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Influential Factors in Modelling SPARK Science Learning System

Marie Paz E. Morales
Educational Policy Research and Development Center
Philippine Normal University
1000 Manila, Philippines

Abstract. The study is focused on the exploration of influential factors in modelling PASCO-designed technology in science classes. Mixed method was employed to critically explore how the SPARK Science Learning System is meaningfully integrated into the teaching of selected topics in Earth and Environmental Science. The SPARK Science learning system is an all-in-one mobile device that integrates the power of probe ware with inquiry-based content and assessment. It is a device that includes a large, full-color display, finger-touch navigation and data collection and analysis capabilities designed to become a discovery-based science learning environment. It provides both the teacher and the students the embedded support for exploring science concepts. Results show that there is a significant gain in student achievement with the integration of SPARK Science learning system. Significant positive correlation is observed between post-test and intrinsic motivation. Correlation between post-test and evaluation and correlation between intrinsic motivation and evaluation, however, posit non-statistically significant correlation. Mapped advantages and disadvantages of using the technology resulted to recurring themes for framework design of using the SPARK Science Learning System to further institute its effect in the curriculum as a precursor towards envisioning the 21st century learning.

Keywords: Environmental Science; Technology Integration, Pedagogy

Introduction

Dramatic technological revolution ushered the new millennium. Focus on digitization and technology use has been the subject of several researchers because of this trend. In many countries, today's students are referred to as "digital natives" and today's educators as "digital immigrants." Thus, there is a need for teachers to work closely with students whose entire lives have been immersed in the 21st century media culture. This enculturation of students as digital natives is described as P21 or better known as "Partnership for 21st Century Skills" (Kellner 2002).

It is well-established by researches that integrating technology into the curriculum and instruction will bring about significant student achievement and therefore deepunderstanding of concepts (Clark, 2010). He claimed, however, that technology has to be integrated meaningfully into the curriculum and instruction, for probable positive impact on student learning and achievement. "Meaningful integration" of technology refers to the process of matching the most effective tool with the most effective pedagogy to achieve the learning goals of a particular lesson. Each tool brings different opportunities to the learning environment and involves a different set of skills on the part of teachers and students. Each can play a unique role in the learning process when used at the appropriate time, under the most suitable learning conditions. It is simply the degree to which a particular technology's capabilities are matched with the expected learning outcomes and supported by fitting pedagogy that will determine the impact that technology has on learning and achievement (Clark, 2010).

This match of the technological tool with pedagogy and curriculum is the main focus of the study. Further, the research would want to establish that this match is feasibly achieved by the attributes of the teachers as the "digital immigrants" working collaboratively with the students as the "digital natives" to help foster the intended partnership and be confluent with the P21 flow.

The purpose of this research is to investigate the use of SPARK Science learning system in Earth and Environmental Science classes. The specific research objectives are to:

1. Determine the effect of using the SPARK devices on student motivation;
2. Establish the effect of using SPARK on student achievement;
3. Identify the influential factors in modelling integration of technology (SPARK Science learning system) in science classes; and
4. Design a framework to integrate technology in science classes and adopt them to the 21st century learning.

Framework and Literature

In the 21st century framework, the definition shifts to learning towards learning technologies and on how instructional technologies can best serve learning. The Association for Educational Communications and Technology (AECT 2003) defines educational technology as "the study and ethical practice of facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources" (Richey, Silber, & Ely, 2008). A revisit of important attributes of learning such as motivation and preliminary attempts of technology integration can explore the initial results of the benefits of technology in the curriculum.

On motivation

One of the many aspects that can help foster better achievement by students in the classroom, according to Slavin (2003), is motivation. He defined motivation as "what gets you going, keeps you going, and determines where you want to go". Many researchers (Brookhart et al. 2006; Palmer 2005; and Mazer, Murphy

& Simonds, 2009) provide an impression that motivation is the key component in reaching a high level of student achievement.

In a study conducted by Martin (2006), he argued that if students set meaningful goals that are attainable, they will progressively achieve higher results. There is a need to provide students with a distinct set of goals that can help them be motivated. He further suggested that if students have predetermined goals they will strive for personal bests with a higher level of motivation. Teachers can play a large role in determining the motivation level of the students in the class. Studies on the effects of teacher self-disclosure on student motivation using Facebook web-based software as medium for disclosure conclude that students were more motivated when their teacher shared some personal information about themselves. However, some disadvantages of this self-disclosure surfaced with too much self-disclosure which led to non-elicitation of same motivation (Mazer, Murphy & Simonds, 2009).

On technology integration and learning

Educational technology has been defined in numerous ways. It usually highlights the teacher and the pedagogies that might be employed on the learner. In the 20th century, four paradigm shifts are characterized as the physical science or media view; the communications and systems concept; the behavioral science-based view; and the cognitive science perspective. Each of these shifts has different philosophical and theoretical orientations that affected theory, practice and definitions of educational technology (Saetller, 2004).

Several studies have been conducted on the goodness and effectiveness of technology as integrated into the curriculum or instruction. According to Floyd et al. (2008), integration of technological advances should be a major part in designing the most effective and innovative emergent technology literacy intervention. Successful technology integration, according to Mishra & Kohler (2006), requires that educators blend strong content knowledge with appropriate pedagogical strategy. From which they were able to come up with Technology-Pedagogy-and–Content Knowledge or TPACK framework. This highlights P21 or known as Partnership for the 21st Century Skills, which focused on "meaningful" integration of technology. As expressed by Clark (2010), integrating technology in meaningful ways involves matching instructional tools with curricular goals, desired student outcomes and instructional practice. Choosing the "right" tool for a learning task requires not only familiarity with the kinds of tools available, but also depends upon an understanding of how those tools can support the development of desired knowledge and skills. As with any tool selected for any purpose, the choice of what technology to use and how to use it must be guided by a set of beliefs-a vision-for how learning is best supported. Though technology integration is foreseen as a way of attaining meaningful learning on the part of the digital natives, there were several studies marking the disadvantages of technology integration. One of which was noted by Schmidt in Veitch (2010) who voiced a concern that people might be losing deep-reading skills, as they spend less time reading long-form literature passages. This probably has an effect on cognition and reading, although no one really knows what that does. Gasser and Palfrey (2009) identified multitasking as a skill developed when students are engaged in technology integration. They claimed multitasking does not render learning impossible. It does not even necessarily make it more difficult to accomplish tasks. Multitasking is likely to change learning qualitatively by making the learner rely on different memory systems that vary in flexibility when it comes to the use of knowledge. However, they also mentioned that the loss of attention and the time spent switching from task to task is likely to have an adverse effect on digital natives' ability to learn complex new facts and concepts. Some of these issues and concerns of technology integration into the curriculum were addressed by Siemen's (2005a) theory of connectivism, where he claimed that technology has also contributed to a rise in informal learning where the majority of education no longer occurs in formal settings but through learning communities of practice, personal networks and through completion of work related task. In contrast to established theories of learning, the essence of connectivism is that learning is viewed as a connections/network-forming process (Siemens, 2005b).

Meaningful technology integration touches ground on motivation and appropriate use of tools to match the learners and pedagogy at hand. The information provided by this research is of value to science teachers working on similar objectives. This also allows science teachers to explore and improve their motivation techniques which may later lead to a deep conceptual understanding of the subject matter. Further, the results would help establish effectiveness of technology-inspired science classroom in trying to be at par with the 21st century learning.

Methodology

The study used mixed methods in order to gather data and pertinent observations regarding the use of technology in science classroom. Presented below is the summary of the study including different stages, data gathering procedures, participants and statistical analysis. Qualitative method was used to validate quantitative results derived from the investigation.

Table 1: Summary of the Methodology

Stages of the Study	Data Collection	Instrument/Tool	Data Analysis
Preparation and Pre-Implementation	• SPARK Science Learning System Orientation • Administration of pre-tests	• Literacy and Technology Checklist • Intrinsic Motivation Inventory • Achievement Test • Evaluation Form	• Average ratings and Aiken's content validity coefficient • Averages of technology literacy constructs
During Instruction	• Lesson Sessions using SPARK Science Learning System	• SPARK Science Learning System	
Post-Implementation	• Administration	• Intrinsic	• Paired sample

	of post-tests, post-implementation interviews	Motivation Inventory • Achievement Test • Evaluation Form • Interview protocol	t-test • Correlation • Interview transcriptions

Participants

The participants of this study included one intact class of tertiary students who were specializing in physics and were enrolled in both Computer Literacy 1 and Earth and Environmental Science classes. These are pre-service physics students who qualified as Philippine government scholars in science teaching. They enjoy the consortium benefits with the De La Salle University, Manila. As government scholars, these students were nationally selected from different science oriented and non-science oriented high schools all over the Philippines. They also enjoy the benefits of the grant and are envisioned to be the future Physics teachers.

Materials and Instruments

SPARK Learning System - This is an all-in-one mobile device that integrates the power of probe ware with inquiry-based content and assessment. The device includes a large, full-color display, finger-touch navigation and data collection and analysis capabilities. It is designed to become a discovery-based science learning tool, providing both the teacher and the students the embedded support for exploring science concepts. It has more than 60 free pre-installed SPARK-labs which are standard-based guided inquiry labs in a unique electronic notebook format that integrates background content, data collection, analysis, and assessment. (PASCO Scientific, 2008).

Literacy and Technology Checklist - This instrument established the students' knowledge and know how in technology, literacy and web expertise, which is requisite to the use of SPARK Science Learning system. The three major parts of the instrument are background information, technology component, and literacy & web expertise. The second part highlights technology component using a four-point Likert scale system. In addition, the other components are in open-approach.

Intrinsic Motivation Inventory - This is a multidimensional instrument intended to appraise participants' subjective experience related to a target experiment in laboratory sessions. It has been used in several experiments related to intrinsic motivation and self-regulation (Gottfried, 1985). There are several versions of this inventory. The two versions were used in the study are the full 45-item tool that completes the 7 subscales, and the 25-item version that was used in the internalization study, including the three subscales of value/usefulness, interest/enjoyment, and perceived choice.

Achievement Test - The achievement test is a 19-item test, which has undergone content validation by three science experts and science educators. Item analysis procedures have reduced the number of questions of the set from 25-items to 19-items. The test covered topics on radiation and insolation which are the major topics on which the SPARK Science Learning System were integrated.

Evaluation Form - This is a 13-item survey in Likert scale intended to identify the insights of the students on the use of SPARK Science Learning System as a technology in the teaching and learning of science concepts. This post-implementation tool was administered to students where they were asked to tick on the appropriate cell. Part of the tool included questions related to the advantages and disadvantages of using SPARK Science Learning System in open-ended format.

Procedure

Preparation and pre-implementation

Pre-implementation commenced with the preparation of the equipment and the instruments needed for the study. Correspondence with De La Salle University, physics laboratory technicians and computer literacy instructor of the participants was done prior to implementation of the technology integration. As pre-intervention procedure, Literacy and Technology Checklist, Intrinsic Motivation Inventory, and Pre-Test (Achievement Test) were administered.

Profiling of students was conducted to determine their background information and their technological literacy. Since every participant is a government scholar in physics teaching, these students are highly motivated to study Physics. Thus, SPARK Science Learning System was integrated to Earth Science lessons instead of lessons in Physics.

Table 1. Technology Literacy Checklist

Respondent	Gender	High School	Access on Technology	Experience with Technology	Computer Literacy and Web Expertise
R1	Male	Marikina Science High School	0.7	0.9	0.8
R2	Male	Ramon Magsaysay Cubao High School	0.7	0.9	0.6
R3	Female	Tala High School	0.7	0.8	0.5
R4	Female	LPNHS (main)	1.0	0.9	0.8
R5	Female	DARSSTHS	1.0	0.8	0.6
R6	Female	Patoc National High School	1.0	0.8	0.4
R7	Female	Ramon Magsaysay Cubao High School	1.0	0.8	0.5
R8	Female	Sorsogon national high school	1.0	0.8	0.7
R9	Male	Jonu Rural School	1.0	0.7	0.4
R10	Female	Muntinlupa Science High School	1.0	0.7	0.7
R11	Female	Rizal National High School	1.0	0.8	0.8
R12	Female	Lagro High School	1.0	1.0	0.8
R13	Female	NOHS	0.7	0.6	0.5
R14	Female	Jose P. Laurel High School	1.0	1.0	1.0
R15	Female	Rosario National High	0.7	0.8	0.7

		School			
R16	Female	San Jose National High School	1.0	0.8	0.5
R17	Male	Pasay City South High School	1.0	0.9	0.8
R18	Male	Ramon Magsaysay Cubao High School	1.0	0.8	0.7
R19	Female	Cavite National High School	1.0	0.9	0.8
R20	Female	Paranaque national High School-Lahuerta	1.0	0.8	0.7
R21	Female	Cavite National High School	1.0	0.9	0.7
R22	Female	MORMS	1.0	0.8	0.4
R23	Female	Mount Carmel School Of Infanta	1.0	0.8	0.7
R24	Male	Binan National High school	1.0	0.9	0.7
R25	Male	Baclaran high School	1.0	0.9	0.7
R26	Male	DARSSTHS	1.0	0.8	0.7
R27	Male	Paranaque National High School-Lahuerta	1.0	0.8	0.6
AVERAGE			**0.9**	**0.8**	**0.7**

Table 1 shows the background information and the summary of the technology literacy of the participants. The indices were computed as ratios of the averages of student ratings based on a four-point Likert scale and the theoretical average in each of the constructs: Access with technology, experience with technology, and computer literacy and web expertise. All values are close to 1 which connotes that all students are technologically literate enough ready to use the SPARK Science Learning System.

These students were products of public high schools directly administered and monitored by the department of education. Everyone graduated either from science oriented schools, science high schools or department of science and technology-science education institute node schools. These participants can be said to be at par with one another in terms of learning experiences. Further, it can be inferred that majority of these students have access to computers with internet capabilities. This may be through the Learning Resource Center provided by the department of science and technology, the Philippine Normal University and the consortium benefits with the De La Salle University, Manila. The majority of the participants use computers and other computer related technology for personal interest and lesson-related activities which make their technology usage a part of their daily routine. This means that they are well-informed in manipulation of devices and technology which has the same features as that of a computer. They can be considered ready users of the SPARK Science Learning System.

During instructions

The succeeding sessions were focused on the integration of the SPARK Science learning system to two major topics in Science 3 (Earth and Environmental Science). The two major topics: radiation and insolation, in the course syllabus of Science 3 (Earth and Environmental Science) were selected for the purpose of the study. Session plans were prepared to map out the integration and instruction of the selected topics.

The implementation of the integration of the SPARK Science Learning System in selected topics was conducted in several sessions. The first session highlighted the orientation on the SPARK Science Learning System. This orientation was conducted at the Philippine Normal University. In this session the researcher presented the visual reference, the user's guide, and the quick start guide to the participants. Discussions on how to use the instruments and some comparison with the classical laboratory procedure were also presented and discussed with the students. The first impression of the students was that the instrument maybe very expensive. They expressed some anxiety on the use for reasons that they may damage the said instrument. Further discussions on the said instrument was done by comparing SPARK Science Learning System with some common and familiar technology these students are adapted to like the touch screen mobile phones and PSPs which helped them concretely visualize the introduced technology (SPARK Science Learning System).

The succeeding sessions were hands-on orientation on the instrument and integration of the SPARK Science Learning System on selected topics in Science 3 (Earth and Environmental Science) - Radiation and Insolation. The integration procedure followed pedagogically accepted process as presented in the session plans prepared by the researcher and content validated by experts including the researcher's consultant. Within the short span of time students were able to come up with good results using the SPARK Science Learning System.

Post-Implementation

To determine the effect of the SPARK Science Learning System, an achievement test was administered to the participants after implementation of SPARK integration. Post-test results were statistically compared to the results obtained in the pretest to determine gains if any in student achievement. Intact group pre-test-post-test design was used in the study. One limitation of the study is identifying comparable set of participants. Thus, only anecdotal comparison of the student achievement using SPARK Science Learning System with student achievement without the integration was done to validate the significant statistical difference in the pre- and post-test results on student content knowledge. The intrinsic motivation inventory and evaluation tool were administered to determine whether the students were intrinsically motivated by the SPARK Science Learning System integration. Correlation of post-test with intrinsic motivation, post-test with evaluation, and intrinsic motivation with evaluation was done to identify the factors that may have influenced the gains in student achievement. Transcriptions of interviews and annotation of verbatim answers on the open-ended questionnaire part of the evaluation were used to further identify influential factors in the design of framework on technology integration.

Results

The primary goals of this study are to establish the effect of using SPARK Science Learning system on student achievement; to determine the effect of using the SPARK devices on student motivation; to identify the influential factors in modelling SPARK Science learning system in science classes; and design framework to integrate technology in science classes and adopt them to the 21st century learning. Results of the study are presented according to these major goals.

On the effect of SPARK Science Learning System on student achievement

To determine if there was a significant gain in students' content knowledge, statistical comparison of the pre-test and post-test of the participants through paired sample t-test was done as presented in Table 2.

Table 2. Paired Sample Statistics

Pair	N	Pre Test Mean	Post Test Mean	p-value
Pre-Test and Post-Test	25	9.00	13.60	0.00*

(*)Significant at 0.05

The participants performed better in the post test as compared to the pre-test with the implementation of the SPARK Science Learning System. The difference in the pre-test mean and the post-test mean was statistically significant with a p-value of less than 0.05 (p-value = 0.00 < 0.05). As targeted, the integration of SPARK Science Learning System has brought about significant gains in the student achievement. This implies that the integration of SPARK Science Learning System in selected topics in Earth and Environmental Science is highly effective. Anecdotal comparison of student achievement using SPARK Science Learning System with student achievement without the integration was also done to validate the significant statistical difference in the pre- and post-test. Students from other classes encountered difficulty in meaning making when it comes to learning the concepts of Earth and environmental science. They usually scored lower in examinations given to them. They are not that active during class discussions and more often they encountered erroneous sets of data when performing comparable experiments with those done by the participants.

On the effect of SPARK Science learning system on student motivation

Table 3. Correlation of SPARK Evaluation, Post-Test and Intrinsic Motivation

Categories	Post-Test	Evaluation	Intrinsic Motivation
Mean	13.64	4.75	5.68
Pearson			
Post-Test	1.00	-0.063	0.618*
Evaluation	-0.063	1.00	-0.353
Intrinsic Motivation	0.618*	-0.353	1.00
Model Summary**		**0.464****	

(*) Significant at 0.05 *** Predictors: Post-Test, Evaluation & Intrinsic Motivation*

Table 3 presents post-test mean value of 13.64 out of the 19-item test of the participants. This means that the participants were able to correctly answer more than 70% of the items about radiation and insolation through the integration of SPARK Science Learning System. Evaluation of the SPARK Science Learning System has a high mean value (4.75 out of 5). This connotes that participants express positive attitude towards the use of SPARK Science Learning System in learning science concepts. Intrinsic motivation has moderate mean value of 5.68 out of 7.

Significant positive correlation is observed between post-test and intrinsic motivation. The other pairs: post-test & evaluation and intrinsic motivation & evaluation posit non-statistically significant correlation. Low positive correlation of three variables: post-test, evaluation, and intrinsic motivation presented in the "model summary" was observed with an R-value of 0.464. This is lower than the usually accepted value of 0.5. This implies that there may be other constructs of learning that are better predictors of student achievement other than the evaluation of the technology (SPARK) and the post-experimental intrinsic motivation.

Discussions

The high mean value of the evaluation of the SPARK Science Learning System is complemented by the student answers in the open-ended portion of the evaluation. They positively identified several advantages of using the device as follows:

> *"Learners will now find it easy and fun to do experiment. The results will be no doubt accurate."*
> *"The SPARK is very useful during the experiments; students can easily record data accurately while doing the graphs and tables at the same time."*
> *"Besides from being handy, it is also good in understanding a concept because the background gave the information about the concept and after this is a follow up question that will help the student think."*
> *"It gives background concepts on the activity to be performed and asks questions to tests our knowledge on the topic."*
> *"Results are readily seen…continuous to record data and can be saved."*

"The device can be easily manipulated. It provides learners with necessary guide questions that directly lead to further understanding of the lesson and its concepts."
'The concepts are already stated in the activities."
"It's accurate, innovative, safe."

Similar answers were provided by selected students during the post-implementation interview. They pointed out how the SPARK Science Learning System was helpful and engaging to students. They attested that SPARK Science Learning System is novel to them and is very visual in perspective, which matches their learning needs and style.

"Na-amaze ako mam sa nagagawa ng instrument or device."
(I was amazed with what the instrument can do.)
"Yes mam, the SPARK Learning System helped a lot. I was able to answer the follow up questions with ease and also the evaluation questions."
Mam sometimes it's hard to learn using books alone because they are not that much available or engaging, unlike the SPARK, it has a way of making interactions work out.
"Yes mam, sa tulad ko po na madali makaintindi pag may illustrations mas maganda para sa amin ang mga ganitong device para mas maintindihan and concepts."
(Yes Mam, for student like me who hardly understands concepts in science but can possibly do so with good visuals.)
"I would recommend the use of SPARK Learning system but in partnership with written outputs, written graphs and computations."

However, students have also identified several areas of weaknesses and improvement in integrating SPARK Science Learning System in science lessons to make learning much more meaningful and appreciated by them. In the post-instruction interview, these pre-service students believe that the full potential of SPARK Science Learning System may be achieved in combination with other written curriculum materials. The positive correlation of post-test and intrinsic motivation could mean that they were already highly motivated in the subject area as they are science-oriented students but this intrinsic motivation is hardly identified with the integration of the SPARK Science Learning System. This result is complemented by students' answers when asked about some disadvantages of using the SPARK Science Learning System as follows:

"Graphing skills of the students and manipulating data may be affected negatively."
"Less interaction or cooperation among students since it can be done individually."
"The students will be lazy and always depends on the SPARK."
"The students might just rely on the tool in graphing and not do it manually."
"There will be little interaction between the teachers and the learners. Learners will only depend on the approaches."

From the transcriptions, students still hold on to the ideology of learning by doing. Graphical skills may not be developed if graphs are automatically done by the instrument. Since everything becomes automated, students seem to exert less effort and they perceive this as being lazy or not being able to give their best shot in an activity. They further claim that the tool may just develop dependency of the students to equipment rather than on their own skills. Although they were working in groups and the nature of the course is collaborative and inquiry-based, they feel that interactions within the group for them to nurture relationships and build their socialization skills are fewer with the tool at hand. They also experience less interaction with the teacher since all answers regarding the topics presented can be understood using the SPARK Science Learning System.

In terms of student achievement, integration implementing SPARK Science Learning System was a success. The integration brought about significant and meaningful learning on the part of the participants. Motivation, on the other hand, did not positively correlate with student perceptions on implementing the technology. The same non-correlation result was found between student achievement and student perception on the integration of SPARK Science learning system. This suggests that some other factors were able to influence the motivation of students to learn such as other pedagogical techniques, teaching and learning of other important science process skills that the technology is incapable of doing, and learning environment. These factors were identified by the participants in their verbatim answers in the open-response part of the evaluation tool.

Implementing the SPARK Science Learning System could touch grounds on learning and innovation skills, which focus on creativity, critical thinking, communication and collaboration. This is a good foundation in preparation for the shift towards P21 or 21st Century Learning. Embedded in the learning system are activities that could promote the needed attributes of students to attain learning and innovation skills. With the technology, students could be able to exhibit a range of functional and critical thinking skills related to information, media and technology. The use of the SPARK Science learning system gives students more opportunities to develop skills related to information, media and technology. Life and career skills are also needed for students to navigate the complex life and work environments in the globally competitive information age. This can be achieved by combining the SPARK Science learning system with other curriculum materials that may develop the latter identified skills. These are the needed skills of a new generation student to be able to adapt and be a successful citizen. These are the bases of identifying the influential factors needed in modelling the SPARK Science learning system in science classrooms.

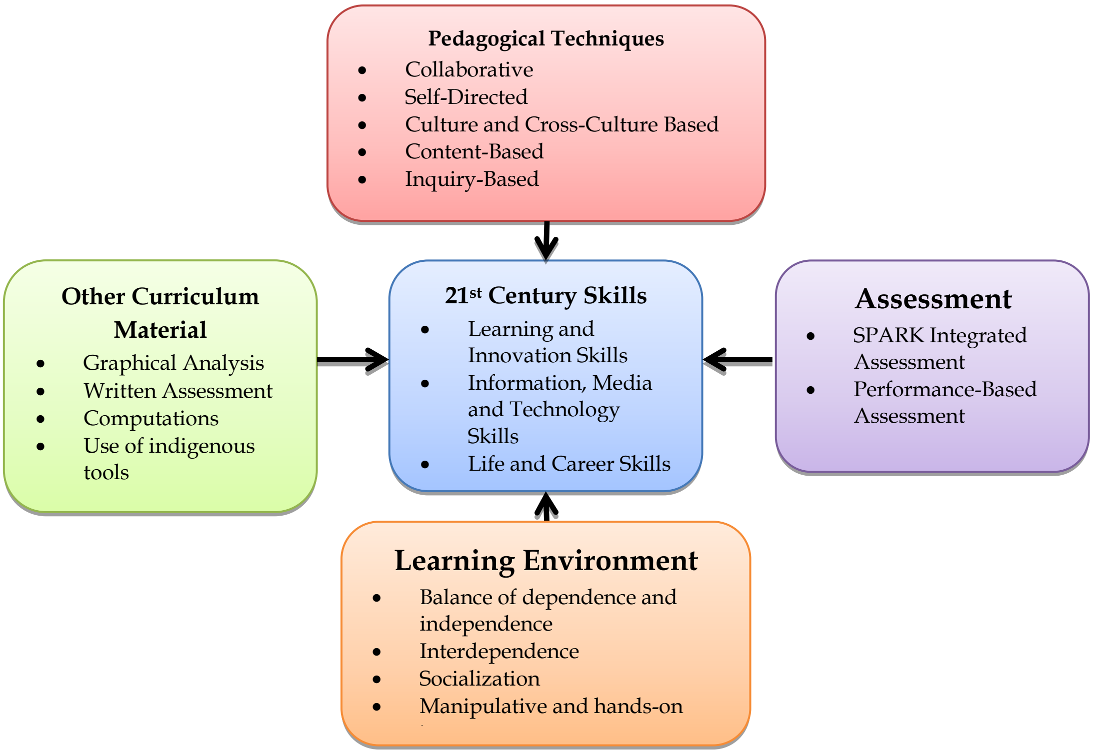

Figure 1: Framework of Implementing Technology Integration

The framework presented in Figure 1 shows all the influential factors of modelling the SPARK Science Learning System. It was identified that integration of the SPARK Science Learning System was effective to a certain extent. The low correlation observed between evaluation of the technology & intrinsic motivation and evaluation of the technology with post-test result led to the idea that positive results may not be solely attributed to the integration of the SPARK Science Learning System in the pedagogy. It was noted that probable combination of other curriculum materials, proper learning environment, proper planning of integration process, and other forms of assessment could lead to much more meaningful integration of the SPARK Science Learning System. As claimed by Mishra & Kohler (2006), successful technology integration requires that educators blend strong content knowledge with appropriate pedagogical strategy. From the study, it can be gleaned that factors that influence the significant effect of integrating technology are clustered into four. These are pedagogical techniques, other curriculum materials, assessment procedures, and learning environment. To achieve full meaning of technology integration, combinatorial presentation of the four constructs with the integration would achieve meaningful learning. This is known as Technology-Pedagogy-and–Content Knowledge or TPACK on which the designed model is aligned.

Conclusions and Recommendations
The foci of this study were to establish the effectiveness of the integration of the SPARK Science Learning System on selected topics in Earth and Environmental Science. It is intended to determine whether or not integration of SPARK Science Learning system positively affects student motivation eventually leading to student achievement; to identify influential factors on modelling technology and to design framework of technology integration. The intervention administered was effective because it led to a significant gain in the pre-test and post-test mean difference on student knowledge of the content. This implied a meaningful integration of the SPARK Science Learning System on Earth and Environmental Science. The integration of the SPARK Learning System also had positive effects on student post-experimental intrinsic motivation and was evaluated positively by the respondents. These were separately manifested in the means or averages of the data sets. However, it was noted, that two of the three variables: post-test, evaluation, and post-experimental intrinsic motivation had low positive correlation. It can be inferred that although the integration was effective, constructs other than student motivation and evaluation of the integrations contributed to the mean gain in the pre-test and post-test difference. Post-instruction interviews with the students provided other details of the low correlation. Further, influential factors that are needed in the much more meaningful integration of the SPARK Science learning system were deduced from the post-implementation interviews and open-responses of the students in the evaluation. These factors were noted as inputs to the design of framework which captured all study results for meaningful integration of technology (SPARK) leading to development of 21st century skills as preparation to P21 learning. Integrating technology is not just using the technology. It is a special skill of combining the technology with other learning constructs such as curriculum materials, pedagogy, assessment and learning environment to achieve the full potential of the technology to induce learning to the students.

Though the study is able to enhance student achievement and has provided framework for meaningful integration of technology, there are still some limitations. The identified participants were government scholars in the field of sciences thus they are already science enthusiasts. Large gains in terms of student achievement and learning motivation may be deduced if the study is replicated to a group of non-science students. An experimental design with a control group may be adopted to compare student achievement with the integration to those without technology integration. The focus of the experimental study would be cognition, process skills and affective domains of learning. Pre-and post-implementation interviews may also be conducted highlighting motivation constructs and not only focused on perception of the students on the use of the technology. Classroom observations can be done to determine other significant observations which may not be provided by interviews and test results.

Replication of the study is needed to fully establish effectiveness of meaningful integration of technology in learning science. A study to test the designed model may help launch meaningful integration of technology that leads to the development of the 21st century skills. Teacher education curriculum designers may look into the feasibility of the model or framework in developing pre-service students' TPACK that would greatly support the development of teachers' competencies that would help mold the 21st century learners.

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