharing, synchronous web browsing, and feedback. Thus, students in the first experimental group studied the course content through the use of virtual classrooms using advance organizers, while students in the second experimental group learnt the content via the use of virtual classrooms only without using any advance organizers.

Advance organizers were provided to students in the first experimental group via virtual classrooms at the beginning of each lecture before starting in-detail lesson explanation and discussion via virtual classrooms. Specifically, expository advance organizers were utilized to give students some foundational information to form an idea about each newly introduced topic. Moreover, a more official concept map was used to present some crucial components of every new topic. Thus, new concepts were presented in a clearer picture, their origins, definition, and main characteristics. Fig.1 presents a comparison between both experimental groups in accordance with the use of advance organizers.

Figure 1.

Results

Once the experiment ended by the end of the academic semester, dimensional arithmetic mean scores of participant students in both experimental groups regarding

Comment[Author26]: I'd reword this sentence as it doesn't read quite right. Starting with 'keeping in mind', makes it read as though that you have a further point to make about the research plan.

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Comment[Author27]: I've received these attached tables and figures.

Comment[Author28]: Just to clarify, you're stating that the difference between the groups and within them is not statistically significant, meaning they are comparable. This reads as though you're saying that individual students all have equivalent ISPS, which I presume is not what you're saying.

Comment[Author29]: This may be stated elsewhere, but I'd just restate here how many lectures for each group were undertaken as part of the experiment.

Comment[Author30]: The procedures for the lesson here are pretty clearly set out.

their integrated science process skills, as measured by the developed evaluation card, were extracted, and then modified gain ratio was calculated. T-tests for independent samples were used to compare the modified gain ratios of students in both groups.

Table 2.

Table (2) reveals that the t. value for the difference between the modified gain ratios of participants in both groups regarding the skills of the procedural definition domain was (4.40). It shows that the mean score of students in the first experimental group was (M=13.42), while it was (M=11.02) for peers in the second experimental group. That is, there was a statistically significant difference between participants in both groups regarding their skills in the procedural definition in favor of first experimental group students. This difference ($p = 0.013 < 0.05$) indicates that learners in the first experimental group who studied the course via virtual classes with the use of advance organizers outperformed their peers in the second experimental group who studied the course through virtual classes without the use of advance organizers.

To check the soundness of this result, Eta Square ($\eta 2$) was used to make sure of the effect size of the virtual classes where advance organizers are used in the procedural definition skills of students in the first experimental group. Findings showed that $\eta 2$ calculated significance was (0.361). To put it in different words, there was a significant effect of using advance organizers in virtual classrooms on the development of students' skills in the procedural definition. Additionally, qualitative analysis of the learners' research proposals' content proved that participants in the first group were more worthy in considering criteria for research title's good formulation, writing the main question the research will address, documenting resources and references, and formulating the phenomena and their conditions or terms associated with the result and its causes. In addition, participants in the first group were more worthy in identifying research population in comparison with their peers' ability in the second group.

With regard to participants' skills in variables identification and control domain, table (2) indicates that the t. value for the difference between the modified gain ratios of participants in both groups regarding the skills of variables identification and control domain was (5.948). It shows that the mean score of students in the first experimental group was (M=4.21), while it was (M=11.63) for peers in the second experimental group. That is, there was a statistically significant difference between participants in both groups regarding their skills in variable identification and control in favor of first experimental group students. This difference ($p = 0.021 < 0.05$) indicates that learners in the first experimental group who studied the course via virtual classes with the use of advance organizers outperformed their peers in the second experimental group who studied the course through virtual classes without the use of advance organizers..

To check the validity of this result, Eta Square ($\eta 2$) was used to make sure of the effect size of the virtual classes where advance organizers are used in variables identification and control skills of students in the first experimental group. Findings showed that $\eta 2$ calculated significance was (0.385). To say it differently, there was a significant effect of using advance organizers in virtual classrooms on the development of students' skills in variables identification and control. In addition, qualitative analysis of the learners' research proposals' content proved that participants in the first group were more worthy in identifying persistent, independent and dependent variables, identifying affecting variables, controlling fixed variables, and

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Comment[Author31]: This is a sound conclusion. I don't feel you are overstating it here - it is a significant difference.

Comment[Author32]: This is the first point at which I'm understanding that the qualitative data consisted of learners' research proposals. We need to see much more about this before we can evaluate whether your methods of analysis and conclusions are correct. Instinctively, however, I can't envisage how thematic analysis - which elicits common or emphatic themes from text - could be used to judge the value of a research proposal. I would suggest that the qualitative analysis either needs to be described in far more detail, rethought of in terms of its data and methods, or excluded altogether. As it stands now, the way it is presented detracts from rather than contributes to the quality of the paper.

highlighting conditions for variables' fixing and not fixing; in comparison with their peers' ability in the second group.

Comment[Author33]: Again, thematic analysis doesn't evaluate content, it states what themes researchers talk about. You would need to then set out how you were evaluating learners' work based on these themes. This would be an unusual approach but could work if you were to expand upon and justify these methods.

Results regarding participants' skills in writing the research questions and hypotheses domain table 2 shows that the t. value for the difference between the modified gain ratios of participants in both groups regarding the skills of stating the research questions and hypotheses domain was (6.90). It shows that the mean score of students in the first experimental group was (M=18.02), whereas it was (M=15.16) for peers in the second experimental group. That is, there was a statistically significant difference between participants in both groups regarding their skills in stating the research questions and hypotheses in favor of first experimental group students. This difference ($p = 0.034 < 0.05$) indicates that learners in the first experimental group who studied the course via virtual classes with the use of advance organizers outperformed their peers in the second experimental group who studied the course through virtual classes without the use of advance organizers.

To ascertain this result, Eta Square ($\eta 2$) was used to make sure of the effect size of the virtual classes where advance organizers are used in writing research questions and hypotheses skills of students in the first experimental group. Findings showed that $\eta 2$ calculated significance was (0.379). That is, there was a significant effect of using advance organizers in virtual classrooms on the development of students' skills in stating research questions and hypotheses. Additionally, qualitative analysis of the learners' research proposals' content proved that participants in the first group were more worthy in isolating direct questions from logical ones, deciding the research questions to be answered, formulating probable answers for every question, splitting long or short questions, and writing research alternative and null hypotheses. In addition, participants in the first group were more worthy in recognizing hypotheses that are described quantitatively from those that can be tested descriptively in comparison with their peers' ability in the second group.

With regard to the fourth domain, table 2 indicates that the t. value for the difference between the modified gain ratios of participants in both groups regarding the skills of research procedures and experimentation was (5.40). It shows that the mean score of students in the first experimental group was (M=17.06), whereas it was (M=14.70) for their mates in the second experimental group. In other words, a statistically significant difference was noticed between participants in both groups regarding their skills in research procedures and experimentation in favor of first experimental group students. This difference ($p = 0.046 < 0.05$) indicates that learners in the first experimental group who studied the course via virtual classes with the use of advance organizers outperformed their peers in the second experimental group who studied the course through virtual classes without the use of advance organizers.

To be sure, of this result, Eta Square ($\eta 2$) was used to make sure of the effect size of the virtual classes where advance organizers are used in research procedures and experimentation skills of students in the first experimental group. Findings showed that $\eta 2$ calculated significance was (0.352), which means that there was a significant effect of using advance organizers in virtual classrooms on the development of students' skills in research procedures and experimentation. Besides, qualitative analysis of the learners' research proposals' content proved that participants in the first group were more worthy in identifying proposed experimental design, describing sampling type and technique, concluding results in a short time, and using appropriate equipment; in comparison with their peers' ability in the second group.

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With regard to findings related to the last domain, table 2 shows that t. value for the difference between the modified gain ratios of participants in both groups regarding the skills the interpretation of the research's results was (3.457). It shows that the mean score of students in the first experimental group was (M=11.49), but it was (M=10.09) for their colleagues in the second experimental group. That is, a statistically important difference was found between participants in both groups regarding their skills in research results interpretation in favor of the first experimental group students. This difference ($p = 0.043 < 0.05$) indicates that learners in the first experimental group who studied the course via virtual classes with the use of advance organizers outperformed their peers in the second experimental group who studied the course through virtual classes without the use of advance organizers.

To test the correctness of this result, Eta Square ($\eta 2$) was used to make sure of the effect size of the virtual classes where advance organizers are used in the interpretation of research results skills of students in the first experimental group. Findings showed that $\eta 2$ calculated significance was (0.344), showing that a significant effect of using advance organizers in virtual classrooms on the development of students' skills in research results interpretation was found. In addition, qualitative analysis of the learners' research proposals' content proved that participants in the first group were more worthy in including answer of research in a prior research related to research chosen topic, processing results or data, identifying relevant principles, and laws or theoretical frameworks; in comparison with their peers' ability in the second group.

Comment[Author34]: I would condense both the reporting of the findings and their checking to one paragraph, as the reporting of results is a little long-winded for the depth of content actually contained. I'd cut back a little on word count here if possible and save it for more discussion of results below.

Moreover, finding in table 2 show that t. value for the difference between the skills of participants in both groups related to the evaluation card as a whole was (10.608). The mean score of students' achievement in the first group was (M=74.19), in comparison with their peers' achievement in the second group that was (M=62.59). To say it differently, there was a statistically significant difference between the mastery levels of students' integrative science process skills in both groups as a whole in favor of the first group. The difference that was ($p = 0.036 < 0.05$) shows that skills of students who studied the course content through the use of advance organizers in the virtual classes were developed more than the skills of their mates in the second experimental group who studied the course content via virtual classes but without the use of advance organizers.

Comment[Author35]: An apt conclusion based on an accurate interpretation of the results.

To be certain whether this result is correct or not, ($\eta 2$) was used to determine the effect size of advance organizers in virtual classes in the learners' integrated science process skills as a whole. Findings prove that the calculated significance of ($\eta 2$) for the difference between participants' modified gain ratios in both groups was (0.395). Therefore, it can be argued that utilization of advance organizers in virtual classes have an impact on the development of students' integrated science process skills as a whole.

Discussion

The main aim of the present study was to investigate the effect of using advance organizers in virtual classrooms on the enhancement of the integrative science process skills of students enrolled in "Research Project" course at Najran University. Analysis of data collected via the use of an evaluation card shows that there is a significant effect of these advance organizers use in the development of participants' skills in all tested skills and subskills. These findings corroborate the results concluded by earlier studies regarding the effect of using advance organizers in the achievement of

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different learning outcomes. Among these studies was Birabil [48], which concluded that advance organizers-based teaching strategy could improve learners' academic achievement and retention. Results also support the results by Babaei, Izadpanah [35] that proved the effectiveness of advance organizers in improving students' listening comprehension. They are congruent with the results of Van der Meij [14], which confirmed the effectiveness of advance organizers included in educational videos in developing students' programming skills. moreover, results are in agreement with the findings of Nevisi, Hosseinpur [36] with regard to the effectiveness of advance organizers in developing learners' ability to write an English abstract and Susan and Oche [37] regarding the impact of advance organizers on the development of students' attitude towards biology.

Effectiveness of other methods and strategies in developing learners' integrative science process skills was also verified. Sharma [38], for an example concluded that the use of the seven-stage educational model (7E) was effective in developing the 9th graders' integrative science process skills. Harahap, Nasution [39] also asserted the efficacy of blended learning approach in fostering students' science process abilities during plant tissue culture. furthermore, Prayitno, Corebima [40] confirmed the efficiency of inquiry-based in developing 7th graders' science process skills.

Conclusion and Recommendations

In the present study, advance organizers, through virtual classrooms attached to Blackboard system provided by Najran University were used to teach students the content of an academic course titled "Research Project". Results indicated that advance organizers were of great effect on enhancing the integrative science process skills mainly the research skills of enrolled students. In light of these findings, it can be claimed that advance organizers utilization in virtual classrooms could be advantageous for students and can develop the processes of instruction and research as well. Therefore, institution of higher education are called to train enrolled faculty members on how to use such advance organizers in virtual classrooms using the allowed learning management environments. Besides, faculty members, in their turn, are encouraged to use advance organizers in their virtual classrooms to improve their learners' skills in various subjects. Researchers, for their part, are recommended to investigate the effect of using advance organizers in other educational contexts in developing different educational outcomes.

Comment[Author36]: You need more discussion of findings here to demonstrate critical engagement with your results and those of prior research. Developing your research gap and rationale further will help you find more to say here.

Comment[Author37]: I see now why you included this section above. In what way does this finding corroborate the 7E model? Was the 7E model used to develop your cards in some way? This is unclear.

Comment[Author38]: How does this corroborate those findings when the study is with university students rather than secondary-school students?

Comment[Author39]: This is the first we're mentioning training. It hasn't been established whether that AOs are already a component of teacher-training or CPD, or whether current training in this area is insufficient. It might be better to say that institutions of higher education would benefit from quality teacher-training in this area and that future research ought to establish how sufficient this training in KSA is.

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Comment[Author40]: These are fine recommendations, it may be worth developing them slightly further in the discussion above.

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