DESIGNING INSTRUCTION TO ENHANCE STUDENTS' SELF-DIRECTED LEARNING SKILLS: A CASE OF WHATSAPP INTERACTIVE AND WHATSAPP-SUPPORTED JIGSAW INSTRUCTIONAL MODES

Eucharia Chekwube Ogbonna [1], Chinwe Rose Nwagbo [1], & Christian Sunday Ugwuanyi [2]

[1]Department of Science Education, University of Nigeria Nsukka
[2]Department of Education Foundation, Faculty of Education, University of the Free State, Bloemfontein, South Africa

Abstract

The study investigated the effects of WhatsApp interactive and WhatsApp-supported Jigsaw instructional modes on students' self- directed learning skills. A quasi-experimental research design was used using non-equivalent comparison groups for pre- and post-testing. Four hundred twenty-nine (429) year III Biology students from Federal Colleges of Education in South-east Nigeria made up the study's population. 106 individuals were chosen using a multi-stage sample approach that combined random and purposeful sampling procedures. Data were gathered using the Personal Responsibility Orientation self-directed learning skill scale, or PRO-SDLSS. The mean and standard deviation were used to answer the study's questions, and analysis of covariance (ANCOVA) was used to evaluate the hypotheses at the 0.05 level of significance. The study's findings demonstrated that the instructional Jigsaw modes for both interactive WhatsApp and Jigsaw supported by WhatsApp improved students' scores in the area of self-directed learning. Gender had no significant impact on students' self-directed learning abilities ($p > .05$) $F (1, 101) = 0.067$, p = 0.796. $F (1, 101) = 0.928$, $p = 0.338$ indicates a significant interaction between gender and therapy on students' abilities to study on their own. Based on their findings, the researchers suggested that teachers use WhatsApp for digital intervention to improve their students' abilities to learn independently.

Keywords: Self-Directed Learning Skills, Instructional Modes, WhatsApp-Interactive, WhatsApp-Supported Jigsaw.

Introduction

Twenty-first century skills are becoming progressively indispensable for favourable competition and survival in today's world. These 21st century skills are categorized into three, namely, the learning skills, literacy skills, and life skills (Fadel, 2018). Both the literacy skills and the life skills are hinged on the learning skill, which is needed by all students to survive in a technologically driven world. Appropriate science teaching is needed to impart the learning skills that would enable learners to think critically, objectively and get actively involved in their own learning (Nwagbo, 2022). According to Javed, Athar and Saboor (2019), The 21st century skills include learning and regeneration

skills, learning to learn, managing metacognition, lifelong learning and self-directed learning skills. Self-directed learning skill is the basis for lifelong learning and include the ability of learning to learn (Karatas, Senturk & Teke, 2021). Self-directed learning skill enables learners to develop awareness of their own learning needs and take flexible responsibility to achieve them. Brockett and Hiemistra (2012) identified three components of self-directed learning namely person, process and context. The "person" component refers to the attributes and skills of the individual such as inventiveness, zeal, flexibility etc.; the process component refers to the teaching and learning operating systems while the context refers to the socio-cultural and socio-political settings and orientations.

There is need to enhance students' self-directed learning because self-directed learning skill is important in promoting students' achievement and self- confidence. Kana'n and Osman (2015) reported a positive relationship between self-directed learning skill and science achievement among Qatar students. It also prepares students for lifelong learning. According Karatas, Senturk and Teke (2021) developing skills for self- directed learning is important because knowledge and experiences learned in schools are not enough for the future life of the learners. Self-directed and lifelong learning skill is important for continuous learning in order to remain up to date with trends of information and research in one's field. Self-directed learning skill prepares students for the unpredictable world of work; when the desirable job is not available, a self-directed graduate tends to fit into the available job once the initial training is given. This is the essence of advocating for 21st century skills in Science, Technology, Engineering, and Mathematics (STEM) Education.

Self-directed learning is one of the significant targets of higher education (Nasim & Tahere, 2017). Schools' learning activities must promote the acquisition of self – directed learning skills so that it may support students to prosper in their current and upcoming learning (Kana'n & Osman, 2015). Previous research in the Nigerian context reported that College of Education students had low level of SDL particularly on the self-control sub-scale (Nwagu, Enebechi & Odo, 2018). This demands that instructional methods in Colleges of Education be modified to provide favorable circumstances for acquisition of SDL.

Introducing learner-centered instruction and connecting technology into learning may be beneficial in enhancing students' SDL. Guglielgmino (2013) noted that chances for advancement of self- directed learning exist along a continuum in different instructional methods and advocated that teachers use techniques for developing SDL skills in schools. Akgunduz and Akinoglu (2016) reported that social media tools like Facebook, you-tube, slide-share, daily motion and flicker had positive impact on students' self-directed learning. There is limited knowledge on the effect of WhatsApp on students' SDL. WhatsApp is an easy-to-use application that operates in most smart phones. It is popularly used by undergraduate students to send multimedia messages like pictures,

videos, audios along with simple text messages (Lenhart, Madden, Macgill & Smith, 2007). The popularity, accessibility, efficiency, and relative cost advantages of WhatsApp as a common means of interaction amongst students motivated researchers to design WhatsApp-supported jigsaw and WhatsApp interactive instructional modes to enhance students' self- directed learning skills.

WhatsApp interactive instruction is a form of blended learning in which WhatsApp group platform is used as a mobile response system to improve interactivity in a conventional lecture instruction. The approach creates opportunity for interactions between the students and the lecturer and amongst students. WhatsApp-supported jigsaw instruction on the other hand is also a form of blended learning which merges the innovation provided by social media networking and the traditional smaller group activities provided by jigsaw technique. Jigsaw technique is a learning strategy in which learners are members of two groups (about 4-5 students per group) and they work together in these groups to achieve their learning goals.

The general purpose of this study was to compare the effect of WhatsApp- supported jigsaw and WhatsApp interactive instructions on students' self- directed learning skills. Specifically, the study examined the:

i. mean self-directed learning skill scores of students exposed to WhatsApp-supported Jigsaw and those exposed to WhatsApp interactive modes of instruction

ii. influence of gender on the mean self-directed learning skill scores of students

iii. interaction effect of WhatsApp-aided instructional modes and gender on Biology students' self-directed learning skill

Research Questions:

The study was guided by three research questions as follows:

1. What are the mean self-directed learning skill scores of Biology students exposed to WhatsApp-supported Jigsaw and those exposed to WhatsApp interactive modes of instruction?

2. What is the influence of gender on the mean self-directed learning skill scores of Biology students?

3. What is the interaction effect of WhatsApp-aided instructional modes and gender on Biology students' self-directed learning skill score?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance

Ho₁: There is no significant difference in the mean self-directed learning skill scores of Biology students exposed to WhatsApp-supported Jigsaw and those exposed to WhatsApp interactive modes of instruction

Ho₂: There is no significant influence of gender on the mean self-directed learning skill scores of Biology students.

Ho₃: There is no significant interaction effect of WhatsApp-aided instructional modes and gender on Biology students' self-directed learning skill scores.

Theoretical Framework

Activity theory proposed by Engestrom (1987) provides a useful framework for analyzing self-directed learning skills of students in the online milieu of WhatsApp-aided instructional approaches. Activity theory posits that activity and learning are interactive and interdependent; and that human actions have both cultural and technical facets (Engestrom, 1987; Jonnassen, 2002; Bertelson & Bodker, 2003). Barhoumi (2015) identified six levels of activity theory; objective level, individual level, community level, technological level, hierarchical structure of activity level and regulatory level.

The relatedness of the principles of activity theory and the instructional features of WhatsApp-aided instructional approaches are obvious. At the objective level, the instructional goals have social and cultural properties in the system. The teacher needs to consider these properties while setting the instructional objectives and all through the course of planning and implementation of instruction. In the WhatsApp-supported jigsaw for instance, the teacher considers the cultural and social properties of each learner when grouping students to different jigsaw home groups. The groups at the end become heterogeneous mixing individuals of different gender, reasoning styles, races, tribes etc.

The individual level of activity theory views learners as key players participating actively in knowledge creation. Self-directed learning skills cannot be developed if learners do not participate. The two modes of WhatsApp-aided instructions give learners opportunity for active participation. In WhatsApp-supported Jigsaw technique, each home group member has a particular subtopic to research on, develop and present to the members of his or her jigsaw home group members both in face to face and in online via WhatsApp forum. In WhatsApp interactive instruction, the teacher presents questions to students via WhatsApp group platform after the conventional lecture. This gives each individual opportunity for participation because students' responses provide the basis for the succeeding lectures. Students can access and share additional instructional media. The WhatsApp group forum also provides opportunity for social interactions in an online setting.

The social world created by WhatsApp-aided instructional approaches transform learners from passive recipients of learning contents to community of learners actively involved in creation and transmission of knowledge. This aligns with the community level of activity theory and is in consonance with the social constructivists' perspectives.

Methodology

Design of the study

The study adopted quasi-experimental research design. Specifically, pretest, posttest non-equivalent comparison groups design. In similar studies, Adonu et al (2021), Adene et al (2021), Ejimonye, Onuoha et al. (2020), Ejimonye et al. (2020), Njoku et al. (2020), Offordile et al. (2021) have adopted this design. The area of study was South-East Nigeria which is made up of 5 out of the 36 States in Nigeria. The five states are Abia, Anambra, Ebonyi, Enugu, and Imo.

Population and sample

The population for this study comprised 429-year III Biology students in Federal Colleges of Education in South-east Nigeria. The population composition by gender was 34 males and 395 females. The sample for this study was 106-year III Biology student-teachers in South-east Nigerian Government-owned Colleges of Education. The sample composition by gender was 14 males and 92 females. The multi- stage sampling procedure involving random and purposive sampling techniques was used to constitute the sample.

In the first phase, two States (Enugu and Imo) were randomly drawn from the five States in the South-East zone. This was done using simple random sampling (without replacement). Secondly, one Federal College of Education was selected from each of the two States drawn using purposive sampling. Intact class of year III Biology students from one of the schools was allocated to WhatsApp- supported jigsaw group A, while that of the second school was allocated WhatsApp interactive group B. Only students who fulfilled the inclusion criteria such as ownership of WhatsApp- enabled phones, and willingness to participate, were used for the study. Students that possess basic mobile phone (no facility for WiFi or internet access) and those with smartphones but are unwilling to participate were excluded from the study.

Measure

The Personal Responsibility Orientation- Self Directed Learning Scale (PRO-SDLS) adopted from Stockdale and Brockett (2010) was used for data collection. The instrument consists of twenty –five (25) items that measure four factors namely control of one's own learning, initiative for learning with or without the help of others, self –efficacy

and motivation. The instrument has fourteen (14) positive items and eleven (11) negative items. The items are structured on a five -point scale of strongly disagree, disagree, sometimes, agree, and strongly agree with score values of 1,2,3,4,5 respectively for positively worded items and the reversed 5,4,3,2,1, respectively for negatively worded items. According to Stockdale and Brockett (2010), total scores from items 2,9,10,15,17,25 is a measure of learners' initiative; total scores from items 4, 5, 6,13,19,23 is a measure of learners' control; total scores from items 1,7,12,21,22,24 is a measure of learners' self-efficacy while total scores from items 3, 8,11,14,16,18,20 is a measure learners' motivation components of self-directed learning skills (see appendix A, p.16) Scoring protocol for the PRO-SDLS by Stockdale and Brockett 2010. The researchers chose the PRO-SDLS because the instrument was developed particularly for use in higher education to assess level of students' self-directed learning capability (Beard, 2016). The instrument has a high internal consistency estimate of 0.92.

The instructional guides used in this study were WhatsApp-supported Jigsaw Lesson Plans and WhatsApp Interactive Lesson Plans. The lesson plans covered both the contents and duration for both WhatsApp-supported jigsaw and WhatsApp interactive instructional modes. However, the lesson plans for both instructional modes varied in organization and pedagogy. In WhatsApp-supported jigsaw instruction, the teacher divided the students into groups (WhatsApp groups and physical groups), and divided the lesson topic into sub-topics. The sub-topics are assigned to each student in the 'home' groups. Students work in small 'expert' groups (4-6 students per group) to discuss the assigned sub-topics before re-converging to 'home' groups made up members of different 'expert' groups. These groups interact in both blended learning activities (in-class and online through WhatsApp). The teacher floats from group to group to supervise students' activities. The students later presented their findings group by group to the entire class where the teacher harmonized the works of various groups. In WhatsApp interactive instructional mode, there was online interaction involving the whole class and the teacher, in addition to the conventional lecture. Additional instructional materials such as instructional videos, audios, pictures as well as questions and comments were shared and these helped in better understanding and preparation for subsequent lectures.

Experimental Procedure

A five-day training program was organized by the researchers for the research assistants. They were trained on how to teach Ecology using WhatsApp-supported jigsaw and WhatsApp interactive instructional modes with the aim of enabling students to gain mastery of the content and also enhance students self-directed learning skills.

The procedures involved in implementing WhatsApp-supported jigsaw and WhatsApp interactive instructions were highlighted. The contents and organization of the lesson packages for each instructional mode based on the prepared lesson plans were

extensively discussed. The research assistants were advised to adhere to the contents of the lesson plans during treatment sessions.

Prior to treatments, students were pre-tested to obtain their initial self-directed learning skill levels. This was done by administering pre-PRO-SDLS. The pre-test scores were recorded for each group (WhatsApp-supported jigsaw group A and WhatsApp interactive group B). The students were then exposed to treatments after which the post-PRO-SDLS was administered to both groups. The pre-PRO-SDLS and post-PRO-SDLS had the same contents except that the items were re-shuffled. Pre-tests scores and post test scores were collated and subjected to data analysis.

Data analysis

Mean and standard deviation were used to answer the research questions, while analysis of covariance (ANCOVA) was used to test the hypotheses.

Results

Table 1: Mean analysis of the self-directed learning skills scores of students exposed to WhatsApp-supported jigsaw and those exposed to WhatsApp interactive modes of instruction

		Pre-SDLS		Post-SDLS		Mean gain
Treatment	n	Mean	SD	Mean	SD	
WhatsApp-supported jigsaw	50	87.46	14.89	91.56	14.91	4.10
WhatsApp interactive	56	87.28	10.94	88.67	11.16	1.39

The students who participated in the WhatsApp-supported jigsaw mode of instruction had pre-self-directed learning skills (SDLS) mean scores of 87.46 and 14.89, respectively, and post-self-directed learning skills (SDLS) mean scores of 91.56 and 14.91, respectively, while the students who participated in the WhatsApp interactive mode of instruction had pre-self-directed learning skills (SDLS) mean scores of 87.28 and 14.91, respectively. Besides, the mean gain scores of 4.10 and 1.39 for the students exposed to WhatsApp-supported jigsaw and those exposed to WhatsApp interactive modes of instruction respectively, indicate that the students exposed to WhatsApp-supported jigsaw mode of instruction had higher SDLS mean score than their counterpart exposed to WhatsApp interactive mode of instruction. However, the post standard deviations of 14.91 and 11.16 for the two groups respectively imply that the students exposed to WhatsApp-supported jigsaw mode of instruction had higher variation in their individual SDLS scores than those exposed to WhatsApp interactive.

Table 2: Analysis of covariance of the effect of WhatsApp-supported jigsaw and those exposed to WhatsApp interactive modes of instruction on students' mean self-directed learning skills scores

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared (η^2)
Corrected Model	16781.513ᵃ	4	4195.378	354.192	.000	.933
Intercept	25.536	1	25.536	2.156	.145	.021
PreSDLS	16503.263	1	16503.263	1393.278	.000	.932
Treatment	3.058	1	3.058	.258	.612	.003
Error	1196.336	101	11.845			
Total	877298.000	106				
Corrected Total	17977.849	105				

a. R Squared = .933 (Adjusted R Squared = .931)

According to Table 2 data, there is no statistically significant difference between the mean self-directed learning skills scores of Biology students exposed to WhatsApp interactive modes of instruction and those exposed to WhatsApp-supported jigsaw, $F_{(1, 101)}$ = 0.258, p = 0.612, and 2 =.003. The associated probability value of 0.612 is higher than the 0.05 level of significance, so the null hypothesis was not disproved. According to the effect size of 0.003, exposure to the WhatsApp-supported jigsaw and WhatsApp interactive forms of instruction only accounts for a 0.3 percent variation in the students' self-directed learning abilities.

Table 3: Mean analysis of the Self-directed Learning skills scores of male and female prospective Biology teachers

		Pre-SDLS		Post-SDLS		Mean gain
Gender	N	Mean	SD	Mean	SD	
Male	14	87.28	13.28	88.42	13.52	1.14
Female	92	89.01	13.00	90.28	13.07	1.27

Male students had pre-self-directed learning skills mean scores of 87.28 and 88.42 and post-self-directed learning skills mean scores of 90.28 and 13.07, according to Table 3 data, while female students had pre-self-directed learning skills mean scores of 89.01 and 89.01 and post-self-directed learning skills mean scores of 90.28 and 13.07, respectively. The male and female students' respective mean gain scores of 1.14 and 1.27 show that the female students had a higher SDLS mean score than their male counterparts. Besides, the post standard deviations of 13.52 and 13.07 for the male and female respectively imply that the male students had higher variation in their individual SDLS scores than the female students.

Table 4: Analysis of covariance of the effect of WhatsApp-supported jigsaw and those exposed to WhatsApp interactive modes of instruction on students' mean self-directed learning skills scores

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared (η^2)
Corrected Model	16781.513ᵃ	4	4195.378	354.192	.000	.933
Intercept	25.536	1	25.536	2.156	.145	.021
PreSDLS	16503.263	1	16503.263	1393.278	.000	.932
Treatment	3.058	1	3.058	.258	.612	.003
Gender	.799	1	.799	.067	.796	.001
Treatment * Gender	10.990	1	10.990	.928	.338	.009
Error	1196.336	101	11.845			
Total	877298.000	106				
Corrected Total	17977.849	105				

a. R Squared = .933 (Adjusted R Squared = .931)

Table 4 revealed that there is no significant difference ($p>$ .05) in the mean self-directed learning skills scores of male and female prospective Biology teachers, $F_{(1, 101)} = 0.067$, $p = 0.796$. Since the associated probability value of 0.796 is greater than the 0.05 level of significance, the null hypothesis was not rejected.

Table 5: Mean analysis of the post-self-directed learning skills scores of male and female prospective Biology teachers exposed to WhatsApp-supported jigsaw and those exposed to WhatsApp interactive modes of instruction

Treatment	Gender	n	Mean	SD
WhatsApp-supported jigsaw	Male	8	89.87	15.78
	Female	42	91.88	14.91
WhatsApp interactive	Male	6	86.50	10.89
	Female	50	88.94	11.28

Table 5 showed that male students exposed to WhatsApp-supported jigsaw mode of instruction had post-self-directed learning skills mean score of 89.87 with standard deviation value of 15.78, while the male students exposed to WhatsApp interactive mode of instruction had post-self-directed learning skills mean score of 86.50 with standard deviation value of 10.89. On the other hand, female students exposed to WhatsApp-supported jigsaw mode of instruction had post-self-directed learning skills mean score of 91.88 with standard deviation value of 14.91, while the female students exposed to WhatsApp interactive mode of instruction had post-self-directed learning skills mean score of 88.94 with standard deviation value of 11.28. This result indicates that both male and female students exposed to WhatsApp-supported jigsaw mode of instruction had higher mean self-directed learning skills scores than the male and female students exposed to WhatsApp interactive mode of instruction.

Hypothesis three of no significant interaction effect of gender and WhatsApp-aided instructional modes on students' self-directed learning skill was tested using data in Table 4.

Table 4 revealed that there is a significant interaction effect of treatments and gender on Biology students' self-directed learning skills, F (1, 101) = 0.928, p = 0.338. This is for the fact that the associated probability value of 0.338 is less than the 0.05 level of significance. Thus, the null hypothesis was rejected and there is a significant interaction effect of treatments and gender on Biology students' self-directed learning skills.
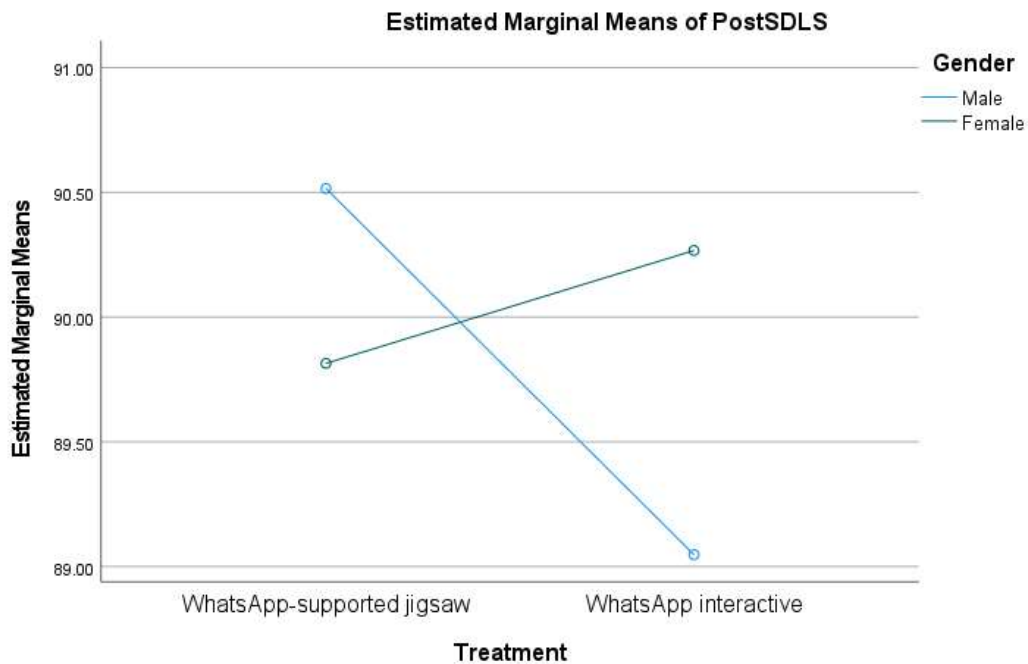
Figure 3: Profile plot showing interaction effect of treatments and gender on students' self directed learning skills

Figure 1 suggests a cross over or disordinal interaction effect of WhatsApp-aided instructional modes and gender on students' self -directed learning skills. Female students exposed to WhatsApp-supported jigsaw instructional modes had higher self-directed learning skills than both male and female students exposed to WhatsApp interactive modes of instruction.

Discussion

The two modes of WhatsApp- aided instructions facilitated students' self-directed learning skills. This may be due to the instructional features of WhatsApp interactive and WhatsApp-supported Jigsaw instructional modes to which students were exposed to. This

finding is in agreement with the opinion of Gugliemino (2013) that learning approaches which give learners responsibility and have them work in teams of small groups could enhance students' self-directed learning. When learners assume responsibility to pursue set goals during the learning process, they equally develop self-direction in learning. Students exposed to WhatsApp –supported jigsaw and WhatsApp interactive instructional modes had increased opportunity to access various forms of learning resources like videos, pictures. texts, audio etc. These boost students' motivation, an important factor of self-direction in learning. The social environment of WhatsApp also provided an enhanced opportunity to process and exchange information conveniently and this may have contributed to students' improved self-directed learning skills.

The findings also revealed that students exposed to WhatsApp-supported Jigsaw had slightly higher self-directed learning skill scores than students exposed to WhatsApp-interactive instruction, though not statistically significant. The higher mean gain may be due to the fact that students exposed to WhatsApp- supported Jigsaw mode assumed more learning responsibility and compulsorily worked more in small groups.

The findings of the study also showed that female students had slightly higher self-directed learning skill mean score than their male counterpart but the difference is not statistically significant. sThe findings of this study disagree with the finding of Nwagu Enebechi and Odo (2018) that there is significant gender difference in students' self-directed learning in favour of males. The finding of this study also disagrees with the finding of Tekkol and Demirel (2018) that there is significant gender difference in students self-directed learning skills in favour of females. The contradiction between the finding of this study and those of previous researchers (Nwagu et al., 2018; Tekkol & Demmirel, 2018) could be as a result of WhatsApp-aided instructional modes to which students were exposed to in the present study. The instructional features of WhatsApp-aided instructional modes kept both male and female students engaged. In WhatsApp-supported jigsaw instructional mode for instance, each student is responsible for preparing a particular sub-topic which is presented to the home groups. This goal is achieved through students' collaborative work in different expert groups. These arrangements may be responsible for countering any existing gender differences in learning outcome.

The result of the test of interaction of gender and WhatsApp-aided instructional modes revealed a disordinal or crossover interaction effect of WhatsApp-aided instructional modes and gender on students' self-directed learning skills. Female students exposed to WhatsApp-supported jigsaw instructional modes had higher self-directed learning skills than both male and female students exposed to WhatsApp interactive modes of instruction. This implies that although the two modes enhanced the self –directed learning skills of male and female students, there was a real interaction effect of treatments and gender. WhatsApp-supported jigsaw instructional mode facilitated the self-directed

learning skills more in females than in the male students. The virtual social environment created by WhatsApp learning platform may have provided an elaborate space for collaboration and increased participation for both male and female students thereby improving their self-directed learning skills.

Recommendation

Based on the findings of the study, the researchers recommend that teacher educators utilize digital interventions through WhatsApp to enhance prospective Biology teachers' self- directed learning skills thereby boosting their level of 21st century skills.

References

Adene, F.M., Umeano, E.C., Adimora, D.E., Ugwuanyi, C.S., Okeke, C.I.O., Offordile, E.E., Amaeze, F.E., Uzodinma, U.E., Abdullahi, Y., Ejiofor, J.N. & Ishiwu, E.N. (2021). Effectiveness of Peer Collaborative Learning Strategy on Self-Esteem of Pupils with Behaviour Problems in Nsukka Education Authority. *Journal of Critical Reviews, 8*(1), 1055-1069. http://www.jcreview.com/fulltext/197-1615692041.pdf?1615708380

Adonu, C.J., Nwagbo, C.R., Ugwuanyi, C.S., & Okeke, C.I.O. (2021). Improving Students' Achievement and Retention in Biology using Flipped Classroom and Powerpoint Instructional Approaches: Implication for Physics Teaching. *International Journal of Psychosocial Rehabilitation*, 25(2), 234-247

Akgundus, D., & Akinoglu, O. (2016). The effect of blended learning on the student attitude and self-directed learning skills in science Education. *Turkish Online Journal of Educational Technology, 15*(2), 106-115.

Barhoumi, C. (2015). The effectiveness of WhatsApp mobile learning activities guided by activity theory on students' knowledge management. *Contemporary Educational Technology,6 (3),* 221-238.

Beard, J. L. (2016). *Self- directed learning: A potential predictor of technology integration confidence among preservice teachers.* (Ph.D dissertation) University of Tennesse.

Bertelson, O. W. & Bodker, S. (2003). *Activity Theory*. In J. M Carroll (Ed.), HCI model theories and frameworks: Towards a multidisciplinary science (pp. 291-324). San Francisco, CA: Morgan Kaufmann

Brockett, R. G. & Hiemstra, R. (2012). *Reforming the meaning of self-directed learning: an updated model,* Presentation made at 52nd annual adult education research conference, Toronto Ontario Canada.

Ejimonye, J.C., Onuoha, J.C., Ugwuanyi, C.S., Eneogu, N.D., Ugwuanyi, B.E & Ogbuehu, S.N (2020a). Effectiveness of Two-Dimensional Animation Technique in Enhancing Students' Motivation in Quantitative Economics Concepts. *International*

Journal of Future Generation Communication and Networking (IJFGCN), *13*(1):27-38.

Ejimonye, J.C., Ugwuanyi, C.S., Okeke, C.I.O., & Nwoye, M.N. (2020b). Two-Dimensional Animation and Students' Achievement in Mathematical Economics: Implications for Science Teaching. *International Journal of Engineering Research and Technology, 13*(6), 1220-1230

Engestrom, Y. (1987). *Learning by expanding: An Activity theoretical approach to developmental research*. Helsinki, Finland: Orienta-Konsultit OY.

Fadel, C. (2018). 21st Century Skills: how you can prepare students for the new global economy? Partnership for 2st century skills. Retrieved from https://www.p21.org

Guglielmino, L.M. (2013). The Case of Promoting Self-Directed Learning in Formal Educational Institutions. *SA-eDUC Journal,10*(2), 1-18.

Javed, M.S., Athar, M. R. & Saboor, A. (2019). Development of a twenty-first century skills scale for agri varsities. *Cogent Business and Management, 6,* 1-23.

Jonasen, D. H. (2002). Learning as activity. *Educational Technology 42*, 45-51

Kan'an, A., & Osman, K. (2015). The Relationship between Self-directed Learning skills and Science Achievement among Qatari Students. *Creative Education 6*,790-797.

Karatas, K., Senturk, C. & Teke, A. (2021). The Mediating Role of Self-directed Learning Readiness in the Relationship between Teaching Conceptions and Lifelong Learning Tendencies. *Australian Journal of Teacher Education, 46 (6)*, 54-77.

Lenhart, A., Madden, M., Macgill, A., & Smith, A. (2007). Teens and social media. New York Press

Nasim, S. & Tahere, E. (2017). Relationship between self-directed learning readiness and academic self-efficacy and achievement motivation in students. *International educational studies 10(1)*, 225-232.

Njoku, M.I.A., Nwagbo, C.R., & Ugwuanyi, C.S. (2020). Effect of Peer Tutoring and Peer-Led Team Learning on Students' Achievement in Biology. *International Journal of Database Theory and Application (IJDTA)*, *13*(1),1-10. https://doi.org/10.33832/ijdta.2020.13.1.01.

Nwagbo C. R. (2022). Teaching or cheating in science education practices: The 21st century experience. 174th Inaugural Lecture, University of Nigeria, Nsukka.

Nwagu, E. N; Enebechi, J.C. & Odo, A. N (2018). Self-control in learning for healthy living among students in a Nigerian College of Education. SAGE open Research paper. Doi:10.1177/2158244018793679.

Offordile, E.E., Umeano, E.C., Adene, F.M., Obi, M.C., Ugwuanyi, C.S., Okeke, C.I.O., Adimora, D.E. (2021). Improving the academic achievement of low achieving

secondary school students in physics using peer tutoring learning strategy: Implications for Engineering Career. *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)*, 11(3), 201–212

Stockdale, S. L., & Brockett, R. G. (2010). Development of the PRO-SDLS: A measure of self-direction in learning based on the Personal Responsibility Orientation Model. *Adult Education Quarterly. 61*, 161-180. Doi: 1177/0741713610380447.

Tekkol, I. A. & Demirel, M. (2018). An investigation of Self- directed learning skills of undergraduate students. *Frontiers in Psychology*. DOI:10.3389/fpsyg.2018.02324