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Learning Sciences with Technology: The Use of Padlet Pedagogical Tool to Improve High School Learners' Attainment in Integrated Sciences

Sakyiwaa Boateng*
Walter Sisulu University, Mthatha, South Africa

Mercy Nyamekye
University of Education of Winneba, Winneba, Ghana

Abstract. This study sought to examine the integration and application of an online collaborative instructional technological tool, known as Padlet, to reinforce and strengthen Ghanaian high school learners' understanding of Integrated Sciences (IS). The study utilised a sequential mixed-methods exploratory design to collect qualitative and quantitative data. The study used purposeful sampling to select four high schools to participate in the study. Twenty science teachers and 100 high school learners were sampled for the study. The sampled teachers were trained in a professional learning community on the utilisation and integration of Padlet in classroom instructions and integrated the tool in their classroom instructional practices for one month. Data collection was carried out through classroom observations, semi-structured interviews, and learner task performance assessments. Quantitative data were analysed descriptively to determine the relationships between the variables using the Statistical Package for the Social Sciences' (SPSS) mean, frequencies, t-test, and ANOVA. The qualitative data were analysed using thematic content analysis. The findings show increased learner engagement and retention, which improved learner achievement in the subject. Therefore, it is recommended that effective pedagogical courses should be included in the training of science teachers on technology integration to facilitate learner understanding and retention in the subject.

Keywords: Integrated Sciences; online collaborative learning; Padlet tool; pedagogical tool; science learners; science teachers

1. Introduction

Integrated Science (IS) is a compulsory subject in the Ghanaian Education system that is offered to all senior high school learners across all grade levels from Senior

* Corresponding author: Sakyiwaa Boateng, sboateng@wsu.ac.za

High School (SHS) 1 through to Senior High School (SHS) 3 (which is comparable to grades 10 to 12 in most global education systems). This subject combines Physics, Chemistry, Biology and Agricultural Sciences. However, it has been found that SHS learners have been achieving poor grades and have been struggling to understand basic concepts in Integrated Science, especially abstract concepts on energy and forces, interactions in nature, and basic chemistry concepts (Anamuah-Mensah et al., 2017; Quansah et al., 2019). The situation became more disturbing in 2018 and 2019 when the West Africa Examinations Council (WAEC, 2020) recorded a high number of failures in Integrated Sciences and the other elective science subjects. As most Integrated Science teachers use the traditional approach of instruction, a significant number of these teachers do not integrate or use pedagogical technological tools for the teaching and learning of Integrated Science in Ghanaian classrooms. Similarly, high school learners in Ghana do not get the opportunity to use interactive technological tools when learning Integrated Science therefore they often find it difficult to understand basic scientific concepts and are reluctant to study the subject (Azure, 2015).

Evidence from research has shown that science learners who achieve high scores in science and pursue further studies in the science fields are more likely to complete their degrees and find good jobs on completion (Organisation for Economic Co-operation and Development [OECD], 2016). Studies by the World Bank have also shown that countries that produce more science-oriented individuals are more competitive which leads to more significant development and labour output (World Bank, 2016). Therefore, the Chief Examiner of the West African Secondary School Certificate Examinations (WASSCE) (WAEC, 2019) recommends that teachers conduct practical and activity-oriented lessons in sciences and improve their instructional practices using technological tools. This means that all stakeholders in education, including teachers, must ensure that learners understand scientific concepts by using effective instructional practices, incorporating simple digital web-based technologies and frequent formative assessments that can engage learners with the learning process.

The use of effective instructional practices is one of the most substantial factors involved in the process of learning (Han, 2021). In a school where science is taught, alternative instructional delivery practices are required since the primary goal of science education is to assist learners to achieve a functional understanding of scientific concepts linked to real-life situations, attitudes, and values necessary for their daily life encounters (Johnson et al., 2013). Bondie et al. (2019) mention that learners who experience effective instructional practices from their teachers are more likely to attain higher test scores and academic achievements.

Most learners who study science at the SHSs are not exposed to virtual platforms and creative and innovative pedagogies. This prevents learners from developing basic, integrated, and manipulative skills in the science process. In order for teachers to utilise effective instructions in their classrooms, they need to know their learners through assessments that inform them about their students' progress (Gezer et al., 2021). This can be achieved through classroom assessment techniques, which embed assessment within the instructional process and inform teachers about students' understanding and misconceptions (Veldhuis & Van den

Heuvel-Panhuizen, 2019). Lee et al. (2020) show that formative assessments provide teachers with evidence-based proof that can support learners to reach their planned learning goals. Black and Wiliam (2018) present three procedures to reflect on formative assessments: where the learners currently are in their learning, where the learners should be in their learning, and what must be done to help them to get there. The teacher gathers data on learner understanding, analyses and interprets the data, and adjusts instruction accordingly. However, despite the body of research regarding the benefits of formative assessment on learning outcomes and achievement, information about the manner and efficacy of teacher use of the Padlet tool is very limited.

Integration of Web 2.0 tools, such as Padlet and other technological tools, and their impact on science education have been documented in many empirical studies (Firat & Köksal, 2019; Gursoy & Goksun, 2019; Onbasili, 2020). Many of these studies have integrated Web 2.0 pedagogical tools into their classroom instructions and have shown significant evidence of increased retention and academic achievement among learners (Udosen, 2020). Hence, the need for the government to support teachers to incorporate Web 2.0 into their classroom instructions by ensuring that science teachers' instructions provide the basis for learner support and engagement (Baidoo et al., 2022) and utilise technological tools that are aligned with learners' needs, their prior experiences and their technological competencies.

Although there have been numerous studies on Web 2.0 as a pedagogical tool in the classroom for science teaching, learning and assessment (Hursen, 2020; Nyawanza, 2017), there have been limited empirical studies on the types of classroom dynamics that drive pedagogy in Integrated Science teaching and assessment where science teachers incorporate the Padlet tool. Also, little research (Baidoo et al., 2022) exists on how teachers, who use the Padlet tool, integrate it with varied pedagogies and assessments to promote effective Integrated Science learning and teaching. Furthermore, there are few studies about learners' views and attitudes regarding the use of the Padlet tool in Integrated Science teaching and learning in high schools in Africa, particularly in Ghana. Against this background, this study investigated the implementation of the Padlet tool in Integrated Science classrooms to improve learner retention and achievement in Integrated Science in high schools in Ghana. The following questions were posed:

1. What creative pedagogies are adopted by the science teachers to enable learners to increase engagement and learner attainment when using the Padlet tool as a vehicle for teaching and learning Integrated Science?
2. What is the impact of the Padlet tool as a vehicle for teaching and learning of Integral Sciences on the learner's achievement?
3. What are the learners' and teachers' views when using the Padlet tool as a vehicle for teaching and learning Integrated Science?

The following hypotheses were tested:

1. Demographic variables, such as school, specialisation, and years of teaching by the teacher, would significantly affect the Creative Pedagogies (CP), Views of Teachers (VT) and the Formative Assessment (FA) strategies used by teachers during Padlet integration.

2. There is a significant positive correlation between instructional practices (IP), Thoughts and Opinions of Teachers (TAOT) and the Assessment for Learning (AFL).
3. Using Padlet tools to teach significantly improves learners' performance in Integrated Science.

2. The Theoretical Framework

This study was anchored within the Online Collaborative Learning Theory (OCL) and the Technological Pedagogical Content Knowledge Theory (TPACK). The OCL Theory was proposed by Harasim (2012, p.81) as a "new theory of learning that focuses on collaborative learning, knowledge building, and internet use as a means to reshape formal, non-formal, and informal education for the Knowledge Age". OCL involves idea generation, organisation, and intellectual convergence that are essential to learning. On the other hand, the TPACK theory (Mishra & Koehler, 2008) focuses on teachers' knowledge and proficiency in using technological tools in classroom instructions. Thus, the model directly applies to technology integration, as a teacher acquires technological skills, pedagogical skills, and content knowledge to strengthen self-efficacy for integrating technological tools in the classroom context. This study used these skills as an evaluative framework for the teachers' use of Padlet in their classrooms to teach integrated sciences.

3. Literature and studies

3.1 Padlet as a 21st Century Pedagogical Tool

New technologies and innovations transform how we teach and learn in the twenty-first century. Today, e-learning is an emerging demand of the information age, as it serves as a substitute for traditional teaching methods for learners while also encouraging collaborative learning (Myers, 2018). Moreover, technologies create limitless chances for discoveries that will equip learners to confront current problems. Learners are expected to use technological tools to synthesise newly learned knowledge, collaborate with peers, solve issues, and make decisions to succeed in today's complex, diverse, and global world (Collins & Halverson, 2018). The success of this type of learning requires learners to adapt to the information age and harness the power of technology to produce new knowledge (Ramachandiran & Mahmud, 2018). However, teachers are regularly confronted with new technology challenges of integrating technological tools into classroom instruction, as the demands of these learners continue to evolve (Johnson et al., 2016).

Padlet was introduced as a pedagogical tool to support both learners and teachers for collaboration and creativity in the classroom. Padlet, formerly Wall Wisher, is a free web-based tool that enables teachers and learners to build an online bulletin board environment (Weller, 2013) similar to that of "sticky notes" as ideas and responses are shown on the application's wall. Users can create walls to publish text, links, images, videos, and other related materials that are available to those who have access to the Padlet wall. Padlet has been demonstrated to be productive, enticing, and to have a positive effect on learners' learning (Ali, 2021).

It also enhances learners' skills in collaboration, creativity and writing by engaging them in their learning (Nadeem, 2021).

Although Padlet is a Web 2.0 tool for interaction on a virtual wall and has been used for simple instructional tasks and more complicated tasks among experts (Weller, 2013), it was not explicitly created for educational purposes. Thus, a presentation is required to demonstrate and explain the use of this tool and encourage active involvement and idea sharing among learners (Deni & Zainal, 2018).

3.2 Using Padlet as an Adaptive Creative Pedagogical Approach to Enhance Teaching and Learning

Borich (2016) explains that adaptive teaching methodology is a pedagogical method of instruction where the teacher employs the topic's content to suit the learners' needs, skills, interests, and characteristics. This is done to engage the learners in their academic endeavours and to improve their conceptual understanding of science concepts using technology. Ikwumelu et al. (2015) believe that adaptive teaching involves the whole class but that instructions cater to individual learners since the teacher gives feedback to the learners. Learners revise their work after receiving feedback from their teacher.

Researchers believe that there are several ways for teachers to adapt and implement adaptive pedagogy in their classrooms (Ikwumelu et al., 2015), for example, the teacher could alter the lesson so that the science concepts are meaningful to the learners' level of understanding. Often, the teacher also alters the way the content is assessed to measure the learners' mastery of science concepts by adapting games or audio-visuals to engage the learners.

4. Methodology

4.1 Research Design and Participants

The study employed a mixed methods sequential exploratory research design, using a combined quantitative-qualitative approach. This design was used to provide rich data by addressing different views from the participants allowing respondents more time to evaluate their responses, provide clarification, provide comprehensive examples when appropriate, and communicate their reasoning with precision (Tashakkori & Teddlie, 2009).

4.2 Sampling procedure

Purposive selection was made to obtain the four SHSs from the Greater Accra Region as participants in the study. A simple random sampling method was used to select five science teachers and 25 Integrated Science learners from each participating school. The underlying principle was that the random sampling gave each participant an equal chance of being selected and omitted bias. Sharma (2017) suggests that simple random sampling minimises sampling errors. The choice of the second-year Home Economics learners was made because we believed that these learners had the fundamentals of Integrated Sciences and had progressed to the second year with theoretical experiences that would enable us to get reliable data. The lottery method of simple random sampling was used to select the learners for this study.

Participation in the study was voluntary. Each participant was notified of the anonymization of the data and each step of the research procedure. The Research Committee of the University of Education of Winneba gave ethical permission.

4.3 Research Instrument

For the quantitative part of the study, data were collected using structured questionnaires (see supplementary resources). We adopted five questionnaire items from the Dewitt et al. (2015) study on collaborative learning. There were two types of questionnaires, for learners and for teachers. The Creative Teaching/Pedagogies and Views Questionnaires (CTPVQ) for learners had three main sections: Section A was biographical data and Section B contained ten items which dealt with the teaching approaches used by the science teachers when Padlet was integrated in class. Section C had ten items which sought learners' views on the use of the Padlet tool.

The CTPVQ for teachers had four main sections: Section A was for biographical data; Section B had items on creative pedagogies that teachers employed; Section C had items on formative assessment strategies; and Section D had items on the views of teachers on the integration of the Padlet tool.

Participants were requested to fill out a five-point Likert-type scale ranging from 1 to 5 (5: Strongly Agree; 4: Agree; 3: Undecided; 2: Disagree; and 1: Strongly Disagree). The questionnaire items were validated by experts experienced in the field. The internal consistency reliability value for the instrument was measured using Cronbach's alpha and achieved a reliability of 0.95. This value indicates good internal consistency for the scale.

For the qualitative part of the study, data were collected using observation schedules, interviews, and task performance analyses (see supplementary resources). The interview questions were semi-structured and allowed for probes. Interview questions were developed with the objective of the study in mind. Unstructured observation schedules were used. Detailed field notes were taken during the classroom observations. Standardised test questions were given to learners at the end of the intervention to determine the impact of the intervention on their performance.

4.4 Intervention

The 20 science teachers selected for the study were engaged in a three-day community of practice workshop after school hours to gain mastery and competency on using the Padlet as an instructional tool. The training focused on assessments for learning and creative pedagogies that Integrated Science teachers could use to improve learner retention and achievement in the subject.

Immediately after the training sessions, four teachers were purposefully sampled from the 20 selected teachers to integrate the Padlet tool in their classroom instructions. Data were collected for four weeks in the second term of the 2019 academic year. Videos on various Integrated Science topics were put on pen drives for the teachers to upload onto the Padlet tool. This enabled learners to better observe and understand abstract scientific concepts. Teachers used the uploaded videos primarily as "starters" or "introductions" and in their main

lessons. Learners watched the videos shown by the teachers and then responded to all questions or tasks, which were also typed on the Padlet wall.

4.5 Data analysis

Quantitative data were analysed through SPSS (Version 21). Data were converted to frequencies, percentages, mean scores, and standard deviations summarised into tables. In addition, the data were subjected to statistical tests using MANOVA, Partial Correlation, and Pearson's Product Moment Correlation to measure the relationships between independent and dependent variables (creative pedagogies, views, and formative assessments). Qualitative data were analysed using thematic content analysis (Braun & Clarke, 2006). This method identifies common or recurrent themes in the data and describes the essential elements. The authors then reviewed the data using a constant comparison coding process (Yin, 2015). Finally, to verify the interviews, the authors asked the participants to check their responses and confirm that they were correct reflections.

5. Results

5.1 Profile of Participants

The activities described in the previous sections are presented in this section. In addition, the themes and associated categories emerging from the triangulation of analysed data from the field notes, interviews and the questionnaires are also presented.

Table 1: Demographic characteristics

Variables		Statistics	
		Frequency	**Percentage (%)**
Gender:			
	Male	7	35
	Female	13	65
School:			
	School A	5	25
	School B	5	25
	School C	5	25
	School D	5	25
Qualifications:	Bachelor of Education (BEd)	7	35
	Master of Education (MEd)	9	45
	Master of Philosophy (MPhil)	4	20
Specialisation:			
	Biology	4	20
	Chemistry	4	20
	Physics	4	20
	Integrated Sciences	4	20
	Agricultural Sciences	4	20

Age			
	26–30	5	25
	31–35	9	45
	36–40	6	30
Number of years teaching			
	1–5 years	7	35
	6–10 years	8	40
	11–15 years	2	10
	16–20 years	3	15
Forms Taught			
	Forms 1 and 2	8	40
	Forms 1 and 2	3	15
	Forms 2 and 3	3	15
	Forms 1, 2 and 3	6	30

5.2. Pedagogies adopted by the science teachers to increase learners' engagement and attainment using the Padlet tool

The classroom observations were conducted to find out how teachers used the Padlet tool in teaching topics in Integrated Sciences, how teachers involved learners using creative pedagogies and how the teachers engaged and used assessments for learning strategies. Results were coded and analysed.

The teachers used interesting starters to introduce their lessons, alongside sharing the learning goal with their learners. These starters were always related to the topic to be learnt for the day and were mostly audio-visuals (videos).

Teachers varied their instructions. The use of textual power point presentations was very low as videos were more often used. Teachers allowed learners to share their ideas in class through presentations. For all the schools, learners gave oral or written summaries of their learning in a 3-2-1 count down. This strategy enabled the learners to do quick mental science.

The teachers also arranged for learners to work in small groups to submit tasks using the Padlet tool and to foster collaborative learning of both high and low achievers.

The teachers created an environment with multiple modes of communication and learning. Therefore, a creative ICT-based learning environment permitted learners to express their knowledge through several forms which necessitated a strategy that enabled students to compare, integrate, and synthesise many channels of communication and learning.

The teachers encouraged student-initiated activities which appeared to centre on engaging activities as a tool for encouraging learning. Student-initiated activities necessitated the teachers' support to foster an enabling environment and a sensitive, interactive discourse.

The teachers made good use of the formative assessment for learning strategies. "Waiting time" was given to learners to think about possible responses to the teachers' questions. Groups provided varied answers from the observations of the videos they watched. This made the learning and teaching of abstract science concepts simple. Project assignments were placed on the Padlet for the learners to do and submit in groups. The learners were very careful about the type of responses they provided since it was a learning platform. At times, learners provided answers to the teacher's questions and then the teacher read and provided feedback on the learners' responses and clarified key ideas for learners.

It was hypothesised that "variables such as school, area of speciality and years of teaching by the teacher would significantly affect the Instructional Practice (IP), the Thoughts and Opinions of Teachers (TAOT) and the Assessment for Learning (AFL) techniques". This hypothesis was tested by exposing demographic variables and teacher IP, TAOT and AFL to multivariate analysis to determine if these variables had a significant impact or not. Results are shown in Table 2.

Table 2: Multivariate Analysis of Variance for IP, TAOT and AFL among Teachers Categorised by School, Speciality, and Years of teaching

DV/Statistics	Independent Variables		
	School	Specialisation	Years of teaching
	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)
CP	A = 46.40(1.14) B = 45.80(1.09) C = 45.60(1.14) D = 46.60(2.51)	Biology = 45.80(1.79) Physics = 45.20(1.30) Chemistry = 47.00(1.58) Integrated Sc. = 47.20(1.52)	1–5 yrs = 46.14(1.34) 6–10 yrs = 46.25(1.75) 11–15 yrs = 46.50(0.71) 16–20 yrs = 45.33(2.08)
FA	A = 46.60(1.67) B = 45.40(2.79) C = 46.20(1.92) D = 46.05(2.09)	Biology = 44.20(2.68) Physics = 45.80(2.28) Chemistry = 47.00(0.71) Integrated Sc. = 47.20(0.84)	1–5 yrs = 47.14(0.90) 6–10 yrs = 45.75(2.12) 11–15 yrs = 48.00(0.00) 16–20 yrs = 43.00(1.00)
VT	A = 47.00(1.41) B = 47.40(0.55) C = 47.00(0.71) D = 47.80(0.84)	Biology = 47.00(1.22) Physics = 47.20(0.84) Chemistry = 47.40(0.55) Integrated Sc. = 47.60(1.14)	1–5 yrs = 47.43(1.13) 6–10 yrs = 47.50(0.76) 11–15 yrs = 47.50(0.71) 16–20 yrs = 46.33(0.58)
Λ	.168	.129	.529
Df	3,17	2,17	3,17
F	$.582^{ns}$	1.634^{ns}	$.129^{ns}$
Sig	.682	.402	.935
η^2	.023	.008	.044

^{ns} = not significant at .05; A = School A; B = School B; C = School C; D = School D; CP = Creative Pedagogies; FA = Formative Assessment; VT = Views of Teachers

The MANOVA results in Table 2 reveal a non-significant multivariate main effect for area of specialty and number of years of teaching as independent variables, as

related to teacher IP, AFL and TAOT (dependent variables) respectively. This implies that the above hypothesis is not supported.

When the Wilks Lambda is not significant, school, as a variable, does not affect the Instructional Practices (IP), Assessment for Learning (AFL) and Thoughts and Opinions of Teachers (TAOT). However, Wilks Lambda reveals that one independent school variable significantly affects multiple variables (IP, TAOT and AFL). Therefore, Eta ($\eta^{2)}$ also shows the size of the impact of the independent variable on the dependent variables (IP, TAOT and AFL).

Results for age, gender, teacher qualification and forms taught (as independent variables) also show an overall insignificant effect on both teacher IP, TAOT and AFL (as DVs). For gender, age, qualification area of specialisation and forms taught [Wilks Lambda $\lambda = 1.00$, $F_{(1,17)} = 0.001$, $p>.05$, partial $\eta^2 = .002$; Wilks Lambda $\lambda = 1.00$, $F_{(2,17)} = 0.002$, $p>.05$, partial $\eta^2 = .003$: Wilks Lambda $\lambda = 1.00$, $F_{(2,17)} = 0.000$, $p>.05$, partial $\eta^2 = .000$; Wilks Lambda $\lambda = 1.00$, $F_{(6,17)} = 0.003$, $p>.05$, partial $\eta^2 = .001$]. This indicates that demographic variables, such as gender, age, qualification, area of specialisation and forms taught, do not affect IP, TAOT and AFL of teachers.

5.3 Correlation between IP, TAOT and AFL

The second hypothesis stated, "There is a significant positive correlation between IP, TAOT and AFL". Results of this hypothesis are presented in Table 3.

Table 3: Partial Correlation between IP, TAOT and AFL

Predictor Variables	**Outcome Variables**		
	CP	*VT*	*FA*
IP	-	-	-
TAROT	.285^{ns}	-	-
AFL	.327^{ns}	.228^{ns}	-

^{ns} = not significant at .05; IP = Instructional Practices; AFL = Assessment for Learning; TAOT = Thoughts and Opinions of Teachers

Results in Table 3 reveal a positive correlation between the three study variables (IP, TAOT and AFL). However, these correlations are insignificant. This implies that the second hypothesis is also not supported. TAOT is .285 and not significant because the sample size is minimal. In addition, the coefficients are all positive.

5.4 Impact of the Padlet tool, as a vehicle for teaching and learning of Integrated Sciences, on learner achievement

The third hypothesis states, "Using Padlet tools to teach significantly improves learners' attainments on the Integrated Sciences".

Table 4: Analysis of Difference between Task Performance of Learners before and after the Use of the Padlet Tool

DV/Statistics	Groups of Schools			
	A	B	C	D
	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)
Task Performance Before Use of Padlet Tools	23.00*(3.06)*	24.96*(3.03)*	25.88*(3.22)*	23.32*(2.61)*
Task Performance after Use of Padlet Tools	34.08*(2.46)*	35.56*(1.87)*	35.40*(2.71)*	36.08*(1.85)*
Df	*24*	*24*	*24*	*24*
T	*26.135***	*22.599***	*16.240***	*24.048***
Sig	*.000*	*.000*	*.000*	*.000*

*** = significant at .01; A = School A; B = School B; C = School C; D = School D; CP = Creative Pedagogies; FA = Formative Assessment; VT = Views of Learners*

Table 4 shows the mean score for assessment attainments before using the Padlet tool and after using the tool. A Matched Pairs *t*-test analysis of mean difference shows that a significant difference existed between the assessment attainments mean scores before and after using Padlet. In each school, the mean score after the use of Padlet was better than the mean score before the use of the Padlet tool. This implies that the use of the Padlet significantly improved assessment attainment in each school. Thus, the third hypothesis is supported.

Table 5: Pearson's Product Moment Correlation between Learners' Views on Use of Padlet Tool and Teaching Approaches

Variables	**Teaching Approaches**		
	df	*r*	*Sig*
Views of Learners on the use of the Padlet Tool	98	.308**	.002

** = <.01

Results in Table 5 show that learners' views on the use of the Padlet tool positively correlated with learners' evaluation of teaching approaches adopted by teachers. Hence, the learners had a positive view of the teachers' approaches. Pearson's R was used because there were no variables to control such as gender and form.

5.5 Views in using the Padlet tool as a vehicle for teaching and learning Integrated Science

In learners' views, two themes emerged, namely, creative and innovative pedagogies and getting engage oriented. Learners believed that their science teachers used innovative teaching approaches during the lesson. For example, they responded that their teachers gave them learning goals before the main lesson was taught in class. They also noticed that their science teachers put them in sizable learning groups to share learning ideas on different topics. According

to the learners, they mostly watched exciting videos about science concepts related to different topics their teacher taught in class, which allowed them to better understand the topic for the day. Two learners narrated:

> *"Yes, we watched science videos every time, especially at the beginning of the lesson. Then teacher put us into small groups and make us share our group ideas by typing it on the wall" (Rejoice).*

> *"My teacher asks questions on the science videos we watch and mostly we respond to the questions on the wall. With that we are able to read our classmates' responses" (Serwa).*

The second theme which is getting engage and oriented manifest that the teachers really orient the learners how to use Padlet before engaging them. The learners also indicated that their teachers gave them orientation notes before using the tool in their classrooms and gave them time to read the notes that prepared them to use the Padlet tool. The learners felt that the Padlet was an excellent tool for learning Integrated Sciences. One learner narrated:

> *We received some form of orientation by our teacher. That was accompanied by orientation notes. The notes were made so easy to read. As a result, we never struggle with the Padlet tool, although it was new to us (Frank).*

Other learners enjoyed using the Padlet tool. Learners' engagement was strong and learners were happy to see their own and their group ideas on the walls that showed that they were able to learn from their friends quickly. More collaborative learning was seen in the use of the Padlet tool. One learner mentioned:

> *"Indeed, this is a great tool because it can be used even outside my classroom. I even like the fact that I can search the internet even when using the Padlet to get more information on other concepts" (Tony).*

Learners happily used the Padlet tool since they could locate the delete, upload, and text features very quickly, which allowed them to type their work on the Padlet wall.

5.6. Teachers' views on the Integration of Padlet in the Science Classroom Pedagogies

Two themes emerged from the teachers' views, namely, the ability to use creative pedagogies, and formative assessment strategies. The first theme focused on the science teachers' ability to use creative pedagogies/innovative teaching approaches while integrating the Padlet tool in the science classroom. The teachers used starters in introducing their lessons in class and showed more videos to the learners which were related to the science concepts learners were expected to learn. The creative pedagogies teachers used also included teachers' sharing the learning goals with learners. The Problem-Based Learning (PBL) approach was emphasised. Learners were given specific scenarios concerning the science topic, and they were tasked to find solutions to the problems. Two teachers narrated:

> *"I used interesting starters which were critical thinking questions based on the topic to be learnt for the day" (Ms Agyei).*

> *"I made the learners watch at least a video relating to every science topic and ensure that I ask them questions which they respond to by writing on the wall. I ensure that I give them enough time to respond to questions" (Mr Ntim).*

The second theme was the formative assessment strategies teachers used with the Padlet tool. One hundred percent of the science teachers stated that they could provide learners with varied, creative, high order questions to encourage them to think critically on all the science concepts they were taught in class. These questions followed a video on a science concept. After watching videos, learners were tasked to talk about their observations in groups. One teacher mentioned:

> *"Most of the questions I posed are higher order questions. I often used inquiry-based strategies to get learners thinking out of the box for solutions. In addition, I also assess my learners through group presentations" (Mr Nyame).*

Through these varied questioning techniques, learners could respond to the questions by typing their responses on the wall. Using the PBL strategies, teachers gave learners tasks in which the learners provided varied responses in group presentations in the classroom. The teachers enjoyed using the tool to provide basic classroom assessments for learning strategies by allowing all high achieving and low achieving learners to share their ideas on the wall and by engaging all learners. One teacher narrated:

> *"I gave the learners problem questions to make them think more and learn science better" (Mrs Anderson).*

A series of tasks were designed for the learners to carry out after classes related to activities done in class each week.

6. Discussion

The results of the questionnaire, classroom observations, and the semi-structured interviews indicated that the implementation of Padlet, as a pedagogical tool, was appreciated by the participants. With Padlet, as an instructional pedagogy, teachers implemented creative pedagogies in their classrooms to increase learners' engagement, learning collaboration and the chance to master their learning. Individual learners could learn at their own speed and participate anonymously in online conversations. The entire class was engaged. Students were observed reading information which the teacher had uploaded on Padlet, including videos and other materials for each concept in sciences. This finding aligns with the study findings conducted by Baidoo et al. (2022) that the use of Padlet tool, as an instructional approach, allowed the teacher to engage learners in a virtual interactive session, making learning meaningful, significant, and relevant, while enhancing learners' levels of attention and responsiveness. This finding also supports Nadeem (2021) who found that using Padlet in education enabled students to relate to the sub-topics discussed in class as students interacted with classmates and the teacher. Thus, the creative pedagogies enabled teachers to use group tasks, which fostered collaborative learning and successfully eliminated the anxiety and disquiet of traditional teaching methods. This means that there was a significant positive correlation between the Creative

Pedagogies (CP), Formative Assessment (FA) and Views of Teachers (VT) however, these correlations are not significant.

The Matched Pairs *t*-test analysis of mean difference shows that a significant difference exists between learners' achievement mean scores before and after using Padlet. In each school, the mean score after the use of Padlet was better than the mean score before the use of the Padlet tool. This implies that the use of the Padlet significantly improves learner achievement and retention. This finding corroborates that of Udosen (2020) which described Padlet as an effective tool with a significant role in improving learner achievement and motivation.

The findings on learners' views and their rating of teaching approaches adopted by their teachers revealed that the mean records on learners' evaluation of teaching approaches were 41.00, 47.48, 40.84 and 42.12 for learners from schools A, B, C and D, respectively. In addition, these means were subjected to a One-Way Analysis of Variance, and the results indicated that a significant difference existed between the learners' evaluations of teaching approaches of their teachers. The learners expressed positive views towards the use of the Padlet tool, which confirms the results of a similar study conducted by Gursoy and Goksun (2019).

One hundred percent of the science teachers stated that they were able to creatively provide learners with varied high order questions for them to think critically on all science concepts they taught in class. This finding is in line with Firat and Köksal's (2019) study that reveals that Padlet is an effective tool in education. Furthermore, it was remarkable that all the teachers and learners who participated in this study said that this was their first encounter with an online application and that the researchers provided guidelines for them to successfully use the Padlet tool without any difficulties.

7. Conclusion

The outcome of the study of the integration of Padlet tool in improving learning outcomes among high school Integrated Science learners in the Greater Accra Region of Ghana shows that the implementation of technological tools in education can be successful. Effective use and integration of web-based tools will enable both teachers and learners to cope with the numerous challenges arising from conventional teaching and learning. It is evident from the results of the study that using and integrating the Padlet tool in science teaching allowed teachers to engage in interactive virtual sessions where learners instantly submitted and shared completed class tasks and group assignments. The Padlet tool allowed the learning process to extend remotely beyond the classroom while it enhanced learners' levels of attention, responsiveness, interest, engagement, and participation. This, in turn, made learning more meaningful, significant, and relevant. Therefore, it is recommended that governments and policymakers embark on developing practical pedagogical courses geared towards the training of teachers in the use of technological tools in science classrooms. In addition, existing government policies on technology should be periodically reviewed to ensure the rapid integration of technology in the teaching and learning of Integrated Science in schools. The Ghana Government and the Ministry of Education should also consult internet providers to ensure that all senior high

schools have high-level connectivity at subsidised rates to empower teachers and learners to access science information from the internet. Finally, more Professional Learning Community sessions should be established countrywide to tailor more learning and teaching activities to accommodate all learners.

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8. References

Ali, A. (2021). Using Padlet as a Pedagogical Tool. *Journal of Learning Development in Higher Education*, 22. https://doi.org/10.47408/jldhe.vi22.799

Anamuah-Mensah, J., Ananga, E.D., Wesbrook, J., & Kankam, G. (2017). *National Teachers' Standards for Ghana-Guidelines.* Ghana Ministry of Education.

Azure, J.A. (2015). Senior High School Students' views on the teaching and learning of integrated science in Ghana. *Journal of Science Education and Research*, *1*(2), 49–61.

Baidoo, M., Ameyaw, Y., & Annan, J.N. (2022). Assessing the effectiveness of Padlet Instructional Tool in the Teaching and Learning of some Ecological Concepts. *International Journal of Sciences*, *11*(04), 27–33. https://doi.org/10.18483/ijsci.2554

Black, P., & Wiliam, D. (2018). Classroom assessment and pedagogy. *Assessment in Education: Principles, Policy & Practice*, *25*(6), 551–575.

Bondie, R.S., Dahnke, C., & Zusho, A. (2019). How does changing "one-size-fits-all" to differentiated instruction affect teaching? *Review of Research in Education*, *43*(1), 336–362.

Borich, G.D. (2016). *Observation Skills for Effective Teaching*. Routledge. https://doi.org/10.4324/9781315633206

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Collins, A., & Halverson, R. (2018). *Rethinking education in the age of technology: The digital revolution and schooling in America*. Teachers College Press.

Deni, A.R.M., & Zainal, Z.I. (2018). *Padlet as an educational tool: Pedagogical considerations and lessons learnt* [Conference presentation]. Proceedings of the 10th International Conference on Education Technology and Computers (pp. 156–162) Oct 26–28, Tokyo, Japan.

Dewitt, D., Alias, N., & Siraj, S. (2015). *Collaborative learning: Interactive debates using Padlet in a higher education institution* [Conference presentation]. International Educational Technology Conference, 27–29 May 2015, Istanbul, Turkey.

Firat, E.A., & Köksal, M.S. (2019). Effects of instruction supported by Web 2.0 tools on prospective teachers' biotechnology literacy. *Computers & Education*, *135*, 61–74.

Gezer, T., Wang, C., Polly, A., Martin, C., Pugalee, D., & Lambert, R. (2021). The relationship between formative assessment and summative assessment in Primary grade mathematics classrooms. *International Electronic Journal of Elementary Education*, *13*(5), 673–685. https://doi.org/10.26822/iejee.2021.220

Gursoy, G., & Goksun, D.O. (2019). The experiences of pre-service science teachers in educational content development using Web 2.0 Tools. *Contemporary Educational Technology*, *10*(4), 338–357.

Han, F. (2021). The relations between teaching strategies, students' engagement in learning, and teachers' self-concept. *Sustainability*, *13*(9), 5020. https://doi.org/10.3390/su13095020

Harasim, L. (2012). *Learning theory and online technologies*. Routledge. https://doi.org/10.4324/9780203846933

Hursen, C. (2020). The effect of problem-based learning method supported by Web 2.0 tools on academic achievement and critical thinking skills in teacher education. *Technology, Knowledge, and Learning, 26*(3), 515–533. https://doi.org/10.1007/s10758-020-09458-2

Ikwumelu, S.N., Oyibe, O.A., & Oketa, E.C. (2015). Adaptive teaching: An invaluable pedagogic practice in social studies education. *Journal of Education and Practice*, *6*(33), 140–144.

Johnson, A.M., Jacovina, M.E., Russell, D.G., & Soto, C.M. (2016). Challenges and solutions when using technologies in the classroom. In Crossley, S.A., & McNamara, D.S. (Eds.), *Adaptive Educational Technologies for Literacy Instruction* (pp. 13–30). Routledge. https://doi.org/10.4324/9781315647500-2

Johnson, J., Uline, C., & Perez, L. (2013). *Teaching practices from America's best urban schools: A guide for school and classroom leaders.* Routledge. https://doi.org/10.4324/9781315853499

Lee, H., Chung, H.Q., Zhang, Y., Abedi, J., & Warschauer, M. (2020). The effectiveness and features of formative assessment in US K-12 education: A systematic review. *Applied Measurement in Education*, *33*(2), 124–140. https://doi.org/10.1080/08957347.2020.1732383

Mishra, P., & Koehler, M.J. (2008). *Introducing technological pedagogical content knowledge* [Paper presentation]. Annual Meeting of the American Educational Research Association, March 24–28, New York City.

Myers, T. (2018). *Exploring the use of synchronous and asynchronous tools to support problem-based learning* [Doctoral dissertation, Capella University].

Nadeem, N.H. (2021). Students' perceptions about the impact of using Padlet on class engagement: An exploratory case study. In I. Management Association (Eds.), *Research anthology on developing effective online learning courses* (pp. 1919–1939). IGI Global. https://doi.org/10.4018/978-1-7998-8047-9.ch095

Nyawanza, M. (2017). The use of mobile technology in lectures: Using an Audience Response System (Padlet) to enhance the student learning experience. *Worcester Journal of Learning and Teaching*, 11.

Onbasili, Ü.I. (2020). The effects of science teaching practice supported with Web 2.0 tools on prospective elementary school teachers' self-efficacy beliefs. *International Journal of Progressive Education*, *16*(2), 91–110. https://doi.org/10.29329/ijpe.2020.241.7

Organisation for Economic Co-operation and Development [OECD]. (2016). *PISA 2015 Results (Volume II): Policies and practices for successful schools*. OECD Publishing. https://doi.org/10.1787/9789264267510-en.

Quansah, R.E., Sakyi-Hagan, N.A., & Essiam, C. (2019). Challenges affecting the teaching and learning of integrated science in rural junior high schools in Ghana. *Science Education International*, *30*(4), 329–333. https://doi.org/10.33828/sei.v30.i4.10

Ramachandiran, C.R., & Mahmud, M.M. (2018). *Padlet: A technology tool for the 21st century students' skills assessment* [Conference presentation]. International Conference on Educational Awareness and Policy (ICEAP), Jakarta, Indonesia, Volume: 1.

Sharma, G. (2017). Pros and cons of different sampling techniques. *International Journal of Applied Research*, *3*(7), 749–752.

Tashakkori, A., & Teddlie, C. (2009). Integrating qualitative and quantitative approaches to research. In Bickman, L., & Rog, D.J. (Eds.), *The SAGE Handbook of Applied Social Research Methods* (*2nd* edition, pp. 283–317). Sage. https://doi.org/10.4135/9781483348858.n9

Udosen, I. (2020). Utilization of Padlet technology and performance of senior secondary two students in agricultural science in Uyo Local Government Area. *International Journal of Advancement in Education, Management, Science and Technology*, *4*(3).

Veldhuis, M., & Van den Heuvel-Panhuizen, M. (2020). Supporting primary school teachers' classroom assessment in mathematics education: Effects on student achievement. *Mathematics Education Research Journal*, *32*(3), 449–471.

Weller, A. (2013). The use of Web 2.0 technology for pre-service teacher learning in science education. *Research in Teacher Education*, *3*(2), 40–46.

West African Examinations Council (WAEC). (2019). *West African Secondary School Certificate Examinations (WASSCE). Chief Examiner's Report*. WAEC Press.

World Bank. (2016). *World Development Report 2016: Digital Dividends*. World Bank. https://doi.org/10.1596/978-1-4648-0671-1

Yin, R.K. (2015). *Qualitative research from start to finish* (2nd edition). Guilford Publications. https://doi.org/10.1111/fcsr.12144

APPENDIX 1: RESEARCH INSTRUMENTS

INSTRUMENT A: QUESTIONNAIRE FOR TEACHERS

Creative pedagogies and views questionnaire for teachers

This short exercise is to investigate science teachers' creative teaching approaches / pedagogies and views on the use and integration of the Padlet tool in the Integrated Sciences classroom, to enable learners increase in engagement and learning outcomes. Please kindly provide truthful responses to each item. You are to indicate the extent to which you agree with the items below. There is no right or wrong answer. Please in each case, tick (√) in the appropriate box. Your effort will be a useful contribution to knowledge. The information you provide will be treated with all confidentiality.

SECTION A: Demographic characteristics

Name of School: ☐

Sex: Male: ☐ Female: ☐ Age: ☐

Qualification: ☐

Area of Specialization: ☐

Number of Years of Teaching: ☐

Classes/ Forms Taught: ☐

SECTION B: Creative Pedagogies

Items	Fully Agree	Agree	Undecided	Disagree	Fully Disagree
1.I set goals at the beginning of Integrated Sciences instruction.					
2. In teaching Integrated Sciences concepts I show video simulations on the Padlet for learners to observe.					
3. In teaching Sciences instruction concepts, I can also show power point presentations to engage learners.					
4. I use group work to engage learners on the Padlet tool during Integrated Sciences instruction lessons to improve learning outcomes.					

5. I can use the Padlet to perform more scientific practical activities to improve learning outcomes.					
6. I allow learners to discuss Integrated Sciences instruction concepts in pairs and then share their views on the Padlet tool.					
7. In using the Padlet, the teacher is to occasionally give projects to learners in groups.					
8. The teacher is to build an online Integrated Sciences portfolio with learners when using the Padlet.					
9. I can also use the Padlet to find out what learners already know about an Integrated Sciences concept to be taught.					
10. The teacher can use the Padlet to search for more information on the internet on Integrated Sciences topics					

SECTION C: Formative Assessment Strategies used by Integrated Science Teachers

Items	**Fully Agree**	**Agree**	**Undecided**	**Disagree**	**Fully Disagree**
1.Before I teach Integrated Sciences, I share the learning goals with my learners.					
2.When using the Padlet tool, I ask learners divergent questions about scientific concepts in class.					
3. When using the Padlet tool, I ask learners convergent questions about scientific concepts in class.					
4. I give learners questions to check for their understanding of scientific concepts using the Padlet tool.					
5. I give learners the task of drawing out a concept or idea that they learned in the Integrated Science lesson.					

6. I give learners time to think before they respond to my questions on the Padlet tool.					
7. The teacher is to provide prompt feedback on learners' responses to Integrated Sciences questions on the Padlet tool.					
8. The teacher is to provide prompt feedback to learners' responses orally and written on the Padlet.					
9. I ask learners to write down three things that they have learnt in Integrated Sciences on the Padlet tool.					
10. I ask learners to write a summary of the scientific concepts they have learnt for the day to check their understanding.					

SECTION D: Views of Teachers on the use and Integration of the Padlet Tool

Items	**Fully Agree**	**Agree**	**Undecided**	**Disagree**	**Fully Disagree**
1. I have no difficulty in using the Padlet in the Integrated Sciences classroom.					
2. I like to see my learners/ comments on the Padlet					
3. Padlet motivates me to interact with my learners inside and outside of the Integrated Sciences classroom.					
4. Padlet encourages my learners to interact and complete tasks together or in groups.					
5. I feel less stressed when I use the Padlet to teach Integrated Sciences in class.					
6. I feel less stressed when I use the Padlet to give learners Integrated Sciences projects to work on.					

7. Padlet encourages my class to interact in groups to complete an assigned task together.					
8. Padlet allows me to read all the responses from learners in class by reading their posts and comments on the class wall to check for their understanding of Integrated Sciences cconcepts.					
9. When I post on Padlet wall, I am careful to check my grammar and use the right Integrated Sciences terms.					
10. It is a good idea to use Padlet to teach Integrated Sciences.					

INSTRUMENT B: QUESTIONNAIRE FOR LEARNER

Creative Pedagogies and Views Questionnaire for Teachers

This short exercise is to investigate learners' ideas on the use of the Padlet tool in learning Integrated Sciences concepts. Please kindly provide truthful responses to each item. You are to indicate the extent to which you agree with the items below. There is no right or wrong answer. Please in each case, tick (√) in the appropriate box. Your effort will be a useful contribution to knowledge. The information you provide will be treated with all confidentiality.

SECTION A

Name Of School: ☐

Sex: Male: ☐ Female ☐ Age: ☐

Programme: ☐

SECTION B: teaching approaches used by the Integrated Sciences Teachers

Items	Fully Agree	Agree	Undecided	Disagree	Fully Disagree
1.In teaching Integrated Sciences, the teacher set goals at the beginning of instruction.					
2. The teacher showed video simulations on the Padlet for us to observe.					

3. In teaching Integrated Sciences concepts, the teacher showed a power point presentation to engage the learners.					
4. The teacher made us work in groups to engage learners on the Padlet tool during Integrated Sciences lessons to improve our learning.					
5. I can use the Padlet to perform more scientific practical task and activities to improve learning.					
6. The teacher allows us to discuss Integrated Sciences concepts in pairs and in groups and then we share our views on the Padlet tool.					
7. In using the Padlet, the teacher occasionally gives projects to us in groups.					
8.When we type our responses to our teacher's questions, we build an online Integrated Sciences portfolio together with our teacher.					
9. Our teacher makes us write about what we know already or what we will like to know about an Integrated Sciences concept on the Padlet wall.					
10. The teacher can use the Padlet to search for more information on the internet on Integrated Sciences topics.					

SECTION C: Views of Learners on the use of the Padlet Tool

Items	Fully Agree	Agree	Undecided	Disagree	Fully Disagree
1. I have no difficulty in using the Padlet in the Integrated Sciences classroom.					
2. I like to see my classmates share on the Padlet.					
3. Padlet motivates me to interact with my classmates inside and outside of the Integrated Sciences classroom.					
4. Padlet enables me to share ideas with my friends.					
5. I feel less stressed when I use the Padlet to learn Integrated Sciences in class.					
6. I learned new concepts from the other posts on Padlet					
7. The materials posted on Padlet were clear					
8. The materials posted on Padlet were useful					
9. When I post on Padlet wall, I am careful to check my grammar and use the right scientific terms.					
10. It is a good idea to use Padlet to learn Integrated Sciences					

INSTRUMENT C: INTERVIEW SCHEDULE FOR TEACHERS

The purpose of this interview is to find out the teaching approaches, formative assessment strategies and views adopted by Integrated Sciences teachers to improve learning outcomes during the use of the Padlet tool. Your responses will be treated with all confidentiality. Thank you for your co-operation.

1. Do you include knowledge and skills into your learning goals?
   If 'yes', why do you say so? If no, give your reason.
   ……
   ……

2. How will you define learner engagement?
   ……
   ……
   Do you believe your learners were more engaged, less engaged or about the same during the use of the Padlet in the Integrated Sciences classroom?
   If yes, why do you say so? If no, give your reason.
   ……..
   ……
   ……..
3. What do you feel is one of the greatest benefits or positives that resulted from the use of the Padlet tool?
   ……
   ……
   ……
4. Did you notice any negatives or drawbacks because of using the Padlet with learners during the study?
   If yes, why do you say so? If no, give your reason.
   ……
   ……
   ……
5. Tell me about the techniques or strategies you use to encourage learners to participate in class when you ask questions to check if learners understand Integrated Sciences concepts.
   ……
   ……

INSTRUMENT D: INTERVIEW SCHEDULE FOR LEARNERS

The purpose of this interview is to find out the views and teaching approaches adopted by your Integrated Sciences teacher/s to improve your learning outcomes during the use of the Padlet tool. Your responses will be treated with all confidentiality. Thank you for your co-operation.

1. Do you find it easy to use the Padlet tool?
   If yes, why do you say so? If no, give your reason.
   ……
   ……
   Did your teacher take you through the orientation notes on the Padlet before you started using it?
   If yes, why do you say so? If no, give your reason.
   ……
   ……
2. What Integrated Sciences topic/s did you use the Padlet to learn in class?
   ……
   ……
3. What do you feel is one of the greatest benefits or positives that resulted from the use of the Padlet tool?
   ……
   ……